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TE ARAI DEVELOPMENT

Sand Erosion Management Plan

Prepared for

Te Arai Coastal Lands Development Trust Ltd

14 November 2012

Table of Contents

Appendices

EXECUTIVE SUMMARY

A protective covenant applies to the land for the purposes of protecting neighbouring land from wind blown sand and to ensure the stability of both the foredune and the land itself. This sand erosion management plan (SEMP) has been prepared to ensure that the requirements of the covenant are fully addressed.

The SEMP addresses the potential sand instability implications of a change in land use from a productive forest to an alternative landuse including golf, housing, enhancement planting, grass and trees (including pines). The issue is not the more usual dust generation issue but that of sand mobilised by wind and moved in a series of hops along the ground (saltation). The focus of this SEMP is therefore on surface sand stability rather than on the control of airborne dust particles.

The final surface of the completed course will be vegetated with a mix of grass and enhancement sedge and low shrub plantings and this surface will protect the underlying land from sand instability. The completed development is then not expected to be subject to any significant sand instability risk. Instead, the prime risk is considered to be during site development when the underlying sand is exposed during the change from commercial forest to golf course and other uses. In this respect, the site is not as vulnerable to wind blown sand erosion as might initially appear due to the combination of on site factors such as sheltering trees, windrows, re-colonising vegetation, slash etc. However there is potential for erosion. This risk seen as a short term one and one that can be realistically controlled through a combination of sensible and proactive management and practical control options.

The development is located between a protective perimeter belt of existing forest to the west and the coast to the east. Development works are generally well clear of the foredune area; an area where significant enhancement planting is proposed. This SEMP proposes various management measures and control measures to avoid, remedy or mitigate potential sand instability issues during construction. Management measures include the retention of areas of forest between the course and neighbouring properties to the west, undertaking development works in a staged manner and retaining present surface vegetation and as much surface roughness as possible (e.g. remaining forestry slash, vegetation, windrowed materials) until the area is worked for final development. Specific control measures include the application of soil stabilising chemicals, sand fencing, crimped mulching and the planting and grassing of completed areas. Irrigation will be applied to playing surfaces. A monitoring programme is proposed along with contingency planning.

Post development, the land will be maintained as a high quality course by specialist course staff well used to establishing and maintaining a high quality vegetative surface. This surface will be maintained that will ensure land stability objectives are achieved on an ongoing and permanent basis.

The manner in which the development is to be undertaken will ensure the risk of sand instability is minimised. Land adjacent to the site will be protected from invasion from wind blown sand; the foredune area will not be affected by the development (and is to be enhanced with further planting), and the management of the land and development is to be undertaken in a manner that ensures site stability. Once the development is completed, the land is expected to be as least as stable, if not more so, as under the previous commercial forest that was subject to periodic harvesting.

1.0 INTRODUCTION

1.1 Project description

The project involves the conversion of a production forest to a high quality golf course and the subsequent construction of the course, various residential lots and ancillary land disturbing activities. The previous productive forest cover has now been mostly cleared from the footprint of the course and work is ongoing to convert the land to the proposed golf course land use. Effectively, the project proposes a change of land cover from the previous forest cover to that of a vegetated course playing surface with significant enhancement planting. Active land disturbing activities associated with the development are proposed to be completed by about December 2013.

1.2 Protective covenant

The land is part of the larger Mangawhai Forest and which is subject to a protective covenant in relation to sand stability. The purpose of the covenant is to protect adjacent land from invasion by windblown sand and it requires the land to be maintained in a stable state and for land management to maintain this stability.

1.3 Purpose and scope

This sand erosion management plan (SEMP) addresses the long term and the potential construction sand blow erosion impacts on an area of friable sand and ensures the requirements of the covenant are complied with. The implications of both dust and sand movement are addressed, but the primary focus of the SEMP is on the control of the potential effect of wind induced sand blow erosion from site development. A series of management initiatives and methods are proposed to avoid, remedy or mitigate the adverse effects of this potential sand erosion during construction.

The vegetated surface of the completed course will protect the site against future wind erosion and therefore this SEMP is primarily directed towards the construction phase of the development.

2.0 SITE DESCRIPTION

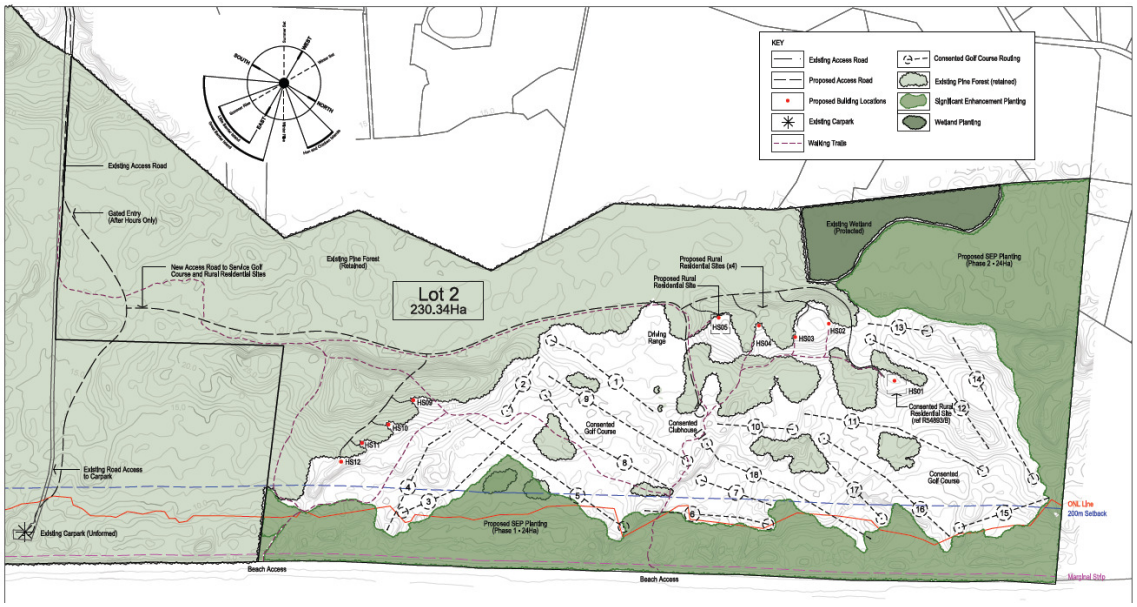
2.1 Site

The site is located on the northern block of the Mangawhai Forest area with access off Black Swamp Road. The coast lies to the east of the site, rural land and forest are located to the west and south respectively, and an extensive area of bare sand dunes lies to the north on reserve land.

The development is located on a site of approximately 616 hectares that extends north from Te Arai Point to the Department of Conservation Reserve located on Mangawhai Spit. The site has recently been subdivided into 3 large lots and the current phase of development is centred in the northern most of the lots (Lot 2) and which has an area of approximately 230 hectares. The golf course occupies about 50 hectares of this land. The footprint for the course and ancillary development has already been cleared from this forest area and the production timber removed.

The extent of Lot 2, and the main features of the proposed development, is shown in Figure 1 below.

Figure 1 General Site Plan



There are a number of distinctly separate areas and activities on the site. These are described from a sand erosion perspective as follows.

1. Coastal strip. This is about 200m wide (from MHWS) but there is some variability to this as can be seen on the above site plan. Felling of the remainder of the forest in this area is to be completed (October 2012), excess slash removed (chipped), existing vegetation with natural value is to be retained and/or enhanced, and enhancement planting is proposed over the

remainder of the coastal strip. An Earthworks and Revegetation Plan has been prepared for the site and a variety of species are specified in this plan. The identified enhancement species are Sand tussock, Bronze tussock, Shore bindweed, Sand coprosma, Knobby clubrush, Small-Leaved pohuehue, Sand daphne and Remuremu. Final plant species selection may vary depending on plant location, availability etc. Enhancement species are considered to be suitable vegetative alternatives to the previous forestry cover, and will not be subject to periodic harvesting (and therefore land disturbance) as occurs with commercial forests.

Photo: Forest removal in the coastal margin

2. Golf course. There are various aspects associated with course development. Broadly these are:

    - Fairways, greens and tees. These are to be the prime playing areas and are to be grassed with specialist course grass species and fully irrigated. Course design requires all organic material (such as the forest 'duff' layer[1]) to be removed to create a 'clean' playing surface.
    - Course rough. These areas will also be in play and will be grassed with specialist course grass species. They will be partially irrigated and integrate naturally from irrigated fairway to planting areas. As with the fairways, all organic material is to be removed from these areas.
    - Enhancement plantings. The planting will consist of indigenous grass, sedge and ground cover as identified above[2]; be undertaken as soon as possible following works affecting that area and no later than 3 months after the works. These areas include those around the fringes of playing areas, in the coastal margin, around house sites etc. Temporary portable irrigation will be available to these areas during establishment.

3. Home sites. Forty five separate home sites are proposed with each being between 1 to 2 hectares in area. Up to 45 house sites may be developed on the wider site which includes not only Lot 2 but also the balance of the land (616 hectares) to the south. Although their locations have yet been finalised, it is expected that most will back onto or into forested areas. Each is to be a separate site and therefore the bare development area of each is small in comparison to

[1] The term 'duff' layer refers to the organic layer on top of the soil (there is little or no topsoil in this sandy environment).
[2] From the Earthworks and Revegetation Management Plan.

the overall development. The sand erosion implications of each are not expected to be significant.

Photo: typical residential site

4. The forest along the western and southern sides is to be retained, and enhancement planting is proposed along the northern side. The sheltering effect of trees such as this typically extends for a distance about 10 times that of tree height; at 30m tree height this means that protection extends for some 300m on either side.

Photo: Retained perimeter forest

5. Other Landuses. A number of other development activities will also occur such as a new access road through the retained forest on the western side, construction of the club house etc. Again these are each relatively small and self contained, and the sand erosion implications of these are not expected to be significant provided the principles and methods of control recommended in this report are adhered to. The same applies to other land use options that may also occur, such as further tree planting, buildings etc.

2.2 Surrounding environment

The surrounding environment is a mix of reserve (to the north), forest and rural land. Five residential dwellings are located on the west and north-western sides with these dwellings varying from 150m to 660m from the boundary. Including the width of the intervening forest margin, the closest dwelling is 350m away from bare work areas.

Indicative wind rose information for the area is appended as Appendix A.

3.0 EROSION PROCESSES

3.1 Sand erosion

The textural size of sand is usually taken to be 2 to 0.1mm in diameter with fine sand being 0.1 to 0.05mm in diameter. Dust is usually made up of particles < 0.2 mm in diameter. Although some of the finer textured sand particles may be moved as dust, sand is generally transported by saltation and by creeping along the ground[3]. Saltation is when wind dislodges sand particles and lifts them a little off the ground (and which can be up to a metre in strong winds) and they then move downwind in a series of jumps or skips. A saltating grain may hit other grains that jump up to continue the saltation. The grain may also hit larger grains that are too heavy to hop, but which slowly creep forward as they are pushed by saltating grains. The rate of movement is typically one-half to one-third the speed of the wind.

Photo: Saltation on site. Wind 25 knots - gusting 35 knots (11-17m/s)

The saltating sand comes to rest immediately in the lee of any object giving it a steeper slope to leeward. Sand moving in this way has sparse vegetation – planting has the effect of lifting wind flow off the surface and therefore reducing the initial saltation thrust.

On a wider context, trees too close to the beach can affect natural processes. Comment has been made of the negative effect that the previous forest has had on coastal erosion at Te Arai and that positive benefits would result from their relocation further away from the coast[4].

3.2 Dust

The effects of dust are usually related to the proximity of neighbours and often, although not exclusively, to residential areas. One initiator of dust from sand is the bouncing (saltating) of sand particles that blast the surface and causes fine dust to be lofted into the air. Development work can exacerbate this. With the relatively large size of sand particles, none of the properties to the west and northwest are considered to be prone to dust nuisance from the works; particularly as the dusty Black Swamp Road is far closer (as is the large dune above the site for the northern properties). The issue at Te Arai is therefore not so much a matter of air borne dust being generated from bare sand but of the movement of sand by saltation. However,

[3] The effect of site machinery during development can 'fluff' up the soil and make it more susceptible to saltation and dust movement.
[4] Dr J Floor Anthoni. 2000. Obstructing the wind. www.seafriends.org.nz/oceano/beachblo.htm

nuisance dust emissions may occur from construction roads etc (this is expected to be more of an on-site issue only) and various control measures are proposed as a result (see Table 1, Section 5).

3.3 Performance standards

For the above reasons, this SEMP is directed primarily towards the control of sand blow erosion (i.e. from saltation and sand creep), and the control of the effects of dust from the site is more of a secondary consideration. But whereas there are trigger levels for air borne dust (e.g. 120 µg/m^3 fixed 24-hour average for insensitive areas[5]), no such triggers or standards have been identified in relation to what might be considered acceptable or unacceptable wind blown sand erosion rates. This is further compounded by the natural erosion of dunes and which is part of natural coastal processes.

In the absence of an appropriate standard, this SEMP seeks to apply a best practicable option approach to the control of wind blown sand erosion during construction and post construction activities.

[5] From Ministry for the Environment 'Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions", 2001.

4.0 SITE CONDITIONS / CONSTRUCTION DETAILS

4.1 General

The aim is to complete golf course construction by about December 2013. To achieve this, construction work will be required to be undertaken both summer and winter and irrespective of the dry and windy seasons. Almost all of the required forest cover has been removed for the development with this work completed in about May 2012. Only scattered blocks of non-economic trees remain to be felled (October 2012). Felling of the remaining trees, stem removal, chipping of excess vegetation is ongoing.

Currently, the golf course site exhibits varying degrees of surface roughness. This results from the vegetation remaining on the land, from forestry slash, wood chip, slightly elevated windrows of root raked vegetation, recolonising vegetation etc. As a general rule, as surface roughness increases, then so does the potential for wind blow erosion decrease. The degree of roughness on site is generally related to the stage of development with roughness decreasing with the successive root raking, mulching and mulch clearing activities. The barest areas are those associated with course preparation.

Coastal margin

In the coastal margin, excess vegetative cover is chipped and either stockpiled or spread over bare areas through which enhancement planting will be undertaken. A reasonable layer is left or placed on the surface sufficient to both plant through and to control sand movement.

Golf course playing surfaces

Playing areas where trees have been felled and removed are subsequently root raked to remove stumps, slash etc. Root raking is effectively undertaken in two stages. The first root raking operation picks up the bulk of the vegetative material and the second removes as much as possible of the remaining vegetation. The organic ‘duff’ soil layer on the surface of the soil is also picked up by these operations. This vegetative and organic material (roots, stumps, slash, duff layer etc) is pushed into windrows and these are about 40m apart. These vegetative windrows are subsequently mulched. The mulched material is removed from the future playing surface areas and deposited in designated areas, shaped as necessary for future golfing purposes, and then covered with sand. Most of the course is in this situation i.e. windrowed with some of the windrows having being mulched. Once the mulch has been removed from these future playing areas the remaining surfaces are effectively exposed pure sand. At present about 10 ha is in this position and this relates to the development of 4 holes of the course.

Photo: Vegetation windrows

Revegetation

Natural recolonisation is occurring in many areas where site construction activities have ceased. This recolonisation includes native grasses, lupin, some gorse etc and has occurred over the last few months. This re-colonising vegetation is forming a protective surface cover and this is to be encouraged as interim protection before final development.

Photo: Natural colonisation

The site has its own hydroseeding equipment that will be used to establish fescue grasses appropriate for playing surfaces on the golf holes. The hydroseeded material will include the grass seed mix, a wood-fibre mulch with a high TAC factor[6] and appropriate fertilisers. The applied mix will be irrigated to ensure germination and establishment. About 150-200m^3 of water/day will be required for each 4 holes of development. The completed course will require about 1200 – 1500 m^3/day for the entire course during the peak demand phase of grass establishment.

The site has instigated a revegetation trial (non-irrigated) involving Pingao, Spinifex, Sand coprosma and Muehlenbeckia. This is a recent initiative and no conclusions have yet been drawn from the trial.

[6] A tackifier or glue to hold the hydroseed mix together until the grass is sufficiently established.

Photo: Revegetation trial (October 2012)

Site personnel

Golf course development specialists with a high level of vegetation establishment expertise will be overseeing site development and they will be seeking to establish a stable surface cover as soon as possible. Although these specialists will be establishing a grass/enhancement planting surface cover and not a plantation forest, the outcomes will be the same. The objective is to achieve a stable surface over the sand as early as practicable and this plan seeks to enable this to occur as expeditiously as possible while minimising erosion risk.

4.2 Implications to sand stability

The susceptibility of the site to sand erosion is a reflection of surface protection and roughness. As indicated above, the degree of surface roughness on site is reflected by forest > felled/slash > windrowed/mulched > 'clean, bare worked areas'. The susceptibility of the various aspects of the development to sand erosion is discussed below.

- Active earthworks to construct and shape playing surfaces (fairways, tees and greens) occur once the mulched material has been removed. The fairways are much bigger areas than that of the tees and greens so are more susceptible to erosion; the tees and greens will generally only have any significant erosion risk if they are contiguous with other work sites. Course design requirements are that the worked areas have no organic material and therefore the resultant sand is vulnerable to wind erosion. These areas are to be grassed as soon as possible after construction and irrigated so the overall risk is predominately the construction phase only.
- Construction of the course rough. These areas are to be established and maintained as secondary playing surfaces but will not have the same grassed input as the prime playing surfaces and will only be partially irrigated. These areas will be susceptible to erosion during construction and while a vegetative cover is establishing. Because of the longer time to vegetation establishment and the reduced wetting, the erosion risk is greater than from irrigated areas.
- Enhancement planting areas. There may be a gap between completion of the shaping of these areas and final planting. Once planted, the density of planting should immediately address wind blow issues but there are implications with the potential time delay between completion of the development works and the planting season. Irrigation is not proposed for

these areas so suitable alternative measures, such as recommended in section 5 of this report, will be used in the interim.

- Small discrete earthwork sites (e.g. separate tees, greens, house sites etc). Been small, the potential for sand blow erosion from these areas is considered to be low unless they are contiguous with bigger bare areas.
- Areas with current surface roughness. This includes areas with sufficient slash cover, burgeoning natural recolonisation (lupins etc). Some of these areas are not prone to erosion; others may require some supplementary erosion control works.

5.0 SITE OPERATIONS

5.1 Erosion sources and control options

Table 1 below outlines a number of control measures that can be used to control site sand movement and instability[7]. They refer to site wide matters as well as to specific control measures. It is anticipated that these procedures and initiatives can be applied to all sources of sand erosion on the site including that associated with golf course development, building sites, construction of the new access road etc. The methods can be used alone or in combination as appropriate for particular situations.

Table 1 – Potential Sand Erosion Controls

Source / type	Control
Site	Retain all perimeter forest margins where possible for wind shelter and sand stability reasons. Do not disturb any area (unless to undertake stabilisation measures) until ready to work that particular area. This includes leaving all areas of natural recolonising vegetation such as lupins etc undisturbed until the commencement of work. Undertake the works in a staged manner. Work should not commence in new work areas until sufficient water and irrigations systems are available (otherwise apply an intermediate crimped mulch cover[8], chemical surface protection or suitable alternative method). Pre-water work areas with sprinklers to allow time for penetration. Ensure sufficient irrigation water. Complete and stabilise work areas as soon as possible. Stabilisation in this sense means establishing a grass cover and provision of irrigation for playing surfaces, and applying a surface resistant to erosion on other surfaces. This surface could consist of crimped straw mulch or chemical soil stabilisation of completed but non-irrigated work areas for interim protection while other vegetation establishes. Provide a surface cover where possible (which could be grass, gravel, wood chip, slash, a crimped mulch cover etc). Educate staff in relation to work staging, avoidance of disturbance outside work areas, weather forecasting, irrigation set-up, the monitoring of control measures etc. Control pests that can affect plant establishment and survival (an active rabbit and possum eradication programme presently underway).
Roads / vehicles	Keep damp if this is a problem. Typical water requirements are 1 L/m^2/hour. Keep vehicle speeds to 10 km/h.

[7] This is not an exhaustive list and site personnel may suggest other effective measures.
[8] Straw is recommended because it generally lacks seeds. It should last for several months but it will break down.

	Another option is the application of a dust suppressant chemical to the road surface.
Windrows	Windrows are raised barriers and aid interim site stabilisation, particularly where perpendicular to the wind. Retain for as long as possible; do not disturb until ready to work in that area.
Mulch	Apply straw mulch at a rate of about 6 tonnes/hectare and then run non-angled discs to crimp/insert the mulch 5 – 7cm into the soil. Mulch will break down over time therefore this is a medium term option. Consider using for all non-irrigated areas once work has been completed – install as soon as work has been completed.  Photo: Crimped straw mulch for dust control (Note: this example also incorporated grass seed)
Chemical soil stabilisers	Chemicals can be applied to the soil to bind and stabilise it and make it resistant to erosion. There are a number of different chemicals available for this purpose – these chemicals can be applied through a hydroseeding unit or water cart. An example of a typical chemical used elsewhere in New Zealand for sand stabilising purposes is attached as Appendix B[9].
Wind barriers	Install wind barriers as appropriate. Their effectiveness is greatest when fencing is perpendicular to the prevailing wind and has a porosity of about 50%. Blowing sand seldom reaches 1m above the ground therefore barriers should be at least this height (and will have greater capacity for catching sand when higher again). Windrows are therefore very useful in this regard (but do need to be perpendicular to the prevailing wind for full effectiveness). Fabrics, brush (slash), vegetation windrows, vegetation barriers can all be used for wind barriers. They can be removed once areas are stabilised.
Miscellaneous	Ensure sufficient water is available on site for each stage of development.

[9] Trials are about to be undertaken (late October 2012) with this chemical to assess different application rates and product effectiveness at the site.

5.2 Monitoring

Site monitoring procedures are recommended in Table 2 below. Photographs of particular incidences should be taken.

Table 2 – Monitoring Programme

Monitoring Activity	Frequency
Weather forecasting. Check weather forecasts for strong winds and dry conditions and prepare appropriate sand blow responses.	Daily
Site inspections. Look for control failures, blowouts, inspect the land adjacent to work areas for sand movement/deposits etc. Undertake appropriate responses e.g. irrigate area if planted, apply crimped mulch, chemical soil stabilisers, wind barriers etc as appropriate.	Daily
Inspect sand erosion activities (Table 1) to ensure all control measures are working appropriately. Remedy as appropriate.	Daily and as new work commences
Check irrigation systems are fully functional.	Weekly
Assess plant survival with an aim of 90% survival. Assess their sand erosion control effectiveness; provide supplementary short term control as necessary (e.g. install wind barriers).	Monthly
Strong wind inspections. Assess for any discharges of dust that cross the site boundary and amend site conditions accordingly.	Strong winds
Complaints. Address as required.	As received

5.3 Contingency measures

The measures proposed above in sections 5.1 and 5.2 cover a range of situations and together set out a management regime by which development activities can occur without significant erosion risk. Monitoring is a key component by which site conditions can be assessed and appropriate responses made as required.

A range of contingency measures are proposed should specific and immediate responses be required in particular areas or for a particular activity. A supply of the selected chemical should be kept on site at all times and which can be utilised immediately through the site hydroseeding gear. Wind break fencing material should also be stored on site to be used as required (this is more likely to be in the foredune area should a blow-out occur[10]). If crimped mulch is to be used, then a supply of straw is to be maintained on site. Water could also be used as a contingency measure. For longer term control, site development procedures will be assessed and amendments made as required.

[10] Unlikely to originate from development works because of their distance from the foredune area.

6.0 EFFECTS

There is a risk of wind blown sand erosion occurring from the conversion of approximately 50 hectares of plantation forest to alternative land uses such as a golf course during the construction phase on the loose and erodible sand. However, the risk is not a permanent one but for a maximum 2 year period between plantation felling and the commencement of use of the golf course – little or no risk is expected once the site is fully re-vegetated. The risk is considered to be primarily one of potential sand blow erosion (movement of the sand by wind). Dust nuisance is considered a secondary issue because of the sand medium and the distance to the few neighbouring dwellings.

Although effectively all of the original forest cover has been removed and the site is in varying stages of development, not all of the site is free mobile sand. The forest remains on the western side of the development and has a sheltering effect from the prevailing wind for possibly half of the site. Site development and natural colonisation of pioneer species has resulted in varying degrees of surface roughness on the site and this is having beneficial interim stabilisation benefits.

A significant factor to site stabilisation is the specialist course development expertise that is available on site. The objective of golf course development is to establish a stable vegetative surface over the sand as early as practicable and this is the same as that sought by this plan. Irrigation is available for a significant proportion of the development and this will help achieve quick surface stabilisation from various vegetative plantings. Although the end vegetative cover may be different to that of the previous forest cover; from a wind blown sand erosion perspective, the results will be the same.

A number of management options are outlined in this SEMP to minimise the erosion risk during development. Site management recommendations include ensuring minimal or no disturbance of unworked areas and undertaking development in a staged manner. Recommended control measures include the use of crimped mulch, soil stabilisers and wind barriers. It is considered that crimped mulch could be of particular value to protect and encourage vegetation development in non-irrigated areas where establishment might be expected to be slower than where irrigated. Chemical soil stabilisers can be applied through equipment already on site and be expected to last sufficiently long to enable establishing vegetation to establish sufficient surface protection.

The site is not as vulnerable to wind blown sand erosion as might initially be thought due to the combination of on site factors (sheltering trees, windrows, re-colonising vegetation, slash etc) but there is potential for erosion to occur. This erosion risk is seen as a short term one and one that can be realistically controlled through a combination of sensible and proactive management and various practical control options.

7.0 SITE MANAGEMENT

7.1 Responsibilities

The site's project manager will have overall responsibility for ensuring site operations are undertaken and maintained in accordance with this SEMP. These include having regard for the matters detailed in Tables 1 and 2. Post construction, the green keeping staff will assume responsibility for the site and sand stability.

7.2 Training

Environmental training, including sand erosion control procedures, will be given to all staff as part of their site induction. More specialised personnel, such as green keepers etc, will be given more detailed information to ensure full understanding of the sought outcomes of this plan.

7.3 SEMP Review

This SEMP may need to be reviewed as a result of:

- any significant change to construction activities or methods;
- the results of monitoring, or internal/external assessments;
- legal or planning requirements;
- consultation;
- changes in expectations.

The SEMP will be updated as appropriate following the review(s).

8.0 REFERENCES

DJ Scott Associates / Earthtech Consulting. Earthworks and Revegetation Management Plan, Te Arai. September 2012.

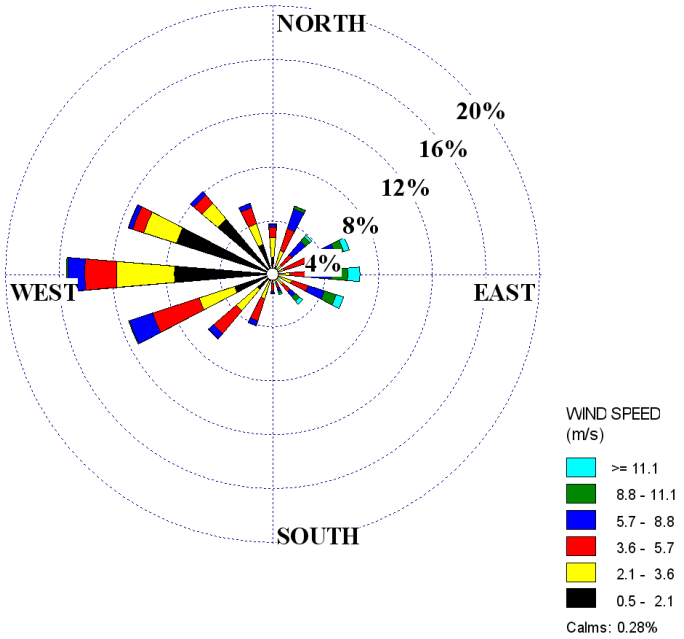
D. P. Thornton, MSc Thesis. The New Zealand National Environmental Standards for Ambient Air Quality: Analysis and Modelling Case Study. 2007.

Environment Bay of Plenty. Erosion and Sediment Control Guidelines for Land Disturbing Activities. Environmental Guideline 2010/01. June 2010.

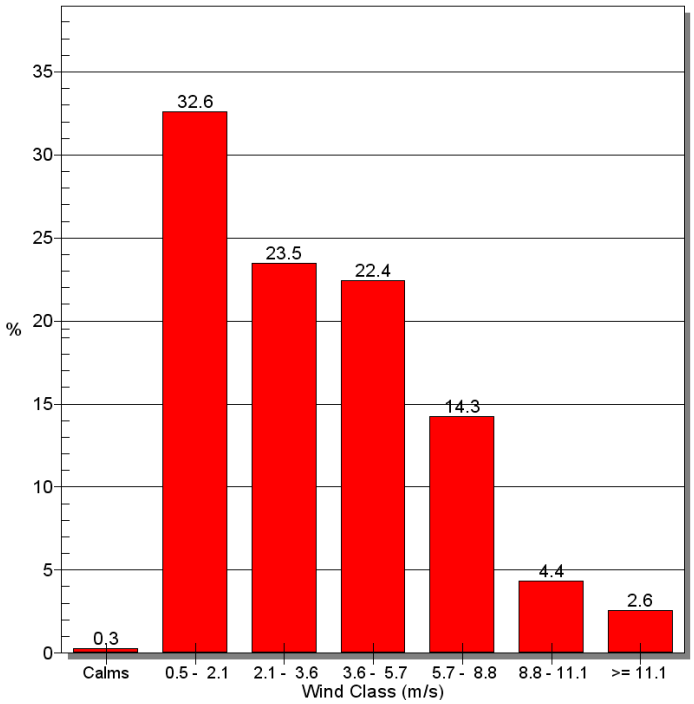
J Floor Anthoni. 2000. Obstructing the wind. www.seafriends.org.nz/oceano/beachblo.htm

Ministry for the Environment 'Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions". 2001.

APPENDIX A – WIND ROSE INFORMATION[11]



Wind Rose: Marsden A meteorological station, November 1995 - March 2000, showing the frequency of winds from given directions and in a range of speed classes.



Wind class frequency distribution: Marsden A meteorological station, November 1995 - March 2000. Average wind speed = 3.95 m s-

[11] From D. P. Thornton, MSc Thesis. The New Zealand National Environmental Standards for Ambient Air Quality: Analysis and Modelling Case Study. 2007

APPENDIX B – SOIL CHEMICAL STABILISER EXAMPLE

Location: Papamoa New Zealand
Client details: HEB Construction and Fulton Hogan Alliance
First installation date
10/1/2010

Gravel Lock

Gravel Lock
Stabilization & dust control products
Supplying the CIVIL industry with innovative solutions to real problems
CSC Environmentally Friendly

CSC- SAND STABILIZING

at 100 mils per sqm

Gravel Lock

Application Rate 100mils : CSC per sqm

Purpose: Stabilization/Prevent wind blow

Expectations: 12 months

Application Method: Sprayed

Note: a very exposed and public site

Equipment used: Hydro seeder pump and water carts
Weather on the date of application: fine
CSC added: 100 MILS PER SQM
SAND depth: 1-20M
Depth Treated: 3-20mm
Comments: sand very fine

Lance & Demelza - Aukett Contractors Ltd

From: Grant Lewis <g.lewis@xtra.co.nz>
Sent: Wednesday, 17 October 2012 7:41 a.m.
To: lance@gravellock.co.nz; acl@vodafone.net.nz
Subject: FW: CSC at TEL

Hi Grant,

Yes I can confirm that we have been using Gravel Lock CSC to stabilise sand from wind erosion over extensive areas of our earthworks site. The product has proven to be effective at controlling dust for up to 9 months, depending on the application rate. We also used it to effectively stabilise topsoil from rill erosion.

CSC is a key component of our dust control strategy on TEL and has performed well for us.

Please feel free to contact me if you have any questions.

Regards,

Jake

Jake Crockford | Environmental Manager | **TEL Construction Alliance** | 65 Tara Road PO Box 11287 Papamoa 3171 | Phone +64 7 542 9900 | Fax +64 7 542 9430 | Mobile +64 27 2704336

FULTON HOGAN | HEB
TEL CONSTRUCTION ALLIANCE

From: Gravel Lock [mailto:info@gravellock.co.nz]
Sent: Friday, 12 October 2012 3:58 p.m.
To: Crockford, Jake - Tauranga Eastern Link
Cc: info@gravellock.co.nz
Subject: CSC at TEL

Hi Jake
As we spoke on the phone today, we have a potential client who wants to make sure they comply with the Auckland Regional Council environmental standards for dust & erosion control
Can you please confirm that you have been using Gravel Lock CSC for the past 18 months on the 28km TEL Alliance project. Can you please confirm you are using CSC for sand stabilisation to minimise sandblow & deal with erosion control

Could you also please give us your opinion about how the product has performed in your project

Thanks,
Grant Lewis
021 677 604

Gravel Lock NZ Ltd
Freephone 0800 199 199

1