SOIL STABILITY RECOMMENDATIONS

NEW ZEALAND DEFENCE FORCE'S RAUMAI BOMBING RANGE

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SUMMARY

This report has been prepared for the Ohakea Air Force's Property Officer for the purpose of generating a stability programme for the Raumai Bombing Range.

The Raumai Bombing Range consists of 186 hectares of a complex of sand dunes and sand plains, and a coastal foredune boundary of 1.6 km. Of this 1.6 km of foredune, approximately 100 m is currently extremely eroded, a further 500 m severely eroded, and the remaining 1000 m slightly to moderately eroded. Inland, approximately 8.0 hectares is non vegetated and unstable dunes.

This report outlines the instability problems occurring at the Range and the management practices required to rectify the problems. In order to understand the problems and how to overcome them the report briefly discusses the erosion processes occurring.

Generally the inland erosion is the result of an unstable foredune environment, the first line of defence against wind erosion. Inland erosion is causing the burial of inland access tracks and water supply dams. One blow is currently flowing directly into the neighbouring forestry.

In order to overcome the instability of the area it is recommended to firstly concentrate on the foredune areas prior to stabilising inland areas which are being fed by an unstable foredune. In stabilising the foredune several methods are proposed and the method required is dependant on the degree of erosion. These methods range from foredune reshaping and rebuilding to a maintenance programme. Inland stabilisation methods recommended mostly involves a planting and fertiliser programme.

In order to ensure long term stability of the area following stabilisation it is imperative that the vegetative cover is maintained. In order to achieve this small blowouts must be planted before they develop into much larger blowouts and also vegetated areas are annually fertilised.

It is also recommended that any years works programme is determined in conjunction with the Manawatu-Wanganui Regional Council as priorities between years and this report may vary considerably. The Regional Council is also willing to assist in the overseeing of any restabilization works and can recommend contractors for any stage.

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PURPOSE

The purpose of this report is to outline the current sand instability problems occurring at the Raumai Bombing Range and recommendations in terms of a management plan to:

1. rectify the problems, and
2. set up a maintenance programme to ensure long term stability of the area.

Plate 1 shows an aerial photograph of the area.

BACKGROUND INFORMATION

DESCRIPTION OF PROPERTY

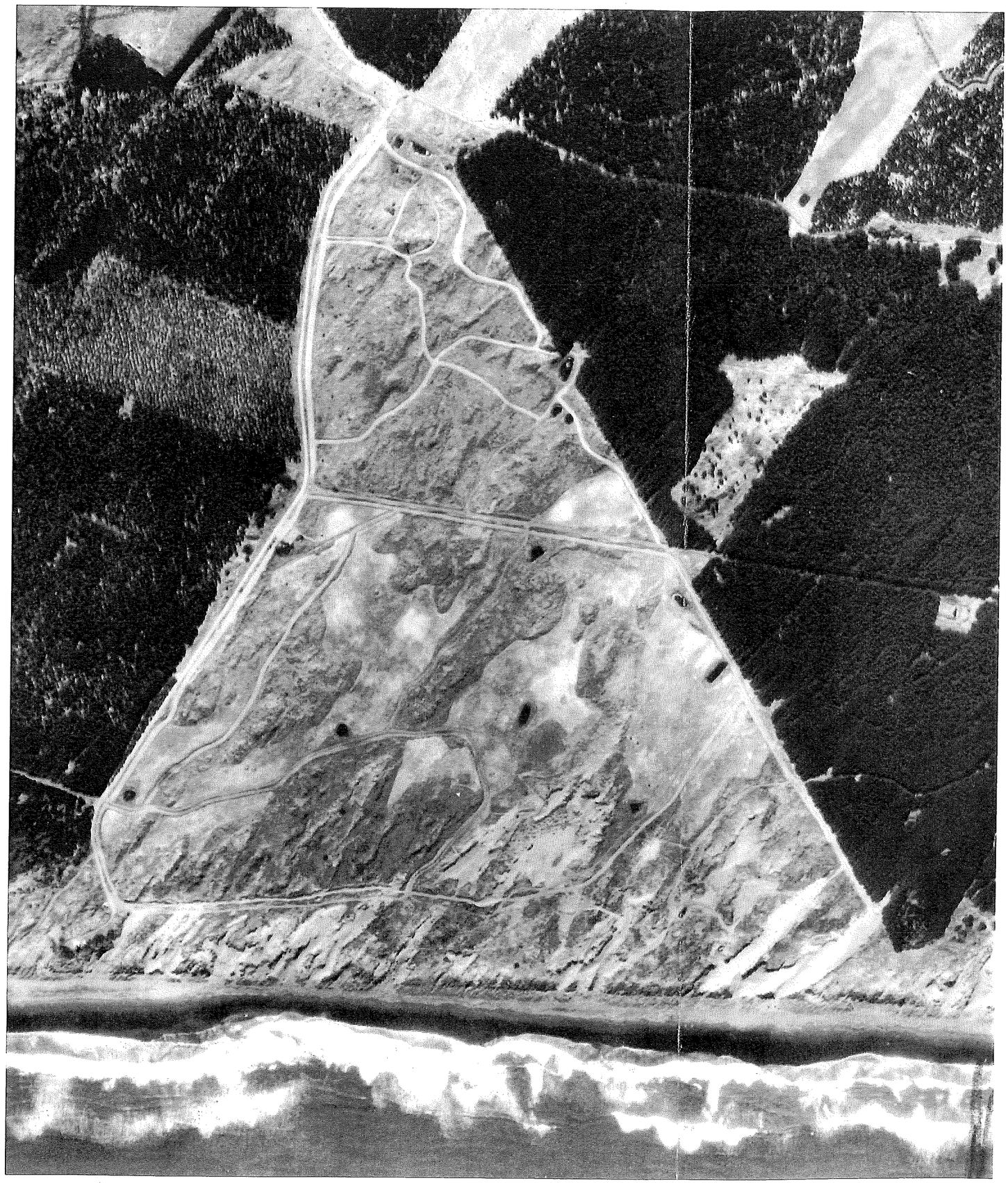
The area is classified under the NWASCA Landuse Capability Classification system as class VIIIe1. It is described as land being formed on young, unstable dunes of which are undulating to strongly rolling coastal foredunes, exposed to strong salt laden winds. They typically extend up to 400 m inland and consist of unstable sand with little soil development. There is potential for extreme wind erosion.

The Raumai Bombing Range has the legal description of Lot 1 DP 70991 BLK VI Koitiata SD and comprises of 186 hectares in total. Over 80 of these hectares is currently planted with exotic forestry. The remaining 105 hectares consists of a complex of vegetated and non vegetated sand dunes and sand plains. This vegetation dominantly marram grass, spinifex, pingao, lupin, boxhorn, and other dune association species. Access is from Raumai road, Santoft.

The western boundary borders the Tasman sea and the length of coastal foredune is approximately 1.6 km. This foredune is the primary line of protection from wind erosion and of the 1.6 km of foredune approximately 100 m suffers extreme erosion, while severe erosion occurs on a further 500 m. The remaining 1000 m has slight to moderate erosion.

Of the inland dune system approximately 8 hectares is currently devoid of sufficient vegetation to prevent moderate to severe wind erosion.

The area contains numerous tracks and water dams. The tracks provide vital access for support for the aerial bombing range while the dams present are for fire fighting purposes. Several major sand blows currently occurring are reducing the effectiveness of these tracks and dams.



FOREDUNE ENVIRONMENT AND LAND FORMING PROCESSES

A basic understanding of the foredune environment and land forming processes is the first step in developing a management plan for overcoming the instability problems. Therefore the formation of blowouts, parabolic dunes and low mobile sand-sheets occurs by the following processes:

Blowouts

Blowouts form when strong onshore winds erode a gap in the foredune. The wind blows through the gap sweeping sand from the beach and foredune in an inland direction. Where the foredune has been cut back by wave action leaving an non vegetated cliff of loose sand, strong onshore winds may initiate blow-out formation. Blowouts also develop in the foredune system where the stabilising vegetation has been damaged or destroyed.

Unless the gaps in the foredune system are repaired by sand accumulations colonised by stabilising vegetation the blowouts increase in size and migrate inland under the influences of the prevailing winds. Series of consecutive blowouts developed in an unstable foredune system often grade into parabolic dunes.

Plate 2 showing blowouts in the foredune, parabolic dunes, and low mobile inland dunes.

Parabolic Dunes

Blowouts migrating inland under the influence of the prevailing winds have an advancing nose of loose sand and trailing arms of sand which have been partially fixed and stabilised by vegetation. In this way the blow-out develops into a parabolic or U-shaped dune.

The dunes retain a parabolic form as long as they remain partly vegetated so that the trailing arms are held back by vegetation. When the stabilising vegetation is removed the parabolic form is lost and wind action produces large transgressive sand dunes. Transgressive dunes are dunes that have been driven in the direction of the effective wind over any surface except mobile sands.

Low dune mobile sand-sheets

Low mobile dunes are generally less than 30 m above sea level and partially aligned to the prevailing onshore winds. Wind reworking the foredune and/or narrow beach ridges causes the landward migration of mobile sand-sheets.

Formation of low dune mobile sand-sheets is initiated where the stabilising cover of vegetation on the foredune and beach ridges is damaged or destroyed. They are highly unstable with many active blowouts. Vegetation cover is sparse and insufficient to trap and hold sand blown from the beach.

VEGETATION PRESENT

The main vegetation present on the dunes includes marram grass, spinifex, and pingao.

1. Spinifex grass (*Spinifex sericeus*)

Spinifex grass is a native species and is common to the sand dunes around the coasts of New Zealand, Australia and New Caledonia. At the Raumai Bombing range it is generally found on the lower slopes of the frontal foredune.

It is identifiable by its rough or course grass appearance, silvery colour, and creeping runners that run down or across the dunes.

Other features include the large seedheads of radiating spikes (female, seedbearing inflorescence), which, once mature or ripe, blow free to roll about the beach until becoming lodged and releasing their seeds. Spinifex also spreads by horizontal creeping runners which give out roots and side runners at each leaf junction.

Plate 3 showing spinifex grass on the front of the foredune and marram grass on the top of the foredune and hind dunes.

2. Marram Grass

Marram grass is exotic to the New Zealand coastline and is the dominant vegetation on the total dune system at the Raumai Bombing Range. It can be identified by its spiny postrate form and tends to grow in clumps. Its height varies according to the site and may extend to 1 metre. Marram grass spreads vegetatively by runners or by seed.

3. Pingao (*Desmoschoenus spiralis*)

Pingao is a native sand binding planting and was a prominent feature of New Zealand's dunelands. There are small isolated patches at the Raumai Bombing Range and mostly located either high up on the frontal foredune or immediately in behind the foredune.

It is identifiable by tufts of course grass-like leaves which are of a golden colour and are borne on long, thick rope-like stems trailing across the dunes.

4. Other sand association species such as lupin, boxhorn etc. are also present.

IDEAL FOREDUNE CHARACTERISTICS

Stability research has shown that an ideal foredune has the following characteristics:

- The dominant seaward slope to achieve the maximum aerodynamics should be 1:5.
- The crest of the dune will be relatively flat in relation to its height.
- The land ward slope will be approximately 1:3.
- The dune will be completely vegetated.
- The dune is even longitudinally and contains no blowouts.

The objective of any reshaping programme should aim to achieve the above characteristics.

PREFERRED VEGETATION

Spinifex grass (*Spinifes sericeus*) is the preferred primary stabilisation plant on the foredune over marram grass. The primary reasons for this includes:

- Spinifex creates a lower more aerodynamic shaped dune system. Wind currents tend to pass over them in a less erosive laminar state. Marram vegetated dunes tend to create humocky dunes which are prone to periodic blowouts if not managed correctly.
- Spinifex develops runners at the base of the seaward side of the foredune into the driftwood zone, where as marram will not. Hence spinifex dunes tend to build outwards rather than upwards as with marram grass.
- Spinifex vegetated dunes will generally recover more quickly from erosion by wave action due to the nature of their runners whereas marram vegetated dunes eroded by wave action often tend to form blowouts.
- Spinifex is endemic to New Zealand.

However the major problems with spinifex grass dunes is establishing them. Spinifex grass is very difficult and slow to establish manually when compared to marram grass. Spinifex is extremely sensitive to browsing animals such as rabbits and hares, especially during its establishment. The biggest problem with spinifex is its cost. Presently plants have to be

sourced from outside commercial nurseries and last season the cost of planting material required for 1 hectare was around $12,000 when compared to marram grass, $2,500.

The Manawatu-Wanganui Regional Council is currently undertaking trials on establishing spinifex in this area and on how to improve the success rate. It is hoped that the results from these trials will reduce the cost of establishing spinifex.

Pingao as discussed earlier is also a good sand stabiliser of the upper and hind foredune slopes and inland dunes. It is however slow to establish and the current cost of the planting material needed for 1 hectare is similar to that of spinifex.

Marram vegetated hind dunes are generally stable if (i) the foredune is stable and, (ii) the hind dune has a fertiliser and maintenance programme.

RECOGNIZED PROBLEMS AT THE RAUMAI BOMBING RANGE

Inspection of the Raumai Bombing Range shows the following problems:

- The vegetation cover on the coastal foredune and some inland dunes has not been adequately maintained. Research has shown that during the wind erosion process, 95% of sand saltates across the first one to two centimetres of the ground. It is this zone where the wind is most erosive. An adequate vegetation cover raises this wind zone above the soil surface thus restricting the transportation of sand.
- Prolonged inadequate vegetation cover of the foredune has resulted in the formation of numerous blowouts. Blowouts present in the foredune result in areas where the wind will concentrate and the nature of the wind flows under these situations is usually highly turbulent. This enhances further erosion of the sides of the blow-out and causes sand to drift through to the hind dune. With time these will develop into inland drifting dunes.
- The general slope of some sections of the foredune is excessive which enhances erosive turbulent wind currents which promotes blow-out development.
- Periodically high seas cause wave erosion of the lower section of the foredune. Often this erosion produces vertical banks of one to two metres. The healing process from this wave erosion is dependant on the vegetation type present and the amount of drift wood present on the upper beach. Under marram vegetation the healing process is often slow and can result in the development of small blowouts. Spinifex on the other hand can heal much more quickly. Drift wood also serves to trap sand and therefore slowly rebuilds the lower foredune.

The erosion occurring at the Raumai Bombing range is causing the burial of inland access tracks and water supply dams for fire fighting. Also one inland sand drift is currently flowing directly into the neighbouring commercial forest.

Inadequate vegetative cover has generally resulted from a lack of maintenance of firstly the foredune, and secondly the inland dunes. Depletion of vegetation promotes blow-out formations. The use of the site as a bombing range has not caused accelerated erosion of the foredune area. This activity may however have aggravated the depletion of vegetation on a small area of inland dunes in the past. Restricting the current bombing activities to targets located on the sand flats has reduced the incidence of this.

EXTENT OF THE PROBLEMS

Generally the unstable areas include the foredune and those inland dunes adjacent to the foredune. Of the 1.6 km of foredune present at the range, approximately 600 metres is suffering from severe to extreme erosion and requires major stabilisation works using a combination of techniques. The remaining 1000 metres is currently suffering slight to moderate erosion and requires the initiation of a maintenance programme. Of the inland dunes present approximately 8.0 hectares is currently raw sand and the erosion severity varies from moderate to severe. The remaining inland dune system which is vegetated is obviously currently stable.

If a stabilisation programme is not initiated the results will be the continuation and expansion of drifting inland sand. It will to a greater degree continue to flow over tracking, infill water

supply dams, bury neighbouring commercial forestry. It will also undermine the stability of the watch tower.

STABILIZATION RECOMMENDATIONS

All unstable areas at the Raumai Bombing Range have been segregated according to the techniques needed to achieve stabilisation. These segregated areas are shown on plate 4.

On the foredune three different areas have been recognised and includes:
1. areas which require major reshaping
2. areas of the foredune requiring rebuilding
3. areas that can undergo a maintenance programme.

The inland dunes have been separated into stable and unstable dunes.

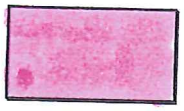
The methods required for stabilisation include:

1. Foredune stabilization requiring major reshaping

Approximately 500 metres of foredune requires major mechanical reshaping. The estimated area in total is 1.4 hectares.

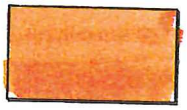
Plate 5. An area of foredune requiring reshaping using heavy earth moving machinery.

KEY

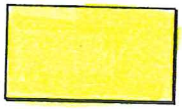


Major Reshaping Required

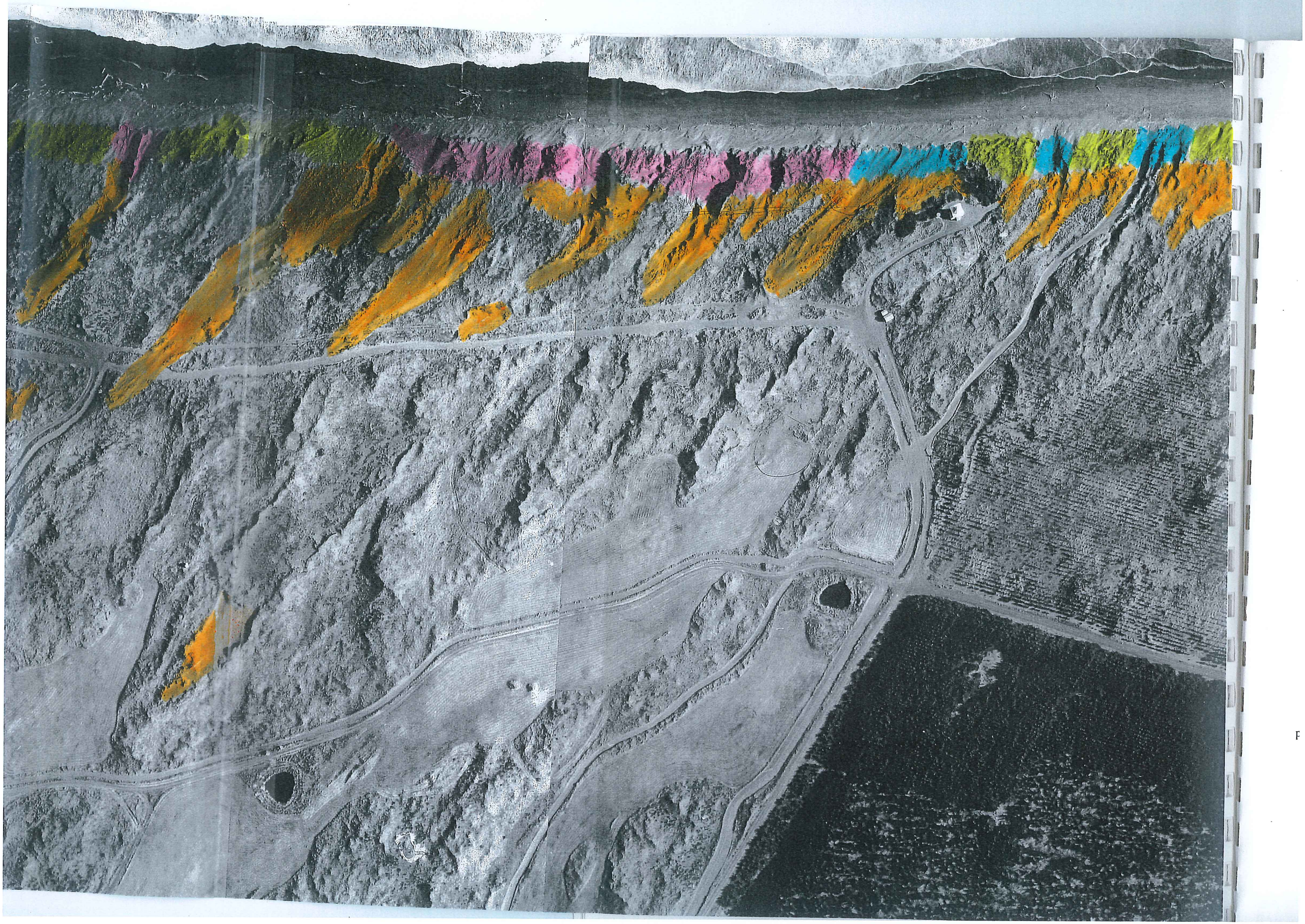
Foredune Rebuilding Required

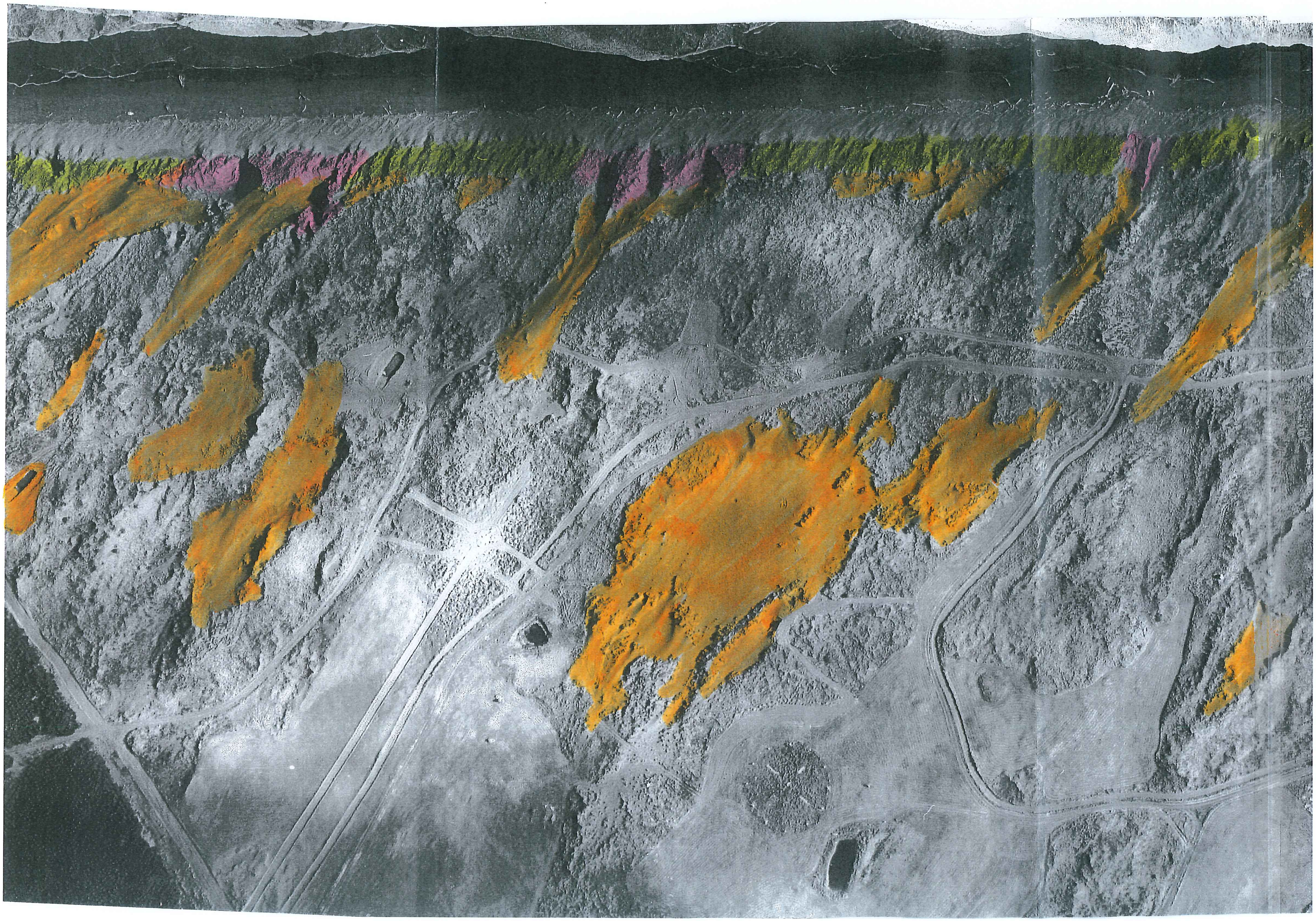


Marram Planting



Maintenance Programme





Typically, this area is characterised by:

- numerous blowouts present,
- the dune height is generally excessive,
- the slope of the windward side of the dune is excessive and encouraging erosive turbulent wind conditions,
- the vegetation present is inadequate and any fertilisation programme would not promote a complete vegetative cover in the long term, and
- there is sufficient sand present at the recognised areas to rebuild the dune system to an ideal slope and shape.

The main objectives required when reshaping the foredune using machinery must be:

1. to achieve the ideal foredune characteristics as discussed earlier. This will ensure that the erosive nature of any winds are minimised especially during the period when the vegetation is becoming established.
2. A complete vegetation cover must be achieved as quickly as possible to ensure the long term stability of the area.
3. Where practical, any spinifex vegetation present on the front of the foredune must be retained if possible. The long term of any foredune management plan is to achieve a spinifex dominated dune system due its improved long term stability. Having spinifex partially present will enable this process to be quickened.

The reshaping process recommended includes:

1. Using D7 or D8 bulldozers the proposed area is reshaped by infilling the excessively high dunes into the blowouts immediately adjacent to them. The cost in reshaping increases exponentially as the distance of sand to be pushed increases. Also, often two bulldozers working in tandem will push 50% more sand than two bulldozers working separately.
2. Any reshaping must achieve slopes of 1:5 on the windward side of the foredune and 1:3 on the leeward side of the foredune. It is important that any changes in slope do not occur abruptly. Abrupt slope changes enhances the erosive native of the wind across that point.
3. All reshaping works should aim to be completed by mid June of any one year.
4. As soon as the area achieves the desired characteristics the planting programme must commence. Using marram grass, it is planted across the slope at 80 cm spacings within the row. The distance between rows should be no more than 1 m. Marram planting must be completed by early to mid July to ensure adequate establishment is achieved prior to the strong spring winds and hot dry summers.
5. Any areas which fail to adequately establish must be blanked the following year.

Continuation of dune reshaping in subsequent years involves marrying in the new works with previous works using the same slopes and heights.

It is common to place a straw mulch between marram plants on the front of the foredune at the planting time. This practice enhances the establishment by providing protection for the marram plants, inhibits the erosion of sand from between the plants, provides organic matter and nutrients, and serves as a moisture reservoir for the marram during establishment. This practice however increases the cost of the job considerably and is usually only undertaken on areas where land or properties on the leeward side of the dune can not afford to be inundated with aeloin sand.

2. Foredune rebuilding

Foredune rebuilding is required on approximately 100 m of foredune and involves an estimated area of 0.3 hectares.

Typically this area is:

- devoid of sufficient sand reserves for mechanical reshaping or the blowouts are presently small enough where some sort of sand trapping system would rebuild the area, and
- often there is spinifex grass present immediately adjacent on the seaward side of the blow-out.

Plate 6. An area of foredune requiring re-building for stabilization.

The rebuilding process would involve:

1. The placement of brush material over the bare sand areas so as to prevent further erosion of this sand, and secondly act as a sand trap for sand coming from the beach.
2. On wide blowouts large logs can be placed across the blow-out and backed up with brush material. Together these will act as a sand trap. Often the sand does not build up initially on the logs but immediately on the leeward side of the logs where a change of wind speed occurs. Hay bales placed across the blow-out in a solid barrier can also achieve similar results to the log placements. A semi-permeable barrier (50% permeability), such as a low slat timber fence or wind cloth, is often far more effective in trapping sand for rebuilding purposes. A semi-permeable barrier reduces the amount of wind flowing around the ends of the solid barrier. If the wind flow is shifted to the ends of the barrier so is the point of erosion. The time period needed to achieve suitable sand deposition is dependant on a multitude of factors and several barriers may be required for the greatest effect.
3. The placement of brush material may need to be a continuous process until a small dune parallel to the coastline forms. Once this dune forms it should be planted using marram grass with rows running parallel to the coast line and planting spaces within the rows 80

cm apart. The distance between rows should not exceed 1.0 m. This vegetation will also serve as a sand trap and will be much more effective than just brush and logs. The planting must be completed between May and July to ensure good establishment prior to the spring winds and dry summer months.

4. All marram plantings must be fertilised to aid establishment.

Material suitable for brush includes prunings from pine trees of which there is an abundance in the adjacent Santoft forest. The laying of brush material involves the placement of branches in parallel rows across the main wind direction with the distance between barriers being no greater than 6 to 8 times the height of the brush barrier. Brush barriers are however very labour intensive but their construction may be undertaken at any time of the year.

3. Areas requiring a maintenance Programme

The foredune presently requiring a maintenance programme occurs on approximately 1000 m of foredune and involves an estimated area of 3.2 hectares.

These areas are typified generally by a complete vegetated cover and slope characteristics not dissimilar from the ideal situation discussed earlier. There are however some small non vegetated areas that if left will develop into major blowouts.

The recommended programme for this area includes:

1. Immediate blanking of all bare sand areas using marram grass planted at 80 cm spacings. All plantings should be undertaken between May and July to enhance establishment.
2. The commencement of a maintenance fertiliser programme at the rates discussed in a later section on fertiliser programmes.
3. Some small blowouts within this area shown on the attached aerial photograph may require brushing prior to replanting. The purpose of this would be to create a uniform foredune for long term stability.

The fertiliser programme for the foredune will, in the long run, ensure long term stability for the area. A fertiliser programme promotes complete vegetation cover and therefore reduces the incidence of blow-out formations. Vegetation recovery is also quicker when the plants are healthy.

4. Inland Unstable Dunes

Inland unstable dunes occupies approximately 8.0 hectares of land. They are usually associated with immediately adjacent unstable foredunes, however there are several large areas further inland which are currently bare.

A recommended programme for these areas includes:

1. Marram planting at 1.0 m x 1.0 m spacings over all exposed areas.
2. The introduction of a fertiliser programme for new plantings at the rates discussed in a later section on fertiliser programmes.

Plate 7. Unstabel inland dunes.

An inland dune should not be planted if the adjacent foredune feeding the dune is unstable. All planting must commence from the coastal end of the dune. The reason for this is that if the dune is not completely planted the new plantings will not be buried in the future.

Some of these planted areas can be used for a marram nursery for future plantings.

5. Inland Stable Dunes

These areas are presently completely vegetated and to ensure the maintainment of the vegetative cover a maintenance fertiliser programme should be undertaken.

RECOMMENDED PROGRAM OF WORKS

For a multitude of reasons total stabilisation will not be achieved in one year. Therefore a stabilisation programme must be undertaken in the following sequence:

1. Establishment of a Marram Nursery
2. Stabilisation of the foredune
3. Stabilisation of inland dunes

It is however possible to undertake inland stabilisation prior to completing the restabilisation of the foredune. If this is undertaken it is imperative that the section of the foredune feeding the proposed inland dunes has been completely stabilised. Failure to do this will result in

continued deposition of sand onto these inland areas, and with time these newly planted areas will become buried.

MARRAM NURSERY ESTABLISHMENT

Generally marram nurseries require minimal labour input during the year and the benefits of having an on-site nursery include:

- guaranteed supply of material
- avoidance of paying royalties from buying in planting material
- convenience

Often marram nurseries are sited on the flat leeward side of an inland dune that require stabilising. This removes the need for stabilising this area in the future. Ideally a marram nursery is best sited on a moist sand plain which is sheltered from the prevailing winds and is easily accessible under all conditions. At the Raumai Bombing Range there are numerous suitable sites.

The area required is dictated by the amount of material required. One hectare of marram nursery should adequately supply enough planting material for approximately two to three hectares depending on the age of the material being pulled. Generally planting material is pulled after two years, however pulling may occur after only one year but at lower yields. Obviously yields are improved immensely by fertilising. It is recommended that at least one hectare of marram nursery is established.

In establishing the nursery the initial spacings should be 1m x 1m and absent of other vegetation. They should also be located where they will not be inundated with drifting sand. At the range it is also recommended that they are located away from the bombing targets to prevent possible damage.

The Regional Council can arrange supplies of the initial planting material and can also organise the sale of any surplus nursery material in the future.

The fertiliser programme required for nursery establishment and maintenance is discussed in the next section.

FERTILIZER PROGRAM

Coastal sand dunes have low levels of plant nutrients and are usually deficient in nitrogen, phosphorus and potassium. Fertiliser application will improve the establishment and growth of dune vegetation.

At the Raumai Bombing Range the following fertiliser programme is recommended:

Nursery

Successful marram nursery establishment and maintainment requires three fertiliser dressings as shown in the following table.

Timing	**Rate** (per hectare)
Spring (September/October)	• 10 kg phosphorus (usually applied as cropmaster at a rate of 65 kg per hectare) 50 kg nitrogen (usually applied as 100 kg of urea and the remaining nitrogen coming from the cropmaster)
Early Autumn (March)	• 10 kg phosphorus (usually applied as cropmaster at a rate of 65 kg) • 25 kg nitrogen (usually applied as urea at rate of 40 kg with the remaining nitrogen coming from the cropmaster)
3-4 weeks prior to pulling (May)	• 25 kg nitrogen (usually applied as 55 kg of urea)

Fertilising a marram nursery can easily be undertaken by hand and the timing should be in conjunction with light rain.

For establishing complete vegetation cover

The fertiliser requirements for the establishment of vegetation are as follows:

1. 100 kg nitrogen per hectare split evenly into two or three dressings. The first dressing should be applied at planting, the second at the start of the spring, and the third during the autumn. Once the vegetation is established, two dressings (spring and autumn) will be sufficient. Nitrogen is usually applied as urea, ammonium sulphate or calimonium nitrate. The reason multiple dressings are required is that nitrogen is extremely easily leached. Slow release forms of nitrogenous fertiliser can be used however they are much more expensive.
2. Phosphorus fertiliser should be applied at a rate of 20 kg P per hectare per year as a single application at planting and then re-applied at the start of the growing season (spring). Phosphorus is usually applied as superphosphate or cropmaster.
3. Potassium requirements should be satisfied by the amount of K present in superphoshate or cropmaster.

Maintenance fertiliser requirements once complete vegetation cover achieved

Maintaining a fertiliser programme once the vegetative cover becomes established is the most effective method of retaining long term stability of the dune system. Retaining a vegetative cover reduces the need for extensive planting programmes, or at worst expensive reshaping. It is therefore recommended that the following maintenance fertiliser programme be adopted:

One dressing applied in the spring containing 80 kg of nitrogen, 20 kg phosphorus, and 15 kg of potassium. The phosphorus and potassium would normally be applied as superphosphate or cropmaster while the remaining nitrogen would be applied as either urea or ammonium sulphate.

It is recommended that only the dune areas are fertilised. Generally the sand plains pose less of a problem if they become devoid of vegetation. In the past it has been found that the most efficient and effective method of applying all fertiliser requirements has been by helicopter.

MAINTENANCE PROGRAM

A annual maintenance programme must include the following:

1. A maintenance fertiliser programme as discussed earlier.
2. Annual marram blanking of bare exposed areas of sand.
3. Minor reshaping (in the planting season) of the toe of foredune as blowouts occur.
4. If blowouts occur out of the planting season, these areas can be immediately mulch covered to prevent the erosion intensifying and replanting the next planting season.

LEGAL REQUIREMENTS

Under the provisions of Regional Councils Proposed Regional Policy Statement any vegetation clearance or soil disturbance on Landuse Capability Classification Class VIIIe1 is a discretionary activity, and therefore requires a resource consent. It would be expected that this consent would be treated as non notified.

OTHER SUGGESTIONS

It is recommended that the Air Force approach the New Zealand Army Engineers Regiment at Linton Base for assistance in the reshaping process. They have suitable machinery for undertaking work of this nature.

REGIONAL COUNCIL INPUT

The Regional Council has much experience in the restabilisation the foredune and inland sand country environment and can provide assistance in overseeing any works. Outside contractors for various operations can also be recommended.

The Regional Council also has limited funding for certain soil conservation projects. Under the present criteria the soil stabilisation works required at the Bombing Range would attract a 25% subsidy but would be subject to certain conditions regarding the nature of the works and an annual maintenance programme. The criteria and availability of Regional Grant for soil conservation works is periodically reviewed.

CONCLUSIONS

It is recognised that the current state of the foredune is contributing to the inland sand dune flows and in order to prevent further inland erosion and the burial of inland assets it is recommended that a stabilisation and maintenance programme is adopted. Long term stabilisation will only be obtained through ideal slopes, complete vegetative cover, and a maintenance programme. Any stabilisation programme must be initiated at the source. Stabilising inland dunes is ineffective if the source is not stabilised first. The most appropriate method used for stabilisation is dependant on the degree and severity of erosion present. Any programme of works must be reassessed annually as priorities will change. And for these works to be successful their timing is critical.

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