AFRICA'S GREAT RIFT VALLEY LAKES ARE DYING

1. Drying up:

reduced inflow, lower water levels, increased water extraction

2. Polluted with chemicals, waste water and sediment:

increased algae blooms and sediment flows into lakes, reduced oxygen.

A Case Study

Lakes Awassa (Ethiopia) & Naivasha (Kenya)

Mitigation - The Vetiver System

The two lakes are quite similar in size, altitude, and climate. They area afflicted by the same problems

Lake Naivasha: 500 sq miles, a.s.l: 1700 m surrounded by intensive commercial farms adjacent to lake, eroding and intensively farmed uplands, deforested uplands, tourism, expanding urban center - Naivasha

Lake Awassa: 500 sq miles, a.s.l: 1700 m - intensive commercial farms adjacent to lake, eroding and intensively farmed uplands, deforested uplands, tourism, expanding urban center - Awassa

SOLUTIONS

Upland Watersheds of Lake catchments:

Reduce Erosion
Recharge groundwater
Increase water flow to rivers

Lakeshore and flood plain farming:

Reduce sediment flows to lakes
Reduce chemical discharge to lakes
Manage water extraction from lakes

Urban Pollution:

Bring urban sewage discharge to EPA standards - both public and domestic
Control industrial effluent discharge to Lakes

How do we correct the problems?

Improved Technology - linked with:

- Community and individual initiatives
- Government Policies

A NEW AND PROVEN TECHNOLOGY

THE VETIVER SYSTEM

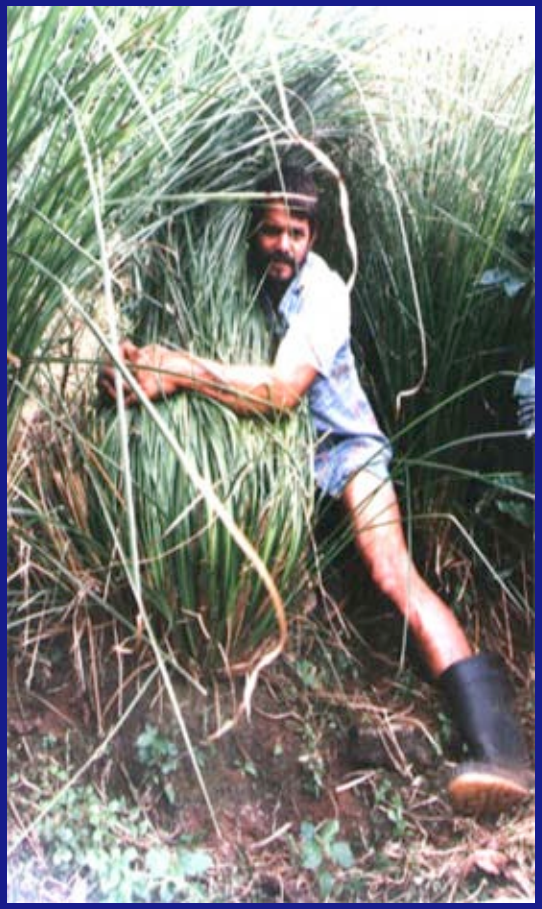
Based on
A unique plant
Vetiver
Chrysopogon zizanioides

THIS PRESENTATION WILL FOCUS PRIMARILY ON THE TECHNICAL SOLUTIONS

This is the plant that can mitigate many of these problems - halting sediment flows, improving river flow, and improving water quality - all at relatively low cost.

***Chysopogon zizanioides* - Vetiver Grass**

The Hedge: a dense barrier above and below ground



The Plant - sturdy and stiff

The Root - 1 year old
Deep and Strong

SPECIAL CHARACTERISTICS OF THE PLANT - VETIVER

- Grows under extreme and wide range of conditions
- Long living perennial grass
- Air temperatures: -15 º C to >55º C
- Soil pH from <3 to >10
- Annual Rainfall <300 mm to > 5,000 mm. Tolerant to extreme drought
- Tolerates at high levels all heavy metals
- Saline tolerant (salinity threshold ECse = 8 dSm-1)
- Fire tolerant
- Tolerant to long and total submergence in water
- Resistant to most pests and diseases
- Powerful (average 75 MPa) root strength and deep root system
- Non competitive and non invasive. According to the PIER level of invasiveness criteria, non fertile vetiver cultivars are rated - 8.
  (An acceptable level for plant importation by the most strict countries is +1)

MASSIVE ROOT SYSTEM

- Just to underscore the differences between Vetiver species, this photo from Vietnam compares *Chrysopogon zizanioides* (non fertile, south India cultivar) with *Chrysopogon nemoralis.* You can see why we promote the south Indian cultivars!!

TOLERANT TO HIGH SALINITY

Saline threshold level is at EC_e=8 dsm^{-1}, and vetiver can survive at 47.5 dsm^{-1} under dry land salinity conditions

TOLERANT TO HIGH ACIDITY

Highly erodible acid sulfate soil in coastal Queensland - one year after planting

REMOVAL OF NITRATES AND PHOSPHATES FROM WASTE WATER

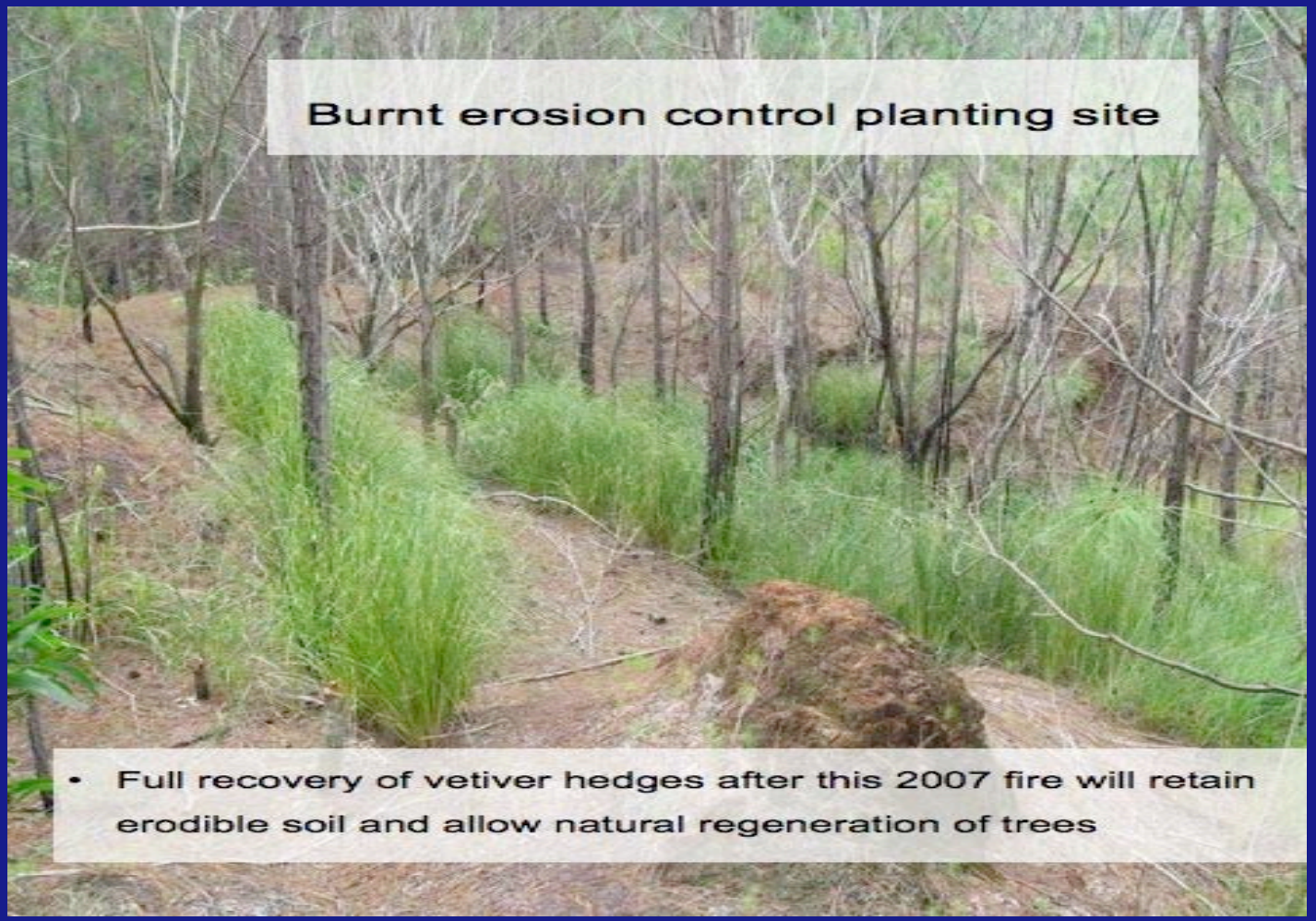
With high capacity of removing N and P in polluted water, vetiver cleaned up blue green algae in 4 days

Sewage effluent infested with Blue-Green algae due to high Nitrate (100mg/L) and high Phosphate (10mg/L)

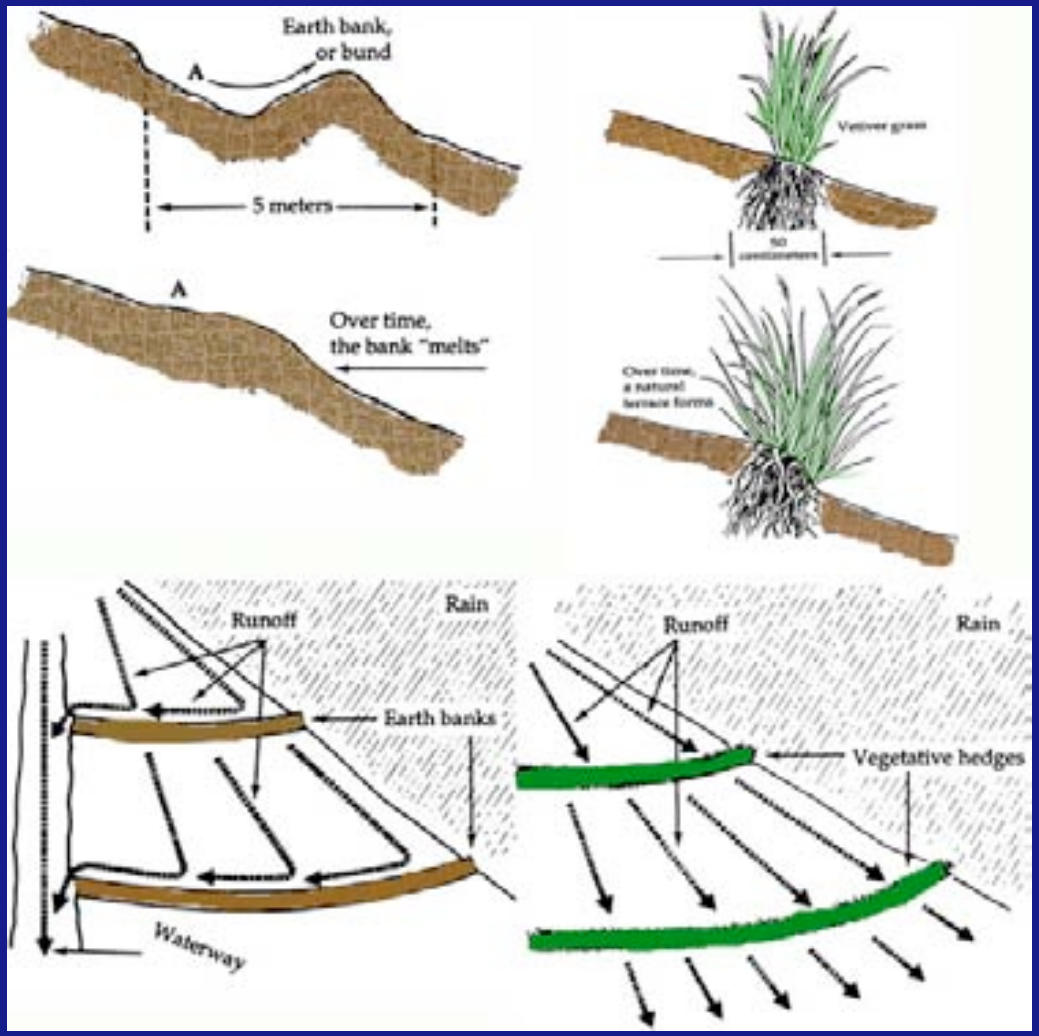
Same effluent after 4 days after treating with vetiver, reducing N level to 6mg/L (94%) and P to 1mg/L (90%)

VETIVER AND FIRE

Vetiver recovers quickly from fire (3-6 weeks) and continues to provide erosion protection even if burnt off completely



THE VETIVER SYSTEM - HOW IT WORKS



Engineered Biological - Vetver

VETIVER FORMS A DENSE BARRIER

Acts as a very effective filter trapping both fine and coarse sediment

EROSION CONTROL UNDER FLOOD CONDITIONS

- Darling Downs, Queensland, Australia. Black cracking soils. Subject to serious flooding and erosion. Virtually flat, Max slope 2%. Vetiver hedgerow with adjacent sorghum crop.

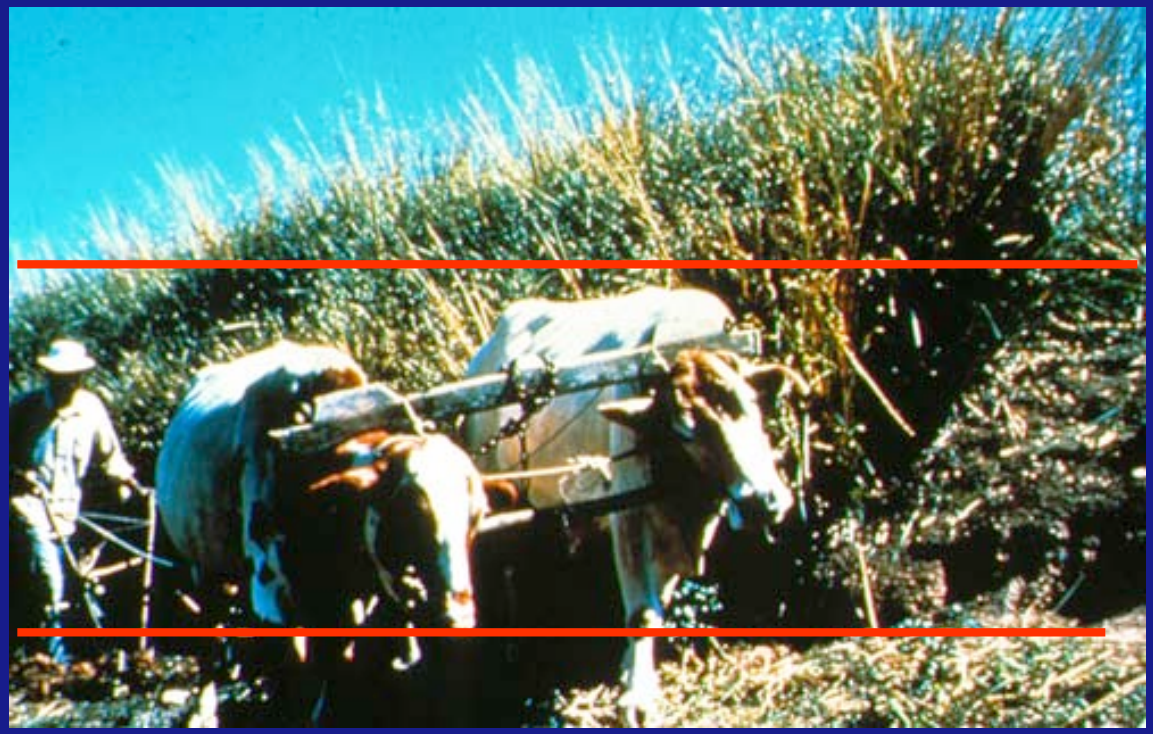
- Same hedge system after flooding, note silt build up in low spots. Ultimately low spot will fill in. This very stiff hedge withstood flash flood conditions.

SMALL FARMERS USE THE VETIVER SYSTEM

Indian farmers in Mysore have been using Vetiver for generations for erosion control and farm boundary demarcation. Very few people had realized this. The leaves are cut every three weeks for forage.Other benefits included more reliable well water.

Ethiopian farmers have been using Vetiver for 20 years for erosion control, forage, thatch, and mulch.They manage it just as Indian farmers do. Note the dense barrier that Vetiver creates, and the natural terrace created by it.

30 YEAR OLD VETIVER HEDGEROW DEVELOPES A NATURAL 2 METER HIGH TERRACE RISER



Vetiver hedgerow planted on a 20% slope in Fiji had developed a terrace with a 2 meter rise after 30 years. This is not possible with engineered structures. Other plants are unable to do this. Vetiver has a unique tillering function.

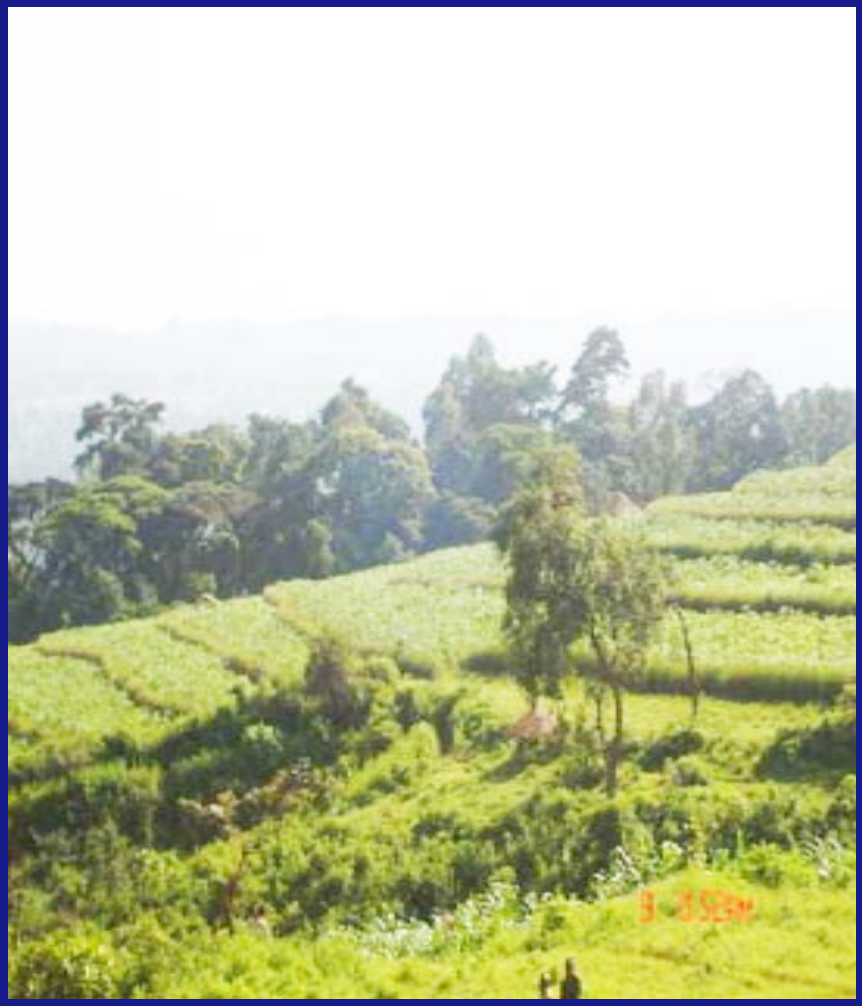
FIFTY YEARS AFTER PLANTING HEDGEROWS STILL FUNCTION

Vetiver hedgerows near Rakiraki, Fiji

Google Earth 2008

WATERSHED - UPLAND SOIL EROSION CONTROL

Erosion control in Ethiopia using Vetiver hedgerows results in 90% reduction in soil loss, 70% reduction in rainfall runoff, and crop yield increases of 50% due to improved soil fertility, soil moisture (drought proofing) and better pest control.



UPLAND CONSERVATION AND AGRICULTURE

High biomass - 70tons/ha dry matter per ha equivalent (top left), Forage (top right), increased maize, coffee, banana yields due to improved soil fertility (mulching), increased soil moisture, and insect - maize stem borer - and banana nematode reduction. PLUS thatching material and handicraft material.

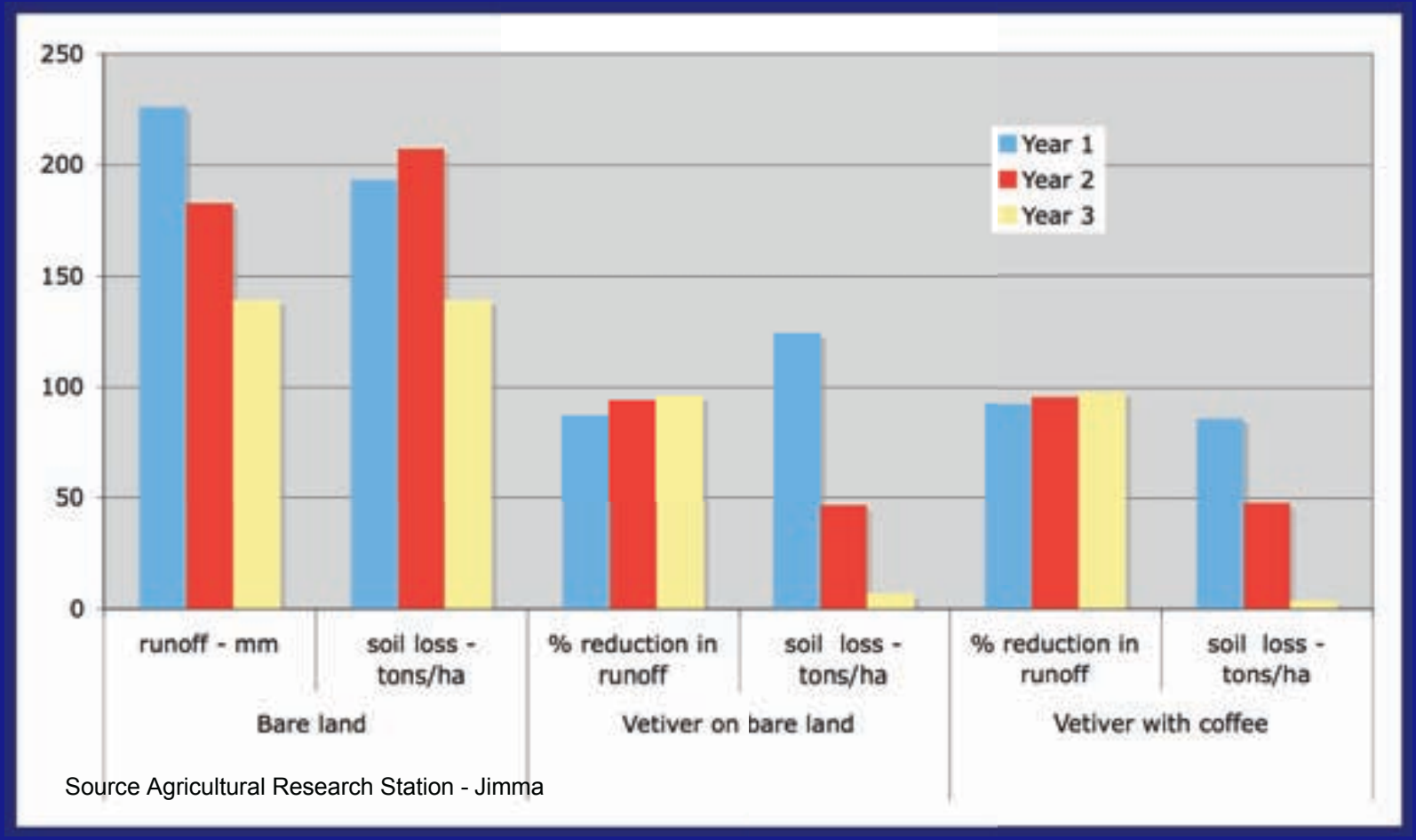
VETIVER - TESTED, USED, AND PROVEN FOR SOIL CONSERVATION BY ETHIOIAN FARMERS

Vetiver hedgerows from space at Mettu, Ethiopia (left), and Jimma coffee research station (below).

RAINFALL RUNOFF REDUCTION AND GROUND WATER RECHARGE

- In Ethiopia uplands wherever Vetiver is used for soil conservation rainfall runoff is significantly reduced, groundwater is recharged, springs run again, wetlands are restored, and ephemeral streams run longer, cleaner, and stronger. The spring (above) provides the only potable water in the area, and is a result of 250 km of Vetiver hedgerow that is the backbone of a 500 ha farm that has been restored from virtual wasteland.

EFFECTS OF VETIVER SYSTEM ON SOIL LOSS AND RUNOFF ON AGRICULTURAL LANDS



Source Agricultural Research Station - Jimma

Vetiver hedgerows improve in performance with age. Farmers say that where they have good 20 years old hedges there is virtually no soil loss or rainfall run off .

UPPER CATCHMENT GULLY CONTROL
The Problem

Sabi Valley, Zimbabwe:

- Trees do not prevent erosion - their roots may be massive, but they are not dense enough.

- This land had once been stabilized with engineered earth contour banks. They were not maintained and stopped functioning. The water-way that was supposed to move water from the diversion banks could not take the water velocity and became this huge gully

THE SOLUTION

Upper Catchment - Gully Rehabilitation Using Vetiver Grass
40 Years After Planting - Fiji

IN THE CONGO GULLIES CARRY SO MUCH RUNOFF THAT THE ONLY WAY TO BRING CONTROL TO THEM IS THROUGH SANDBAG REINFORCED WITH VETIVER.

The bags are filled with soil and planted wit Vetiver. The Vetiver grows right through them, pinning them to the ground, eventually the bags rot and the floor of the gully is a bed of Vetiver. Alain Ndona is the installer. Imagine the sediment that these gullies (originating as highway drains) pour into downstream rivers.

UPPER CATCHMENTS OFTEN HAVE “POINT SOURCE EROSION PROBLEMS” CREATED BY LANDSLIDES AND CONSTRUCTION SITES (ROADS). THESE SOURCES OF SEDIMENT IF NOT FIXED WILL ENTER THE DRAINAGE SYSTEM AND WILL END UP IN THE RIVERS AND LAKES.

ADDITIONALLY MINING SITES CAN CONTAMINATE SOIL AND WATER THAT WILL POLLUTE DOWNSTREAM WATER BODIES.

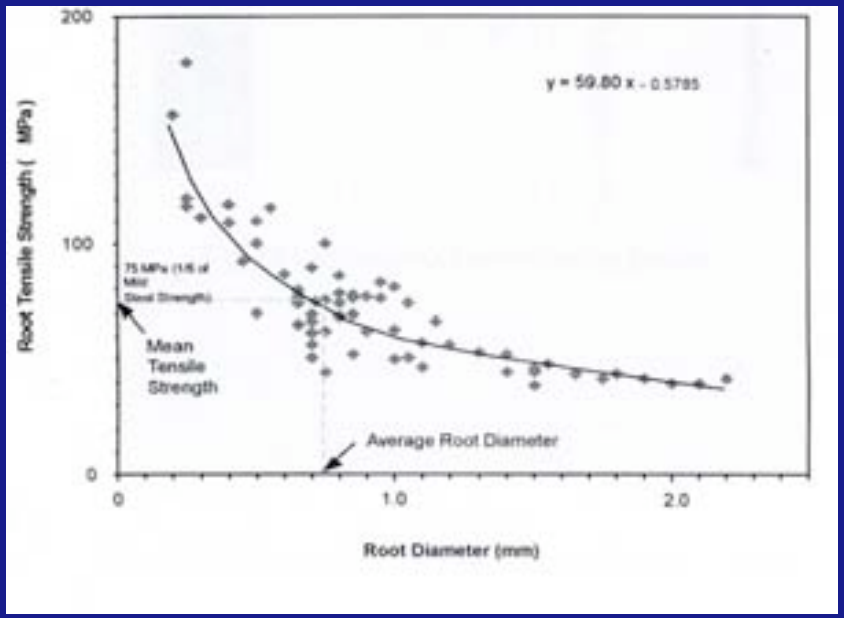
VETIVER SYSTEM CAN BE USED AS A MITIGATION TOOL

VETIVER FOR UPPER CATCHMENT SLOPE STABILIZATION

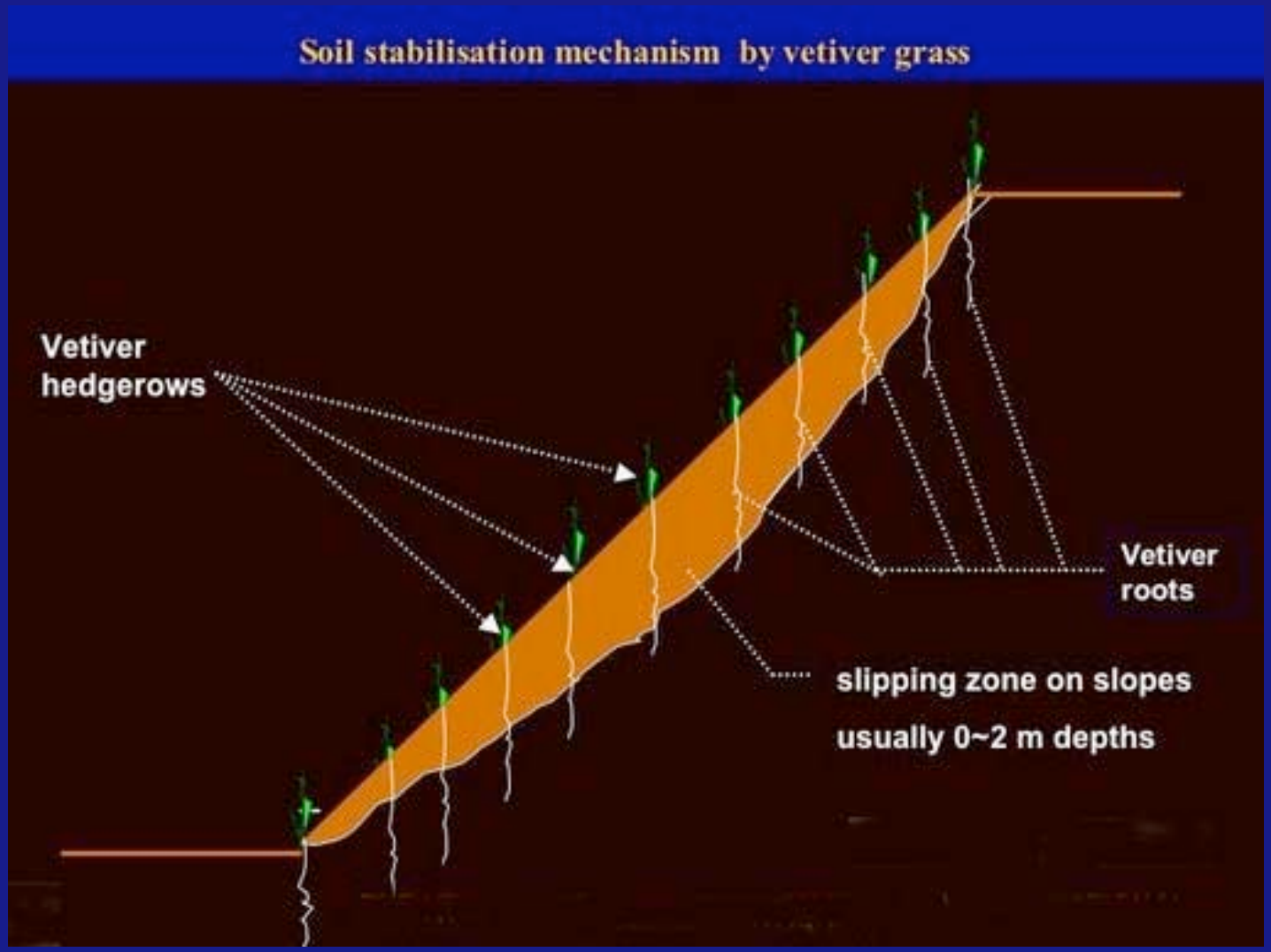
Tensile strength of vetiver roots:

- Tensile strength increases with reduction in root diameter, i.e. stronger fine roots provide higher resistance than larger roots.
- Tensile strength of vetiver roots varies between 40-180 MPa for the range of root diameter between 0.2-2.2 mm.

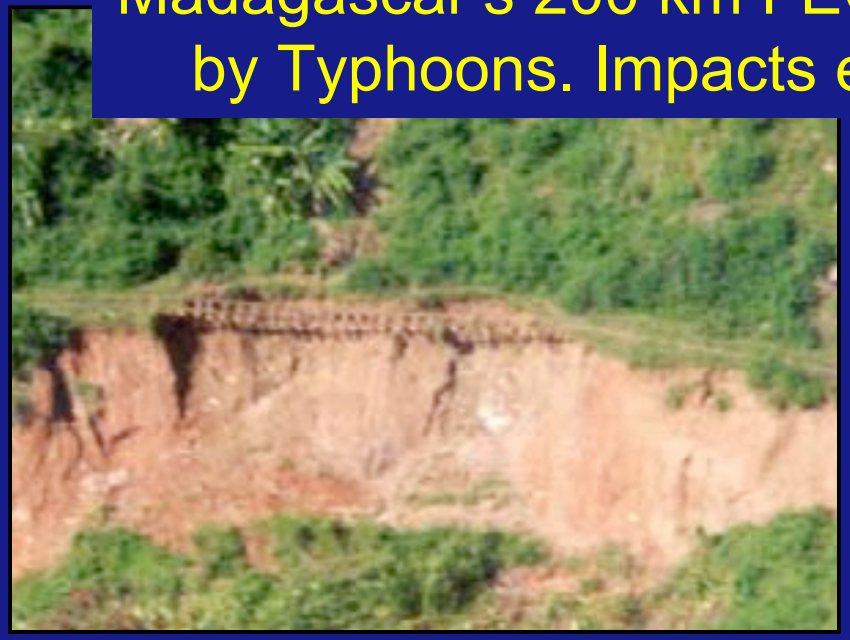
- Mean design tensile strength is 75 MPa (app. 1/6 of mild steel) at 0.7-0.8 mm root diameter - the most common size of roots.
- This indicates vetiver roots are as strong as, even stronger than many hardwood species (Hengchaovanich and Nilaweera, 1996).



HOW THE VETIVER SYSTEM WORKS?
A "LIVING SOIL NAIL"



Madagascar's 200 km FEC Railroad annually destroyed by Typhoons. Impacts economy of 200,000 people



FARMER AND COMMUNITY VETIVER PLANTING ON FEC RAILWAY RIGHT OF WAY

Community, social and land issues were very important, and had to be solved for a successful Outcome. Farmers were able to choose a combination of up to 6 crop models, all included Vetiver.

COMPLETE, STABLE, AND PRODUCTIVE

Construction of highways causes numerous problems

Unprotected highway fill (left) ends up in the nearby river (right), polluting the water supply of thousands downstream users.

This cut (left) was not stabilized and slipped (right) blocking traffic)

Vetiver protects the cut slope of a major highway in Vietnam

VETIVER FOR DYKE, CANAL, AND RIVER BANK STABILIZATION

A section of anti-salinity dyke in Vietnam

The same site after several months (right).

UPPER CATCHMENTS AND LAKE PLAIN AREAS CAN BE THE POINT SOURCE OF POLLUTANTS, BOTH SEDIMENT AND CHEMCALS

THE VETIVER SYSTEM CAN PROVIDE MITIGATION FOR THESE

Some Special Characteristics of Vetiver Suitable for Bio-filter Strips

Stiff and erect stems which can withstand fast flow.

Forming a thick living barrier which slows and spreads runoff and traps both fine and coarse sediment.

Deep root system binding the soil against erosion.

Highly tolerant to adverse growing conditions such as acidity, sodicity, alkalinity, salinity, drought, water logging and extreme temperature.

Highly tolerant to pollutants, agrochemicals and heavy metals, detoxification of industrial and agrochemicals in wetlands.

Vetiver grass:
A fully mature plant showing stiff and erect stems with no stolons or rhizhomes. Vetiver grass flowers but it sets no seed

Forming a thick hedge when mature

When planted close together, vetiver plants form an effective filter

Strong current flattened the native grass but not vetiver on this waterway on the Darling Downs

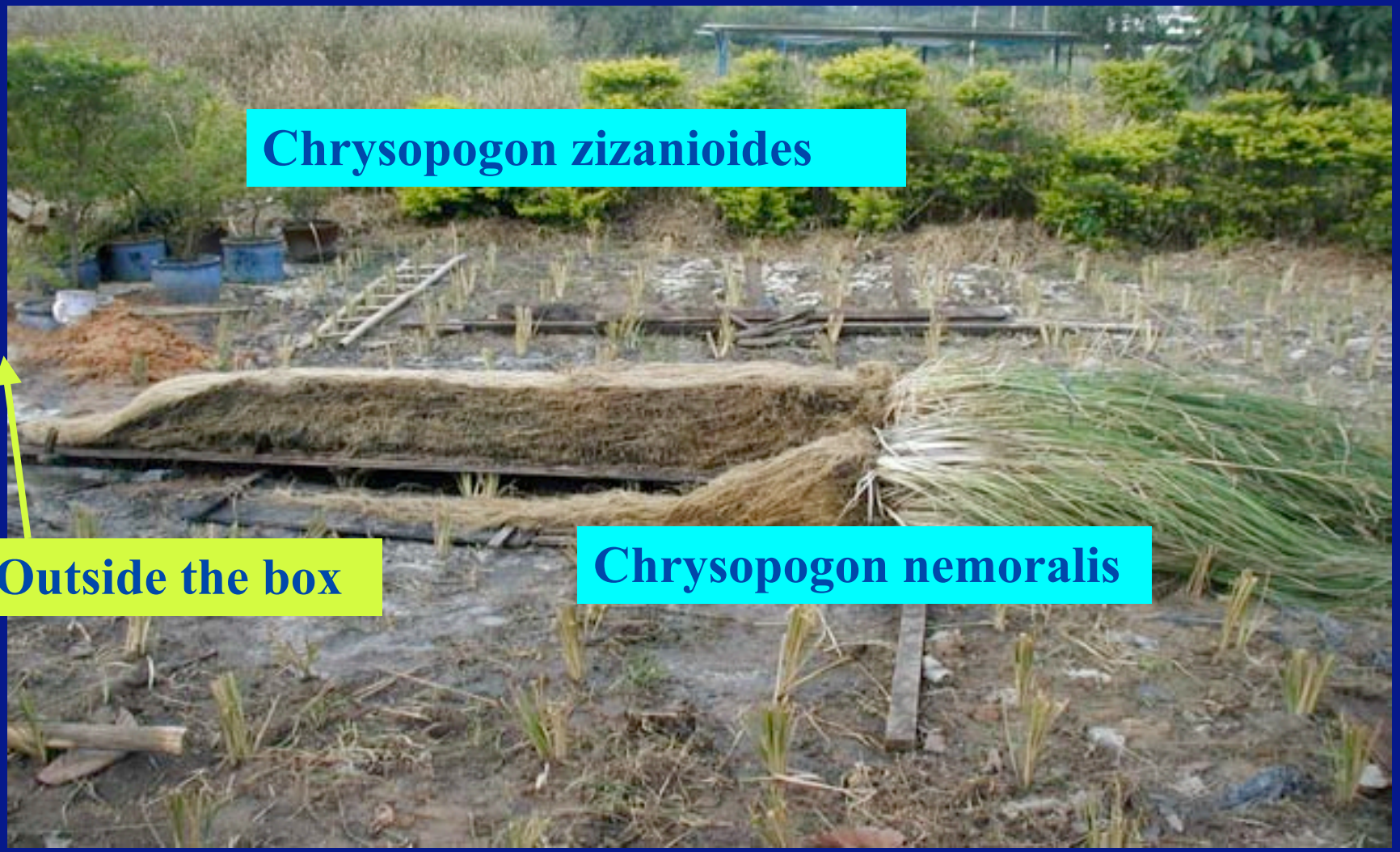
Trapping coarse sediment

Even at this young age the stiff stem is strong enough to trap large size gravel at a quarry

Deep, extensive and penetrating root system, providing extremely firm anchor against water flows

One year old: 3.3m deep

ALWAYS USE NON FERTILE CHRYSOPGON ZIZNANIOIDES



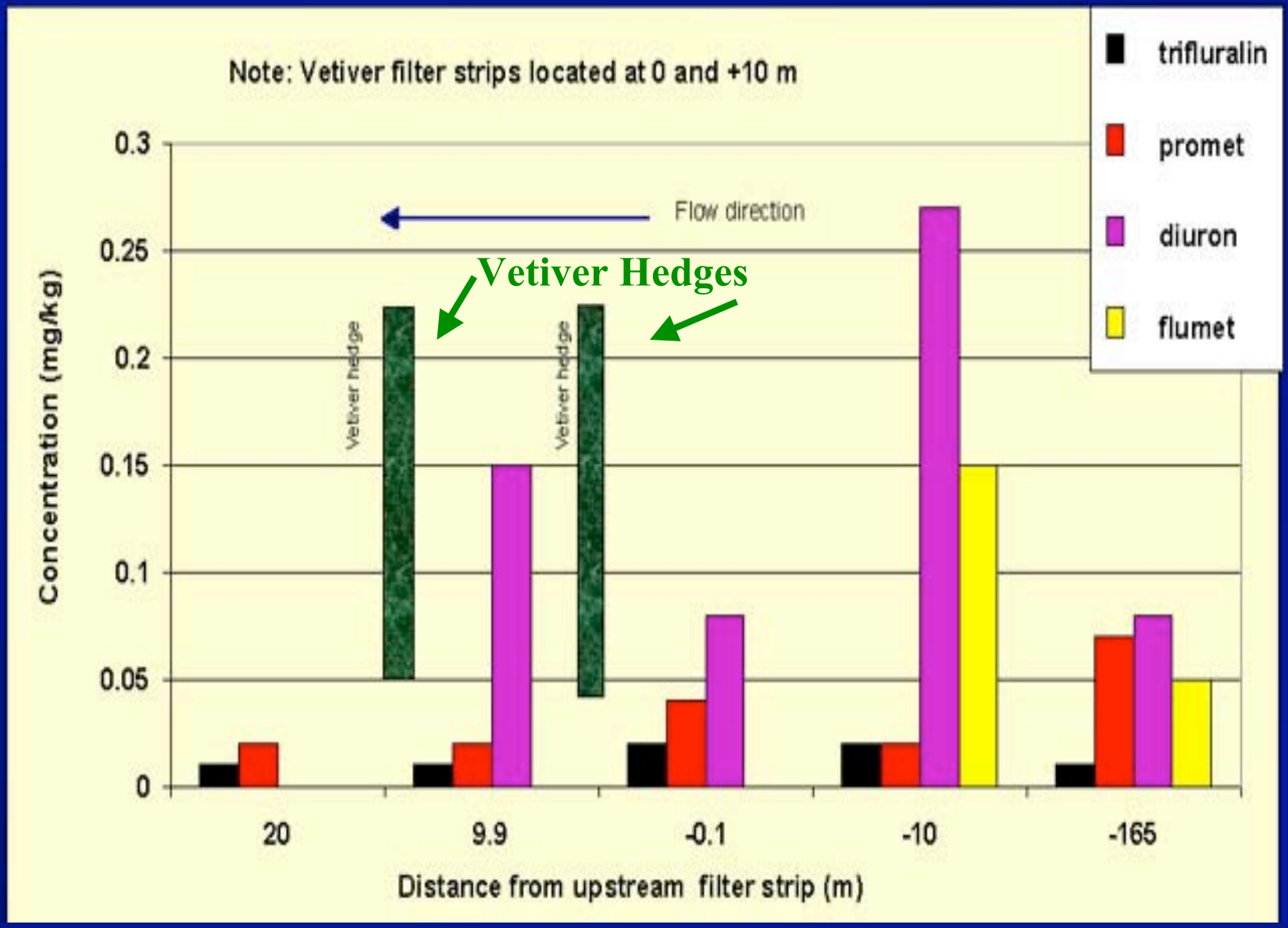
Bio-filter

Trapping sediment in agricultural lands

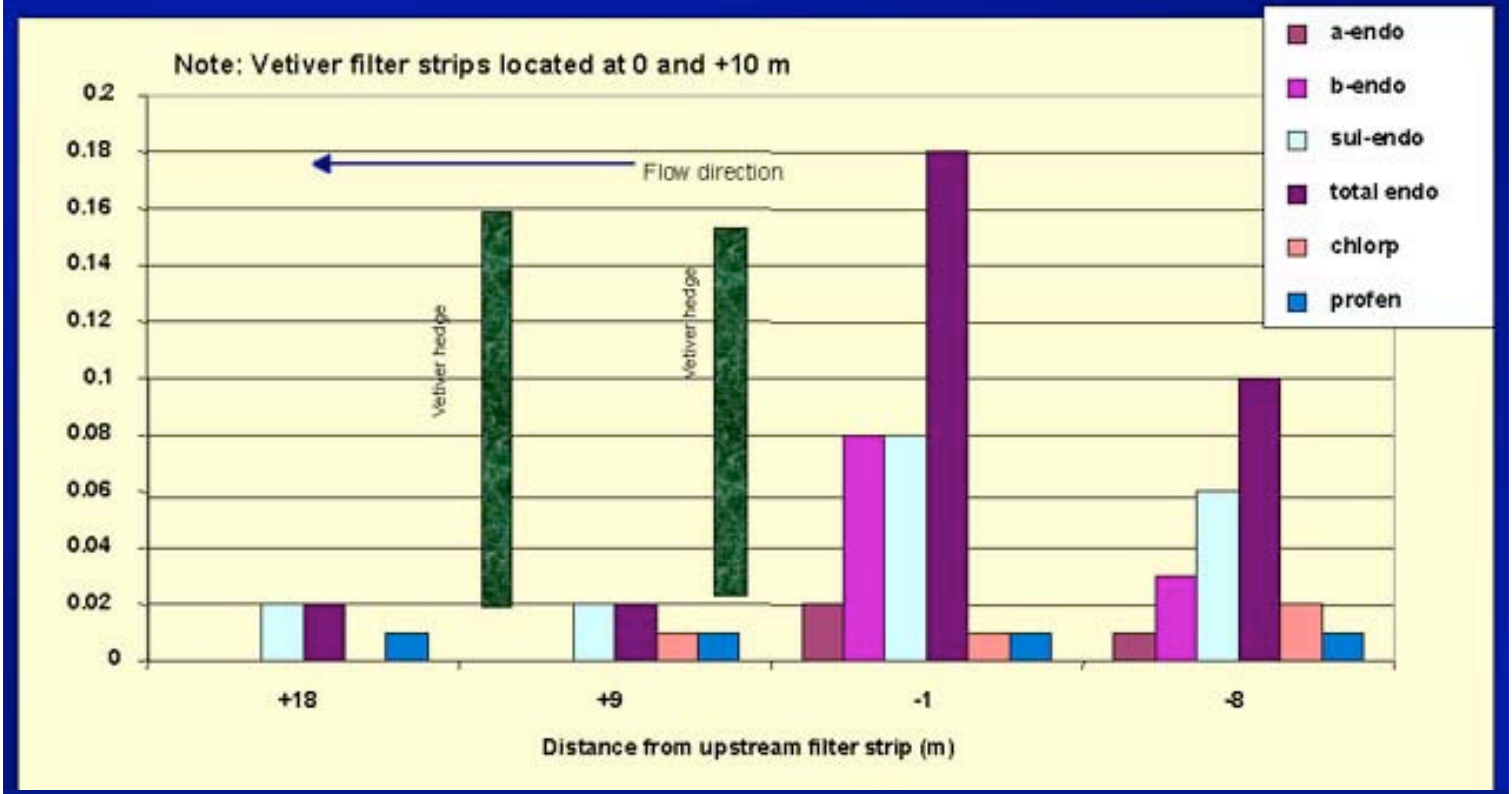
BIO-FILTER: For sediment control in irrigated cotton farm

Trapping sediment and fine particles in cotton field in Emerald, Australia (black cotton soil)

Trapping herbicides on cotton farms in central Queensland



Trapping Insecticides



BIO-FILTER: Filter strip across a waterway of a sugarcane farm

A well established filter strip across a waterway of a sugarcane farm

Waterway stabilisation and sediment control on a cane farm, Mackay, Australia

Planting across gully across a waterway of a grain farm

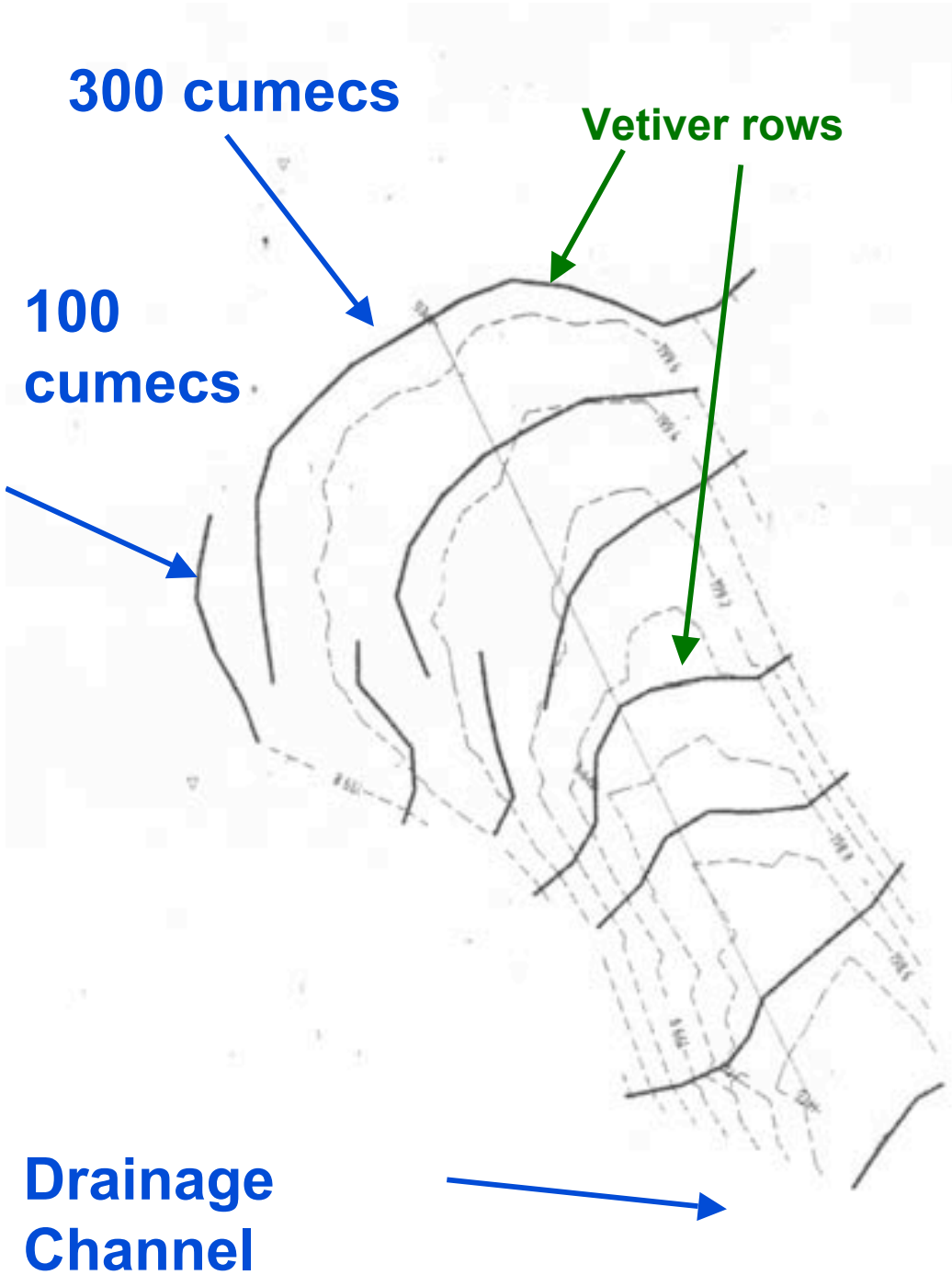
Two and a half year later

More than 500mm of silt are trapped each year

Three and a half year later, the gully floor was full

Flood Erosion Control
And
The Spreading out of Sediment

Control of Erosion Sedimentation caused by flash flooding

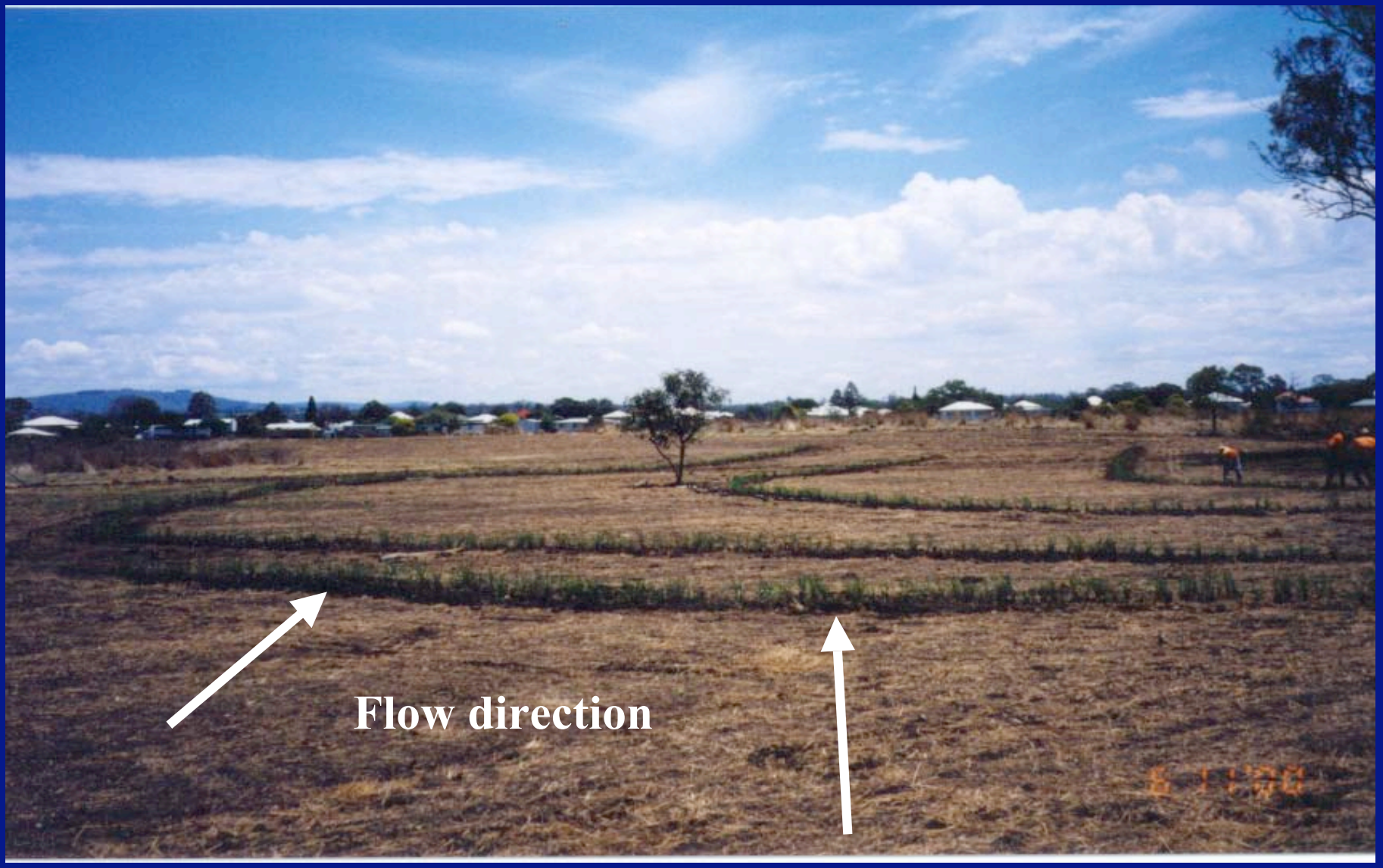


Flood erosion control in drainage channel

Vetiver hedges were established to spread water out and also to divert water to the drain

This could be done across small rivers before discharging into the Lakes

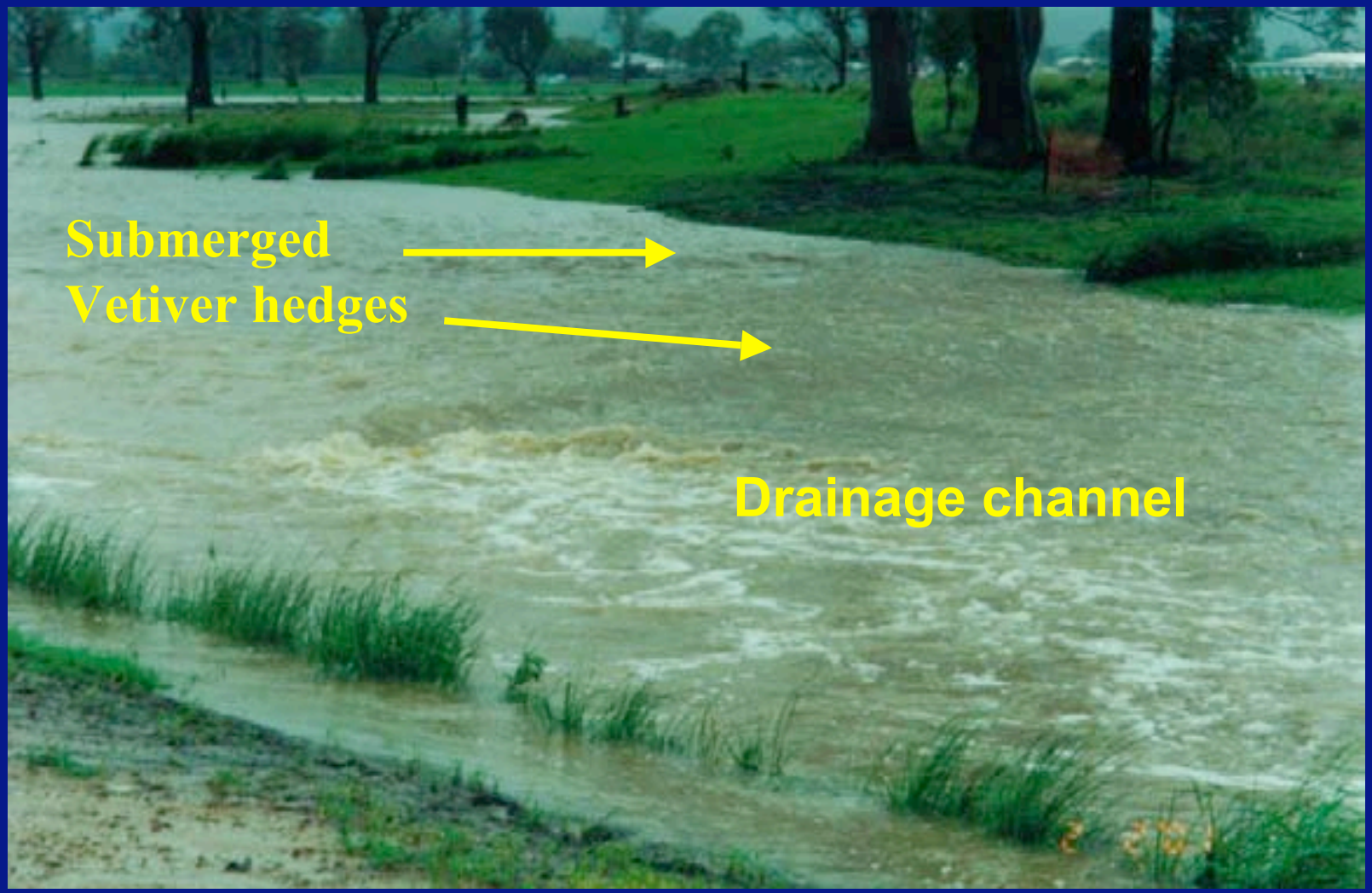
Looking sideway towards the channel opening



A big storm hit the area 3 months after planting and the whole site was flooded (Upper section)

Very fast flow flattened and inundated most of the hedges. The velocity was estimated up to 5m/sec in some areas

Further down stream



Although only 3 month old, the young hedges provide a very effective protection with only minimal erosion at the head of the channel

Strong flow exposed part of the crowns but failed to dislodge the plants

Trapping sediment

Flood erosion control on the flood plain

Vetiver hedges planted on the flood plain to protect crop from flood erosion (on black cotton soil)

Providing effective protection to young crop during flood

Vetiver hedgerow protects crops against flood damage and stops erosion

Providing effective protection to bare fallow land against flood flow (down slope from the hedge)

Protecting the young crop and trapping silt on the up slope side of the hedge

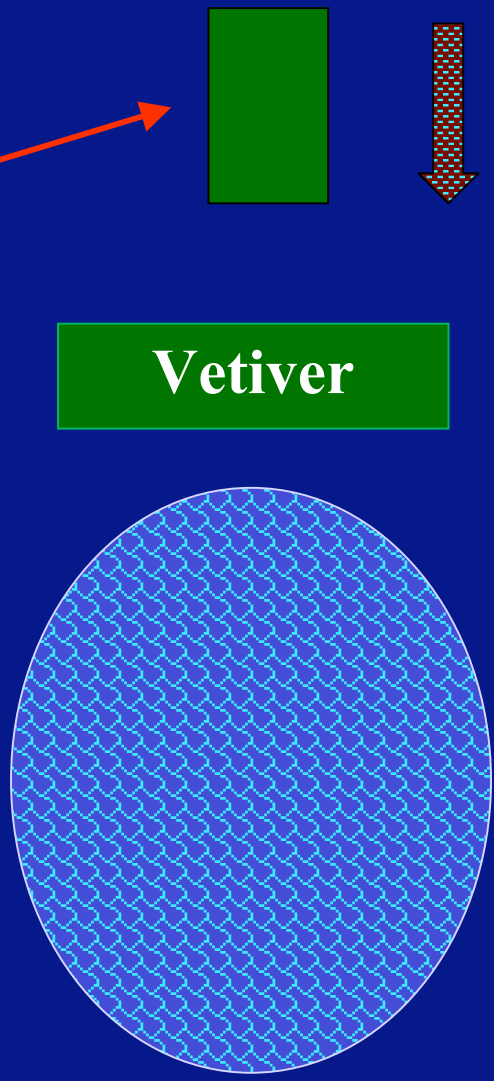
A very productive sorghum crop following flooding. Fully protected by a vetiver hedgerow

Canals and drains can be protected with Vetiver, this will stabilize slope, reduce maintenance costs, and help keep chemicals from entering lakes

The same site at planting (up right) and after several months (lower right). The grass in canal bed is not Vetiver

Proposed Strategy for Sediment Control

- Implement Vetiver Erosion Control measures as practiced in Ethiopia
- Planting vetiver on the flood plain surrounding the lake to trap sediment coming to the lake



SEWAGE AND INDUSTRIAL DISCHARGE INTO LAKES

COMPRISING:

IMPROPERLY TREATED URBAN PUBLIC SEWAGE

NON EXISTANT OR POORLY MAINTAINED PRIVATE SEPTIC SYSTEMS

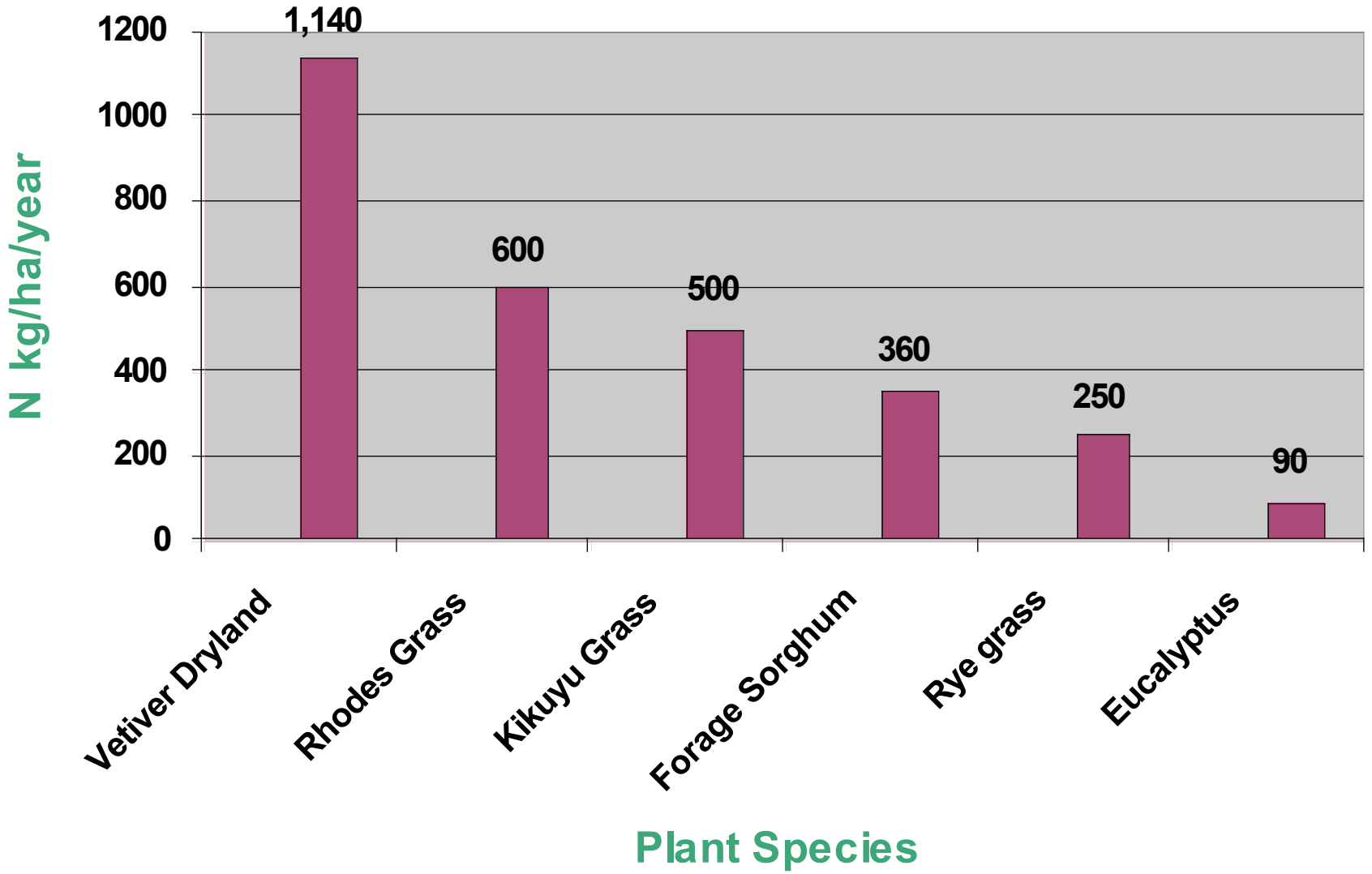
TOXIC EFFLUENT FROM INDUSTRIAL ENTERPRISES

MITIGATE THESE PROBLEMS WITH VETIVER SYSTEM

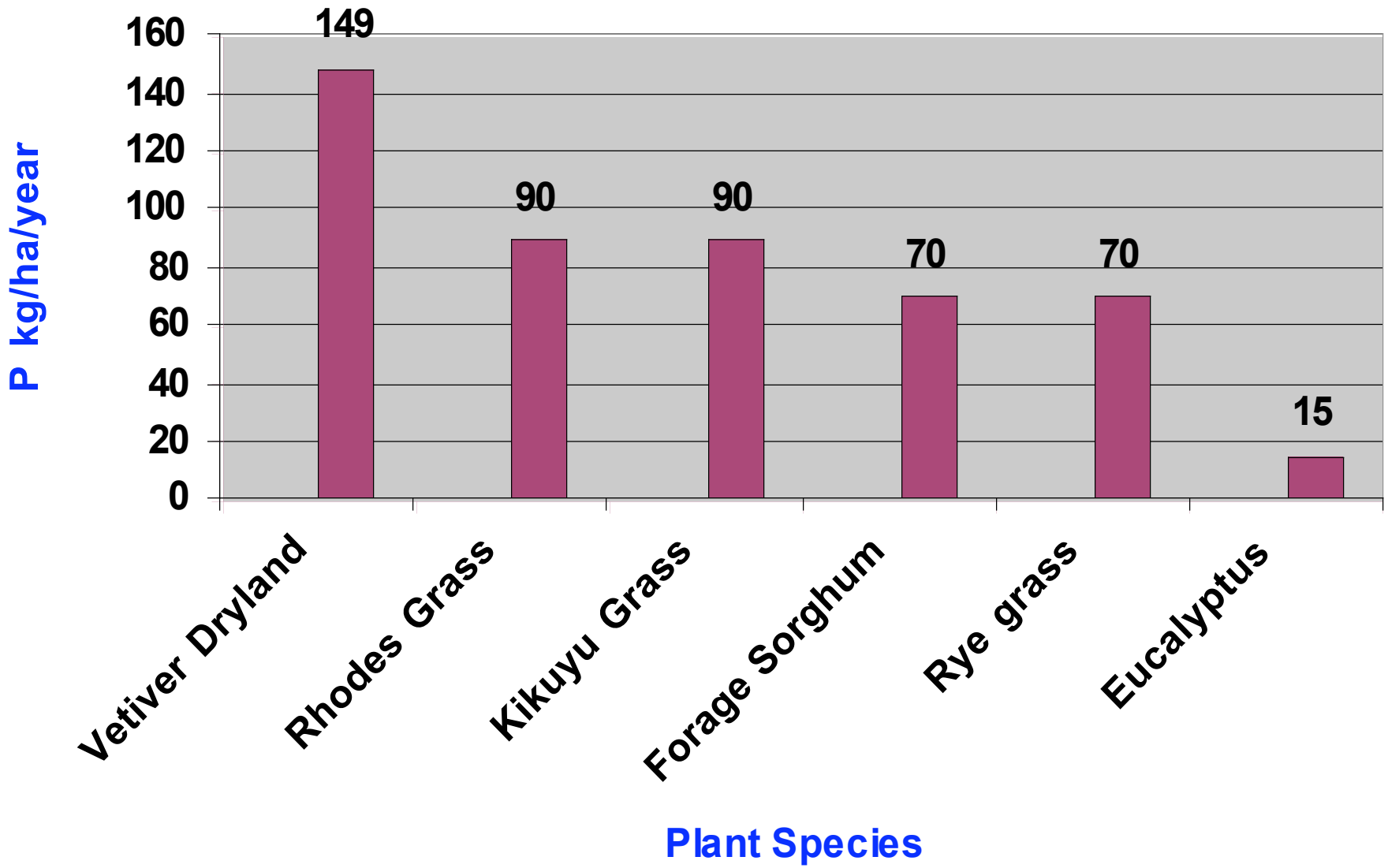
SPECIAL CHARACTERISTICS OF VETIVER SUITABLE FOR WASTEWATER TREATMENT

- Very high capacity for N and P uptake under Dry land, Wetland or Hydroponics conditions
- Very fast growth with very high water consumption under wet conditions
- Biomass up to 132t/ha
- Tolerant high levels of herbicides and pesticides
- Highly tolerant to heavy metal toxicities

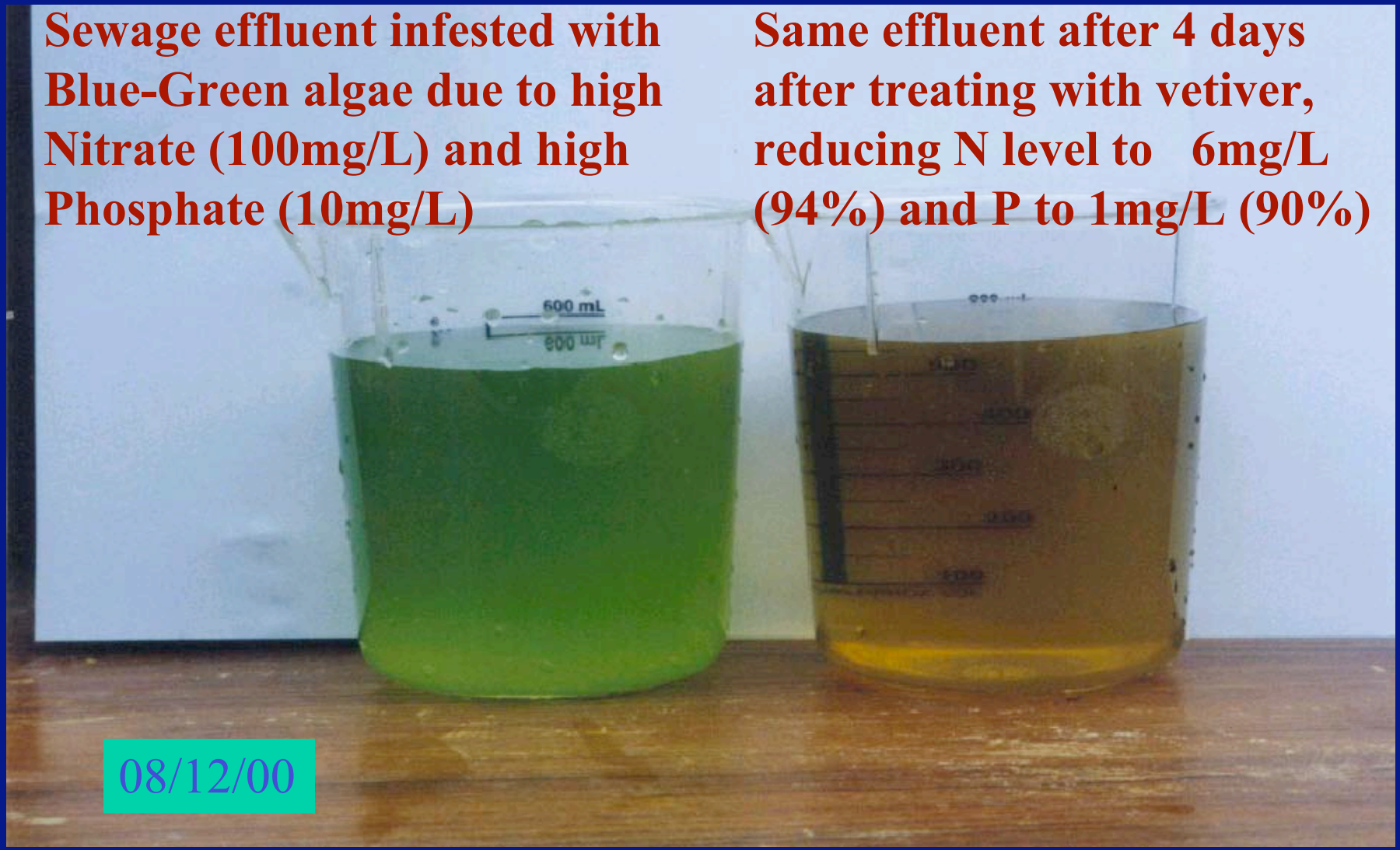
NITROGEN UPTAKE



PHOSPHORUS UPTAKE

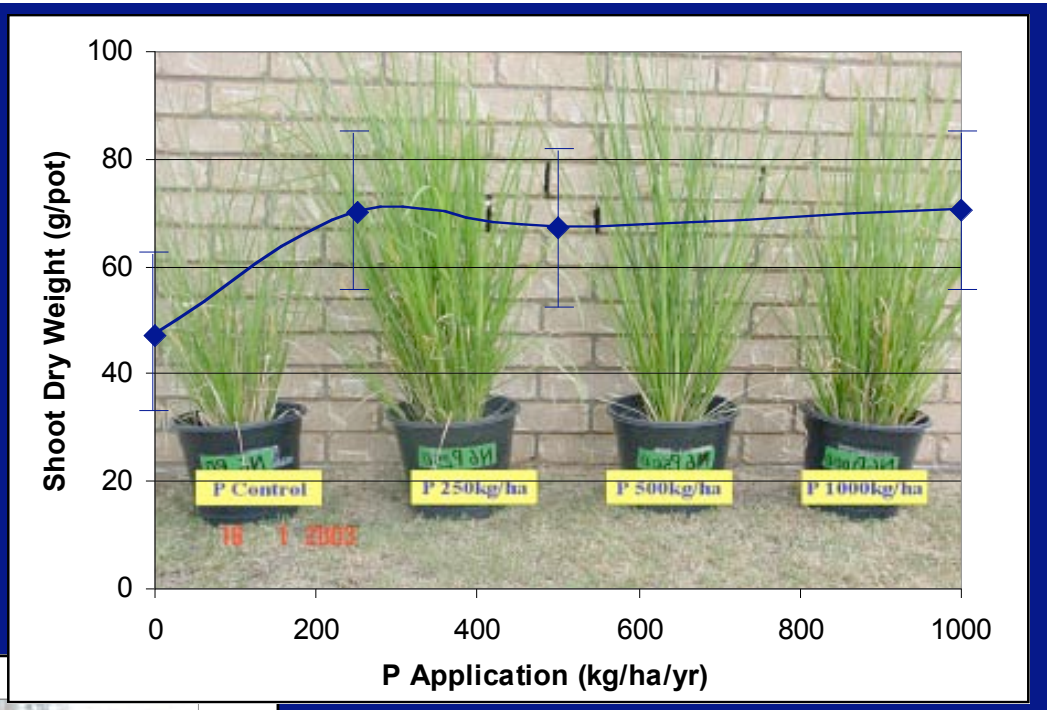


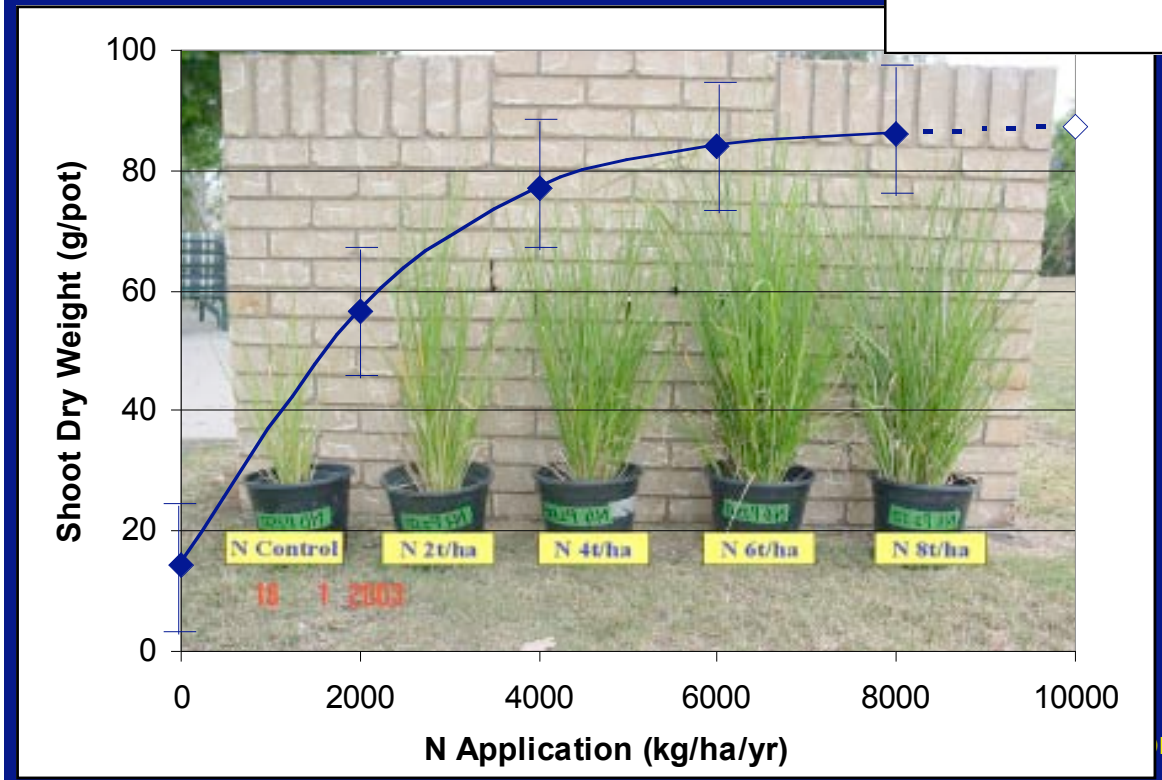
High N and P removal: **With high capacity of removing N and P in polluted water, vetiver cleaned up blue green algae in 4 days**



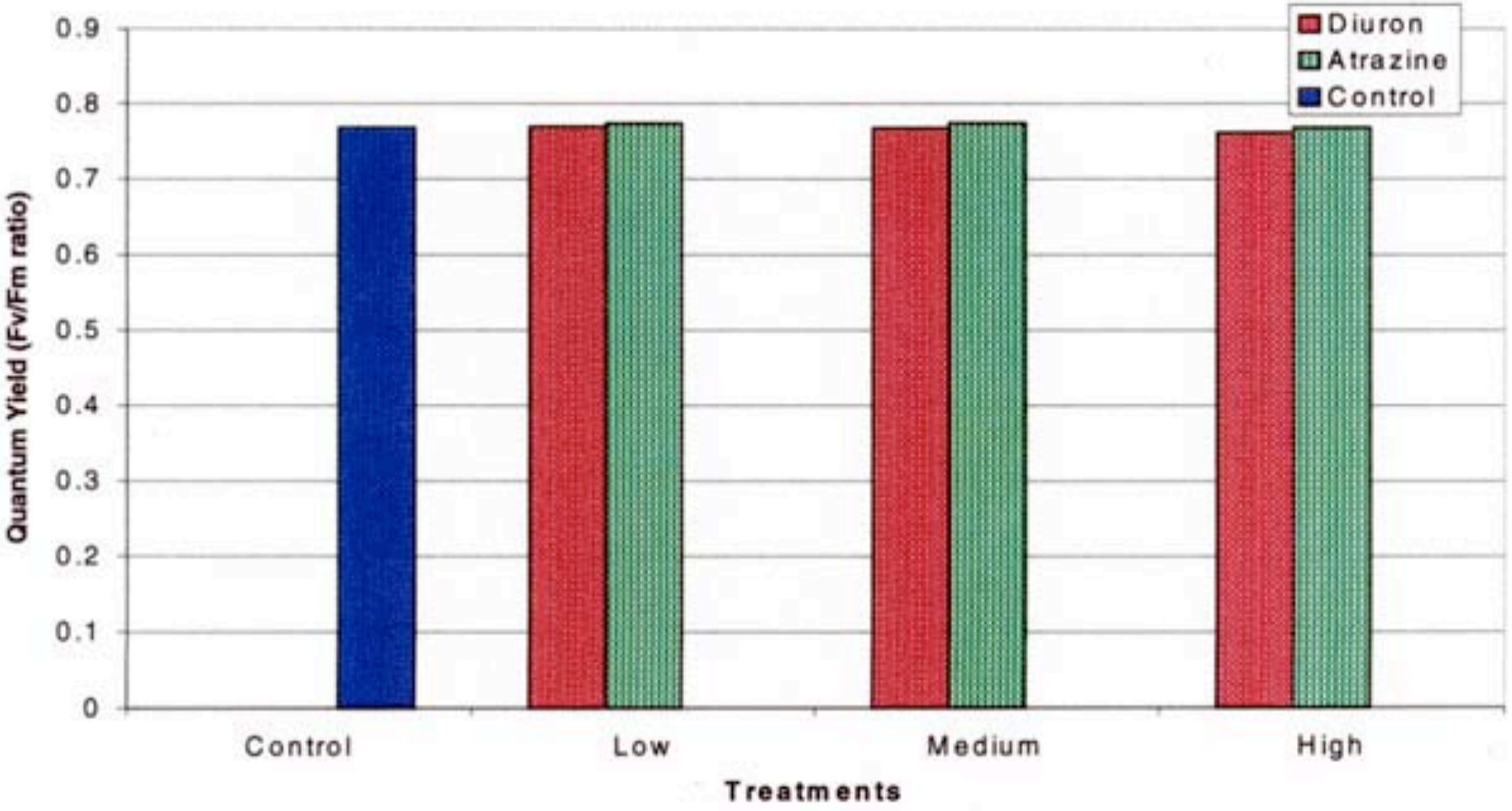
Vetiver roots thrive in high N and P sewage effluent

Tolerance to extremely high levels of nutrients

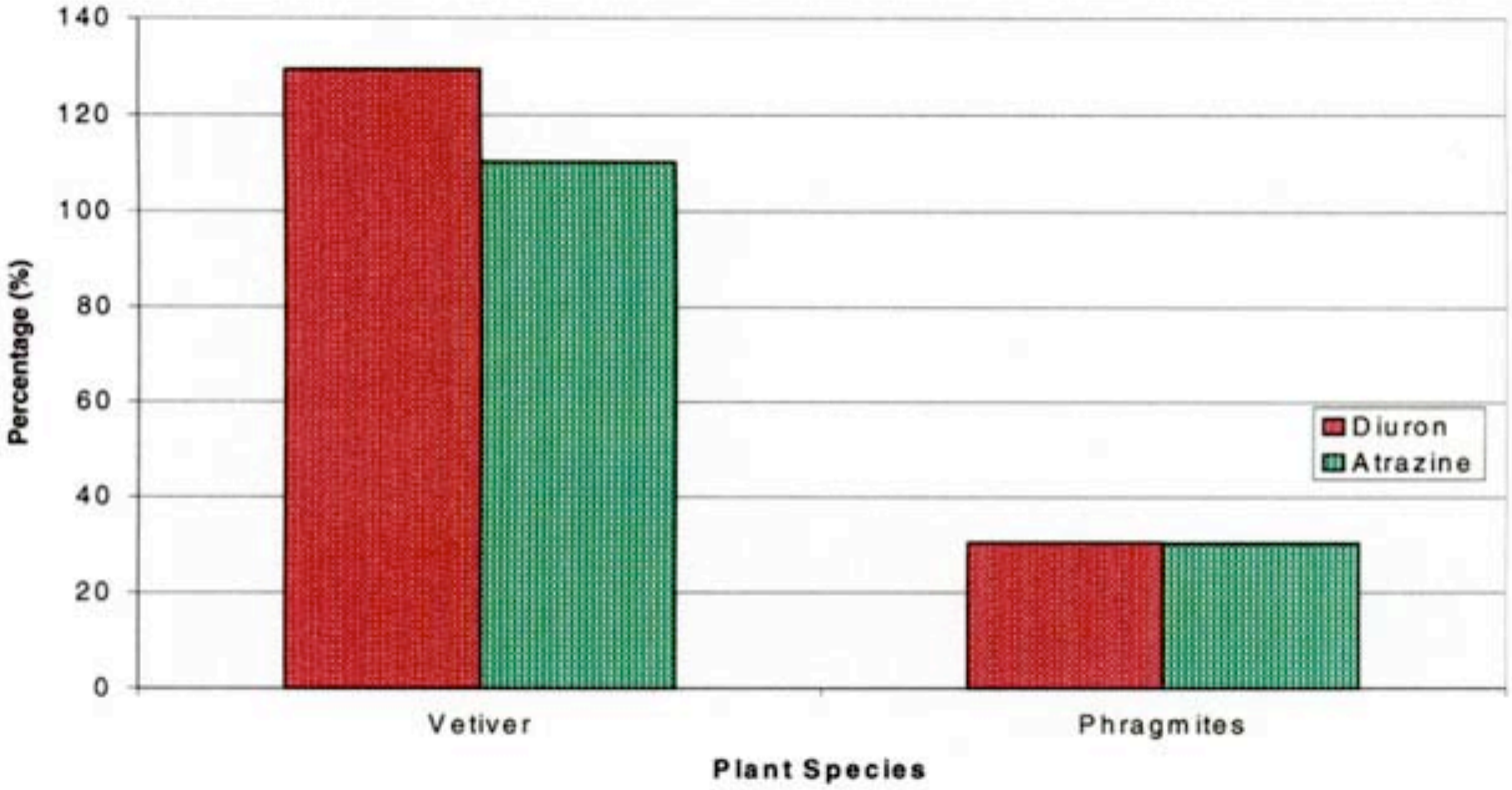




Very high concentration of Diuron and Atrazine herbicides in wetland did not affect vetiver growth



While high concentration of herbicides did not affect vetiver, growth of a common wet plant species Phragmites was severely reduces.

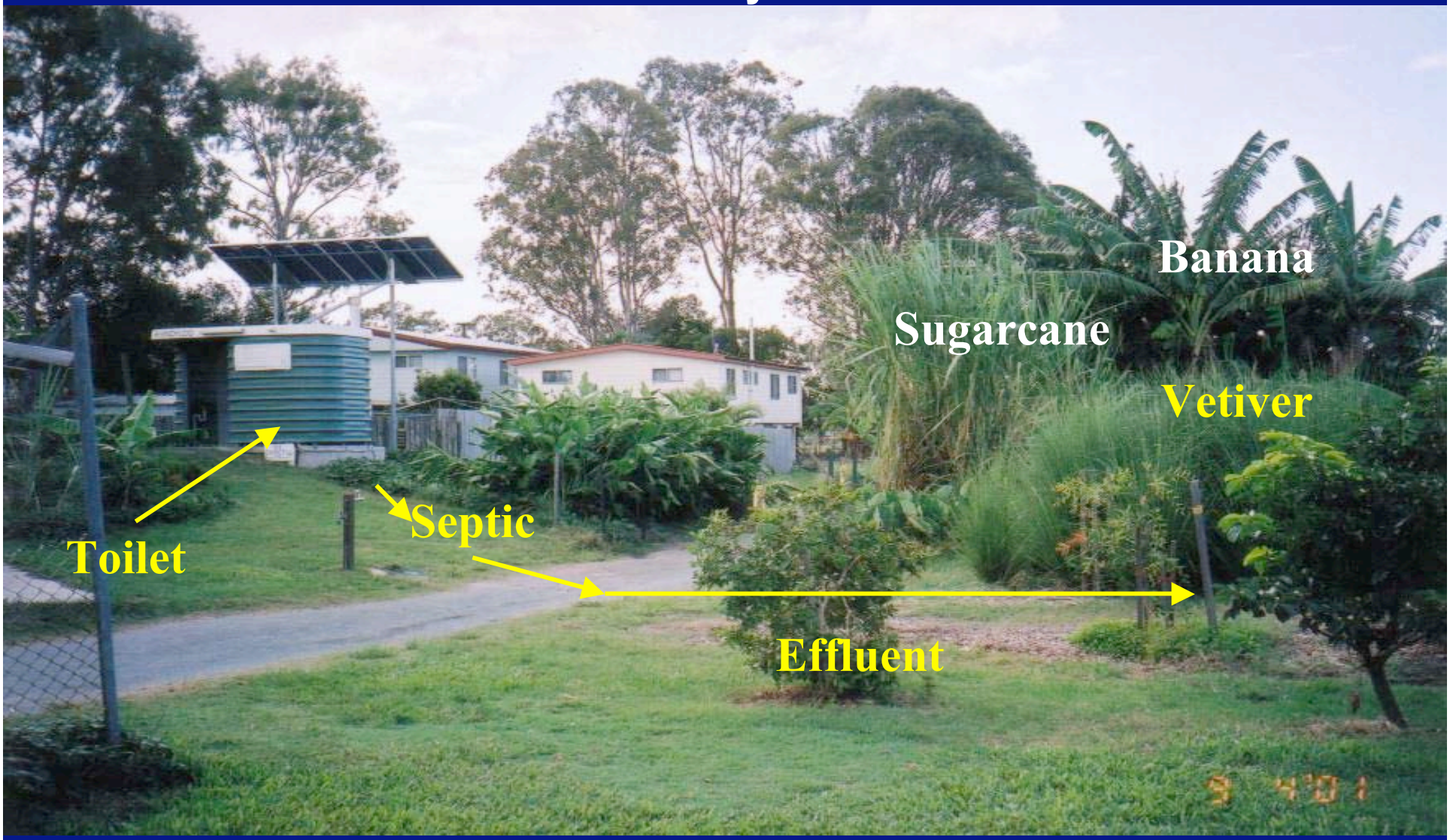


APPLICATION OF VETIVER SYSTEM FOR EFFLUENT TREATMENT

Domestic effluent

Municipal sewage effluent

Domestic effluent : Vetiver was the most effective plant in absorbing effluent discharge from a toilet block on a Community Center

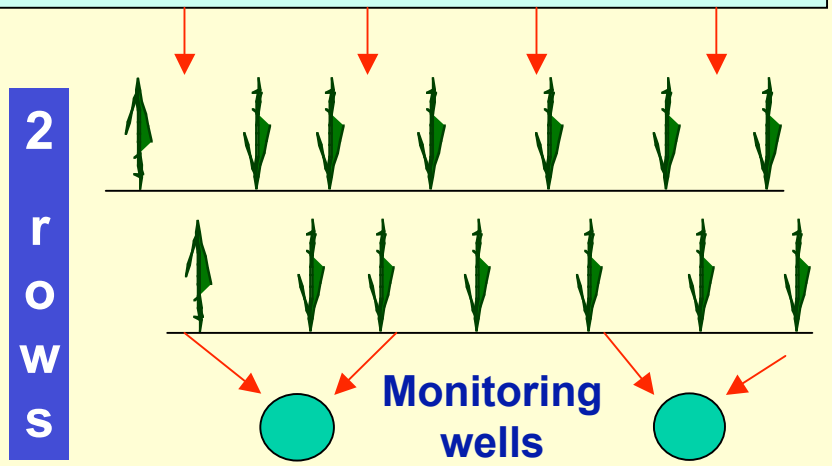


This stand of vetiver absorbed all the effluent discharge from the toilet block, note the luxuriant growth, 5 months after planting

Six months after planting this stand of 100 plants absorbs all the discharge from the toilet block

Effectiveness of Vetiver in reducing N level in domestic blackwater

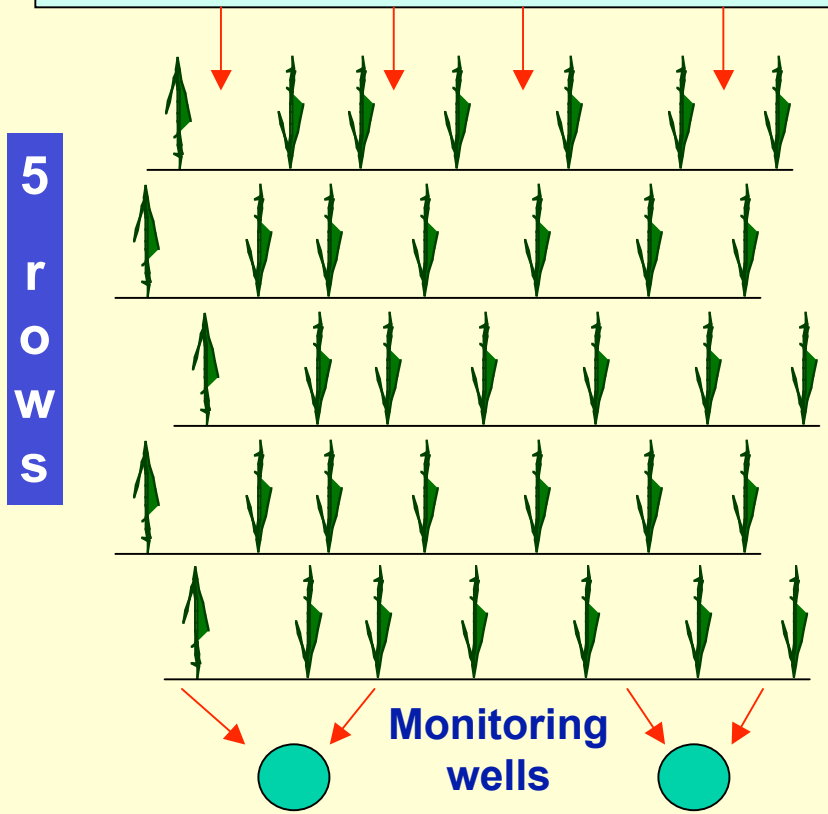
Entry: Total N level at 95.2mg/L



Exit: Total N level at 16mg/L

or a reduction of **83%**

Entry: Total N level at 95.2mg/L

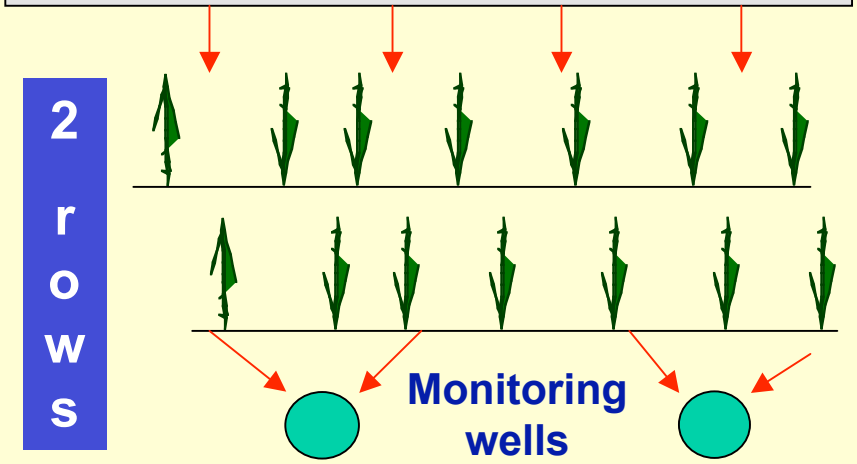


Exit: Total N level at 1.2mg/L

or a reduction of **99%**

Effectiveness of Vetiver in reducing P level in domestic blackwater

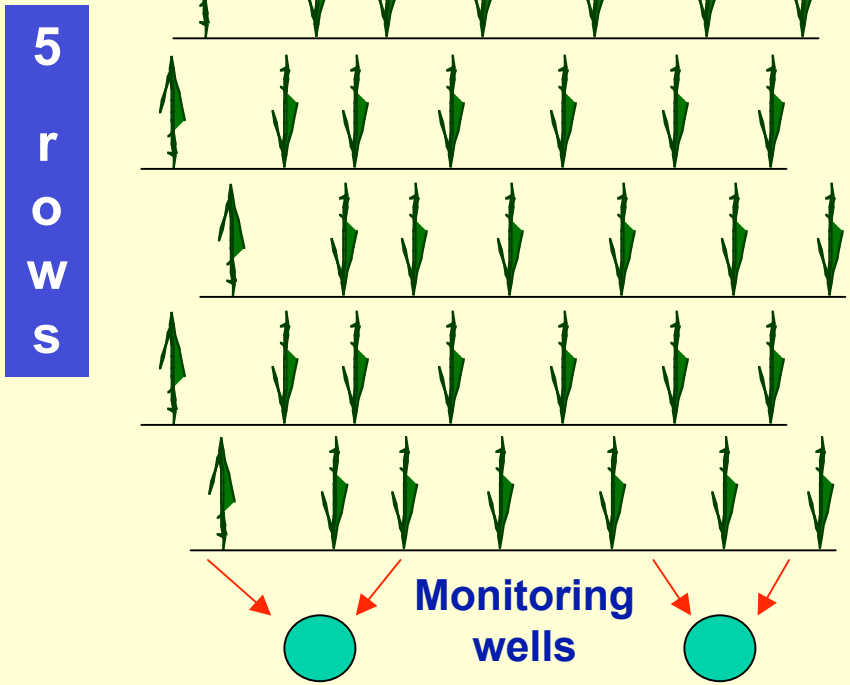
Entry: **Total P level at 1.3mg/L**



Exit: **Total P level at 0.24mg/L**

or a reduction of 82%

Entry: **Total P level at 1.3mg/L**



Exit: **Total P level at 0.20mg/L**

or a reduction of 85%

Municipal Sewage Effluent

Treatment in two phases:

Pre treating effluent in storage pond with vetiver pontoons and pond edges.

Ephemeral Wetlands to treat the main body of effluent to EPA recommended level of N and P.

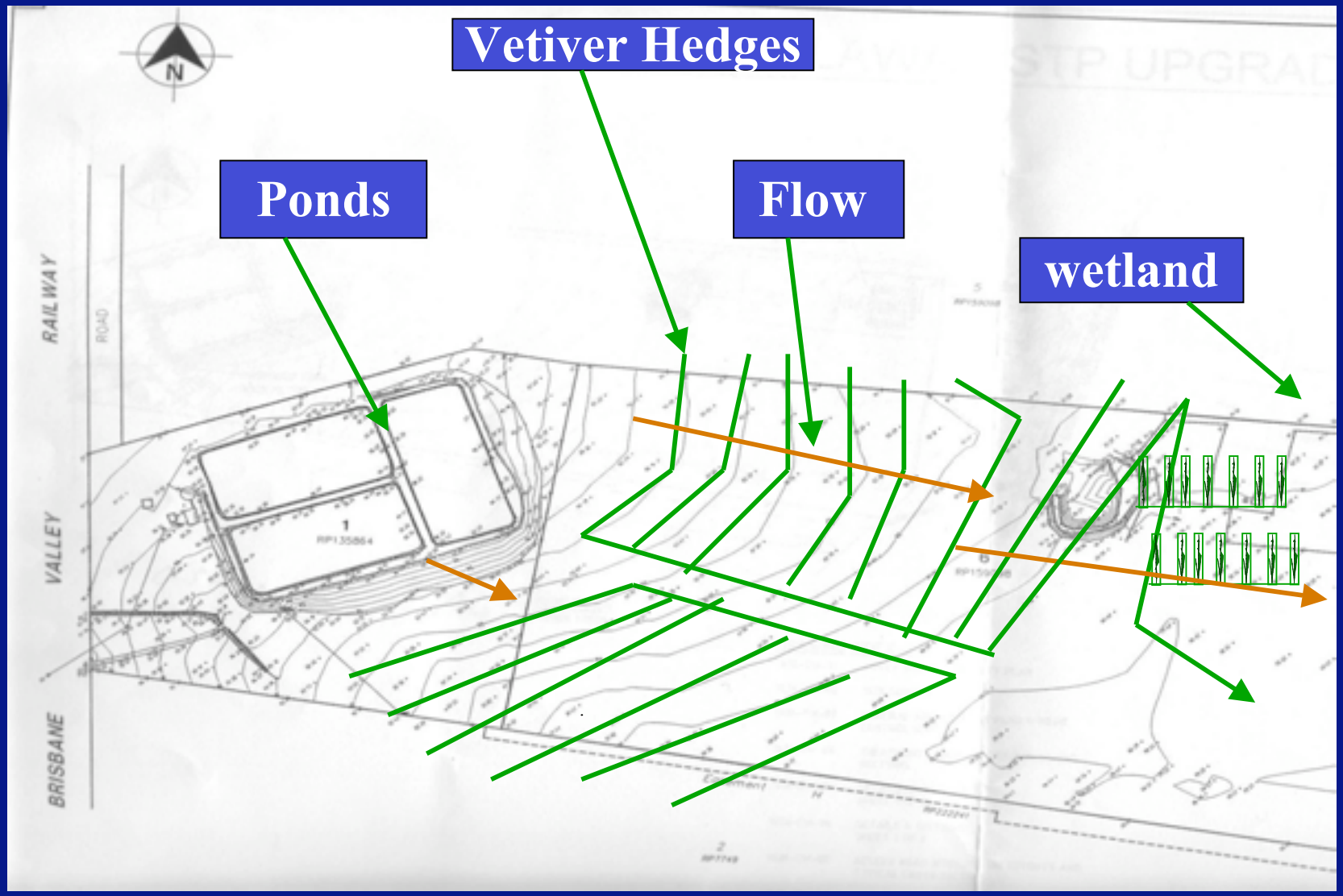
IN KENYA THIS SEWAGE PLANT COULD USE SOME HELP!!

The are made from black cotton soil - the concrete slabs are useless and should be replaced by Vetiver (stability and phytoremediation). The top left image shows industrial toxic material that should have been prtereated before being discharged to this public utility. The pond at the right is a sort of wet land using Eucalypts. Not effective. Vetiver removes 10 times more phosphate and nitrate than Eucalypt. Typical of many badly performing sewage works.

A hospital sewage farm on Lake Awassa

This sewage effluent is being discharged into the Lake. The effluent needs further treatment, a Vetiver wetland would be a low cost and effective solution.

Municipal sewage plant incorporating Vetiver wetland. Diagrammatic layout of contour lines Vetiver planting



Municipal Effluent Treatment in Australia

First step:

Hydroponics treatment of effluent in ponds

Hydroponics treatment of intensive animal farm effluent

Grimshaw / Truong - May 2009

The

This vigorous growth is resulted from the effluent high nutrient load

Second step: Ephemeral wetland treatment of municipal sewage effluent in Australia

Ten months after planting

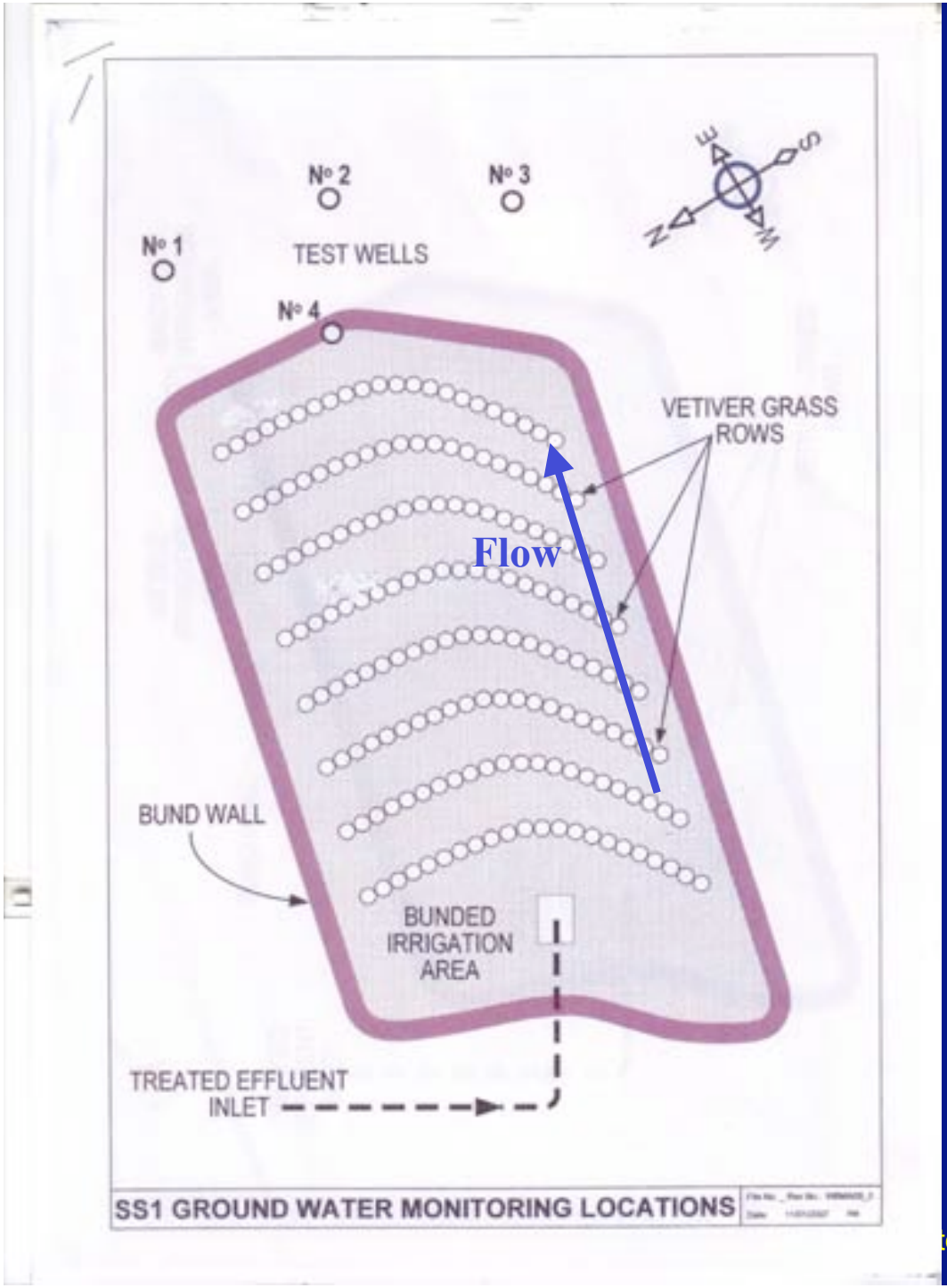
TEST RESULTS OF SEWERAGE EFFLUENT

(License Requirements in Brackets)

Tests	Plant Influent	2002/03 Results (9 month old)	2003/04 Results (18 month old)
PH (6.5 to 8.5)	7.3 to 8.0	9.0 to 10.0	7.6 to 9.2
D. Oxygen (2.0 minimum)	0 to 2 mg/L	12.5 to 20 mg/L	8.1 to 9.2 mg/L
5 Day BOD (20 - 40 mg/l max)	130 to 300 mg/L	29 to 70 mg/L	7 to 11 mg/L
Suspended Solids (30 - 60 mg/l max)	200 to 500 mg/L	45 to 140 mg/l	11 to 16 mg/l
Total Nitrogen (6.0 mg/l max)	30 to 80 mg/L	13 to 20 mg/L	4.1 to 5.7 mg/L
Total Phosphorous (3.0 mg/l max)	10 to 20 mg/L	4.6 to 8.8 mg/L	1.4 to 3.3 mg/L

APPLICATION OF THE VETIVER SYSTEM FOR SEWAGE EFFLUENT TREATMENT

Vetiver was planted to dispose sewage effluent from a small recreational airfield in Queensland, Australia



Planting Design

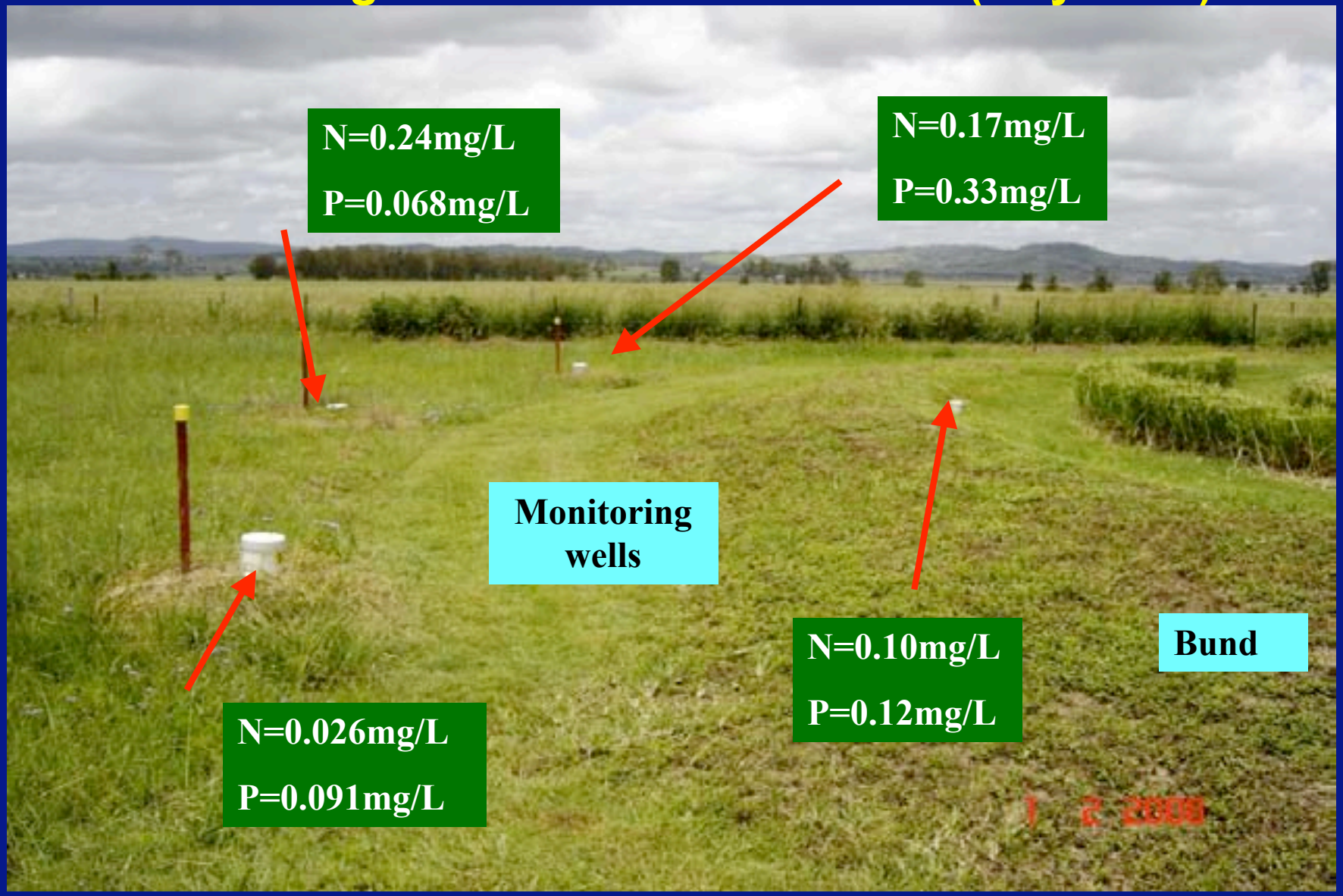
- 8 rows of vetiver 10m long each
-vInter-row spacing 1m
- Plant spacing 5/m
- Total plants 400
- Gravel trench 60cm deep
- Land area 100 sqm
- Bund wall W54 X H30cm

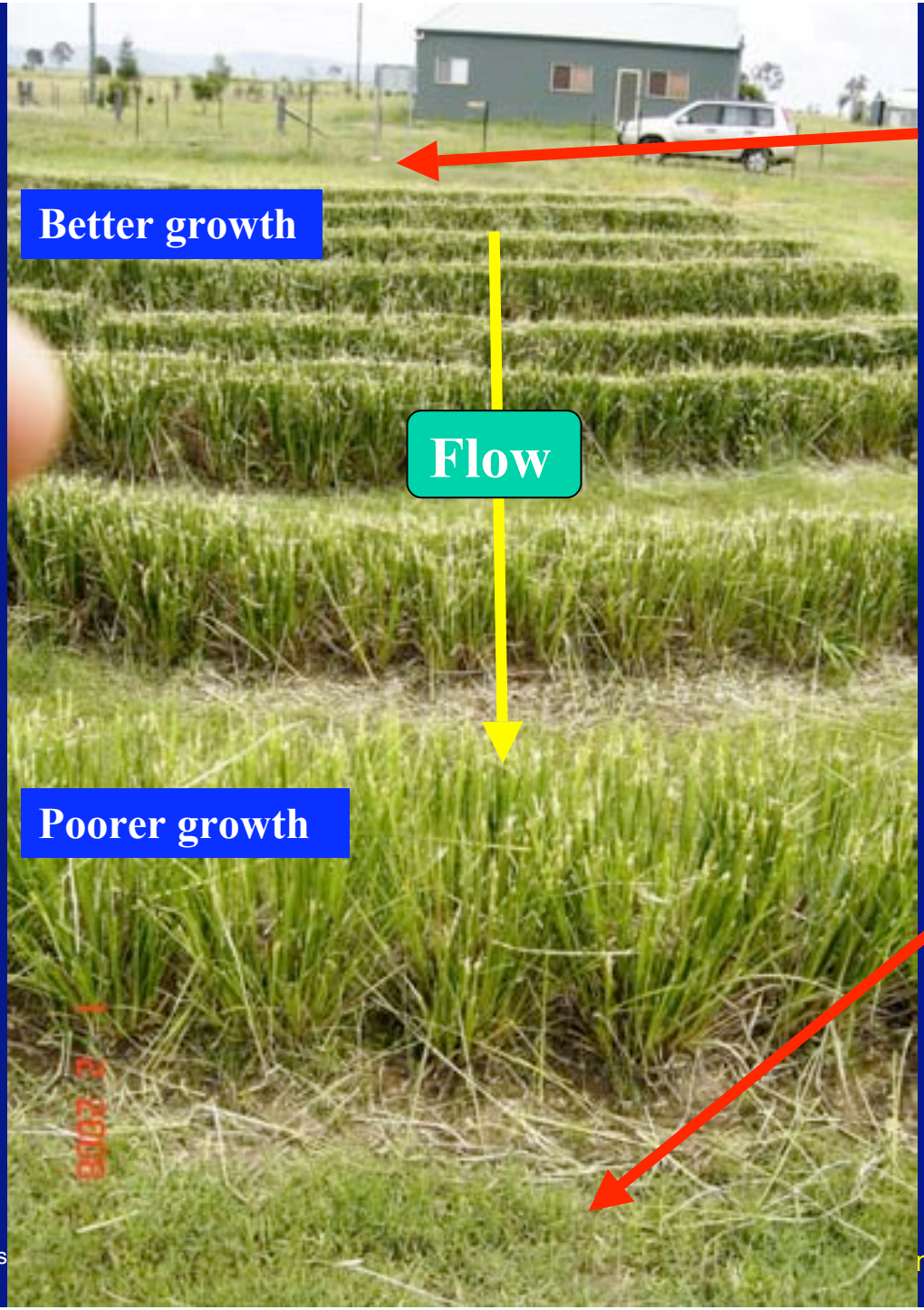
First year: The first few rows have excellent growth, but the last 3 rows are very poor due to lack of effluent

Third year:
Excellent growth, exceeding 2m.

Effluent inlet

Monitoring wells and nutrient levels (May 2008)





IN FLOW

Average daily flow: 1 670L

Average total N: 68mg/L

Average total P: 10.6mg/L

Average Faecal Coliform: >8 000

SUMMARY OF RESULTS

OUT FLOW

Average daily flow: Almost Nil*

Average total N: 0.13mg/L

Average total P: 0.152mg/L

Average Faecal Coliform: <10

* Only flow after heavy rain

Domestic Sewage Disposal

PC: Vant Hoff

Aceh, Indonesia

American Red Cross built 2 ,000 units and will build another 1,500 in 2009

Sewage Disposal

High School, Aceh, Indonesia

Sewage Disposal

Oberoi Resort Bali, Indonesia

PC: Vant Hoff

APPLICATION OF THE VETIVER SYSTEM FOR LANDFILL LEACHATE TREATMENT

Leachate Seepage Control

Landfill Leachate Seepage Control

Leachate after rain on the side slope of an 30 year old landfill

This leachate runoff is highly contaminated with Chromium, Cadmium, Copper, Lead and Zinc. It will eventually run into a nearby creek

Landfill Leachate Seepage

A thick stand of vetiver was planted at the outlet of the leachate seepage

Three months after planting

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Landfill Leachate Seepage

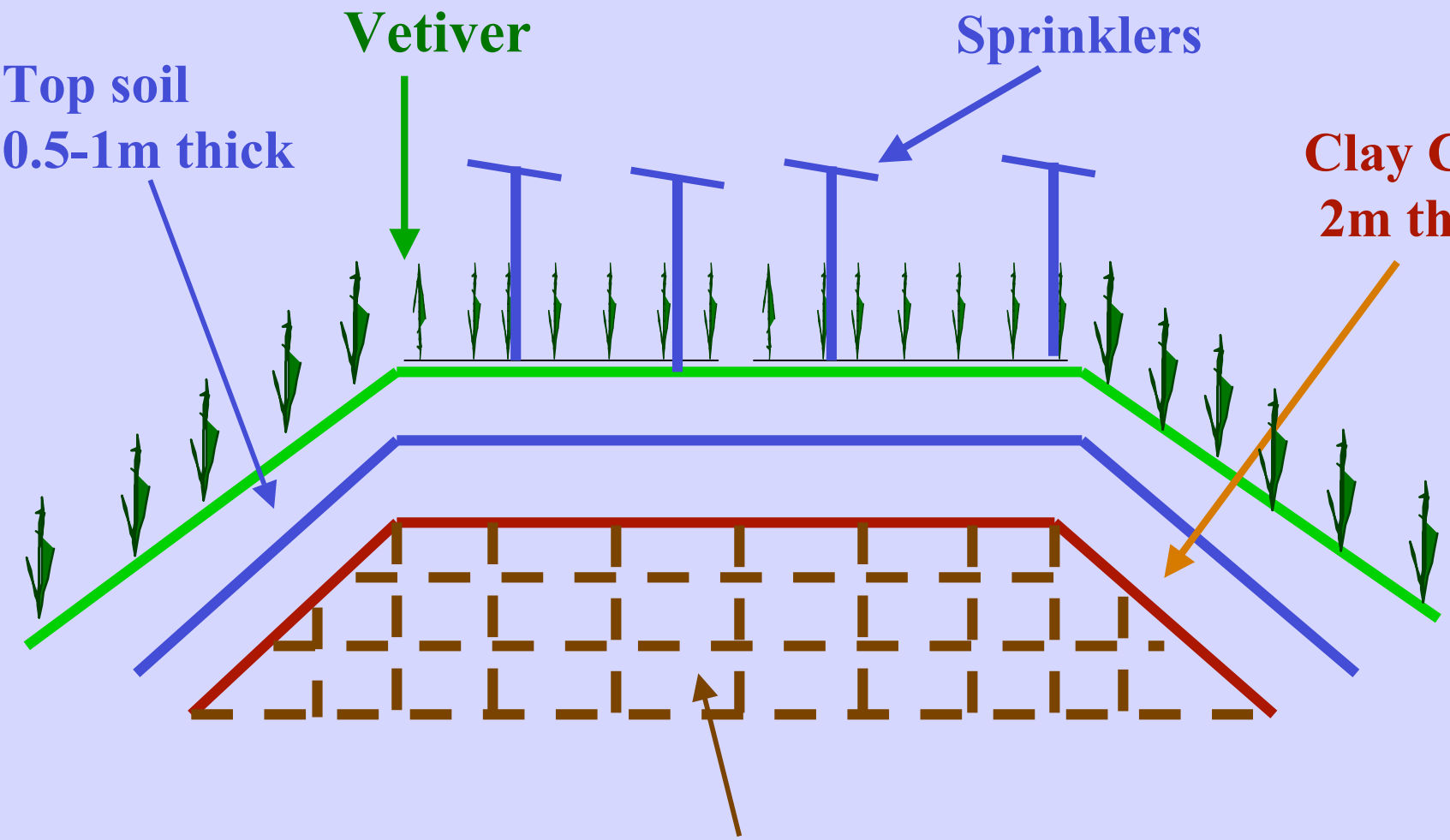
Twelve months after planting, excellent growth, unaffected by heavy metals contamination in the leachate.

Within a year vetiver has completely stopped the leachate seepage

Grimshaw / Truong - May 2009

APPLICATION OF THE VETIVER SYSTEM FOR LANDFILL LEACHATE TREATMENT

Leachate disposal



Diagrammatic cross section of the mound at Stotts Creek Landfill, Muwillumbah

Vetiver planted on the top of the mound

Landfill Leachate Disposal

Landfill Leachate Disposal

Irrigated with leachate after planting each day

Three months after planting: good growth and establishment

Landfill Leachate Disposal

Ten months after planting

Fifteen months after planting and full flower in autumn

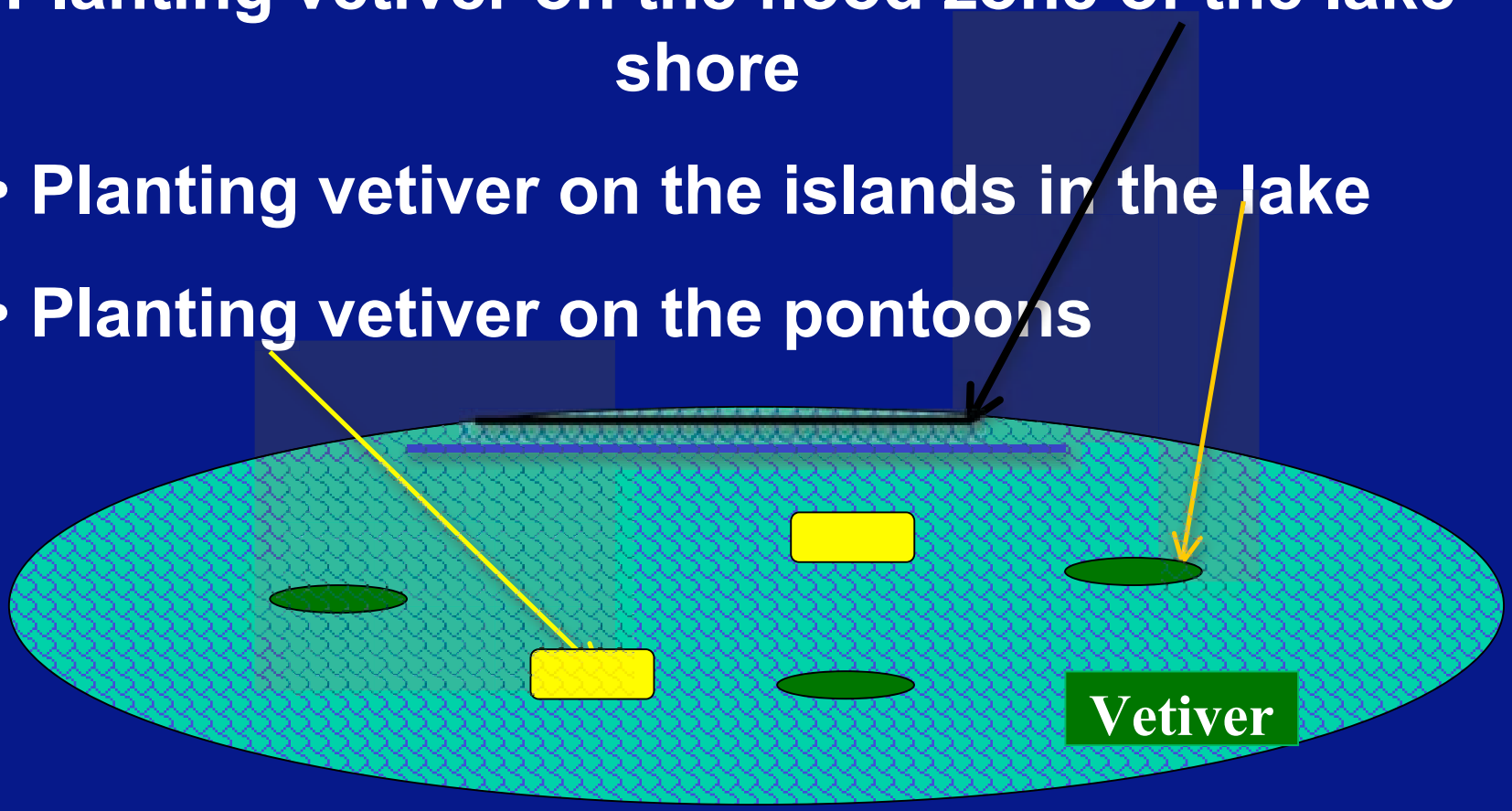
Landfill Leachate Disposal

Vetiver growth was over 3m in the second summer

Growing in highly saline and polluted leachate pool

Proposed Strategy for Pollution Control

- Planting vetiver on the flood zone of the lake shore
- Planting vetiver on the islands in the lake
- Planting vetiver on the pontoons




VETIVER
This grass is being used as a low impact alternative to managing effluent.
The increased uptake rate of Vetiver reduces odours, leakages and contamination of the subsoil and water table.
1 2 2008

NON TECHNICAL ISSUES

Communities, farmer and riparian associations must be involved with all aspects of planning and execution of any new program. Those involved need to understand the problem and be trained in the technology. Community involvement is essential if watersheds are to be treated.

Demonstration of each component should be carried out early so that participants can better grasp the actions and the consequences.

Technical manuals and fact sheets should be developed and distributed to participants. Presentations such as this one will be very helpful in persuading people to get involved.

Vetiver plant material may be a constraint.

Local governments should review policies, amend them to meet the introduced technologies, and be prepared to enforce them.

Further technical information is available at http://www.vetiver.org