rehabilitation

Erosion control and vegetation restoration

Ilmenite Project Madagascar

Hydromulch (Pty) Ltd has been involved in a major sand fixing, erosion control and slope stabilisation undertaking along newly constructed roads at the Rio Tinto/QMM Ilmenite Project at Fort Dauphin in Madagascar. Wind blown sand was a major issue and a decision was made to use barrier netting and Vetiver Grass hedgerows as erosion control protection on the slopes of the excavated Ehoala dune areas, prior to hydroseeding with local grass species. Rehabilitation activities during the construction phase are part of QMM's environmental obligation to the Malagasy government.

In conjunction with QMM Environmental, which has been interacting with the local communities in the mining area for a number of years, Hydromulch initiated a Vetiver sourcing and growing programme with members of neighbouring communities.

ABOVE LEFT: The haul road between the harbour and the quarry cutting through the primary dune, prior to the start of rehabilitation.

ABOVE: The haul road with the wind barrier netting in 500m² blocks and Vetiver hedgerow plantings, showing the hydroseeded indigenous grass cover coming through.

LEFT: Hydroseeding was done, after the Vetiver hedgerow plantings and wind barrier netting had provided a more sheltered environment for grass establishment, and followed by a maintenance application.

BELOW: Hand planting with pioneering dune species.

BELOW RIGHT: Good cover has been achieved with the hydroseeded grasses, after the initial stabilisation with Vetiver.

The mining will take place in an area of coastal plain which is lightly undulated, where the ilmenite deposit is located at three sites, Mandena, Petriky and St Luce, which cover a total of 6 000ha. Ilmenite is used primarily in the paint industry and will be obtained through a dredge mining process. Mandena, an area of 2 000ha with a 20 year mining lifespan, will be the first site to be mined, while the whole ore body will be mined out in approximately 50 years. The project also comprises a recovery plant, associated deep water port, power generation facilities, haul roads, water treatment plants, villages and construction camps with general services and utilities. The deep water port constructed primarily for the export of the product has been partly funded by the World Bank and will also serve as a general purpose port for what will eventually develop into a light industrial zone.

Rio Tinto Plc operating through its wholly owned subsidiary Quebec Iron & Titanium (QIT) entered into an agreement with the government of Madagascar to form QIT Madagascar Minerals (QMM) for the development of the mining project. Hatch Africa and Fluor South Africa were appointed as the engineering consultants for the project in the Mandena Joint Venture which, in turn, appointed Hydromulch to undertake soil erosion control and revegetation of areas disturbed during the construction phase. Once this stabilisation is complete and the construction sites are closed, the rehabilitation work during the operational phase of the mine will be the in-house responsibility of QMM, and nurseries are already set up for this process.

The rehabilitation project undertaken by Hydromulch, which is now in its third year and nearing completion, involved erosion control and the reinstatement of vegetation to approximately 35ha of disturbed land along newly constructed roads and other embankment areas.

The haul road from the quarry to the site of the new harbour involved major earthworks through the primary dune, known as the Ehoala dune, and wind blown sand resulting from the high winds was of major concern in this area. The primary dune cutting is 5,5ha in extent, with the cut slope 160m in height and the fill 90m in height. The sides of the haul road from the processing plant to the harbour were less problematic as they were not fully exposed to the severity of the prevailing winds.

"Experimentation with local grass species resulted in proof that these grass species were unable to withstand the wind strengths on the exposed excavated side slopes above the haul road, as the lifting of the sand particles decapitated the young plants. The wind snaps poles it is so strong and it has been known to blow for up to 40 continuous days sometimes gusting in excess of 30 knots. The decision was made to use the species *Vetiver zizanioides* (recently reclassified as *Chrysopogon zizanioides*) for its abilities in sand fixing, erosion control and slope stabilisation – and to create a sheltered microclimate in the harsh terrain for the establishment of hydroseeded indigenous grass species and hand-planted pioneering dune species, which will allow natural succession to take place over the course of time," said Roley Nöffke of Hydromulch.

This Vetiver species is well-established in the farming communities of Madagascar where it was introduced probably more than a hundred years ago to combat soil erosion. The plant is sterile and non-invasive and remains intact for decades if it is not shaded out by other species. It has strong erect stems which can withstand strong surface water flow. Nöffke explains that it rapidly develops a dense micro-fine root capillary system that binds loose subsoils effectively and can reach as far down into the soil as 2-3m within 12 to 18 months.

Initially a series of soil samples were taken from various locations in need of rehabilitation and submitted to SGS Laboratory in Midrand, South Africa for detailed chemical analysis. The results were interpreted by Dr Ari van Vuuren and he made recommendations. Three specific vegetation zones and related soil types were identified: an area of 'old forest' comprising wooded vegetation, a grassed coastal dune area and an intermediate sandy agricultural area between the mountains and the sea. The laboratory confirmed that the soils were acidic in the old forest areas and alkaline throughout the dune areas. Recommendations for fertiliser were made for the amelioration of the top 150mm of soil profile. Subsoils were noted to have similar values to the topsoils.

The erosion control and vegetation establishment of the two major road projects were carried out progressively as the main contractor proceeded with the earthworks. The areas to be vegetated were topsoiled from the preserved stockpiles of topsoil. The cut side slopes of the excavated Ehoala dune, which were particularly vulnerable, were installed with wind control barrier netting in blocks of 500m² to provide initial shelter, from the excessively windy conditions, for vegetation establishment.

"To illustrate the wind problem, the barrier netting originally stood at 1,5m above the excavated dune and the sand has now built up to such an extent that only 700cm of netting is exposed in some areas," commented Noffke.

For long term erosion control protection of the side slopes of the dune and in other areas with erosion potential, such as behind culvert head walls, drain outlets and along the shoulders of fill slopes, Vetiver grass hedgerows were planted. Rows were prepared by loosening soil in shallow trenches of about 150mm deep and 50mm wide, parallel to the contour and spaced at one metre intervals on all the side slopes of

45° or greater. Suitable organic matter such as rice husks provided by the local communities were mixed with agricultural lime, superphosphate and cattle manure and then placed into the trenches prior to planting, along with a microbial bacteria additive. The Vetiver was planted into the prepared trenches at six potted plants per linear metre and watered regularly until foliage growth indicated root establishment – this took a minimum period of six weeks in the absence of any heavy precipitation. Additional fertiliser applications of NPK were made after six weeks and again after 12 weeks. Any plants that did not establish were replaced.

The areas between the wind barriers and Vetiver hedgerows were scarified to form horizontal drills or furrows 100-150mm apart and 30-50mm deep, prior to the placement of brushwood. Suitable brushwood material (the total quantity used was 360 000m^2) obtained from the felling of invasive woody alien plants, and approved by QMM Environmental, was spread flush to the ground with branches overlapping, over the areas to be hydroseeded. The hydroseeding application over a total area of 36ha was carried out by a hydroseeder capable of spraying a distance of up to 40m and with a built-in agitation system and a specialised centrifugal pump for handling varying viscous and slurry formulations. Hydroseeding was also done on road embankments in the construction camps and village for QMM and contracting staff.

The seed mixture used for hydroseeding comprised commercially available grass species: *Eragrostis curvula* and *E. tef, Chloris gayana, Cynodon dactylon, Panicum maximum, Paspalum notatum* and the exotic clover for nitrogen fixing, *Trifolium subterranean*. Locally collected grass seeds obtained by QMM Environmental included *Stenotaphrum dimidiatum* (Buffalo Turf Grass), *Dactyloctenium aegyptium* (Common Crowfoot), *Imperata cylindrica* and *Cynodon dactylon*. Seeds of the indigenous shrub *Flacourtia ramoutchi* were added to the hydroseeding mix in the Ehoala dune area. A soil binding agent, Hydropam, was added to the mix to create a suitable microclimate in combination with the organic supplements, Gromor, locally sourced rice husks, imported cotton husks and cattle manure, all processed through a hammermill. NPK fertiliser was added as detailed in Dr van Vuuren's recommendations, along with agricultural lime (particularly important for the acidic soils) and a highly concentrated blend of beneficial organisms for use on soils with low microbial activity.

Hand planting was done of dune pioneers – shrubs indigenous to Madagascar – after the establishment of the grasses. *Tambourissa purpurea* was used as a pioneer to begin the restoration of the coastal forest areas and *Scaevola taccada*, an evergreen succulent spreading shrublet, was used on the sand dunes.

"Hydroseeding is a science," said Nöffke. "There needs to be an understanding of the soil and how to ameliorate soil conditions and apply seed. The areas then need to be managed and a maintenance period of at least a year is required to obtain good cover. The initial hydroseeding at the Ilmenite project was followed up by a maintenance hydroseeding application twelve months later. Good vegetation cover has already been attained on slopes that are not in the teeth of the wind. The hydroseeding vehicle is to remain behind at the project once we have completed the contract, for the purposes of any future maintenance and the future rehabilitation in the mined areas, which is to be undertaken by QMM."

ABOVE: Children helped to deliver the Vetiver on 'market day'.

BELOW: Marie Agnes built a secure house for her grandchildren with income generated from the propagation of Vetiver.

BELOW: The Garry family's nursery where over 120 000 Vetiver plants have been propagated to date.

BELOW RIGHT: Andre David Mahalogny from the Mangaiky district purchased six Zebu cattle with the proceeds of his Vetiver nursery.

Roley Nöffke of Hydromulch buying from Vetiver collectors.

Farmer Arthur has utilised all the space around his dwelling to maximise his production of Vetiver plants.

Community based Vetiver propagation programme

It was estimated that the erosion control and vegetation reinstatement programme as a whole would require about two million Vetiver plants and Hydromulch, in conjunction with QMM Environmental, initiated a Vetiver sourcing and growing programme utilising family groups in neighbouring communities. Nöffke commented that fifteen communities were approached initially during December 2006 and this had expanded to 35 by August 2008.

Vetiver plants are abundant in Madagascar and are found growing along the perimeters of fields and rice paddies and in rural pasturelands, where it is reputed that they were originally imported and planted by missionaries and latterly farmers, for erosion control. Nöffke has seen plants with clump sizes that indicate they could be over 60 years in age. He commented that another use made of the young Vetiver plants was as grazing for domestic animals – the juvenile plants are palatable. He made the point that no Vetiver plants were imported into the country for the project.

Some of the families involved in the project sourced parent material from their farming locations close to the rehabilitation sites and were paid for the material, while others were given slips of the parent material to grow on in community nurseries of their own making. Hydromulch briefed the villagers on the correct cropping and trimming procedures and demonstrated sustainable harvesting methods – removing material without damaging the parent plant. They were also encouraged to identify and collect viable strong material and often travelled great distances to source suitable material.

Potting bags and Vetiver planting material in the form of slips were delivered to the communities that had chosen the propagation route. The growers filled the bags with a suitable growing medium and planted the slips. Open ground nurseries were also encouraged, so that the growers could establish a stock for future demand. Along with the potting bags, the growers received fertiliser sticks, spades, rakes, plastic watering cans and wheelbarrows. The families were paid for the initial planting process, with a second payment being made once the plants were satisfactorily established with well-developed root systems. According to Nöffke, establishment takes between three and six weeks during which time regular watering is needed. The communities selected for the propagation process were close to reliable water sources. Some communities are involved in the post-establishment maintenance of the plants and are being paid accordingly. Once established, the plants were collected by Hydromulch ready for planting out into the harsh roadside environment.

The communities or families in the various villages are subsistence farmers that grow mainly rice, while those on the coast are fishermen. In the Mangaiky Village, 'Andre's community' has propagated over 230 000 Vetiver plants to date and, in the same village, the Auguste family has propagated in excess of 250 000 plants. In the Mangarivotra Village, the 'Antahova Community' will soon reach their target of 80 000 plants, while Maria Agnes's family from the Mandromdromotra Village has grown 100 000 plants. These are some of the 35 groups involved in this programme, supplying the on-site holding nursery with stock. A total of in excess of two million Vetiver plants has been used for erosion control on the project. The community based programme has already generated in excess of US$ 150 000 for the respective communities, during the construction phase of the Ilmenite Project.

The local farmers have invested their returns in buildings and stock. Farmer Auguste built a large robust house with the income his family received, while Madame Marie Agnes built a secure house for herself and her grandchildren from the income generated through Vetiver propagation. Andre David Mahalogny from the Mangaiky district bought six Zebu cattle with the proceeds generated by his family's Vetiver nursery. With the money he earned, Farmer Arthur carried out the traditional restitution ceremony at his father's grave, while Farmer 'Jonesey' is educating his children with the payment received for the 240 000 Vetiver plants grown by his family. EM

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