VETIVER FOR INFRASTRUCTURE PROTECTION
"Vetiveria zizanioides: Native to the Indian subcontinent, this plant is known for its dense, tufted, evergreen habit. It is an important ornamental grass, native to tropical and subtropical regions. The plant grows in large clumps from a much-branched root stock with erect culms as 1.5m high.

Plantae Flora of the World

"Vetiver grass is widely used throughout the tropics for planting on the sides of roads as an anti-erosion measure, for protective partitions on terraced fields, and as a border for roads and gardens...

Plantae Flora of the World
THE APPLICATION OF THE VETIVER SYSTEM AS A BIOENGINEERING TOOL ON DRY LAND AND WATER COURSES, FOR EROSION AND SEDIMENT CONTROL, STABILISATION, AND DISASTER MITIGATION, HAS BEEN USED WORLDWIDE, INCLUDING AUSTRALIA, BRAZIL, COLOMBIA, CENTRAL AMERICA, CHINA, FIJI, MALAYSIA, SOUTH AFRICA, VENEZUELA AND VIETNAM. EXTENSIVE RESEARCH AND DEVELOPMENT OF THE VETIVER SYSTEM, HAS SHOWN THAT WHEN PLANTED IN ROWS VETIVER FORMS STRONG AND DENSE HEDGES. THE APPLICATION OF VETIVER HEDGEROWS AND THE UNIQUE CHARACTERISTICS OF VETIVER GRASS MAKE IT EXCEPTIONAL FOR EROSION CONTROL AND STABILISATION.

WHY VETIVER

The combination of these unique characteristics makes Vetiver exceptionally effective for soil bioengineering and infrastructure protection:

- Stiff and erect stems create dense hedges withstanding high velocity flows, trap sediment, and control water runoff, protecting against erosion
- Deep, extensive and interlocking root system that grow vertically reaching depths of 5+ metres, creating dense underground reinforcing root wall structures
- Strong roots with a tensile strength of 75Mpa equivalent to 1/6th of mild steel
- Roots improve soil sheer strength by 45%
- Thrives in a variety of soils; sandy, sodic, saline, water logged, acidic, alkaline and toxic contaminants
- Tolerant to climatic and environmental variations; drought, flooding and submergence, and air temperatures of -15C to 55C
- Roots develop from nodes, if buried, so Vetiver rises with the ground level
VETIVER SOIL BIOENGINEERING APPLICATIONS

- Slope Stabilisation and Protection
- Erosion and Sediment Control
- Batter Stabilisation and Protection (roads/railways/highways)
- River and Stream Bank Stabilisation
- Dike and Dam Wall Stabilisation and Protection
- Protection of Hard Concrete and Gabion Structures
- Filter Strip/Sedimentation Trap
- Stabilise Gully Head Erosion

HOW THE VETIVER SYSTEM WORKS

Vetiver grass (Chrysopogon zizanioides L.) is a fast growing perennial grass with a vast interlinked root system and strong stems, which together create a wonderful plant with the capacity to address a multitude of environmental, engineering, and industrial rehabilitation issues. The Vetiver System application of Vetiver grass has the capacity to create living walls, filter systems, and act as “live nail” reinforcement.

Vetiver’s unique attributes, the root and stem system, combine to work both above and below ground to ensure erosion control, soil and water conservation and steep slope stabilisation.
ROOTS
Below the surface the dense, deep and penetrating root system of Vetiver grass can reach vertical depths of 5+ metres, binding and reinforcing soil shear strength by up to 45%. The roots are extremely fine and strong with a tensile strength of 75 MPa, which is equivalent to approximately 1/6th of mild steel reinforcement.

When planted in hedgerow format, due to its clonal nature, the roots of the plants grow and interlock, creating vast underground, dense and strong root wall systems, which serve to bind, stabilise and increase the tensile strength of the soil. Protecting against erosion, instability and flood disasters.

STEMS
The strong, thick and stiff stems create above ground hedges, which dissipate wind and water energy, slow down water flow, trap sediment and control water runoff. These hedges act to protect the topsoil, ensuring that it remains in place and overtime, create natural barriers to flow by trapping soil and sediments.

RESILIENCE
A resilient and adaptable grass, Vetiver is disease and pest resistant, can recover after fires, and withstands prolonged periods of flooding and drought, surviving in air temperatures of -15C to 55C. Vetiver can grow and thrive in a variety of soils: sandy, sodic, saline, waterlogged, acidic, alkaline and toxic (from pH 3.3 – 12.5). Most importantly, Vetiver grass is sterile, it has no above or underground runners, which means it has NO WEED POTENTIAL, allowing for Vetiver to be shaped and applied for specific use without the threat of it spreading or competing with other vegetation.
EROSION CONTROL AND INFRASTRUCTURE PROTECTION

Vetiver’s unique attributes, the root and stem system, combine to work both above and below ground to provide the structural strength and protection mechanisms to address the main causes of slope instability: surface or sheet erosion and internal structural weakness. Erosion and instability predominately occur in areas of erodible or dispersible soil or where man has artificially altered the natural landscape, undermining its stability and natural processes. Vetiver is especially effective in these circumstances as it both strengthens and protects.

Conventional hard engineering structures fail to address the requirements of erodible soil types, as their rigidity means that they cannot work with the natural processes of the land. Ultimately the land will erode and undermine the hard engineering structures. Therefore, these rigid structures are only a temporary fix for erosion control and do not create long-term stabilisation solutions.
The application of the Vetiver System extends beyond land based infrastructure protection, to the utilisation of Vetiver in water-based situations and water disaster mitigation. The deep root system of the Vetiver grass means it has the capacity to withstand high velocity flows of floodwaters, whilst also strengthening the soil, making it difficult to dislodge the plant, ensuring the longevity of the hedge. Extensive application and testing has shown that Vetiver can resist flows of up to 5 metres per second. Under high velocity flows the stems can bend over, providing extra protection to surface soil whilst reducing flow velocity. Under low velocity flow, the stems act as a barrier to reduce flow velocity.

These attributes make Vetiver the perfect tool for infrastructure protection, to protect against erosion, instability and flood disasters.
ADVANTAGES OF VETIVER

- Sustainable
- Non-invasive
- Environmentally harmonious
- Stabilises and strengthens soil, improving integrity of infrastructure
- Slows water flow, allowing for proper water infiltration
- Can withstand water flows of 5m/sec
- Long-term solution: gets stronger as it grows
- Traps sediments
- Exceptional resistance to high velocity water flows – thrives through storm seasons
- Carbon sequestration (estimated 150 tons per hectare per year)
- Erosion control – above and below the surface
- Drought tolerant
- Survives flooding
- Improves water quality – nutrient and toxic contaminants removal
- Aesthetically appealing
- Creates grassland habitat for wildlife
- Minimal ongoing maintenance costs (compared to hard-armour methods)
WHY NOT USE NATIVE PLANTS?

As environmental awareness has evolved, the desire to utilise indigenous plants where possible has developed. However, local native plants are mostly adapted to a low fertility, unpolluted and clean Australian environment. Therefore they generally cannot be used for land stabilisation purposes on artificially disturbed sites, as they do not have the unique attributes of Vetiver, such as:

- **Tolerance to extremely adverse growing environments:**
  - High soil salinity, acidity and alkalinity conditions
  - Heavy metal contaminants and agrochemicals such as weedicides and soil amendments
  - Prolonged drought and inundation
- **Penetrating, long and extensive root system**
- **Highly adaptable to various soil types, from beach sand, and heavy clay to decomposing rocks**

Vetiver is a sterile grass, it has no above or underground runners, which means it has **no weed potential** and cannot self-spread. Therefore, it poses no threat to the environment and other vegetation, both native and introduced species.

Lomandra a native plant commonly found on the edge of drainage lines and watercourses in Queensland and NSW. There are two species; the taller and more erect Lomandra longifolia is commonly used in Australia for erosion control and stabilisation. The shorter Lomandra hystrix is not commonly used. Lomandra is of the sedge family and thus is shallow rooted and normally grown in a wetter environment. As a native species it does possess properties making it adaptable to Australian climatic conditions, however when compared with Vetiver, it is inferior for effective erosion control and stabilisation.
In 1995, a 2-year trial was initiated in Mackay Queensland, to demonstrate the effectiveness of Vetiver grass for erosion control and batter stabilisation. This trial was conducted as a comparison between Vetiver (Chrysopogon zizanioides L.) and Australian natives – Lomandra longifolia and native Vetiver (C. filipes).

After two years of growth, all three plants had been well established. However, following a prolonged period of rain, 400mm over two weeks, the effectiveness of the grasses for erosion control and stabilization was revealed. The sections planted with the native plants, Lomandra and Vetiver Filipes, had collapsed, whilst the section planted with Vetiver (Chrysopogon zizanioides L.) remained intact, proving that its unique characteristics make it the superior plant for erosion and stabilisation works.

The combination of Vetiver’s deep, strong and penetrating root system with its tall, tufted and dense stems, allows Vetiver to withstand the conditions and circumstances that cause erosion and slope instability. Lomandra, although it has some very good qualities, does not come close to the effectiveness of Vetiver for this application. The extensive research and development that has been conducted over the past 30 years proves Vetiver’s applicability as the ideal bioengineering solution for infrastructure protection, erosion and sediment control and steep slope stabilisation. Vetiver is the most researched non-agricultural and non-industrial crop ever reported.
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<tr>
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<th>LOMANDRA</th>
<th>VETIVER</th>
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<tr>
<td><strong>ROOTS</strong></td>
<td>- Shallow roots, grow to depth of about 30cm</td>
<td>- Deep roots, grow to depth of 5+ metres</td>
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<td>- Improve soil shear strength by 50% but only to the depth of the roots</td>
<td>- Improve soil shear strength by 45%</td>
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<td>- Tensile strength of 75Mpa equivalent to 1/6th of mild steel</td>
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<td><strong>SOIL</strong></td>
<td>- Grows in sandy, sandy loam &amp; clay soils</td>
<td>- Thrives in a variety of soils; beach sand, and heavy clay to decomposing rocks</td>
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<td>- Best growth in pH neutral soil (6.5 – 7.5)</td>
<td>- Survives in sodic, saline, water logged, acidic, alkaline and toxic soils</td>
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<td>- Commonly grows in non-saline soils</td>
<td>- Grows in pH 3.3 – 12.5 soils</td>
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<td>- Moist, well-drained, moist moderate drainage</td>
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<td><strong>STEMS</strong></td>
<td>- Blades grow up to 1.2 metres high</td>
<td>- Blades can grow up to 3 metres high</td>
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<td>- Perennial tufted</td>
<td>- Perennial tufted</td>
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<td>- Can resist high velocity water flows, up to 5 metres per second</td>
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<td><strong>TOLERANCE</strong></td>
<td>- Moderately drought tolerant</td>
<td>- Drought, flooding and submergence tolerant</td>
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<td>- Can survive in temperatures of -10 to 31C</td>
<td>- Survives in air temperatures of -15C to 55C</td>
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<td><strong>ISSUES</strong></td>
<td>- Does not like prolonged wet conditions</td>
<td>- Does not like overshading</td>
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<td>- Cannot withstand high rainfall and flooding conditions</td>
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**THE SANTOS ROMA HUB**

**BLYTHE CREEK CROSSING**

This is AFTER the rehabilitation attempt – the lomandra died off through the dry months and also cattle grazed all the grasses (Rhodes etc), and damaged the jute mesh.
ADVANTAGES & DISADVANTAGES:
HARD ARMOUR VS. VETIVER

**HARD ARMOUR**

ADVANTAGES:
• Instant fix – acts most efficiently at the beginning

DISADVANTAGES:
• Lifecycle – weakens over time
• Require long-term maintenance – lifecycle costs are higher
• Less sustainable
• Expensive to build and maintain
• Less forgiving of foundation conditions
• Not aesthetically pleasing
• Issues with weeds and accumulated sediment
• Rocks may shift – reduce hydraulic capacity of design

**VETIVER**

ADVANTAGES:
• Sustainable
• Non-invasive
• Environmentally harmonious
• Stabilises and strengthens soil, improving integrity of infrastructure
• Slows water flow, allowing for proper water infiltration
• Can withstand water flows of 5m/sec
• Long-term solution: gets stronger as it grows
• Traps sediments
• Exceptional resistance to high velocity water flows – thrives through storm seasons
• Carbon sink
• Erosion control – above and below the surface
• Drought tolerant
• Survives flooding
• Improves water quality – nutrient and toxicity removal
• Aesthetically appealing
• Creates grassland habitat for wildlife
• Minimal ongoing maintenance costs (compared to hard armour methods)

DISADVANTAGES:
• Initial establishment phase is longer than hard armour
CASE STUDY:
COOKTOWN - STABILISATION OF ROAD INFRASTRUCTURE

THE ISSUE:
Cooktown, in Far North Queensland, is a tropical environment with highly erodible and infertile soil. Erodible soils are highly problematic for infrastructure development and protection, which was experienced in this case with road infrastructure. Severe erosion and drainage problems were occurring on both cut and fill batters, culvert inlets and outlets, steep batters and the surrounding gullies, which all threatened the integrity of the roads, posing long-term issues for road infrastructure.

Erosion of new cut batter
Fill batter erosion
Old batter erosion
Table drain erosion
Although commonly used, conventional concrete and hard rock protection is ineffective, due to its inability to address the underlying cause of erosion and instability in the soil. Hard rock solutions served as superficial protection but failed due to undermining. Ultimately the rocks provided no protection for the highly erodible soil and they sunk into the batters, creating issues in themselves.
THE VETIVER SYSTEM SOLUTION

Vetiver served as the ultimate solution for this highly erodible and infertile soil, as it offered a multi-layered approach. Vetiver served to strengthen, stabilise and protect the soil against erosion and therefore ensure the integrity of the road infrastructure.

Vetiver System designed hedgerows were applied to batters, dykes, culverts and table drains. The root system of the Vetiver hedgerows strengthened and stabilised the soil, whilst the stems served to spread water flow, reduce flow velocity, and trap sediment, which protected the topsoil and further reduced erosion.
THE RESULT

Vetiver completely stabilised, strengthened and protected against erosion, ensuring the ongoing integrity of the road infrastructure. It took Vetiver hedgerows 7 months to fully stabilise the area and offered continued protection and stabilisation against erosion.

Batter protection 8 months

Fill batter protection 3 months

Table drain protection

Steep batter and culvert protection

Culvert protection 16 months

Cut batter stabilisation 16 months
EXPERIENCE

Veticon is highly experienced in the design and implementation of Vetiver System (VS) solutions for infrastructure stabilisation and protection works in both land and water based situations. Vetiver Systems are an effective method of infrastructure resilience planning and asset protection.

We provide tailored Vetiver System solutions that address the needs of erosion and sediment control, soil and water conservation, and revegetation for the stabilisation, protection and integrity of; roads, railways, commercial and residential buildings, dam walls, riverbanks, coastal foreshores, and drains, protecting against erosion, instability and flood disasters.

A unique bioengineering tool, Vetiver is ideally designed to address infrastructure development and protection, due to its soil binding and strengthening properties combined with its capacity to reduce water flow velocity, spread and divert water runoff, increase water infiltration, and penetrate dense, difficult, hardpan and rocky layers of soil. The application of VS solutions ensures the longevity of infrastructure investment, restoration and protection.

AUSTRALIAN PROJECTS:
• Queensland Rail: Batter stabilisation
• Queensland Water Resources: Dam wall and spill way stabilisation
• Queensland Harbour and Marine: Rehabilitation of reclaimed saline lands
• Queensland Main Roads: Stabilisation of steep road batters, culverts & table drains
• Gold Coast City Council: Stabilisation of Biggera Creek flood retention dam
• Powerlink Corporation QLD: Stabilisation of power line pylons
• Queensland Motorways: Stabilisation of Logan Motorway batters and drains

INTERNATIONAL PROJECTS:
• China: Highway and railway batter stabilisation Fujian and Jiang Xi Provinces
• China: Riverbank stabilisation Guangxi and Anhui Provinces:
• USA: Land rehabilitation, erosion and sediment control and road batter stabilisation: USAID, Washington DC
• Indonesia: Erosion control of minor village roads in the Citarum Bassin, Java. An Asian Development Bank funded project (2008-10)
• Vietnam: Stabilisation of batters of Ho Chi Minh Highway from Thanh Hoa to Pleiku, Central Highlands
• Vietnam: Dikes and riverbank stabilisation against flood erosion in Quang Ngai, an AUSAID
• Vietnam: Stabilisation of batters of canal and riverbanks and the dyke system protecting cropping land in the flood zone of An Giang Province, Mekong Delta
• Vietnam: Sand dune stabilisation and Highway batter stabilisation Coastal Vietnam

For more information and case studies please visit www.veticon.com.au