Aggregate Operators Best Management Practices Handbook

PART II

Chapter 5 - 7: Planning Modules
SITE LAYOUT MODULE - SLM

Table of Contents

Tables and Figures

SITE LAYOUT MODULE - SLM

Common Concerns: Site Layout

Site layout choices can have a strong influence upon the potential community impacts of an aggregate operation, particularly where it concerns noise, dust and visual aesthetics. This module discusses, in separate sections, site layout with respect to controlling noise, dust and visual landscape impacts and recommends that a Site Layout Map be constructed to help understand and address these concerns.

Noise

Noise is one of the most commonly cited community concerns regarding aggregate operations. As Table MP - 4: Mine Plan Activity And Module Worksheet in Chapter 4 indicates, noise is associated with a great number of common activities at aggregate operations, including blasting, loading, crushing, screening, washing and hauling. This module will assist in identifying noise point sources at aggregate operations and BMPs and other measures that can be used to minimize noise.

Dust

In both urban and rural environments, neighbours of aggregate operations commonly voice concerns about dust. The disturbance of fine soils by extraction and processing activities at sand and gravel pits and rock quarries increases the potential for dust creation, and dust control should be part of ongoing operations. This module will assist in identifying dust-generating activities, situations where dust can be an issue, which people and facilities are sensitive to dust, and what BMPs and other measures can be used to control dust.

Visual Landscape Design

An aggregate operation's appearance may significantly affect the relationship between the aggregate operation and its host community. With increasing environmental and public land use interest in the aggregate industry, managing the appearance of an operation has become an important priority. Visual landscape planning can help to strike a balance between the aesthetic concerns of the community and the economic and operational validity of the operation.

Through the provincial land use planning process, the Province is currently performing a Visual Landscape Inventory. This process involves establishing visual quality objectives, classifying landscapes and designating significant scenic areas. In some areas of the province, visual quality objectives may have to be met for a subsequent permit to be granted, similar to a licence to cut for forestry activities. With British Columbia's world-renowned landscapes proclaimed on every licence plate, and with the developing of the tourist and movie industries, viewscapes are regarded as a provincial resource that, where possible, should be considered at aggregate operations during their productive life spans.

Section 1 - Noise

Aggregate Operation Noise Management

Planning to manage noise at an aggregate operation can include:

- identifying activities that generate noise,
- determining how the configuration of the property amplifies, muffles or reflects noise,
- developing measures and BMPs to reduce noise generation, and
- developing measures and BMPs to reduce the transmission of noise.

Understanding Noise

The intensity of sound is measured in units called decibels (dB) and is expressed on a logarithmic scale. As such, combining sound levels is not a matter of simple addition. For example 50 dB + 50 dB = 53 dB, not 100 dB. An increase of 3 dB in sound intensity doubles the sound energy, or loudness. Likewise, a 12 dB increase in intensity represents an 800% increase in loudness.

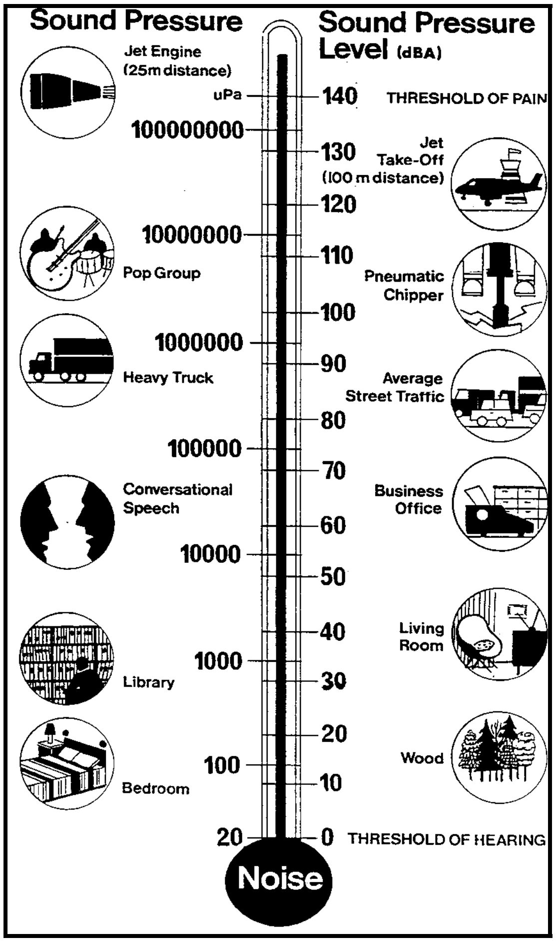
Different criteria are used to measure sound for different purposes. Criteria used to approximate the sounds heard by the human ear, called “A-weighting”, are recorded in dBA. Other measuring options include comparing sound levels over time (Leq), measuring its steady state, or measuring the peak (impact) level.

Noise sources at aggregate operations can include equipment engines, back-up alarms, drills, power generators (“gen sets”), crushers, screens, material falling on to a grizzly or into the empty metal box of a haul truck, the 'body slap' of empty truck boxes, squealing of tracked vehicles, and even the rattle of loose hitches or boxes on trucks travelling through the neighbourhood. Noise control can include scheduling hours of operation, selecting appropriate equipment (e.g., does it have a proper muffler?), constructing sound barriers and berms to contain noise and other options.

The effects of aggregate operational noise on neighbours can vary, but may cause annoyance, disturbance and even a sense of interference with quality of life. Factors to consider include hours of operation (especially early morning), frequency of vehicle traffic on local roads, steps taken to contain noise emissions and, of course, how close the operation is to neighbouring houses.

Wildlife, livestock and even fish may also be affected by noise exposure. Fisheries and Oceans Canada's (DFO) *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* recommends set-back distances for specific substrates and weights of explosive charges (Wright and Hopky, 1998).

Figure SLM - 1: Noise levels from common sources



BC Ministry of Energy and Mines, 1998 , pages 2-9.

Table SLM - 2: Projected un-buffered noise levels for some common aggregate machinery.

Table 3.1. Summary of noise measurements and projected noise levels in decibels (dBA) for common mining equipment (Barksdale, 1991)

		Projected noise levels		
Noise source	**Measurements**	**1,000 ft**	**2,000 ft**	**3,000 ft**
Primary and secondary crusher	89 dBA at 100 ft	69.0 dBA	63.0 dBA	59.5 dBA
Hitachi 501 shovel, loading	92 dBA at 50 ft	66.0 dBA	60.0 dBA	56.5 dBA
Euclid R-50 pit truck, loaded	90 dBA at 50 ft	64.0 dBA	58.0 dBA	54.4 dBA
Caterpillar 988 loader	80 dBA at 300 ft	69.5 dBA	63.5 dBA	60.0 dBA

Norman and others, 1997, page 3-8.

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Table SLM - 3: Common noise generating activities at aggregate operations

Activity	Duration (D) & Potential Impact (I)	Noise Producers	Suggested BMPs & Noise Reduction/Control Methods
Tree Removal, Grading and Topsoil & Overburden Handling	**D** - Intermittent and temporary **I** - Medium	moving vehicles such as skidders, bulldozers, haul trucks, excavators and chain saws	• Berm • Environmental Timing Windows • Equipment Selection • equipment maintenance
Drilling and Blasting	**D** - Intermittent **I** - Low	drilling rig, power plant for drilling rig, moving the rig, detonation	• Environmental Timing Windows • Equipment Selection • electronic detonators
Extraction & Handling	**D** - Moderate **I** - Moderate	moving vehicles such as front-end loaders, excavators, bulldozers and haul trucks	• Berm • Environmental Timing Windows • Equipment Selection • Fences
Processing & Crushing	**D** - Continuous **I** - High	loaders to feed crushers, haul trucks to deliver material to the crusher and remove crushed material; powering of crushing plant (primary and secondary); crushing of material; excavator-mounted hydraulic hammers to pre-crush large rocks	• Berm • Environmental Timing Windows • Equipment Selection • Fences • acoustic screens • barriers/ • enclosure • line hoppers • location • start plants one at time
Grading	**D** - Intermittent **I** - Medium	bulldozers, haul trucks, excavators, graders and scrapers	• Environmental Timing Windows • Equipment Selection
Stockpiling	**D** - Continuous **I** - Low	moving vehicles such as front-end loaders, bulldozers, haul trucks and conveyors to build stockpiles	• Environmental Timing Windows • location
Conveying	**D** - Continuous **I** - Medium	powering of conveyors, roller noise, belt slap and material fall noise	• Drop Height • Environmental Timing Windows • chutes • enclose conveyor • maintenance
Onsite Transport - Truck	**D** - Continuous **I** - Low	haul trucks	• Environmental Timing Windows • Equipment Selection • alternative reversing alarms • locate haul roads at lowest elevation. • speed limits
Loading	**D** - Intermittent **I** - Low	front-end loaders, material drop noise and honking, material falling onto grizzly	• Drop Height • Environmental Timing Windows • Equipment Selection • equipment maintenance • rubber linings • slide or slowly rotate material into truck boxes

After Cole and others, 1999.

Common Aggregate Operation Noise Considerations

Noise management planning may benefit from the following notes in determining the degree of noise control necessary for an aggregate operation.

Existing Noise Levels

The background noise levels around a site can be considered to help determine noise emission targets for an aggregate operation. Aggregate operations within an industrial park or remote forested area will have less noise concerns than operations within urban and rural areas. Noise-sensitive neighbours might include residences, churches, schools, hospitals or other health care institutions, intensive livestock farms, tourist oriented resorts and some factories. Neighbours and sites that are more noise sensitive in general will have a lower tolerance threshold for noise generated from an aggregate operation.

Site Location

Noise emissions can be either dampened or reflected by vegetation and by the land itself. Hard ground such as paved or non-vegetated areas and water surfaces reflect sound very well, whereas soft ground such as grassland, wood lots and cultivated fields absorb sound. Hillsides or cliffs can also reflect sound above the ground surface to where it can be heard for significant distances. For example, operations perched on a hill slope overlooking a large lake may have to pay particular attention to controlling the noise reflection. Alternatively, berms and trees can be used to deflect and/or absorb noise, blocking the straight line by which sound travels (i.e., noise pathway).

Climatic conditions can also affect noise impacts to a limited degree and can be taken into account in the planning stages for an aggregate operation. Low cloud cover can reflect noise back to the ground and prevent upward dissipation. During winter months, the cooling of air increases its density, thus increasing both transmission speed and distance travelled. Prevailing winds can extend noise downwind and reduce transmissions upwind. Precipitation and humidity both reduce noise propagation as the water particles absorb noise energy.

Equipment and Activities

For any type of equipment that an aggregate operation uses, some models are quieter than others. Noise level emissions can be used as one of the criteria when selecting equipment.

Stationary noise-generating equipment and activities can be acoustically contained. Options for containing noise range from local acoustic fencing and shielding to enclosure within a building. The Chief Inspector of Mines will consider a written application for a *Mines Act* variance to replace back-up alarms on mobile equipment with back-up strobe lights.

Site Layout and Plant Location

Where flexibility exists, strategic placement of activities can reduce the level of noise emanating from a site. Locating noise-generating activities as low on the property as possible may allow their noise emissions to be absorbed and blocked by the land. Similarly, crushers and haul roads can be located away from sensitive receptors and exposed locations.

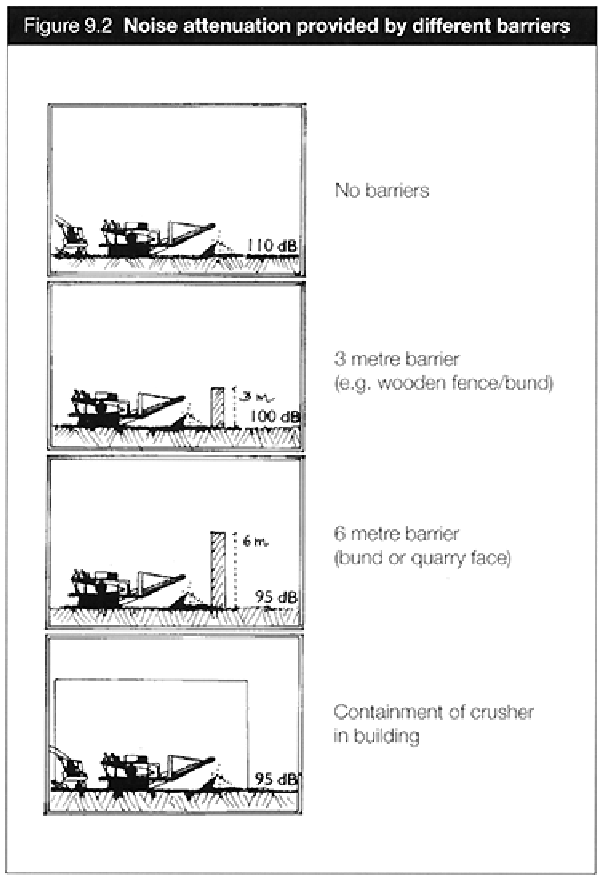
Berms, tree barriers and acoustic fences can be used adjacent to sensitive noise areas or as a perimeter measure to contain noise within the operation's boundaries. A technique commonly used for aggregate operations is to construct an acoustic fence using surplus conveyor belts on a sturdy frame. The weight and flexibility of the belting provides excellent noise absorption.

Noise Management

Working with the Public on Noise Management

It is important for the public to sense that an aggregate site operator is committed to the mitigation or avoidance of noise impacts. Opportunities should be taken to discuss the results of noise monitoring (e.g., when, for how long and why particularly noisy events are likely to occur) with local communities.

Figure SLM - 4:   Noise attenuation provided by different barriers



Cole and others, 1999.

Some operators have successfully implemented community response systems to address noise-related complaints in a fair and expedient manner. A record of complaints, the actions taken, outstanding follow-up actions and subsequent dialogue with complainants are some measures that have been practiced with success.

Methods For Reducing And Controlling Noise

Noise can be controlled at aggregate operations by a number of strategies such as:

- source control,
- containment,
- site layout (stationary objects),
- operations (activities or moving objects) and
- interception (perimeter structures).

Careful site planning can help to contain the noise with the use of the existing topography, existing and introduced vegetation, major landscaping (berms), acoustic fences, tree barriers and combinations of these methods. Operational practices can reduce both the generation and the escape of noise. Finally, interception can be achieved with property edge treatments such as perimeter barriers composed of trees and shrubs or acoustic fences specifically designed to intercept ambient noises. Table SLM - 5 outlines these suggestions with associated BMPs.

Noise Planning Considerations

Noise planning for an aggregate operation encompasses both the planning of the site layout and the development of operational procedures. Although a Site Layout Map is not generally a permit requirement, the plan for noise (as well as dust and visual) considerations could be worked out and documented on such a map. A Site Layout Map could contain the following noise components:

- noise-generating activities,
- off-site facilities that are noise-sensitive ,
- potential noise reflectors (mine faces, hillsides, hard ground and water), topographic hollows and noise absorbing areas (wood lots, shrub areas, grasses),
- placement of berms, stockpiles and tree buffers to create or enhance noise-dampening locations for the site or to act as noise barriers,
- plans to locate noise-generating activities and haul roads in suppressing locations and away far from noise-sensitive facilities,
- procedures to avoid noise generation and contain noise, and
- Designation of existing trees and shrubs as perimeter barriers on noise sensitive sides of the operation.

Table SLM - 5: Site layout, operations and interception noise control options

Management Options	Noise Management and Control Methods	BMPs & Measures
SITE LAYOUT **Containment & Dampening**	• locate haul-roads away from ridge tops and in topographic lows • place processing equipment within natural or excavated hollows, such as the pit or quarry floor • minimize the fall height of material • construct stockpiles to intercept point source and ambient noise • use crushing and screening plants within their design capacity • plan orientation of working faces to reflect noise into dampening areas • use first stage operations to act as screening for noise sensitive areas and receptors • group and position buildings to act as an acoustic barrier • restrict noise generating activities to sheltered areas • create 'sensitive zones' within which activities are limited	• Berm • Drop Height • Fences • Vegetative Cover • Straw Bale Wall • Treed Windbreaks
OPERATIONS **Source Prevention & Escape**	• select low noise emission equipment • ensure smooth road running surfaces • start plants engines one at a time • maintain, repair and lubricate equipment • alert and train staff to reduce noise emissions • limit drop heights during handling • fit acoustic barriers to processing equipment • minimize mobile equipment speeds • use alternative non-audible back-up alarms • vegetate exposed surfaces such as overburden mounds with quick growing ground cover and plants • use rubber linings in chutes, dumpers and transfer points to reduce the noise of rock falling onto metal surfaces • use simple baffles around washing drums and rubber mats around screening, crushing and coating plants • switch off equipment when not in use • avoid unnecessary revving of engines • direct noise away from sensitive areas whenever possible, if the noise source is highly directional • enclose sources of significant noise, such as conveyors and process plants • keep truck tailgates closed where possible	• Drop Height • Equipment Selection • Fences • Vegetative Cover • Water Spray • Speed Limits
INTERCEPTON **Ambient Reduction**	• retain and plant trees or shrubs around the site • place treed berms near noise generation activities (source), receptors or at the perimeter of the site • install acoustic fencing • ensure there are no gaps in acoustic barriers, as noise will leak out	• Berm • Fences • Perimeter Planting • Vegetative Cover

After Thomas, 2000.

Section 2 - Dust

Understanding Dust

Dust is any particle up to 75 microns (µm) in size. A micron is one millionth of a metre. Particles larger than this are called "grit." Dust has a wide variety of man-made and natural origins including vehicle exhaust, agriculture, tire wear, natural and domestic fire and sea salt. Dust can become airborne by wind blowing over exposed surfaces or by mechanical disturbances such as rolling truck tires. Smaller sized dust particles travel farther and are a greater health concern that larger ones.

The most difficult type of dust to control is "fugitive" dust, which is generated by unstable, non-point sources (like movement of equipment) and the effects of wind on stockpiles and areas stripped of vegetation. Fugitive dust is the most common cause of dust complaints at aggregate operations, as it commonly settles on cars and in homes in adjacent areas (Thomas 2000). As Table SLM - 6 illustrates, mining and quarrying operations contribute only a small portion of all fugitive dust in the PM_{10} (smaller than 10 µm) size range.

Table SLM - 6: Example statistic of fugitive dust sources in the USA

Sources of Fugitive Dust (PM_{10})	Percentage of Total Dust Generation
Unpaved roads	28 %
Construction	23 %
Agriculture	19 %
Paved Roads	15 %
Wind Erosion	5 %
Mining/Quarrying	1 %

Goff , 1999, page 88.

Size Fractions of Aggregate Dust

Air quality concerns are often in the news and many cities report daily air quality indices. When the media discus dust, they are usually referring to PM_{10} (particulate matter smaller than 10 µm) or $PM_{2.5}$ (smaller than 2.5 µm) size fractions from all sources. As Table SLM - 7 shows, only about 6% of dust particles generated at aggregate operations falls into this category. No two sites will be identical and these percentages will vary depending upon site characteristics.

Table SLM - 7:Common concerns with aggregate dust by size category.

Dust Size Categories	Size µm (Micrometers)	Concerns	Percentage
Large Dust	10 - 75 µm	Nuisance	94 %
PM 10	2.5 - 10 µm	Health (respiratory)	3 %
PM 2.5	Smaller than 2.5 µm	Health (respiratory)	3 %

Barksdale, 1991.

Dust Generation

The amount of dust generated at an aggregate operation depends upon the site conditions, climate, nature of the material and site operations. As an example, Table SLM - 8 illustrates the results of a preliminary study at American sites of how much dust can be generated by the activities of loading, transporting and reclaiming stockpiles, versus simple wind erosion.

Table SLM - 8: Sample study of USA dust emissions from aggregate storage

Source Activity	% Total Emission	Emission Factor (Kg dust/ tonne aggregate)
Loading into storage	12	0.016
Transportation	40	0.050
Reclaim from stockpiles	15	0.020
Wind erosion	33	0.045

After Cole, 1999.

At an aggregate operation, dust can be generated from numerous conditions, including:

- **Wind**, blowing over exposed soil or stockpiled material (which includes material travelling in trucks or on conveyors, where the material is moving versus the air moving)
- **Falling Material**, such as in loading
- **Ground Abrasion**, where wheels and tracked vehicles kick up dust
- **Handling**, as in extraction, crushing and sizing
- **Drilling and Blasting**

Table SLM - 9 illustrates, common dust generating activities at aggregate operations, each activity's duration and potential to generate dust, reduction and control methods and associated BMPs.

Table SLM - 9: Common dust generating activities at aggregate operations and suggested controls measures

Activity	Duration of Activity	Potential Dust Emission for Uncontrolled Activity	Key Reduction and Control Methods	BMPs & Measures
Topsoil & Overburden Handling	• short • periodic	depends on moisture, silt and clay content of the material and transportation to stockpiles on the site, particularly during the unloading and haulage stages	• restrict the duration of stripping to the immediately necessary period • seal and seed surfaces and disturbed areas as soon as is practicable • protect exposed material from wind with covers (tarps), within voids or by topographical features • spray exposed surfaces of mounds regularly to maintain surface moisture • minimize handling	• Tarp • Vegetative Cover • Water Spray • handling • sealing • Wind Protection
Drilling and Blasting	• short • may be frequent	properly designed and controlled blasts create less dust	• use dust extraction equipment on drilling rigs • drill using water	• dust extraction/filters • dust removal
Extraction & Handling	• long • can be continual	depends on the equipment and technique used, content of material and exposure of the face	• keep working faces as small as possible • reduce drop heights wherever practicable • orientate face to reduce impact of prevailing wind	• Drop Height
Loading	• ongoing during extraction	depends on the nature of the material, whether it is wet or dry, volumes handled and equipment used	• reduce drop heights wherever practicable • protect activities from wind	• Drop Height • Wind Protection
Processing: Crushing & Sizing	• ongoing	depends on type of equipment, exposure to wind and fine contents of material	• enclose crushers and use bag house • use backstops for wind protection • use water sprays	• Wind Protection • Water Spray • enclosure
Stockpiling	• ongoing	depends on the volume and particle size of stored material, whether it is wet or dry and exposure to wind	• dampen material • protect from wind or store under cover • screen material to remove dusty fractions prior to external storage	• Tarp • Water Spray • screen out fines
Conveyor Transport	• ongoing	depends upon the conveyor system, nature of material and exposure to wind	• protect by use of wind and roof boards • shelter transfer points from wind • use scrapers to clean belts and collect scrapings for disposal • minimize drop heights and protect from wind • use water sprays	• Drop Height • Wind Protection • belt cleaning • roof boards
Transport - Onsite Truck	• ongoing	depends on type of road surfacing, road location and size and speed of trucks	• restrict vehicle speed • pave, water or treat roads • wheel or body wash at an appropriate distance from site entrance • load and unload in areas protected from wind • minimize drop heights • sweep paved roads	• Drop Height • Street Cleaning • Water Spray • Wheel Washer • sheet vehicles • speed limits
Transport - Off-site Truck	• ongoing	depends on road, speeds and truck equipment	• use sheeting or tarps • wheel or body wash at an appropriate distance from site entrance • use road sweeping • do not overload	• Street Cleaning • Wheel Washer • bucket covers

Thomas, 2000.

Dust Travel Distances

The distance that dust travels depends upon particle size and wind velocity. The smaller the dust particles the longer they can remain airborne and the wider the area over which they can disperse and deposit. Research has shown that the large dust particles (greater than 30 μm), which make up most aggregate dust, will deposit within 100 metres of their source. Intermediate sized particles (between 10 and 30 μm) are likely to travel 200 to 500 metres. Smaller particles (less than 10 μm), which make up the smallest proportion of aggregate dust, can travel up to one kilometre. The farther dust travels from its source, the more its density in the air decreases, thus reducing its impacts.

Table SLM - 10: Typical travel distances for dust by size fraction

Dust Categories	Size μm (micrometers)	Distance Travelled
Large Dust (a)	30 - 75 μm	100 m
Large Dust (b)	10 - 30 μm	200 - 500 m
PM 10	2.5 - 10 μm	1000 m
PM 2.5	< 2.5 μm	> 1000 m

Thomas, 2000.

Dust Impact

The impact of aggregate-related dust on neighbours is generally confined to the level of nuisance, but may create health concerns under some circumstances. The determining factor is the size of the dust particle. The PM_{10} size fraction is the portion of dust that humans cannot filter out through their normal respiratory process and thus can be inhaled.

It is difficult to determine how much PM_{10} and $PM_{2.5}$ dust is actually generated by gravel pits and rock quarries in British Columbia. In well-developed areas, there may be multiple sources of PM_{10} dust generation. As noted above, over ninety percent of aggregate dust is larger than PM_{10} and will likely settle within 100 - 500 metres of its source. Aggregate operations themselves, therefore, are likely to be localized sources of mainly nuisance-sized dust.

Dust Management

Methods For Reducing And Controlling Dust

Dust control may include such measures as:

- site layout and operational practices that minimize the creation and reduce the escape of dust,
- air quality measures that intercept airborne dust, and
- as a last resort, temporary curtailment of dusty activities until adverse weather conditions subside.

Table SLM - 11 outlines these strategies and associated BMPs and measures.

Table SLM - 11: Control options for dust at aggregate sites

Control Strategies	Dust Control Options	BMPs & Measures
SITE LAYOUT **Minimize Creation**	• locate haul-roads, dump sites and stockpiles away and down-wind from neighbours • minimize the height from which material falls • surface roads with dust-free material • lay out and construct stockpiles to minimize dust creation; use gentle slopes and avoid sharp changes of shape • use crushing and screening plants within design capacity, • use conveyors rather than haul-roads • restrict dust generating activities to sheltered areas • create 'sensitive zones' within which dusty activities are limited	• Berm • Drop Height • Tarps • Vegetation Cover • Wind Protection
OPERATIONS **Control Escape**	• limit spillage by not overloading trucks • enclose or provide wind protection for conveyors, chutes, process plant, stockpiles • install a dust removal system (bag system) for the plant • use sprays and mists at dust sources • fit outlets with cyclones, wet-scrubbers and filters • insist on good maintenance and house keeping • compact, grade, surface and maintain haul-roads • fit dust extractors, filters and collectors on drilling rigs • use mats when blasting • use wind-breaks/netting screens/semi-permeable fences • limit drop heights • fit wind-boards/hoods at conveyors/transfer points • reduce speeds and limit movement of vehicles, use upswept exhausts • spray exposed surfaces (haul-roads, dormant faces and stockpiles) with binders • vegetate exposed surfaces, such as overburden stockpiles, with quick growing plants • pave and sweep haul-roads and other high use semi-permanent dusty surfaces • shake dirt off of trucks with rumble bars and provide vehicle washing facilities • provide a surfaced road between vehicle washing facilities and site exit • use closed or sheeted vehicles to carry dry material	• Drop Height • Tarps • Vegetation Cover • Water Spray • Wind Protection • Wheel Washers • hydroseeding • speed limit • telescopic chutes
AIR QUALITY Dust Removal	• use trees or shrubs around the site as coarse air filters • place treed berms near dust generators, receptors or at the perimeter of the site • use sprinklers, sprayers or mist, with or without additives	• Berm • Vegetation Cover • Water Spray
CESSATION	• shut down the operation if, due to unique weather conditions, the extended dispersion of dust cannot be avoided	

Thomas, 2000

Table SLM - 12 highlights the effectiveness of some dust control measures, based on research by the US Environmental Protection Agency.

Table SLM - 12: Efficiency of dust control measures

Activity	Control method	Control efficiency
Loading Stockpile	• reducing drop height	25%
	• telescopic chutes	75%
	• conveyor sprays	75%
Wind Erosion from Stockpile	• regular watering	80%
	• surface crusting agent	up to 99%
	• vegetative wind break	30%
	• lower pile height	30%
Speed Control*	• chemical surface treatment	50%
	• speed control: 30 mph	25%
	• speed control: 20 mph	65%
* from unregulated	• speed control: 15 mph	80%

Thomas, 2000.

Dust Planning Considerations

Dust control planning for an aggregate operation encompasses both the planning of the site layout and the development of operational procedures. Although a Site Layout Map is not normally a permit application requirement, the planning for dust (as well as noise and visual) considerations could be worked out and documented on such a map. A Site Layout Map could contain the following dust components:

- dust generating activities,
- off-site facilities that are sensitive to dust,
- prevailing wind direction(s) and onsite wind patterns,
- placement of berms, stockpiles and tree buffers to create or enhance wind shadows,
- possible locations of dust-generating activities and haul roads in calm locations and far from dust sensitive facilities, and
- location of existing trees and shrubs to create a wind breaks.

Section 3 - Visual Landscape Design

Understanding Visual Landscape Design

Many industrial and commercial facilities in British Columbia have used landscape design techniques to improve the appearance of an operation, thereby gaining greater public acceptance. It has been found that the public's views on an aggregate operation are formed as a result of three factors:

1. Landscape character	"it doesn't fit in"	• how the appearance of the operation contrasts in form, height, mass and colour with the surrounding natural and built landscape (what is visually prominent: topography, soil, vegetation, farming patterns, existing development patterns)
2. Negative associations	"industrial"	• perceived negative associations with industrial operations, dereliction and disturbance
3. Sense of permanence	"ugly forever"	• even though aggregate operations are a temporary land use, they are often perceived as permanent

After Nicholson, 1994.

Visual Impacts: Types and Sources

The visual impacts of sand and gravel pits and quarries are similar from one operation to another. The two main types of visual impacts are:

1. Obstruction	• blocking a pre-existing view, such as with a stockpile
2. Intrusion	• when something new is added that seems out of place, such as a very straight long berm

After Nicholson, 1994.

Table SLM - 13 lists some of the common causes of visual impacts at aggregate operations.

Table SLM - 13: Potential sources of visual impacts at an aggregate site

Potential Source	Visual Landscape Impacts
Quarry/Pit Landforms	• stockpiles • working faces • haul roads, embankments and ramps • settling pond, soil and overburden storage stockpiles • waste heaps - including scrap
Mobile Equipment	• mobile processing equipment • mine haul trucks • transport and pick up trucks - especially at the main access
Building & Structures	• storage hoppers • crushing and screening plant • conveyors • fences
Miscellaneous Sources	• air pollution (e.g., water vapour, dust, vehicle fumes) • dust deposits (e.g., on surrounding vegetation) • mud on roads • lighting - especially during night time operation
Other Sources	• long term alteration to the existing landform profile (e.g., removal of hills and woodlands) • out of place perimeter planting

After Nicholson, 1994.

Managing Visual Landscapes

Visual Landscape Evaluations

In evaluating visual impacts, the degree of significance can often be judged by determining the number of people directly affected. In particular, a "key viewpoint approach" may be worth considering for aggregate operations located close to urban areas. The steps of this approach are outlined in Table SLM - 14.

Table SLM - 14: Overview of key viewpoint visual landscape approach

Steps	Details

Step 1	• identify key viewpoints; e.g.,
	  • roads
	  • residential areas
	  • foot paths/parks
	  • tourist facilities

Step 2	• determine the extent of potential visibility (directions and distances) • evaluate sensitivity of viewpoint
Step 3	• determine degree of obstruction or intrusion that will occur • determine the potential changes or the visual impact
Step 4	• modify the mine layout and operations to minimize visual concerns

Reducing Visual Impacts

Reducing the visual impact of an aggregate operation mainly involves simple mine layout planning and does not have to be expensive to be effective. Expenditures made upfront may well pay for themselves down the road in terms of expedient permit applications, planning process and improved community relations.

There are four basic control strategies for reducing the visual impacts of gravel pits and rock quarries: *concentration, interim, concealment* and *innovative* approaches. These control strategies are detailed in Table SLM - 15.

Visual Landscape Planning Considerations

Visual landscape planning for an aggregate operation involves surveying the local landscape, estimating how the operation may affect that landscape, planning the site layout and developing operational procedures to reduce the visual impact. Although not required by the Notice of Work and Reclamation Program, the visual evaluation and planning could be worked out and documented on a Site Layout Map. The assistance of a landscape professional, such as a landscape architect, may expedite the process.

A Site Layout map could contain the following visual landscape design considerations:

- key viewpoints and viewscapes
- visual landscape concerns for the operation, such as industrial structures
- character of local landscape (hilly, flat, woodlots, grassland, sizes and shapes) to determine how the operation may blend into the natural landscape pattern

Table SLM - 15: Suggested control strategies for reducing the visual impact of aggregate operations

Control Strategies	Visual Landscape Control Options	BMPs & Measures
CONCENTRATION	• concentrate as many activities within a given area as possible • move extraction and related activities systematically from one area to the next • re-contour and re-vegetate as you go	• progressive development
INTERIM	• hydro-seed berms and stockpiles (also a theft indicator)	• hydroseeding
CONCEALMENT	Site selection • orient operation to limit visibility of working faces • stagger, offset or curve the quarry access to prevent direct views into the site • ensure sufficient land is available to enable landform modeling, off-site planting and perimeter treatment • consider the topographic position and the potential for natural screening • keep mine elements a similar size and scale to that of the local landscape • design lighting to minimize stray light (light pollution) Method of working • work in a direction away from major sight lines • phase extraction to limit the area of active disturbance • perform progressive reclamation • consider alternative extraction methods • design and locate processing plant to reduce visibility, giving attention to colour, cladding, height of structures, etc. Screening • construct and plant berms • build rock/earth walls rather than fencing • retain existing vegetation wherever possible • consider temporary planting at long term operating sites Camouflage • consider colour and cladding of buildings and plant, within safety margins • limit the height of structures, stockpiles and waste dumps as far as possible and design with shallow gradients Haulage • locate loading facilities to minimize their visibility • route internal haul roads to avoid punctuating the skyline • route external truck routes to avoid sensitive properties and landscapes • screen internal and external routes with berms where necessary Housekeeping • maintain the internal quarry environment - especially where visible externally (e.g., remove scrap and keep stockpile and waste disposal areas tidy) • undertake regular weed control of on and off site planting areas • keep external roads clean and mud-free, including the access and visitor facilities	• Berm • Fences • Lighting Management • Sinking the Plant • boundary planting • entrance layout • painting • progressive reclamation
INNOVATIVE	• site tour to familiarize community with operation's visual elements • construct viewpoints • informative signage	• Signage • tours

After Nicholson, 1994.