Good practice guide for assessing and managing the environmental effects of dust emissions

Published in September 2001 by
Ministry for the Environment
PO Box 10-362, Wellington, New Zealand

ISBN 0-478-24038-4
ME Number 408

This document is available on the Ministry for the Environment's Web site:
http://www.mfe.govt.nz

Ministry for the
Environment
Manatū Mō Te Taiao

Ministerial Foreword

The effects of dust emissions from sources such as quarrying, aggregate crushing, abrasive blasting, unsealed surfaces and material stockpiles can cause widespread public concern.

This guide has been developed to provide guidance on how to assess and reduce the environmental impacts of dust emissions. It looks at where dust comes from, its effects on the environment and how we can better monitor and manage dust emissions.

This guide is the result of more than a year of consultation and development with councils, industry, practitioners and communities. It is based on best practice evolved under New Zealand's Resource Management Act.

This guide will be a valuable resource to those involved with dust issues, from those managing the emissions through to those affected by dust. It will help councils prepare regional and district plans and with resource consent decisions. Industry will be able to use the guide to prepare environmental effects assessments and to manage and control their dust emissions.

While a local approach to dust nuisance management is recommended to take account of local conditions and factors, this guide provides practical information and tools that can be tailored to particular situations and communities.

As a result of this work I hope we will see a reduction in the levels of dust emissions caused by human activity and a more consistent approach to dust management nationally.

Marian L. Hobbs

Hon Marian L Hobbs
MINISTER FOR THE ENVIRONMENT

Acknowledgements

The Ministry for the Environment would like to thank the following people for preparing and reviewing this guide:

- Bruce Graham, Graham Environmental Consulting Limited and John Iseli, Specialist Environmental Services Limited (principal authors)
- Kathryn Edmonds and Penny Race, Opus International Consultants (authors of the draft section on legal matters)
- Kevin Rolfe, Kevin Rolfe and Associates Limited
- Mercedes Lenz, Winstone Aggregates Limited and Doug Gordon, New Zealand Minerals Industry Association (peer reviewers of the draft document).

Greg Slaughter, Fulton Hogan Limited, provided valuable assistance with preparation of the Mt Wellington quarry case study.

Thanks also to all those who provided written submissions on the draft documents.

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1 Introduction

1.1 Purpose

This Good Practice Guide aims to provide useful information and recommendations for councils, communities and industry on how to assess and manage the environmental effects of particle or dust emissions from sources such as quarrying, aggregate crushing, abrasive blasting, unsealed surfaces and material stockpiles.

The guide should assist in:

- assessing environmental effects of dust emissions and ways to mitigate them
- developing regional air plans
- considering resource consent applications to discharge contaminants to air
- preparing district plans
- compliance monitoring
- state of the environment monitoring.

The Guide focuses on what is typically referred to as "dust nuisance" effects and impacts on amenity values, such as the soiling of clean surfaces and visual impacts. It does not go into significant detail on potential human health effects of fine particulate (particles less than 10 microns in size – PM_{10}). This is covered in other guidance documents from the Ministry.

The term "dust nuisance" has been chosen quite deliberately, to distinguish it from the very similar "nuisance dust". In other words, the information given here is directed at the management of an effect of dust (i.e. nuisance), rather than managing the specific class of dusts referred to as "nuisance dust" or "nuisance particulates".

The nuisance effects of dust can be subjective and are difficult to measure in any quantitative or objective way. They are also very dependent on the sensitivity of the receiving environment. As a result, the effects cannot be controlled or managed easily through the use of air quality guidelines, which is the approach taken with most other air contaminants.

The recommendations in the guide aim to provide a practical and reasonable approach to the management of dust nuisance problems.

The information provided is complementary to the advice on planning provisions offered by the Ministry's report on *Managing the Amenity Conflicts Arising from Rural Activities* (MfE, 2000).

1.2 Content and scope

The remainder of section 1 discusses the importance of dust as an environmental issue and introduces the reader to the potential sources and environmental impacts of dust emissions.

Section 2 of the guide contains information on the sources of fugitive dust and a discussion of the potential environmental effects of dust emissions. These include effects on human health, soiling of clean surfaces, visibility loss and effects on plants.

Section 3 reviews current and historical legislation relevant to the control of dust emissions and their environmental effects. This includes a discussion of the key requirements under the Resource Management Act (RMA), along with a review of relevant case law.

Section 4 contains a discussion on various management options under the RMA. These include land use planning, regional and district plans, and resource consents (discharge permits). All of these instruments are appropriate for the management of dust nuisance, although they need to take into account the subjective nature of the environmental effects of dust emissions.

Section 5 describes the variety of different methods that can be used to assess dust emissions and their effects, including cumulative effects.

Section 6 then reviews methods for monitoring dust effects and contains recommended methods for different circumstances. These include complaint monitoring, source testing and environmental monitoring. More specific information on the methods used for dust monitoring and related assessment criteria is given in Section 7.

Section 8 reviews the engineering methods available for dust control. For diffuse sources such as housing developments and construction sites, these can be as simple as regular watering of exposed surfaces and on-site speed limits for trucks and other vehicles. Control methods for industrial sources include the use of dust collectors, such as cyclones or bag filters, and total or partial enclosure of potential dust sources, such as conveyors.

The series of Appendices provide further information on dust properties, complaint records, assessment criteria, dust monitoring methods, and dust management plans. Case studies are provided at the end of the guide that highlight the practical issues associated with managing the effects of dust emissions.

This Guide does not cover occupational health issues for workers involved in dusty activities. The Occupational Safety and Health Division of the Department of Labour, relevant legislation and specific guidance information deal with these issues.

1.3 Why is guidance on dust assessment and management important?

The environmental impacts of dust emissions can cause widespread public concern about environmental degradation and/or a decline in amenity. The nature and extent of the problem and significance of the effects usually depend on the nature of the source, sensitivity of the receiving environment and on individual perceptions. For example, the level of tolerance to dust deposition can vary enormously between individuals. However, individual responses can also be affected by the perceived value of the activity producing the dust. For example, people living in rural areas may have a high level of tolerance for the dust produced by activities such as ploughing or top-dressing, but a much lower tolerance level for dust from unsealed roads.

The importance of community perception was clearly demonstrated in the results of a public opinion survey carried out by the (then) New South Wales State Pollution Control Commission and the New South Wales Coal Association (Dean *et al*, 1990). Population surveys and deposition measurements were carried out over a period of three years in areas where dust problems were known to occur. The results showed that individual perceptions were affected by the existing background dust levels, and by the rate of change. The study found that the environmental character of an area (i.e. whether it is predominantly natural, rural, semi-rural, suburban or urban/industrial) and the social nature of an area (particularly the degree of community stability preceding a period of development and associated environmental change) were important determinants of the degree of community response.

The study also found that there was no particular threshold at which people were able to clearly perceive a decline in amenity. This conclusion has important implications for setting loss of amenity criteria or guideline values because any goal, criteria or value based on a universal threshold may be inappropriate.

Given the above, dust nuisance is best dealt with at a local level using management programmes tailored to the local conditions and local community concerns. This can lead to different controls between regions, based on varying receiving environment sensitivities and community perceptions of dust nuisance. It is therefore important to promote sound decision-making and a consistent approach to the management of dust issues throughout New Zealand.

Without a consistent approach founded on good practice there is a risk that certain regions may become “easy targets” for dusty activities because they have a less stringent approach to regulation than other regions (e.g. through rules in regional air quality plans). Industries have also expressed concerns about inconsistent requirements being imposed throughout New Zealand. Different requirements can also be particularly frustrating for trans-regional activities, such as mobile abrasive blasting.

National guidance aimed at achieving sound, reasonable and consistent decisions on dust management should also assist in handling overlapping responsibilities between local and regional authorities. These overlaps have the potential to occur in relation to dusty activities because of a degree of duplication of council functions. This guide provides advice intended to minimise the duplication of functions. The Ministry’s report *Managing the Amenity Conflicts Arising from Rural Activities* (MfE, 2000) also provides useful information in this respect.

1.4 Issues

There are a number of key issues associated with dust management, which will be addressed by this guide. These are as follows:

- Subjective effects. The main problem with the environmental effects of dust is their subjective nature. People may be annoyed by dust fallout on their property, and some may find it objectionable or offensive. There are a number of practical and legal aspects that need to be considered in judging the severity and significance of these effects.
- Assessment methods. Many dust emissions come from diffuse sources, such as bare ground, unsealed roads, mines and quarries. As a result, it is difficult to quantify the emissions, and it is also very difficult to accurately predict the likely effects.
- Variability of the receiving environment. Measurable amounts of dust can be found in most urban and rural environments, but the levels can be highly variable. There are also extreme situations, such as drought-stricken rural areas or fallout from volcanic eruptions, where the natural dust levels can be well above the recognised nuisance levels.
- Land use planning. Dust nuisance problems are often associated with land use activities. This raises the issue of overlapping responsibilities between territorial local authorities and regional councils. There is also a need to recognise and provide ways to minimise the potentia l impacts of dust nuisance through land use planning.
- Understanding cumulative effects. In some areas there may already by relatively high background levels of dust and dust deposition. It is important to determine how these should be taken into account when carrying out an environmental assessment.
- Potential health effects. Although this document deals mainly with dust particles larger than PM_{10}, there needs to be some guidance on when potential health impacts should also be included in an assessment of the impacts of dust emissions.

2 Sources and Environmental Effects

2.1 Dust sources

Airborne dust can arise from a wide variety of anthropogenic sources, including the following:

- wind-blown dust from exposed surfaces such as bare land and construction sites
- wind-blown dust from stockpiles of dusty materials such as sawdust, coal, fertiliser, sand and other minerals
- dust caused by vehicle movements on sealed or unsealed roads
- agriculture and forestry activities
- mines and quarries
- road works and road construction
- housing developments
- municipal landfills and other waste handling facilities
- dry abrasive blasting
- numerous industrial operations, including grain drying and storage, timber mills, stonemasons, mineral processing, cement handling and batching, and fertiliser storage and processing.

Large quantities of dust can also be generated from natural sources, such as dry river beds, pollen from plants and volcanic eruptions.

2.2 Potential health effects

The potential health effects of dust are closely related to particle size. Particle sizes are normally measured in microns, and the size range of airborne particles is typically from less than 0.1 microns up to about 500 microns, or half a millimetre. Human health effects of airborne dust are mainly associated with particles less than about 10 microns in size (PM_{10}), which are small enough to be inhaled. Nuisance effects can be caused by particles of any size, but are most commonly associated with those larger than 20 microns. Further discussion of the relationship between dust particle size and potential effects is given in Appendix 1.

The potential health effects of fine particles (less than 10 microns) are specifically covered under the New Zealand Ambient Air Quality Guidelines (MfE, 1994 and 1999), and will not be addressed further in this guide.

Many forms of dust are considered to be biologically inert, and hence the primary effects on people relate to our sense of aesthetics. There can also be minor health effects, such as eye irritation, when the dust is airborne. Indirect stress-related health effects could also arise, especially if dust problems are allowed to persist for an unreasonable length of time.

Some nuisance dust may have the potential to cause other types of health effects because of the presence of specific biologically active materials. For instance, some mineral dusts contain quantities of quartz, which can cause the lung disease known as silicosis when persistent at high concentrations. Other dusts may contain significant amounts of toxic metals such as mercury or lead.

The management procedures given in this guideline are applicable to all types of dust, regardless of their physical and chemical composition. However, those containing specific toxic components will generally require a much tighter level of control than simple nuisance dust. In some cases Workplace Exposure Standards have been developed for these materials to address occupational health issues (Department of Labour, 1994). Recommendations on the acceptable ambient air concentrations for some of these materials are given in a recent draft technical report prepared for MfE (1999). This Good Practice Guide is directed at the management of dust that causes nuisance or annoyance to people, rather than specific health effects.

2.3 Soiling and amenity value effects

The most common areas of concern include: the visual soiling of clean surfaces, such as cars, window ledges, and household washing; dust deposits on flowers, fruit or vegetables; and the potential for contamination of roof-collected water supplies. Dust deposits inside the house are often the impact of greatest concern in residential areas, followed by soiling of the outside of the house and the effects on paintwork.

Dusty conditions can also affect people's ability to enjoy their outdoor environment, making activities such as barbeques and sports unpleasant and unappealing.

For most people, a major effect of a dust nuisance problem is annoyance at the increased requirement for cleaning. However, this can also involve a financial aspect, through the increased use of cleaning materials, water, and possibly paid labour. This aspect of dust nuisance was addressed in a (by now rather dated) book by Ridker (1970) and in a paper by Narayan and Lancaster (1973). In the latter paper, the authors estimated that the cost differential for maintaining a house in an area of heavy dust deposition compared with a less polluted area of the Hunter Valley, New South Wales, was $90 per annum. An equivalent figure in today's terms could be about $500–$1000, which is significant.

Another related effect of dust nuisance is the potential impact on property values. This is a more difficult and often more emotive subject than soiling effects, but it is also a matter of common concern. Clearly, there is no simple method for quantifying this effect, and it would need to be assessed on a case-by-case basis.

2.4 Visibility

Airborne dust can have effects on visibility, although dust is usually less regionally significant than the effects of smoke from domestic fires and motor vehicles in urban areas. Visibility effects from dust are usually only a concern in the immediate vicinity of a specific source, whereas smoke effects can accumulate across a much wider area.

Visibility effects are largely a matter of aesthetics. However, it should also be recognised that visibility is one of the main ways by which people commonly judge air quality. Some people feel that the ultimate success of air quality management programmes in New Zealand will be measured against ensuring that we do not suffer the widespread degradation in visibility that has occurred elsewhere.

Loss of visibility is also a safety concern under extreme conditions, especially for road traffic or aircraft.

Guidance on atmospheric visibility degradation is being prepared under a separate MfE project and visibility has been adopted as a stage 2 (further development required) air quality indicator under the Environmental Performance Indicators Programme (MfE, 1998b).

2.5 Effects on plants

Dust deposits can have significant effects on plant life, though mainly at high dust loadings. This can include:

- reduced photosynthesis due to reduced light penetration through the leaves. This can cause reduced growth rates and plant vigour. It can be especially important for horticultural crops, through reductions in fruit setting, fruit size and sugar levels.
- increased incidence of plant pests and diseases. Dust deposits can act as a medium for the growth of fungal diseases. In addition, it appears that sucking and chewing insects are not affected by dust deposits to any great extent, whereas their natural predators are affected.
- reduced effectiveness of pesticide sprays due to reduced penetration.
- rejection and downgrading of produce. Once again, this is a particular issue for horticultural crops.

The effects of air pollutants on plants were recently reviewed in a report on ecosystem effects (ESR, 1998), although the coverage of dust effects is minimal. A much more detailed coverage of the effects of dust on plants is given in a report by the Agricultural Engineering Institute (McCrea, 1984). This report gives estimates of the potential losses in crop productivity for various rates of dust deposition. The main focus of the report is on horticultural crops grown alongside unsealed roads, and in this case the losses were shown to be significant within about 200 metres of the source.

Figure 1: Extraction processes and material stockpiles are common sources of wind-blown dust

3 The Legal Framework for Dust Management in New Zealand

3.1 Background legislation

Prior to 1991, the control of air pollution in New Zealand was under the common law doctrines of nuisance, and to a lesser extent trespass and negligence, and the statutory controls of the Health Act 1956 and the Clean Air Act 1972.

The Clean Air Act 1972

The Clean Air Act 1972 (CAA) imposed a general obligation to adopt the best practicable means to reduce air pollution. It limited the application of the Health Act to "nuisance" and "offensive trades" that were not included in the CAA Schedules. Common law remedies remained, particularly as there were no rights to object to licenses or rights to statutory compensation under the CAA.

The CAA was repealed by the Resource Management Act (RMA) in 1991, although transitional provisions continue to apply for some activities (section 418).

The Health Act 1956

Section 29 of the Health Act deems a nuisance to be created:

> *(h) Where any factory, workroom, shop, office, warehouse, or other place of trade or business is not provided with appliances so as to carry off in a harmless and inoffensive manner any fumes, gases, vapours, dust, or impurities generated therein:"*

Other more general nuisance provisions may also be wide enough to include a nuisance generated by dust where an accumulation or deposit is in such a state or situated so that it is offensive or likely to be injurious to health (section 29(b)).

The Health Act is administered by district and city councils. Every person who permits or causes a nuisance commits an offence under the Health Act. The Court may require an owner or occupier to abate a nuisance and may specify the works to be done. A local authority may also abate a nuisance and recover costs. The general penalty for offences is $500 and a further fine not exceeding $50 a day for a continuing offence.

The nuisance provisions of the Health Act 1956 have not been repealed by the Resource Management Act 1991 ("the RMA"). However a nuisance created under the Health Act 1956 is also likely to constitute an offence under the RMA. The offence provisions under the RMA provide for heavier penalties for similar offences as well as the possibility of abatement notices and enforcement orders requiring work to be done to avoid, remedy or mitigate any actual or likely adverse effect on the environment.

3.2 The Resource Management Act 1991

The purpose of the RMA as specified in section 5(1) is *"to promote the sustainable management of natural resources"*. Section 5(2)(c) provides for *"avoiding, remedying, or mitigating any adverse effects of activities on the environment"*. Section 2 of the Act defines "environment" as including:

> *"(a) Ecosystems and their constituent parts, including people and communities; and*
>
> *(b) All natural and physical resources; and*
>
> *(c) Amenity values; and*
>
> *(d) The social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) of this definition or which are affected by those matters."*

The term "amenity values" is also defined in section 2 of the Act. It means:

> *"those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes."*

Clearly, dust nuisance is covered under the RMA because of its potential to cause adverse impacts on amenity values.

Section 9

Section 9 provides that a person may use land in whatever manner they like provided it does not contravene a rule in a plan. If the activity does contravene a rule then a resource consent is required, except when existing use rights apply. The production of dust from a land use will, therefore, not be controlled under a district plan unless the plan includes restrictions on the effects of the use of land that causes the dust emission.

Section 15

Dust is an air contaminant, and is therefore controlled under section 15 of the Act. Section 15(1) means that discharges from industrial or trade premises are only allowed if they are authorised by a rule in a regional plan, a resource consent, or regulations. If a discharge is not authorised in this manner, consent will be required unless a plan prohibits the activity.

Under 15(2) the opposite presumption applies to discharges from any other source. Unless these sources are controlled by a rule in a plan, discharges are allowed as of right and consent is not required.

Section 17

Section 17 of the Act imposes a general duty upon every person to avoid, remedy or mitigate any adverse effect on the environment arising from any activities the individual may conduct or have carried out on their behalf. This applies, regardless of whether the activity is carried out in accordance with any rule, plan or resource consent.

In section 3 of the RMA, "effect" is defined as including:

"(a) Any positive or adverse effect; and

(b) Any temporary or permanent effects; and

(c) Any past, present, or future effect; and

(d) Any cumulative effect which arises over time or in combination with other effects – regardless of the scale, intensity, duration or frequency of the effect, and also includes –

(e) Any potential effect of high probability; and

(f) Any potential effect of low probability which has a high potential impact."

Enforcement provisions

Section 17(3)(a) provides that an enforcement order or abatement notice may be made or served, requiring a person to cease doing something that is or is likely to be noxious, dangerous, offensive or objectionable to such an extent that it has or is likely to have an adverse effect on the environment (sections 314(1)(a)(ii) and 322(1)(a)(ii)). Only a few forms of dust would be classified as "noxious" or "dangerous", but most can be "offensive" or "objectionable" in sensitive areas.

3.3 Best Practicable Option (BPO)

Section 108(1)(e) of the RMA makes provision for requiring a consent holder to adopt the best practicable option to control any adverse effects caused by an activity. The BPO is also commonly included in the review clauses of consents; essentially as a "fall back" option should the other consent conditions prove ineffective in controlling the effects of an activity.

The best practicable option was dealt with in some detail in *The Medical Officer of Health* v *Canterbury Regional Council and Ravensdown Fertiliser Co-operative Limited* (W109/94). The Planning Tribunal (now called the Environment Court) stated that in its view the key word was "practicable":

> *"Practical effect is given to those requirements [the provisions of section 108] by ensuring that the contaminants discharged by the applicant are at a level which on the best scientific and technical information available constitute the best practicable option of minimising adverse effects on the environment" (p.26)*

The Planning Tribunal held that it would be wrong to impose conditions that the holder of the consent could not practically comply with.

In an earlier case, the Planning Tribunal considered it was important the best practicable option condition was the *"most efficient and effective means of preventing or minimising any actual or likely adverse effect on the environment"* (*Peninsula Watchdog Group Incorporated* v *Waikato Regional Council and Coeur Gold New Zealand Limited* (A52/94)). It therefore appears that, the best practicable option will need to be the one that is most efficient and effective, and practicable given the current scientific and technical information available to prevent or minimise any actual or likely adverse effect on the environment. It will be the *"optimum combination of all methods available ... to the greatest extent achievable"* (*Auckland Kart Club Incorporated* v *Auckland City Council* A124/92 at pp.22-23).

In the *Ravensdown Fertiliser* case (W109/94) the Planning Tribunal went on to consider the term "environment" in relation to section 108(1)(e). It held at p.26 that:

> *"... it is clearly more than just the receiving air which must be considered in the context of s.108. It is also relevant to the facts of this case that it is amenity values and the social, economic, aesthetic and cultural conditions of the people of the surrounding area which must be borne in mind."*

In that case odour from the factory was said to clearly be capable of adversely affecting the amenity values of the district and the social, economic, aesthetic and cultural activities that take place there.

The Planning Tribunal noted that there was nothing known to science and technology at the time of the case that meant odours from the factory could be completely eliminated. However it was satisfied that all that was practicable at the time was being done to minimise the adverse effects on the environment of the odour discharge. Accordingly, the best practicable option does not necessarily mean the complete elimination of any adverse effect on the environment.

In *Australasian Peat Limited* v *Southland Regional Council* (C44/96) the Planning Tribunal required certainty in relation to a condition of the best practicable option for the control of dust. It stated that the best practicable option for the control of dust must be specified before it would allow an appeal. The methods specified to control dust included covering storage heaps with mesh cloth, laying and maintaining a concrete pad, installing and maintaining sliding doors on the peat drying plant, sealing a common access way with limestone rock and watering all loose dry peat before and during high wind events.

3.4 Site management plans

Site management plans are commonly required for the management of dust nuisance (see section 8). It is possible for a condition requiring compliance with a management plan to be included in a resource consent under section 108. To be included as a condition, the management plan must meet the criteria for resource consent conditions which means it will need to:

> *"1. Be for a resource management purpose, not for an ulterior one; and*
>
> *2. Be fairly and reasonably related to the development authorised by the consent to which the condition is attached; and*
>
> *3. Not be so unreasonable that no reasonable planning authority duly appreciating its statutory duties could have approved it."* (*Coote* v *Marlborough District Council* (W96/94))

The Environment Court has stated that its preference is for management plans to be prepared in advance and form part of the terms of the consent (*New Zealand Rail* v *Marlborough District Council* (C36/93), *Bird* v *South Canterbury Car Club* (C27/94) and *Hicks and Ors* v *Canterbury Regional Council and Selwyn District Council* (C58/95)). It has been held specifically in relation to dust control that where management practices are to be adopted that:

> *"If the intention is to ensure not only that these steps are taken, but that certain air quality parameters are to be adhered to, then we think those parameters should be specified as conditions of consent ..."* (*New Zealand Rail* case at p.193)

It is not appropriate for a council to try and reserve the power to approve a management plan at a later date outside the formal resource consent procedure (*Macraes Mining Company* v *Waitaki District Council and the Otago Regional Council* (C14/94)). The applicant or requiring authority needs to know what is required when the decision is made.

4 Management of Dust Emissions under the RMA

Most regional and district councils have recognised the need for controls on dust nuisance, and attempt to do so through rules in regional and district plans, and through conditions in resource consents. This section discusses the functions of regional councils and territorial local authorities (TLAs) and describes how these relate to managing dust issues.

4.1 Regional air quality management plans

To assist them in achieving the purpose and principles of the RMA, regional councils and unitary authorities can prepare regional air quality management plans. The plans specify the methods that will be used in managing air quality within a region. They usually aim to achieve the objectives and policies set out in the Regional Policy Statement. Individual sources or groups of sources are typically controlled by rules in plans that specify whether the activities are permitted (with conditions), controlled, discretionary, non-complying or prohibited.

The plans may also include policies and methods for the management of identified issues such as dust nuisance, odour, smoke from domestic fires, and motor vehicle emissions. In addition to rules, non-regulatory mechanisms may be adopted, such as education and development of industry codes of practice. Regional air plans are developed through a process of public consultation and review, before the plan finally becomes "operational". The current status of specific plans should be checked with the relevant regional council.

4.2 District plans

In the case of territorial local authorities, air quality matters are usually covered in a general way in a district plan. District Councils do not have specific functions under the RMA to manage discharges to air, unless delegated to do so by the regional council. However, under section 31 they are responsible for controlling some activities that can cause impacts on air quality, in particular, the use and development of land.

The types of industries allowed in different areas or zones are indicated in the district rules, along with some basic performance criteria or conditions. In some cases these conditions include restrictions on emissions of dust or odour.

4.3 Integrated land use planning

Regional and district councils often have a shared responsibility for the management of activities with the potential to cause dust nuisance. This is because the activities often involve the use of land, which is controlled by the district council, but the resulting environmental effects are controlled at a regional level. A good level of interaction and good communication between the different authorities is therefore essential, especially in the development of regional and district plans. These plans should be developed to prevent duplication so that dust emissions are controlled by consent from only one authority.

At a district level, there is a need for greater emphasis on effects-based planning. The use of simple zoning systems (industrial, commercial, etc) will generally not be sufficient, because of the wide range of different activities that can fall into different land use categories. Encroachment of residences and sensitive commercial activities on existing "dusty" industries is also a significant problem in some areas. Conversely, regional councils need to give a clear direction on the desired environmental outcomes for the region, and the ways in which these will be achieved.

Land use planning measures

The use of buffer zones around activities is one approach to preventing environmental impacts of dust emissions. The role and application of buffer distances under the effects-based principles of the RMA needs to be examined carefully. In some cases implementation of good practice dust control measures can greatly reduce the distance to affected areas. However, there may be cases (such as establishment of district plan zones) where buffer distances provide an appropriate method by which to avoid, remedy or mitigate adverse effects on the environment.

Buffer distances are well recognised internationally. For example, the State of Victoria in Australia (Vic. EPA, 1990) recommends buffer distances for a wide range of industrial sources of dust, odour and other nuisance emissions. The recommended buffer distances typically range from about 200–500 metres. However, it should be noted that these distances are based on the assumption that good pollution control technologies are also being used. An industry with poor controls would require a larger buffer distance.

The use of buffer distances should not be seen as a primary means of control, but as a means of providing an additional safeguard in the case of unintended or accidental emissions. There can also be problems with erosion of the buffer over time where residential areas encroach on existing industries. Changes in industries or processes cannot always be predicted, and "protected' land is often lost through urban sprawl. These risks can be minimised if the industry owns the land in the buffer zone, thereby retaining control over encroachment from sensitive activities.

A useful discussion of the benefits and limitations of buffer zones for planning purposes is provided in the Ministry's report *Managing the Amenity Conflicts Arising from Rural Activities* (MfE, 2000).

4.4 Regional and district rules

Under section 68 of the RMA, councils can use rules to allow, regulate or prohibit activities. Activities can be classified as permitted, controlled, discretionary, non-complying or prohibited (section 88). Land use consents from city and district councils, and discharge permits from regional councils, are required for activities classified as controlled, discretionary or non-complying in the relevant plan.

Regional air plans contain rules relating to dusty activities that generally provide for activities with a low dust potential to be permitted, provided certain conditions are met. Such activities commonly include: wet abrasive blasting, stationary enclosed dry abrasive blasting, small scale quarrying and mineral extraction processes, and dust emissions from unsealed roads. Where the effects of dust emissions are potentially more than minor, consents are likely to be required.

Activities with a greater potential for dust emissions are often classed as controlled or discretionary, and require discharge permits. These can include:

- mobile abrasive blasting
- asphalt or bitumen manufacture or processing
- milk powder or milk based powder manufacture
- pulp, paper, cardboard or reconstituted wood panel manufacture
- steel mills
- synthetic fertiliser manufacture
- timber mills, including moulding manufacture and planing
- waste treatment and disposal, including landfills and commercial composting operations
- large quarries and mines.

Some air plans give guidance on how the council intends to assess dusty activities and how they will determine whether there are any significant adverse effects on the environment. This is a recommended approach as it enables applicants and communities to be clear on what is required and how the activity will be assessed. An example of assessment criteria that may be used in response to a complaint, for instance, is included in Appendix 3.

Requirements of district plans have often been similar to those of regional plans and in some cases have included prescriptive controls on the nature of the dust generating activity. To avoid unnecessary duplication of consent requirements in future the effects of dust emissions should primarily be controlled at the regional level, unless that function has been delegated to the district.

The types of activities that require resource consents vary between individual councils. As a general guide, activities that would have been licensed under the former Clean Air Act 1972 have often received much the same level of control under the RMA. This is not always the case however, and the only way to be sure is by checking with the relevant regional and district councils, or working through the appropriate plans.

4.5 Dust control conditions

Conditions specified in consents and the conditions applying to rules in a plan, often require that there be:

> *"no dust beyond the site boundary which causes an offensive or objectionable effect"*.

This approach is well recognised as a viable method for the control of subjective issues such as dust and odour nuisance. However, the following points should be taken into account when this approach is being used.

1. The assessment as to what constitutes an offensive or objectionable effect should be determined by trained persons, such as council officers, according to clear criteria (Appendix 3).
2. The assessment will need to take into account the frequency of nuisance events, the quantity of dust emissions/deposition and the sensitivity of the receiving environment. Refer to the assessment criteria in Appendix 3.
3. Single isolated incidents may on rare occasions be cause for punitive action. However, more commonly they are used as a signal for greater attention to dust control measures. In the event of recurrent complaints, the discharger should be required to keep a complaint register (if this is not already being done). The council should also record and investigate complaints.
4. Where regular complaints occur, the discharger should also be required to set up procedures for regular consultation and communication with the affected community. A dust monitoring programme with trigger levels for when actions are required should be considered. Implementation of effective dust control measures, as outlined in section 8, may eliminate the need for further action.
5. If the problem continues, then the council should consider taking some of the actions available to it under the RMA. This could include: an infringement fee of between $300 to $1000 to address minor matters, an abatement notice, which requires the discharger to cease or control specific activities, or an enforcement order that must be obtained from the Environment Court. The enforcement order would require the operator to implement proper corrective actions immediately.
6. If legal action is considered, then the council should ensure that a full range of evidence has been gathered (refer to the assessment guidance in Appendix 3) for the assessment of environmental effects. The council should attempt to collect visual evidence of the problem, such as photographs or videos and should record or investigate the meteorological conditions during the incident/s.
7. The results from an existing dust monitoring programme may also be used in support of any action. Alternatively, the council should consider carrying out short-term measurements during specific dust events.

Some councils have used the term "discernible dust" in preference to "offensive or objectionable". Obviously this places a much tighter level of control on activities, which may be appropriate in some urban areas. However, it may be unnecessarily restrictive in industrial and rural locations.

Suggested conditions

Some or all of the following conditions may be applied to air discharge permits for diffuse dust sources, such as quarries and stockpiles. Clearly the specific nature of conditions will depend on the scale and significance of the activity, having regard to the sensitivity of the receiving environment.

- A condition requiring that specific dust control measures, described in the application, are implemented. This requires that the consent holder undertake good practice measures, such as those detailed in section 8.
- Where an appropriate management plan has been presented with the application, a condition requiring that the plan be implemented. Note that the plan must meet the criteria for consent conditions, as detailed in section 3.4. If these criteria are not met, dust control methods should be specified by condition rather than relying on the management plan.
- A condition requiring the consent holder to record any complaints relating to the dust discharge. This record should include the location, date and time of complaint, a description of weather conditions (notably wind speed and direction), any identified cause of the complaint, and the corrective action taken.
- A condition requiring that the discharge does not cause airborne or deposited dust beyond the property boundary of the site that is determined to be noxious, objectionable or offensive. Alternatively, the condition could require that no discharges from any activity on the site give rise to visible emissions, other than water vapour and steam, beyond the boundary of the site that are determined to be offensive or objectionable.

A condition relating to objectionable or offensive dust has commonly been used as a "catch all" to prevent significant adverse effects beyond the site boundary. There is some debate as to whether compliance should be determined by a council officer (specifically referenced in a condition) or on the basis of all evidence gathered during a complaint investigation. Ultimately the courts will examine all available evidence (such as monitoring results, dust sample analyses, photographs, and evidence from officers and complainants) when determining whether an effect has been objectionable or offensive. Refer to the discussion of case law below.

Councils should develop clear criteria for determining and assessing nuisance effects, and this should include specific procedures for complaint investigation. Suggested assessment criteria are provided in Appendix 3. A format for investigating and recording complaint investigations is provided in Appendix 2.

Conditions requiring dust monitoring may be imposed where there is potential for significant adverse effects beyond the site boundary. It is important that the monitoring methods and programme are carefully selected to ensure that meaningful results are received, as discussed in chapters 6 and 7. For large point source dust discharges, in-stack monitoring may be appropriate. Selection of a suitable isokinetic monitoring method is critical, as detailed in the Ministry's compliance monitoring and emission testing guide (MfE, 1998a).

Case law relating to “noxious, offensive and objectionable”

A number of decisions of the Court of Appeal, the High Court and the Environment Court have focused on the meaning of “offensive”, “objectionable” and “noxious” as used in sections 17(3)(a), 314(1)(a)(ii) and 322(1)(a)(ii).

The Court of Appeal in *Watercare Services Ltd* v *Minhinnick* [1998] NZRMA 113 dealt with the terms “offensive” and “objectionable’ in relation to an activity on a site claimed to be waahi tapu. The Court of Appeal stated at the outset that:

“the assessment whether something is noxious, dangerous, offensive or objectionable is an objective one. The bona fide assertion of the person seeking an enforcement order that the matter in question is offensive or objectionable is not enough. There must be some external standard against which that assertion can be measured.”

The case involved the construction of a major sewage pipeline across the Matukutura Stonefields to the Manukau Harbour. The Stonefields are an archaeological site in terms of the historic places legislation. The Historic Places Trust gave approval for the construction of the pipeline subject to various approvals in 1978. Mrs Minhinnick sought an enforcement order on the basis that Watercare Services Ltd was proposing to do something that was likely to be “noxious, dangerous, offensive or objectionable” to such an extent that it was likely to have an adverse effect on the environment (section 314(1)(a)(ii)). Mrs Minhinnick submitted that conveying sewage over and across waahi tapu and the works associated with the pipeline were in the circumstances “objectionable” and “offensive”.

The Court of Appeal held that the legislation (i.e. section 314(1)(a)) required the Court to form its opinion on whether something is noxious, dangerous, offensive or objectionable to such an extent that it has or is likely to have an adverse effect on the environment. In forming its opinion, the Court is to act as the representative of the community at large in determining whether something is offensive or objectionable. It held at p.124 that four steps were involved:

“5. Whether the assertion of the applicant seeking the enforcement order that the subject matter is noxious, dangerous, offensive or objectionable is an assertion honestly made.

6. If so, whether in the opinion of the Court the subject matter is or is likely to be noxious, dangerous, offensive or objectionable.

7. If so, whether in the opinion of the Court any noxious, dangerous, offensive or objectionable aspect found to exist is of such an extent that it is likely to have an adverse effect on the environment.

8. If so, whether in all the circumstances the Court’s discretion should be exercised in favour of making the enforcement order sought or otherwise.”

The Court of Appeal stated that in the second and third steps the Court in forming its opinion is the representative of New Zealand society as a whole, the “community at large”. It went on to hold at p.125 that:

“The views of individual members of society must always be sympathetically considered but the Resource Management Act does not require those views to prevail irrespective of the weight of other relevant considerations.”

In assessing whether something was offensive or objectionable, the Court of Appeal stated that it is necessary for the Court to consider the relationship between the objector and the subject matter and all other features of the case that are said to justify or not to justify the objector's contention.

The *Watercare Services Ltd* case confirmed the approach of the High Court in *Zdrahal* v *Wellington City Council* [1995] NZRMA 289. Justice Grieg in that case highlighted the point that it was not just a case of whether something was noxious, dangerous, offensive or objectionable but it had to be to such an extent that it has or is likely to have an adverse effect on the environment. He stated that:

"If it is objectively offensive or objectionable, that is if reasonable ordinary persons would be offended or find it objectionable, then it does affect the environment of those people and of any other such people living in the vicinity who are likely to be so affected." (p.299)

The Environment Court in *Thompson* v *Davidson* C130/97 had to decide on whether the noise of barking dogs was "offensive" or "objectionable". The Environment Court adopted the approaches of the Court of Appeal and High Court as outlined above. In the *Thompson* case the Environment Court had difficulty finding the level of noise experienced as being offensive or objectionable but found that the Thompsons were annoyed and disturbed by the noise.

5 Assessment of Emissions and Environmental Effects

The information to be submitted in support of consent applications under the RMA is specified in section 88 and the Fourth Schedule of the Act. The extent to which various matters are addressed should be (section 88(6)(a)): *"in such detail as corresponds with the scale and significance of the actual or potential effects that the activity may have on the environment"*. In addition, consent applications must be accompanied by *"An assessment of any potential effects from the discharge, including effects on amenity values, human health, flora and fauna"*.

In the case of discharges to air, assessments of environmental effects depend on whether the activity is existing or proposed. In general, an assessment usually involves the following steps:

- Identify and estimate the mass emissions from the process and activities causing dust to be discharged into the air, and the factors that influence them. This can be done using published emission factors, or measurements on an existing plant.
- Predict the way in which the emissions will disperse downwind of the site. This is usually done using atmospheric dispersion modelling or, in the case of an existing activity, by results from any monitoring.
- Assess the off-site environmental effects, by comparing the predicted or measured dust concentrations against appropriate guidelines and by discussing the potential or actual impacts of the activity with surrounding neighbours and the community. This should also involve investigating the potential cumulative effects of the discharge on the environment in combination with existing background levels and other discharges in the area.

5.1 Emission estimation

There are two ways of determining the air emissions from a process; direct measurement or estimation using published emission factors. Obviously, the first option is only possible with an existing process, although it may sometimes be possible to use test data from other similar plants in support of a proposed development. In addition, emission testing is not possible for many of the diffuse sources that can contribute to fugitive dust emissions.

Emission testing is a specialised activity and the measurements should be carried out using standard methodologies. Recommended test methods for emissions testing in stacks have been summarised in the Ministry for the Environment's Guide to Compliance Monitoring and Emissions Testing (1998a). However this does not include test methods for fugitive dust emissions. There are no recognised standard methods for measuring such emissions. Refer to Chapter 6 for further discussion of ambient dust monitoring.

Emission estimation using published emission factors is the more common approach for most applications for an air discharge permit. Emission factors have been published by a variety of agencies. The most widely used and extensive compilation is that published by the US Environmental Protection Agency in the document known as AP-42 (US EPA, 1996). Some of the dust sources covered in AP-42 include paved and unpaved roads, heavy construction activities, aggregate handling and storage piles, industrial wind erosion, surface coal mining, sand and gravel processing, abrasive blasting, and various forms of mineral processing.

The emission factors given in AP-42 are based on measurements on a limited number of different sources under varying operating conditions. The factors are usually expressed in terms of the mass emission expected for a specific processing rate (e.g. grams of pollutant per tonne of raw material used). The total emissions can therefore be estimated simply by multiplying the expected plant processing rates by the relevant factor. However, these emissions factors must be used with caution and in accordance with the conditions for their use, recognising the numerous assumptions that go into their calculation.

With fugitive emissions, it can be difficult to measure the emissions directly because they can be very diffuse, intermittent, and variable. For this reason the published emission factors have a high degree of uncertainty, and the predicted emission rates should be treated with scepticism. In addition, many of the emission factors are for particles smaller than 30 µm, which only covers a fraction of the particles that can be emitted as nuisance dust. Where emission factors are applied to fugitive dust emissions, it is important that the underlying assumptions are clearly stated.

5.2 Dispersion modelling

Dispersion modelling is a mathematical method used to relate site emissions to downwind ambient air concentrations, under the full range of possible weather conditions. Studies of this type have long been recognised as an acceptable means of evaluating the impacts of contaminant discharges to air from point sources. They are especially suited to the assessment of facilities that have not yet been built. However, they also have advantages over ambient air monitoring for existing operations, including lower costs, and the ability to cover multiple locations and the possible variations in dispersion conditions over time.

There are a variety of models available for this type of work. One of the most common is known as AUSPLUME, which was originally developed for the Victoria EPA in Australia. More sophisticated models may be required for activities involving a large number of emission points, or for locations involving complex terrain or other confounding factors. Regardless of the model used, modelling for dust nuisance needs to take into account the size distribution of the dust particles, and the possible variations in deposition rates due to factors such as rainfall and vegetation effects. This level of detail is rarely available for most sources of nuisance dust.

Most proprietary dispersion models, and certainly those that have been well validated, are related to gaseous pollutants. Depending on the particle size, these models may or may not be valid for the dispersion of dust. If particles are less than 20 microns in size they can be considered to behave as a gas, and follow the standard Gaussian model. However, nuisance effects of dust are usually associated with particles greater than 20 microns. Gaseous dispersion models are therefore inadequate for predicting the concentration of nuisance dust.

There are some models that specifically relate to the dispersion of particulate matter. For example, the Fugitive Dust Model (FDM) developed by the United States Environmental Protection Agency is designed to predict deposition caused by mining operations, dirt roads, and other sources of fugitive dust. More general models such as AUSPLUME, also offer the option of including deposition due to gravitational settling. The model estimates the deposition of material on the ground, and the loss of material from the plume, on the basis of the wind speed and particle settling velocities. Reflection on the ground, expressed as a reflection coefficient, is also taken into account. The additional information required to run AUSPLUME in this way, is the mass fraction, settling velocity and reflection coefficient for each particle size fraction.

Most of these models provide, at best, a crude approximation of particle behaviour through the air. They are unable to account for the effects of localised wind turbulence and increased deposition due to changes in the nature of the terrain, or flow disturbances due to trees, buildings, or other obstructions. User experience with the models would suggest that major changes in the predictions could be achieved through relatively minor adjustments of some of the key parameters. In other words, the modelling is easily manipulated to give whatever result one requires. As such, dispersion modelling should not be regarded as a definitive method for predicting dust nuisance effects, particularly from fugitive sources.

5.3 Effect levels and criteria

There are no national air quality guideline values for nuisance dust effect levels that can be used to say a certain amount of deposition is minor or significant. However, there are a number of criteria in common use and these are discussed later in section 7.4. Generally, the criteria have been derived from subjective observations and investigation of dust levels and nuisance effects.

5.4 Limitations

The methodology described above is usually best suited to assessing the effects of emissions from controlled emission sources, such as vents and stacks. In the case of dust emissions, this would include grain drying and storage, timber mills, and mineral processing.

The method has also been used for assessing the effects of fugitive dust emissions from activities such as mines and quarries, constructions sites, and stockpiles. However, these predictions have a very high degree of uncertainty. The predictions can have some value in identifying the most significant dust sources on a site, or in highlighting the areas most likely to be affected by dust off-site. However, the actual dust concentrations predicted by the method should only be treated in a semi-quantitative sense.

The assessment method is not at all suitable for activities such as mobile abrasive blasting, because of the very high variability in dust emission rates and the lack of any effective containment systems.

The key point to recognise with most fugitive dust sources is that nuisance effects will almost certainly occur if the sources are not adequately controlled. Rather than spending time and money on extensive (and expensive) theoretical predictions of the possible effects, it is likely to be more appropriate to put the effort into the design and development of effective dust control procedures. These procedures should be thoroughly documented in a dust management plan, as described in Appendix 5.

Figure 2: Dust management plans are useful for large sites like this quarry where a range of different dust control measures will be required

6 Monitoring of Environmental Effects

6.1 Complaint monitoring

Complaint monitoring is the only method available for directly assessing the nuisance effects of dust emissions. However, it suffers from a number of shortcomings, including the following.

- Some people may be reluctant to complain, or simply not know who to complain to.
- Other people may complain excessively, or make frivolous complaints, because they are strongly opposed to a particular activity.
- People may stop complaining about a continuing problem, if they feel that no action is being taken.
- People's tolerance or intolerance to dust deposition and airborne dust can vary considerably with individual perception.
- It can sometimes be difficult to identify the cause of specific dust problems, so that one activity may be wrongly blamed for the actions of another.

Notwithstanding all of the above, complaint systems still have an important part to play in the management of dust problems. Prompt responses to complaints can be important in developing good relations between an operator and the surrounding community. Effective complaint investigation can also be important in identifying parts of the operation where dust control procedures need to be improved.

Some councils have developed complaint investigation forms that list the information that should be provided. An example of a form for recording and investigating dust complaints is given in Appendix 2.

6.2 Source emission testing

It is very difficult, if not impossible, to measure dust from ground-based sources, because of the diffuse and unconfined nature of the emissions. Some people have attempted to do this by measuring air concentrations downwind of the source and using reverse modelling to estimate the source emissions. However, this is only really effective if a two-dimensional array of dust monitors can be used for the measurements.

Dust emissions from a stack are much easier to measure, but specialised techniques are required to ensure representative sampling. Measurements should be taken using isokinetic sampling, which ensures that different size particles are all collected with the same sampling efficiency. Further details on this and other sampling procedures are given in the *Guide to Compliance Monitoring and Emissions Testing* (MfE, 1998a).

Specialised sampling methods are also required for the testing of roofline emissions from certain types of industrial processes, such as steel making. Unlike stack emissions, discharges from roof vents are made up of a wide range of particle sizes, and are therefore more likely to cause dust nuisance impacts. Sampling of roofline emissions is difficult, and requires specialised procedures (Trozzo and Turnage, 1981). Particular problems can include low particle concentrations and low discharge velocities. Access to the sampling points is sometimes a problem, and battery-powered sampling equipment is often used because of the absence of electrical power.

Emission testing can provide information on the variations in source emissions, and may be useful in pinpointing the possible causes of a dust nuisance problem. However, it tells us very little about the probable magnitude of the effects from fugitive dust sources.

6.3 Environmental monitoring

Environmental monitoring programmes should be carried out to determine the environmental impacts of the discharge and/or compliance with consent conditions. The extent and level of accuracy of monitoring required either as part of an assessment or as conditions on a resource consent, should be based on the predicted level of the effects and the nature of the receiving environment.

Programmes can be carried out for a variety of reasons, including the following.

Impact assessment

Monitoring the environmental impacts of a specific activity or group of activities. This information may be used in support of an application for consent renewal, or as a check that emission limits and other management procedures are achieving the desired level of control. It can also be used to monitor any changes in plant performance over time. Refer to Chapter 7 for a discussion of the various monitoring techniques available.

Compliance monitoring

Monitoring of compliance conditions specified in the discharge permit for a specific activity. In the case of point sources (i.e. discharge through a stack) these will usually be based on emission discharge limits. However for many dust sources, ambient limits will be more appropriate, at the site boundary and beyond.

Background monitoring

This usually refers to monitoring in areas unaffected by any polluting activities. However, it can also refer to monitoring existing air quality prior to the development of a new activity. Background monitoring is a useful adjunct to assessment monitoring, because it allows the impacts of an activity to be assessed against the existing background concentrations.

State of the environment monitoring

This refers to monitoring based around a regional or national network of monitoring sites. This type of programme determines the overall impact of multiple activities on the environment. It would generally not be directed at specific dust sources. However, dust monitoring may be included in the programme for areas with naturally high dust levels. Assessing the community's perception of dust nuisance may be an important component of such monitoring.

6.4 Monitoring programme design

Objectives

One of the first steps in any monitoring programme design should be to decide on the purpose and objectives of the programme. These will be related to the various monitoring categories described above, and could include the following:

- To monitor any dust impacts arising from an activity and relate them to existing dust levels in the vicinity, and relevant guidelines.
- To provide information that would assist in identifying the cause of any dust complaints.
- To monitor any changes in ambient dust levels over time. This could be important in highlighting any deterioration (or improvements) in dust control practices.
- To provide effects data for use in a future application for consent renewal.

Monitoring frequency and duration

Monitored dust levels can vary markedly over time because of variations in weather conditions, including rainfall, wind speed and wind direction, and also because of changes in the source emissions. These variations need to be given careful consideration in the development of monitoring strategies. In particular, there is very little value in the collection of occasional samples taken at irregular intervals in accordance with some vaguely defined monitoring scheme. Monitoring should be conducted in accordance with a fixed sampling schedule, and preferably over extended periods of time.

Continuous monitoring methods are the preferred approach for most pollutants, because these will effectively cover most of the possible variations in pollutant concentrations over time. However, the high capital and operating costs of continuous monitoring instruments would not be justified in many dust monitoring applications.

Monitoring for dust nuisance is normally carried out using time averaging methods, with sampling periods of 24 hours, seven days or one month. When 24-hour monitoring is being used, the normal approach is to take one sample every six days. This ensures equal coverage to all days of the week when the monitoring is carried out over an extended period of time. For this approach, the minimum monitoring period in any one location should ideally be at least one year to ensure adequate coverage of any seasonal variations. If shorter monitoring periods are to be used, then the sampling frequency should be increased, to at least one day in every three.

It may also be necessary to repeat the measurements at different times of the year to cover the possible seasonal variations.

When the monitoring methods involve weekly or monthly sample collection, meaningful data can only be expected from a continuous series of measurements over periods of at least one year. This is necessary to ensure that process and seasonal variations have been adequately covered.

Number and location of monitoring sites

Monitoring sites should be chosen on the basis of prevailing wind conditions and the expected areas of greatest impact. Dispersion modelling may be needed to determine the latter, although this can often be simply determined from a knowledge of local weather patterns and the location of nearby residential housing or other sensitive activities.

Multiple monitoring sites may be required around any individual source to ensure reasonable coverage of the areas of greatest impact. However, a single monitoring site may be acceptable if it can be shown to be reasonably representative of the worst-case situation.

A single monitoring site can sometimes be quite adequate for impact monitoring around point sources (stack discharges), provided there are no other sources nearby that might affect the results. A minimum of two to four sites will usually be required for most diffuse dust sources. Considerably more sites will be needed if the activity is spread over a wide area, such as an open cast mine (see Waihi Gold case study, Appendix 6).

Supporting information

Consideration should be given to including additional background or reference sites in any programme. This can sometimes be achieved by having sites at right angles to the prevailing wind line, or simply by having a series of three or more sites at increasing distances away from the source, along the prevailing wind line.

Meteorological conditions should be recorded at one of the monitoring sites. This should include a minimum of wind speed and direction, and rainfall. The data can be used to help identify the cause of any high dust results, or in complaint investigations. It will also serve to demonstrate that the monitoring sites have in fact been impacted by emissions from the activity.

Information on routine and non-routine site activities should be recorded on a daily basis. This information can be important in helping to identify the cause of any high dust results or in complaint investigations.

7 Dust Monitoring Methods and Assessment Criteria

7.1 Dust monitoring

There are two general types of dust measurements that can be used as indicators of nuisance effects; dust deposition and total suspended particulate. The key elements of each of these methods are summarised below, with more detailed descriptions given in Appendix 4.

The chosen methods are an integral part of the monitoring programme that should also be related to the scale and significance of the environmental effects and sensitivity of the receiving environment. It is important that accepted standard methods are followed. The advantages and disadvantages of each of the methods are discussed below.

In some cases dust monitoring will not be appropriate, given the scale and significance of the predicted effects. For such small-scale sources, concentrating on good practice dust management measures is likely to be more beneficial.

Dust deposition

Deposited matter or dust deposition, is dust that settles out of the air. Measurement is by means of a collection jar or gauge, which simply catches the dust settling over a fixed surface area over a period of time. The dust is removed from the jar, filtered and weighed, and the results are reported in terms of the weight of dust collected per unit of surface area, and over a fixed period of time, e.g. $g/m^2/30$ days. ISO DIS-4222.2 is the preferred method for deposited dust monitoring in New Zealand (Appendix 4).

The equipment used for deposition monitoring typically collects dust particles greater than about 10–20 microns, although there is no sharp cut-off in particle size and the collection efficiency is known to vary for different particle sizes. The main attractions of the deposit gauge method are its relatively low cost (approximately $500) and simplicity. The main disadvantage is that the measurement period is typically 1 month, and cannot be reduced to anything less than about 15 days without a significant loss in measurement sensitivity. This makes the method quite unsuitable for the monitoring and control of short-term dust problems.

Dust gauges should be carefully sited, having regard to:

- the risk of tampering or vandalism by members of the public
- the impact of nearby structures on wind flow (and thus dust collection efficiency), as required by the monitoring method
- proximity to local dust sources (such as an unsealed road) that may affect the measurement.

Suspended particulate

Total Suspended Particulate (TSP) refers to particles that are suspended in air at the time of sampling. TSP is measured by sucking air through a filter and determining the weight of dust collected from a measured volume of air. The results are reported in concentration terms (typically $\mu g/m^3$). The equipment used for TSP measurements is intended to collect all particles from less than 0.1 up to about 100 microns, although different designs of sampling head can be used to make the system selective for specific size fractions. Once again, the collection efficiency is known to vary for different size particles, and can also vary between different TSP systems. Overall collection efficiencies are usually poor for particles above about 50 microns in size, which makes the method complementary to dust deposition. Conversely, this difference in size selectivity between the two methods means that neither system can be entirely relied upon for effective monitoring of all of the possible sizes of nuisance dust.

TSP samples are typically collected over 24-hour periods, but a number of continuous monitors are also available. The capital costs for TSP monitors are between \$5000 and \$50,000, depending on the type of system. This is considerably higher than the cost of about \$500 for a deposition monitor. However, the TSP method provides much more useful data in terms of dust variations over time, and the possible causes of these variations.

7.2 Other monitoring methods

There are a variety of other monitoring methods that can also be used for assessing dust nuisance, including the following.

Directional dust monitoring – This can be used to identify specific dust sources. Systems are now available for linking dust samplers to a wind sensor, so that the monitor only operates when the wind is from a certain direction. Alternatively, there are directional dust gauges available in which the dust is collected through vertical slots, which can be lined up with the direction of interest. One of these systems is covered by an Australian Standard, AS 2724.5-1987. The effectiveness of this and other possible approaches was reviewed in a publication by Hall *et al* (1993).

Time-lapse video – This provides a simple method for visual monitoring of dust-producing activities over extended periods of time. Its main application is in identifying which activities on a site are in need of better dust control.

Microscopic examination – This can be very useful in investigating complaints of dust fallout. Examination of dust samples under a microscope can often assist in identifying the source. For example, fly ash from a boiler is made up of multi-coloured glass spheres, while dust from a panel beating shop will contain paint fragments. It is also extremely useful in identifying natural dust sources, such as pollen.

Tracer analysis – Analysis of dust for specific tracer elements can also be useful in identifying dust sources. For example, dust from a secondary steel mill will have high levels of iron and other metals such as lead and zinc.

7.3 Commentary

The main limitation with dust monitoring is that the results are nearly always produced some time after the event. As such, dust monitoring is not an effective method for the control of nuisance dust emissions. Dust monitoring programmes should be carried out for one or more of the reasons discussed above. This can include monitoring the effectiveness of dust control programmes. However, they should not be seen as a primary method of dust control.

(Note: It may be possible to use continuous monitors for the control of nuisance dust. However, this application has not yet been successfully demonstrated in New Zealand.)

7.4 Dust effect levels and criteria

National ambient air quality guidelines

National Ambient Air Quality Guidelines (AAQGs) were published by the Ministry for the Environment in 1994 and are currently under review. There were no criteria for dust nuisance in the 1994 guidelines (MfE, 1994), although a limit for dust deposition was included in an earlier proposal document (Bird, 1992). The rationale for not including the deposition guideline was stated as:

> *"In some situations they (indicators for deposited particulate, total suspended particulate, smoke and visibility-reducing particulates) may be useful in addition to the guidelines themselves. These indicators may be used in the immediate vicinity of an individual source or group of sources. Generally, smoke and deposited particulates occur during process upsets. They can be used to trigger remedial action. These indicators are not adequate, however, for purposes of assessing air quality."*

Trigger levels

De facto control limits have been used to assess dust nuisance in New Zealand in the past. The limits commonly used in the past were: 4 g/m^2/30 days deposited dust (as an increase above background concentrations); and 150 $\mu g/m^3$ (24-hour average) or 250 $\mu g/m^3$ (1-hour average) total suspended particulate, measured by high volume sampler. Similar criteria have been used in Australia (Dean et al, 1990), although these allow for a range of different effect levels depending on the nature of the surrounding area ("suburban/residential" or "other").

In the absence of any current national guidelines for dust nuisance, it is appropriate to recommend trigger levels or control limits that could be applied to individual dust sources (Table 7.1). The impact of dust emissions may then be assessed with regard to these limits, among other factors.

Table 7.1: Recommended trigger levels for deposited and suspended particulate

Dust type	Trigger level	Preferred method
Deposited dust	4 g/m^2/30 days (above background concentration)	ISO DIS-4222.2
Total suspended particulate	80 µg/m^3 (24-hour average) – sensitive area 100 µg/m^3 (24-hour average) – moderate sensitivity 120 µg/m^3 (24-hour average) – insensitive area	AS 3580.9.6-1990 (hi-volume sampler)

A sensitive area typically has significant residential development, whereas a sparsely populated rural area may be relatively insensitive to some discharges. Clearly the judgement of sensitivity will be somewhat subjective, depending on the specific circumstances in each case.

The acceptable concentration of *deposited* dust is also related to the sensitivity of the receiving environment. In some industrial or sparsely populated areas, deposition rates of more than 4 g/m^2/30 days may not cause significant nuisance. However, in highly sensitive residential areas deposition rates in the order of 2 g/m^2/30 days, above background concentration, may cause nuisance. It should also be noted that the type of dust may be significant. Highly visible dust, such as black coal dust, will cause visible soiling at lower concentrations than many other dusts.

It is important to note that the recommended trigger level for deposited dust normally applies to insoluble matter. As explained in Appendix 4, dissolved material is not significant when assessing nuisance effects from the majority of dust sources. The exception to this occurs when the source produces water soluble emissions, such as a pulp and paper mill, milk powder plant or fertiliser works.

The recommended trigger levels should only be considered in conjunction with the results of other assessments, including complaints surveys and community consultation. Site-specific trigger levels that are acceptable to the local community should be developed in each case. Estimates of background dust levels must be included in calculating values to compare with these trigger levels.

Current dust levels

General dust deposition levels measured in New Zealand range from about 1–4 g/m^2/30 days. Background concentrations are usually less than 1 g/m^2/30 days, but there are also areas such as Central Otago where the natural dust levels can be up to 10 times this amount. Measurements in the vicinity of specific industrial sources are commonly in the range of 4–8 g/m^2/30 days, but can be as high as 10–20 g/m^2/30 days in extreme cases. The industries include timber mills, quarries, mines, steel mills, and port operations, with the highest results being recorded alongside abrasive blasting operations.

There is only a limited amount of data available on TSP levels around the country, as much of this type of monitoring is directed at the fine fraction, PM_{10}. Background TSP levels in clean environments are about 10–20 µg/m^3. Levels of about 30–60 µg/m^3 have been reported for general urban areas, and about 50–100 µg/m^3 for general industrial areas, such as Penrose in Auckland and Hornby in Christchurch. Levels of up to 300 µg/m^3 have been recorded near some specific industrial sources (e.g. a scrap metal yard), but these are relatively extreme events.

Figure 3: Suspended particulate monitoring equipment

8 Dust Control Methods and Technologies

Control methods for the management of nuisance dust sources are described below. Obviously, not all of these procedures will be applicable to all activities.

8.1 Paved surfaces

Dust deposits on paved surfaces can be thrown into the air by wind or by vehicle movements. Dust pick-up by wind is usually only significant at wind speeds above 5 metres per second (10 knots), but vehicle re-entrainment can occur under any conditions. Dust emissions from paved surfaces can be minimised through use of the following procedures:

- The movement and handling of fine materials should be controlled to prevent spillages onto paved surfaces.
- Minimise mud and dust track-out from unpaved areas by the use of wheel wash facilities.
- Regular cleaning of paved surfaces, using a mobile vacuum sweeper or a water flushing system.
- Speed controls on vehicle movements (see below).
- Wind reduction controls (see below).

Dust emissions from paved surfaces can be reduced by factors of 90% or more, but this is highly dependant on the above procedures being applied rigorously and consistently.

8.2 Unpaved surfaces

Dust emissions from unpaved surfaces are caused by the same factors as for paved surfaces, but the potential emissions are usually much greater. Dust emissions can be controlled using the following procedures:

- Wet suppression of unpaved areas should be applied during dry windy periods, using a water cart and/or fixed sprinklers. As a general guide, the typical water requirements for most parts of New Zealand are up to 1 litre per square metre per hour. It is important to check that the available water supplies and the application equipment are able to meet this requirement.
- Chemical stabilisation can also be used in conjunction with wet suppression. This involves the use of chemical additives in the water, which help to form a crust on the surface and bind the dust particles together. Chemical stabilisation reduces watering requirements, but any savings can be offset by the cost of the additives. Repeat treatments are usually required at intervals of 1–4 weeks. The method is best suited to permanent site roads and is usually not cost-effective on temporary roads, which are common in mines, quarries and construction sites. (Note: chemical additives used for dust suppression should be shown to have no adverse effects on the environment. Waste oil has been used in the past but is generally not suitable for this purpose.)

- Re-vegetation of exposed surfaces. This should be done wherever practicable at mines, quarries and construction sites, and other similar activities subject to ongoing development. Techniques such as hydro-seeding and the use of geotextiles should be used on sloping ground and other difficult surfaces.
- Surface improvements. These include paving with concrete or asphalt, or the addition of gravel or slag to the surface. Paving can be highly effective but is expensive and unsuitable for surfaces used by very heavy vehicles or subject to spillages of material in transport. In addition, dust control measures will usually still be required on the paved surfaces. The use of gravel or slag can be moderately effective, but repeated additions will usually be required.
- Speed controls on vehicle movements (see below).
- Wind reduction controls (see below).

Unpaved surfaces can be a significant cause of dust problems on adjacent paved surfaces (e.g. roads) if there is no control over carry-out of mud and dirt. This can be controlled by the use of wheel wash facilities.

Wet suppression of unpaved areas can achieve dust emission reductions of about 70% or more, and this can sometimes be increased by up to 95% through the use of chemical stabilisation. Revegetation and paving can achieve up to 100% control efficiencies, but have only limited application.

8.3 Vehicles

Vehicles travelling over paved or unpaved surfaces tend to pulverise any surface particles and other debris. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents due to turbulent shear between the wheels and the surface. Dust particles are also sucked into the turbulent wake created behind the moving vehicles. The loads carried by trucks are a potential source of dust, either through wind entrainment or spillages. Mud and dust carry-out from unpaved surfaces is another potential problem, as discussed above.

Dust emissions due to vehicles can be minimised with the follow controls:

- Limiting vehicle speeds. A speed limit of 10–15 km/hr is commonly applied in New Zealand.
- Limiting load size to avoid spillages.
- Covering loads with tarpaulins or the use of enclosed bins to prevent dust re-entrainment from trucks.
- Minimising travel distances through appropriate site layout and design.
- The use of wheel and truck wash facilities at site exits.

Speed controls on vehicles have an approximately linear effect on dust emissions. In other words, a speed reduction from 30 km/hr to 15 km/hr will achieve about a 50% reduction in dust emissions. The other procedures listed can also be highly effective in limiting dust problems.

8.4 Material stockpiles

Fine material stored in stockpiles can be subject to dust pick-up at winds in excess of about 5 m/sec (10 knots). Dust emissions can also occur as material is dropped onto the stockpile from a conveyor. The options for dust control can include the following:

- Wet suppression using sprinklers.
- Covered storage of fine material. Obviously this is an expensive option, but should be seriously considered for use in especially sensitive locations, and for storage of finely divided material with a high dust potential, such as fertiliser, gypsum and other industrial minerals.
- Limiting the height and slope of the stockpiles can reduce wind entrainment. For example, a flat shallow stockpile will be subject to less wind turbulence than one with a tall conical shape. Consideration should also be given to the effect of other site features. For example, it may be possible to reduce wind effects by keeping the stockpile heights below the level of the site noise bund.
- Limiting drop heights from conveyors.
- Use of wind breaks. Wind speed near the pile surface is the primary factor affecting particle uptake from stockpiles. Although a large, solid windbreak is the most effective configuration, aesthetic and economic considerations may preclude that from being appropriate. A study by Stunder and Ayra (1988) found that a 50% porous windbreak was almost as effective as a solid wall in reducing wind speeds over much of the pile, when constructed to the following specifications:
  - height equal to the pile height
  - length equal to the pile length at the base
  - located at a distance of one pile height from the base of the pile.

Wind breaks can be constructed using horticultural cloth supported on poles, or by planting trees. Some of the species commonly used for this purpose include casuarina, cryptomeria and some variety of cupressus. Professional horticultural advice should be sought regarding suitable species for any specific site.

8.5 Conveyors

Dust emissions from conveyors can be caused by wind pick-up, and through losses during loading, discharge, and at transfer points. The following options should be considered for minimising these emissions.

- The use of enclosed conveyers for fine material.
- The use of water sprays or sprinklers at conveyor transfer points.
- Minimising drop heights at transfer points, including use of conveyors that can be raised and lowered.
- Regular clean-up of spillages around the transfer points and any other places where this might occur.

8.6 Other materials handling

Materials handling using front-end loaders or mechanical grabs is another potential source of dust emissions. These mainly occur when the load is dropped into a truck or hopper, but can also be caused by spillages during handling. Similar problems can occur when dusty loads are transferred by gravity discharge from hoppers into trucks.

These problems are best addressed by minimising drop heights, and regular clean-up of any spillages. In some cases (such as wharves or irregular surfaces) covering of the potential spill areas may be necessary to facilitate clean-up. Regular maintenance of hydraulic grabs is important to ensure complete closure. Hopper load systems should be designed to ensure a good match with truck size, and should be fully enclosed on the sides.

8.7 Wind protection

Wind is a major cause of dust emissions from many sites. The effects can be partially mitigated through the use of shelterbelts or temporary screening. It may also be possible to make use of natural land features, or artificial features such as noise bunds, to provide a degree of wind protection. This option should be considered in the initial development of the site layout and design.

Continuous monitoring of wind conditions should be considered when dusty activities are to be carried out in a sensitive location. The information can be used as a trigger for increased dust control activities (e.g. winds above 5 m/sec), or even as a signal for work to cease (e.g. winds above 10 m/sec).

8.8 Fixed plant

This includes equipment such as crushers, shredders, driers, and other processing equipment. These are point sources of dust emissions, which should be controlled using standard equipment such as cyclones, wet scrubbers and fabric filters. However, there is also the potential for fugitive emissions from this type of plant, and these emissions should be controlled using the following procedures:

- Minimise drop heights into hoppers and loading chutes.
- The use of sprinklers or water sprays around hoppers and other transfer points.
- Hooding or enclosure of significant fugitive sources, with the emissions being ducted to bag filters or other dust control equipment.

Fixed dust control systems can achieve control efficiencies ranging from about 70% for cyclones, and up to 95% or more for bag filters.

Figure 4: Wet suppression is an important dust control method for unconsolidated material, stockpiles and unpaved surfaces

8.9 Mobile abrasive blasting

Dust from abrasive blasting in fixed installations is normally controlled using enclosed equipment fitted with dust extraction systems. However, the dust emissions from mobile units are much harder to control because it is often not practical for the operation to be fully enclosed. Some of the options for dust control on mobile abrasive blasting are as follows.

- Partial enclosure of the work area using plastic or cloth sheeting.
- Use of synthetic blasting materials that generate less or no dust (e.g. synthetic carbides, plastic media and sodium carbonate).
- Use of vacuum blasters, in which the blast nozzle is surrounded by a vacuum extraction system.
- Wet blasting or use of a water curtain system around the edges of the structure.

The use of these methods can reduce dust emissions by 50–95%. Other general precautions, such as the use of wind protection, or only spraying under certain weather conditions, should also be observed.

8.10 Dust management plans

Many of the dust control procedures described above depend on people for their operation. As such, effective dust control systems will only be achieved through good site management and by ensuring that the appropriate operational procedures are in place. These procedures and the effects that they mitigate should be clearly described in a Dust Management Plan for the site. Staff responsible for implementing the plan should be clearly identified. The plan should include coverage of the following matters.

- What has to be done and why.
- Who has to do it and/or see that it is done.
- How it will be done.
- The desired outcomes.
- How these outcomes will be monitored.

The contents of the plan should also be subject to regular review.

An outline for a possible Dust Management Plan is given in Appendix 5.

8.11 Codes of practice

A code of practice developed for an industry can provide useful guidance on good practice measures to control emissions. Because these codes are developed by the industry, in consultation with councils, they are generally well accepted by individual businesses. Well-known codes of practice have already been published that address management practices and environmental effects for the pork and poultry industries, forestry and agricultural spraying.

Development of codes for dust-producing industries should be encouraged. A discussion of the benefits and limitations of codes of practice is provided in the Ministry's report *Managing the Amenity Conflicts Arising from Rural Activities* (MfE, 2000).

8.12 Summary

The information provided in this chapter demonstrates that there are many possible dust control options available. Selection of appropriate measures for a site will depend not only on the type of activity, but also on the scale of effects and the sensitivity of the receiving environment. It is important that procedures are in place to ensure that theoretical dust control measures, often discussed at the consent application stage, are implemented in practice. Dust management plans are recommended as a means of achieving this aim.

Appendix 1: Dust particle size

Dust particle size is an important factor in determining the way in which the dust moves through the air. It is also relevant for the possible environmental impacts, especially health effects. Particle sizes are normally measured in microns, and the size range of airborne particles is typically from less than 0.1 microns up to about 500 microns, or half a millimetre. A micron is one thousandth of a millimetre and therefore invisible to the naked eye. Particles deposited on a surface will only become individually visible at about 50 microns. For the purposes of comparison, a single sheet of paper is about 100 microns thick, and the diameter of human hair varies from about 30–200 microns.

When dust particles are released into the air they tend to fall back to ground at a rate proportional to their size. This is called the settling velocity. For a particle 10 microns in diameter, the settling velocity is about 0.5 cm/sec, while for a particle 100 microns in diameter it is about 45 cm/sec, in still air. To put this into a practical context, consider the generation of a dust cloud at a height of one metre above the ground. Any particles 100 microns in size will take just over two seconds to fall to the ground, while those 10 microns in size will take more than 200 seconds. In a 10-knot wind (5 m/sec), the 100-micron particles would only be blown about 10 metres away from the source while the 10-micron particles have the potential to travel about a kilometre. Fine particles can therefore be widely dispersed, while the larger particles simply settle out in the immediate vicinity of the source.

It is the larger dust particles that are generally responsible for nuisance effects. This is mainly because they are more visible to the naked eye, and therefore more obvious as deposits on clean surfaces. These are also the particles that will settle most readily onto exposed surfaces. For this reason, measurement methods for nuisance dust are generally directed at dust particles of about 20 microns in size and above.

Appendix 2: Dust complaint form

Part A: Complaint details

Date:	Time:	Complaint received by:
Name and address:		
Contact phone numbers:		
Complaint details and initial response (if any):		

Process information

(Check with the relevant people on site as to whether there were any abnormal conditions at the time of the alleged incident.) **Process A:** **Process B:** **Other:**

External causes

(Check for road works, ploughing, construction activities, burn-offs, etc)

Possible causes and actions taken

Part B: Site investigation

Date:	Time:	Personnel:
Location:		
People spoken to on site:		
When did the incident occur?		
What was the weather like at the time of the complaint? (Note wind speed and direction, and any significant rainfall over the previous 24 hours)		
Are there any visible dust deposits? (Describe approximate quantities and extent)		
Describe the appearance of the deposits (colour, shape, size, crystalline or powdery, hard, soft, any odour, water soluble, etc)		
Does the problem extend to other properties? (Ask, but also check for yourself)		
Any other relevant observations?		
Any suggested causes (yours or the complainants)?		
Sample collection. Use a small paintbrush (clean) to sweep samples of the dust onto a sheet of paper and then into a clean plastic bag. At least half a teaspoonful will be required for analysis. Lesser amounts may be collected on strips of clear cellotape, which should then be stuck onto sheets of clear plastic to preserve the samples. Label all samples and record the date, time, location, etc. on a separate sheet of paper. Brief description of samples collected:		

Complaint recorded by: (sign) ______________________ Date: ____________________

Site visit details recorded by: (sign) __________________ Date: ____________________

Appendix 3: Dust assessment criteria

The following matters should be considered by councils when determining whether or not a dust discharge has caused an objectionable or offensive effect. It will not be necessary to consider all the listed matters in items 2 to 10 in every case.

1) In all cases councils should consider:

- the **frequency** of dust nuisance events
- the **intensity** of events, as indicated by dust quantity and the degree of nuisance
- the **duration** of each dust nuisance event
- the **offensiveness** of the discharge, having regard to the nature of the dust
- the **location** of the dust nuisance, having regard to the sensitivity of the receiving environment.

   Assessment will be based on the combined impact of these factors, determined from some or all of the following sources.

2) Other validated dust complaints or events relating to discharges from the same site, including previous validated complaints from one location.

3) Collection of dust samples and analysis to identify the source (where necessary and appropriate).

4) Weather conditions at the time of the dust event, notably wind speed, wind direction and rainfall.

5) Information regarding process conditions that may have caused the complaint. The effectiveness of dust control measures at the site should be taken into account.

6) A complaints register held at the site. Councils may require the discharger to keep such a register and identify any cause of an alleged dust nuisance, including remedial action taken.

7) Dust monitoring both within and beyond the site boundary. This includes both deposited dust and suspended particulate monitoring.

8) Results of dust deposition modelling carried out as part of an assessment of effects. These results may be compared to the trigger levels, as discussed in Chapter 7 of this document. Note that this method will have limited application to dispersed area sources or small-scale discharges. Its primary value lies in the prediction of the effects of point source dust discharges, such as stacks.

9) Contents of dust diaries held by people living and working in the affected area. People may be requested to keep such a diary. The diaries would record details of any dust nuisance event, including the date and time of the event, weather conditions (wind speed and direction, rainfall) at that time, a description of the type and amount of the dust detected, and the duration of the dust event.

10) Results of a public survey or field investigation commissioned by the council or the discharger. In this case it is critical that the survey or investigation is professionally designed to ensure that credible and reliable information is gathered.

Explanatory note

The extent of dust nuisance should be determined from all available evidence relating to one or more dust events. In most cases the information specified in items 7–10 (dust monitoring, modelling, diaries and public surveys) will not be necessary. Ideally, good practice dust control measures will be implemented by the discharger to remedy objectionable or offensive effects without the need for expensive investigation. However, for large-scale discharges with potential for significant nuisance or where enforcement action is likely to be required, some or all of the techniques discussed in items 7–10 may be required.

Appendix 4: Dust monitoring methods

Dust deposition

Dust deposition is monitored by determining the amount of dust collected over an exposed surface in a fixed period of time. The equipment used is commonly referred to as a deposit gauge. There are at least three different deposit gauge systems currently being used in New Zealand, and these are based on British, Australian and ISO standards.

The British deposit gauge (BS1747, part 1) consists of a 315 mm diameter glass bowl that is held in a steel stand fitted with a "bird guard". Dust deposits are collected in the bowl and washed by rain into a collection jar at the base of the stand.

The Australian system (AS3580.10.1-1991) is essentially a scaled down version of the BS system (and therefore cheaper), and consists of a 150 mm diameter conical glass funnel supported firmly in the neck of a wide-mouth four-litre glass bottle.

The ISO system (DIS 4222.2) differs from the other two in that the sampling unit and collection jar are one and the same. In this case the gauge is simply made from a plastic open-topped cylinder of about 200 mm diameter by 400 mm high. The cylinder is held in a wire frame, which also extends above the top of the gauge to serve as a bird guard.

Wind tunnel tests have shown that of these three systems, the ISO gauge has the most consistent collection efficiency for a range of different particle sizes and under varying wind speeds. In addition, the ISO gauges are easy to make, with a typical capital cost of about $500. The units are very robust and easily transported to and from the sampling sites. It is recommended that the ISO gauge should be the preferred method for use in New Zealand.

Mention should also be made of some other fairly recent developments in deposition sampling. These include a unit based around an inverted frisbee, and a so-called wedge flux gauge, both of which were developed in the UK. Apparently the wedge gauge has some significant advantages over conventional deposit gauges, for the monitoring of specific dust sources. Neither of these systems has yet been introduced into New Zealand.

Units of measurement

Dust deposition results are normally reported in units of $g/m^2/30$ days, although units of $mg/m^2/day$ have also been used in the past (1 $g/m^2/30$ days = 33.3 $mg/m^2/day$). The use of this latter unit can sometimes be confusing because people see it as meaning the measurements were taken on a daily basis. This is not so. Deposition samples are normally collected over periods of 28–32 days, and the results therefore need to be corrected to a standard time basis. Either time period (1–30 days) can be used, but most practitioners prefer 30 days.

Deposition levels have also been reported in terms of $g/m^2/month$. However, this is unacceptable unless accompanied by a clear definition of a standard "month".

Dissolved versus insoluble matter

The analysis methods for deposit gauge samples usually allow for the determination of both dissolved and insoluble matter. Insoluble matter is the solid material collected by filtering the sample, while the dissolved matter is determined by evaporating some or all of the liquid filtrate. As a general rule, the dissolved material is of no interest in assessing nuisance effects, and this part of the method should be ignored. It would only be of interest when dealing with a specific source that was known to produce water-soluble emissions (e.g. sodium sulphate from a pulp and paper mill, and milk powder from a dairy factory).

The dust deposition criteria given in section 7.4 are usually only applied to insoluble matter.

Total suspended particulate

The standard method for measuring TSP in many parts of the world is the high volume air sampler. This operates by drawing air at a rate of about 1.5 m^3/min through a 25 cm x 20 cm glass-fibre filter, which is weighed before and after sampling under conditions of constant humidity. The filter is mounted horizontally at the top of the sampler, and is protected by a triangular shaped roof. Samples are normally collected over 24 hours (midnight to midnight) using a 1-day-in-6 sampling regime, which is intended to give a representative coverage of the expected variations in particulate levels throughout any year. The method is covered by an Australian Standard, AS 2724.3-1984.

A scaled-down version of the high volume sampler was used in New Zealand for many years, and is still being used in some locations. The system was based around a 55 mm glass fibre filter that was held in a plastic holder mounted under a conical aluminium shelter. The air sampling rate was about 50–75 litres per minute, and samples were collected over periods of seven days.

The New Zealand system was developed for a variety of reasons including cost, portability, and reliability. However, experience over the last 10 years or so has shown that the system is not equivalent to the high-volume sampler and tends to give lower results. In addition, Hi-Vol units are now much more readily available than they were in the past. The local system is therefore being gradually phased out.

It is interesting to note that a number of medium volume samplers have also been developed in other countries (e.g. the Partisol 2000). These are mainly intended for PM_{10} monitoring, but can also be fitted with a so-called TSP head.

Mention should also be made here of a range of continuous dust monitor systems. These were developed mainly for PM_{10} monitoring, but most are available with TSP inlets as well. However, it should be noted that there is currently no standard specification for the size selectivity of these inlets. The available systems include the β-attenuation tape sampler, the Tapered-Element Oscillating Microbalance (TEOM), and a number of units based on light scattering.

The β-attenuation unit operates by drawing air at a rate of 15–20 litres/min through a continuous glass-fibre or teflon tape. A source of β-particles is used to sense the build-up of particles on the tape by changes in the amount of absorption. Measurements are normally averaged over periods of 0.5–2 hours to obtain sufficient sensitivity, and the tape is advanced either at the end of each cycle or some other pre-set interval. The unit can be used for continuous monitoring, and tape life is typically in the order of several months (or years with some recent instruments). The system is not covered by any Australian standard, but has been designated as an "equivalent" method by the US EPA.

In the TEOM, air is drawn through a filter, which is attached to a sensitive oscillating microbalance. Changes in the frequency of oscillation are directly related to the mass of material on the filter. Changes in mass are monitored continuously, although the instrument output is based on time-averaging of the signal, typically over 3–5 minutes. The sampling rate is 16.7 litres/min and micro-filters need to be changed every 1–4 weeks depending on the particle loadings. The system is not covered by any Australian standard, but has been designated as an "equivalent" method by the US EPA.

In the light scattering units, air is drawn through a chamber fitted with a small laser source. The scattering of light by dust particles is detected by a sensor placed at right angles to the beam. The main limitation with light scattering instruments is that the instrument response depends on both the size distribution and the numbers of particles, rather than the total mass of airborne particulate. This can be overcome to some extent by carrying out periodic calibrations using manual filter sampling. However, such calibration "factors" are likely to vary with different monitoring locations and different times of the year, because of the changes in composition and nature of the airborne particles.

The recommended monitor for routine TSP monitoring is the high-volume sampler. However, some of the continuous monitors will also be appropriate for the control of specific industrial sources.

Units of measurement

TSP results are normally reported in $\mu g/m^3$ although mg/m^3 may sometimes be used for very high levels ($1\ mg/m^3 = 1000\ \mu g/m^3$).

Appendix 5: Dust management plans

The following notes give an example of a possible outline for a dust management plan.

Introduction

This should describe the purpose and scope of the plan.

There should be a statement from the company manager or chief executive regarding support for the plan, along with references to any company environmental policy statements, and quality systems. Copies of any relevant material should be included in an appendix.

There should be a statement regarding the need for annual reviews of the plan contents.

Air quality management

This should give a brief description of the site activities, with special mention of the activities likely to generate dust. Specific statutory requirements regarding dust control (e.g. consent conditions) should be summarised here, with copies of the documents given in an appendix.

Specific staff responsibilities for dust management should be clearly stated, including responsibility for maintenance and updating of the plan.

Emission control and maintenance procedures

This should give details of all of the procedures that will be used on the site for dust management. Detailed operating instructions should be included in an appendix, if necessary.

There should also be specifications for any maintenance requirements for dust control equipment (e.g. sprinkler systems, bag filters).

Any requirements for performance testing of the control equipment should also be detailed here.

Sub-contractor management

If some of the work on site is to be done by sub-contractors, there should be a statement here of the procedures that will be used to ensure they are aware of and know what is required to comply with the dust management procedures. There should be a clear statement of reporting responsibilities. If necessary, specific dust control requirements should be written into the formal sub-contracting agreement.

Monitoring programmes

This should summarise the objectives and scope of any dust monitoring programmes, including methodology and site numbers and descriptions. Some of this detail may be given in an appendix.

Any emission testing requirements should also be described.

The system for use of the complaint register should be described, including investigation procedures and reporting requirements.

All monitoring results should be summarised in an annual report, copies of which should be made available to the public, and to the relevant regional and district councils (this may also be a consent requirement).

Appendices

These could include some or all of the following:

1. A copy of the company's environmental policy.
2. A detailed description of the site operations.
3. Copies of all relevant discharge permits or other statutory requirements.
4. Details of equipment maintenance programmes.
5. Details of dust monitoring sites, monitoring methods and control limits.
6. A plan of the site layout.
7. A map showing the locations of any monitoring sites.

Appendix 6: Case studies

1 Waihi Gold Mining Company

Background

The Waihi Gold Mining Company operates an open-cast mine in the town of Waihi. Mining operations started in 1987 and were originally planned to run for about 14 years. The company was granted approval for an extension to the mine in 1998, and mining will now continue through until about 2007.

The mining activities occupy a land area of about 300 hectares. Most of this is taken up by the pit itself (50 ha) and the waste disposal area, or tailings dam (200 ha). Obviously an activity of this size requires more than just one or two strategically located monitoring sites to provide effective coverage of the potential effects. In fact, the programme at Waihi is based around a total of 15 monitoring sites, eight of which are used for total suspended particulate, and 14 for dust deposition.

The dust monitoring programme was first set up in 1982, five years before the start of mining. This was a lot longer than necessary, but nonetheless the data provides an excellent record of "background" conditions prior to the mining activities. Seven monitoring sites were set up in 1982, five in 1984, two in 1986, and one in 1987. Five of the monitoring sites are directed at the open pit, seven of them surround the waste disposal area, and three provide information on dust levels within the town itself.

Monitoring results

A typical set of monitoring results for total suspended particulate (TSP) is shown in Figure A1. This is for the Barry Street site, which is one of the closest to the pit. The results are for seven-day averages. As shown there was no noticeable change in TSP levels at this site when mining commenced in 1987. There have only been a few breaches of the TSP limit specified in the air discharge consent, and no breaches of the mining licence limit.

Comparative results for a site in the commercial centre of Waihi are shown in Figure A2. This site is affected more by vehicle movements and other commercial activities, than by the mine.

Deposition results for the Barry Street site are shown in Figure A3. In this case the results are monthly averages. There were two breaches of the consent limit during the early stages of mine development. The high result recorded in 1996 was observed at all of the deposition monitoring sites. This was caused by the eruption of Mt Ruapehu, which is some 200 km to the south of Waihi.

Figure A1: Total suspended particulate (seven day average) measured at Barry Street, close to the pit

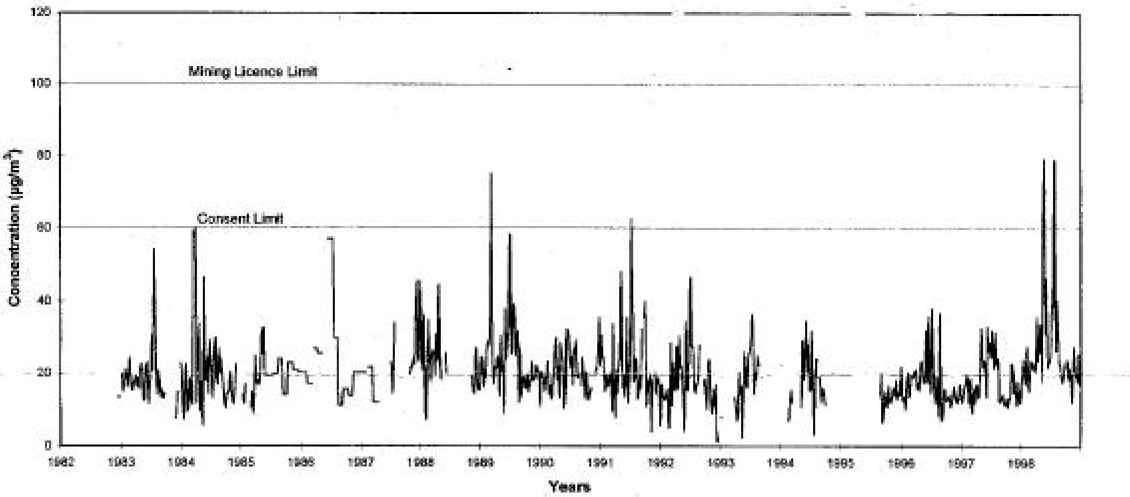


Figure A2: Total suspended particulate (seven day average) measured in the Waihi town centre

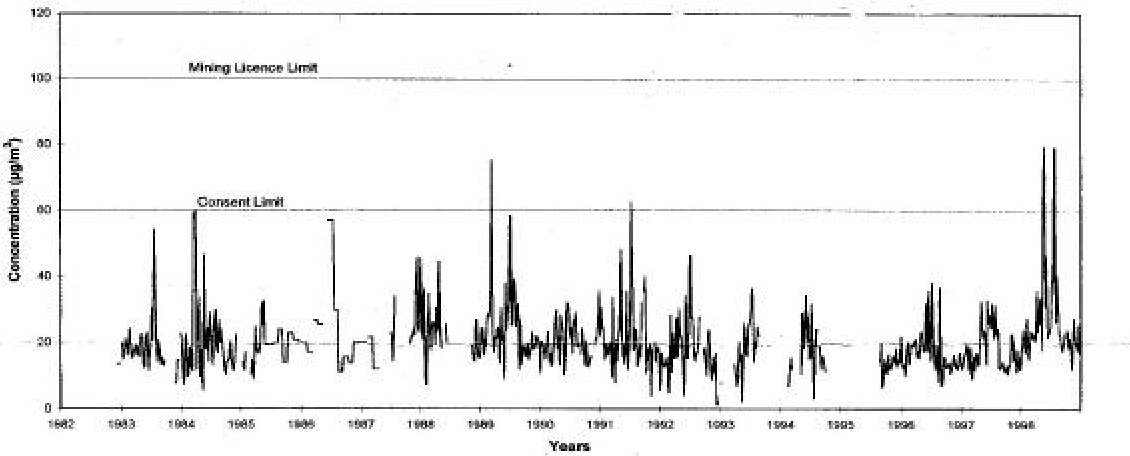
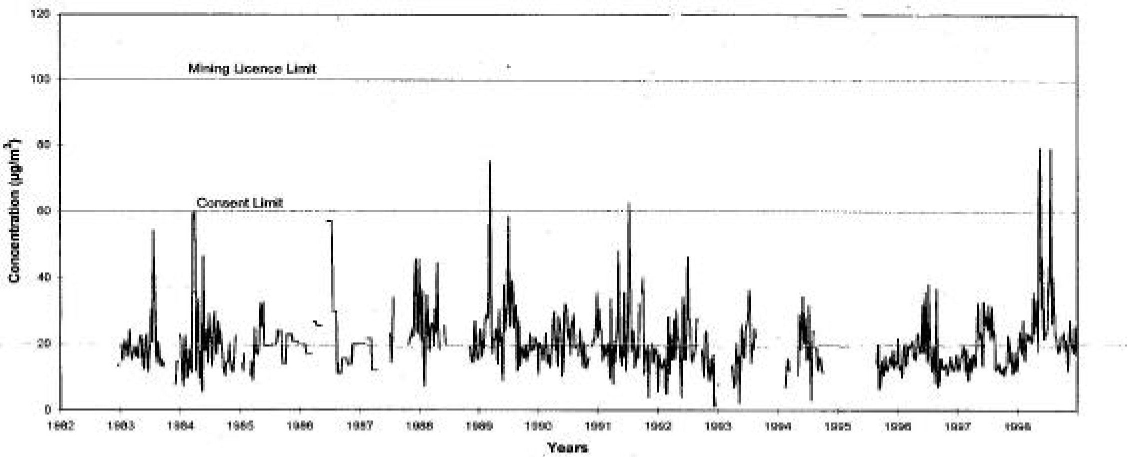


Figure A3: Deposited dust (monthly average) measured at Barry Street



Discussion

The monitoring programme at Waihi has served a number of purposes. It provided useful background data for the initial mining application, as well as important "performance" data to support the more recent application for an extension of the mine. It is used as a compliance monitoring system, although there is no obvious correlation between elevated dust levels and dust complaints. It also provides continual feedback to the company as to the effectiveness of its dust management programmes.

2 Pacific Steel Limited, South Auckland

Background

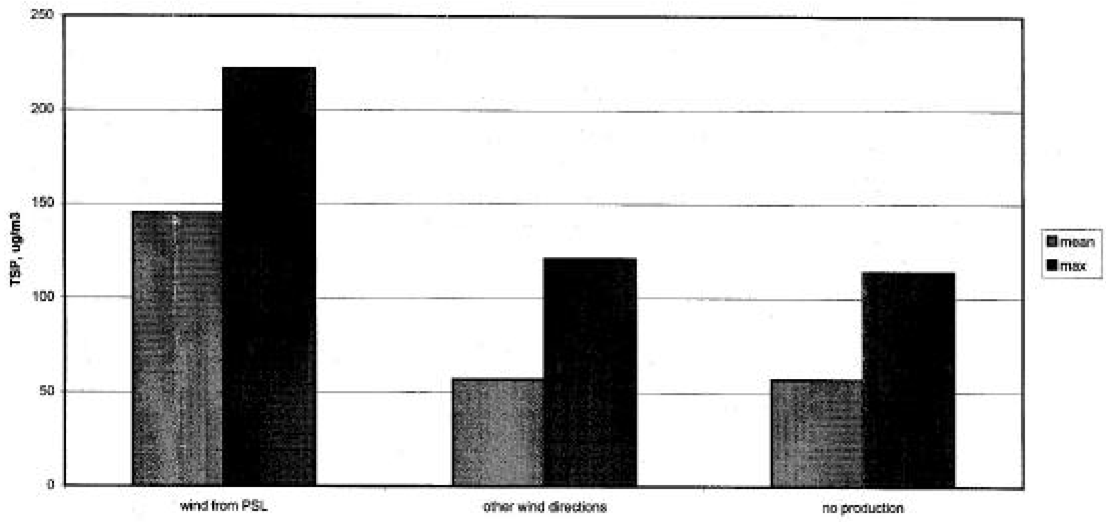
Pacific Steel, a business unit of Fletcher Challenge SteelMakers, have operated a secondary steel smelter in South Auckland for many years. The company established a dust monitoring programme at about the time that it applied for an air discharge permit under the RMA. The programme was based around a network of twelve deposition monitors, three directional dust gauges and two high volume samplers, which were used for monitoring both TSP and PM-10. Only the TSP results will be considered here.

The TSP monitors were located at two points to the east and north-east of the main plant. These were along the prevailing wind lines for the Auckland region. Samples were collected over 24 hours, using a one-day-in-six sampling regime. The company also installed a wind speed and direction monitor on the site, and this allowed the TSP data to be analysed on the basis of wind direction.

TSP monitoring results

TSP results for the period June 1994 to June 1995 are summarised in Figure A4. This shows the average and the maximum dust results for three different situations; wind from the direction of the plant, wind from all other directions, and dust results for the days on which the plant was not operating. This data shows that there was a measurable dust impact from the plant. The information assisted the company in developing management plans to improve the situation. However, the results also showed quite clearly that there were other significant dust sources in the area as well. The results should be compared with the trigger levels discussed in section 7.4.

Figure A4: **Total suspended particulate concentrations (24-hour average) measured at the Pacific Steel monitoring sites, analysed on the basis of wind direction and plant operating hours**



3 Fulton Hogan Mt Wellington Quarry

Background

Fulton Hogan Limited operates a quarry at Mt Wellington, Auckland (Figure A5). Basalt rock is being removed from the quarry with the intention of ultimately developing an industrial and residential subdivision on the site. Because of the close proximity of houses and the continuing residential development adjacent to the quarry, an intensive dust control and monitoring programme is undertaken. During the final stages of quarrying rock extraction will occur within 100 metres of neighbouring dwellings.

The primary activities within the quarry that have potential to discharge dust are:

- drilling and blasting
- excavation of rock
- crushing and screening of rock at up to 90 tonnes/hr
- stockpiling of quarried rock
- truck movement on unsealed surfaces
- an asphalt plant.

Consent requirements

A resource consent was granted by the Auckland City Council in May 1998 to undertake quarrying for five years. The consent contains several conditions relating to the dust discharge into air. As part of the application process a detailed dust management plan was prepared.

Figure A5: Aerial view of the Mt Wellington quarry

Note the proximity of residential properties at the upper right of the photograph.

The principal consent requirements relating to the dust discharge are:

- no noxious, offensive or objectionable discharges beyond the property boundary, in the opinion of an ACC enforcement officer
- ensuring discharges do not exceed concentrations of alert level 200 $\mu g/m^3$ or an absolute limit of 400 $\mu g/m^3$ (as explained below)
- a buffer zone with a width of 65 metres where the boundaries of the site adjoin residential areas
- no uncovered stockpiles within 200m of the site boundary.

Dust management plan and control measures

A comprehensive dust management plan was required by the Auckland City Council and was the subject of a submission from the Auckland Regional Council. The plan details staff responsibilities, contingency measures and specifies the staff members to be involved in an ongoing community liaison committee.

The main dust control measures specified in the plan include:

- application of water prior to blasting at a rate equivalent to 20 kg/m^2
- fine mist sprays at the crushing plant and conveyors
- location of the crushing plant within a raised bund
- dampening of haul roads with a water cart and fixed sprays, restriction of truck speed to 10 km/hr
- enclosing stockpiles of fine materials within a shed
- use of a drill for blasting with vacuum dust extraction and watering
- application of water to the rock excavation face
- removal of as little vegetation, overburden and soil as possible.

Dust monitoring

Dust monitoring is required by the management plan and consent conditions. The existing dust deposition gauge network continues to be used to monitor long term (30 day) dust nuisance at the property boundary. However in this situation the information gathered is of limited value when compared to that received from the real-time suspended particulate monitors.

Suspended particulate monitoring is undertaken using two real-time 'DataRam' monitors located within the plant and near the site boundary. The monitors measure the suspended particulate concentration every five minutes and are connected to an on-site alarm and the quarry manager's cell phone. The alarm is triggered when concentrations exceed 200 $\mu g/m^3$ and 400 $\mu g/m^3$. Triggering at the lower level requires that immediate action be taken to control dust emissions, while triggering at the higher level requires that work cease until the cause of the discharge is identified and rectified.

These suspended particulate limits have rarely been exceeded in the past. To remedy the limit breaches that have occurred, the sprinkler system has been extended to include the asphalt plant stockpile shed where crusher dust is stored. Fulton Hogan is currently in the process of automating the sprinkler system.

During one summer monitoring of PM_{10} was carried out using a high volume sampler to enable comparison to the real-time suspended particulate monitoring and to provide information relevant to health effects. PM_{10} values recorded were low, suggesting that significant health effects are unlikely to be associated with the quarry discharge.

Wind speed and direction are measured at the site. Thus the dust monitoring results can be compared to wind conditions at the time of measurement. This information is provided to the consent authority in a monthly monitoring report.

Community liaison

A community liaison group has been established that includes representatives of the Council, Fulton Hogan and local residents. Monthly meetings allow any concerns or complaints regarding dust emissions to be discussed. In addition, a complaints register is held by Fulton Hogan and individuals are encouraged to contact the company directly in the event of dust nuisance.

Discussion

Because of the location of the Mt Wellington quarry, there is potential for significant dust nuisance if strict dust control measures are not implemented. Careful attention to watering is required during dry conditions. In this case real-time dust monitors provide useful information regarding the effectiveness of the dust control measures. High short-term concentrations trigger an alarm that requires remedial action.

A comprehensive dust management plan is useful for this large site because it ensures staff responsibilities are clearly defined and specific actions are identified. Community liaison and complaints response play an important part in monitoring the effects of the dust discharge. Information gathered from the community, in combination with results from monitoring of dust and wind conditions, assist in identifying and remedying the cause of any dust nuisance events.

4 Port of Timaru Limited

Background

A wide range of bulk cargo materials are received and dispatched at the port of Timaru. Potentially dusty materials handled at the port include fertilisers, wood chips, soya meal, limestone, urea, sand, sugar, grains and seeds. Loose bulk cargo is transferred by hydraulic grabs between the ship and a mobile hopper on the wharf. Material is then discharged from the base of the hopper into trucks for transportation off-site or temporary storage within the port in silos or stockpiles.

Transfer of potentially dusty cargo has occurred at the port for many years and is adequately removed from residential properties that are elevated on a cliff to the west of the port. Few complaints have been made regarding dust emissions from the existing activities. In this case the nature of dust emissions and the scale of effects do not warrant dispersion modelling or complex dust monitoring techniques. This case study offers an example of one approach to the assessment and control of dust emissions from fugitive sources where significant adverse effects are not expected.

Resource consents and dust management plan

Resource consents for the discharge of dust to air and water were granted by Environment Canterbury in early 2001, following notification of the applications. A dust management plan was prepared as part of the consent applications and has been incorporated in the conditions of consent. The plan identifies staff members responsible for dust control, details the specific actions to be undertaken, and requires that dust complaints be recorded and actioned.

Dust control measures

A variety of good practice dust control measures are implemented via the management plan, including:

- use of water sprays on temporary stockpiles
- suction sweeping of the wharf and roadway areas where cargo material has been deposited
- avoiding cargo unloading during strong winds
- covering loaded trucks with tarpaulins
- locating stockpiles in sheltered areas and limiting the height and slope of stockpiles
- a regular maintenance schedule for the hydraulic grabs to minimise discharge via the seals
- minimising cargo transfer distances.

The dust management plan will be reviewed annually to incorporate any improvements to the dust management system.

Discussion

The Port of Timaru cargo handling operation is an example of a dust discharge where the scale and significance of effects does not warrant extensive dust monitoring. Because of the variable, dispersed and somewhat unpredictable nature of dust emissions from these activities, dispersion modelling is of little value as an assessment technique in this case.

The approach taken by the Port of Timaru Ltd to assessment and control of dust emissions has therefore focused on:

- examination of the ongoing history of any effects observed at neighbouring properties, including maintaining a record of any complaints and a point of contact with neighbouring parties
- implementation of good practice measures to minimise dust emissions from the various sources, via a dust management plan.

Development of a dust management plan is useful for this type of operation where there are various diffuse dust sources. The plan ensures that specific operational tasks are clearly identified and assigns responsibility to staff members. Any sub-contractors are required to appoint a staff member responsible for compliance with the plan.

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