Vetiver System for Stream Bank Stabilisation

(With special references to the river and canal bank stabilisation in Australia and Vietnam)

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Stability of Stream and Water Retaining Structure Banks

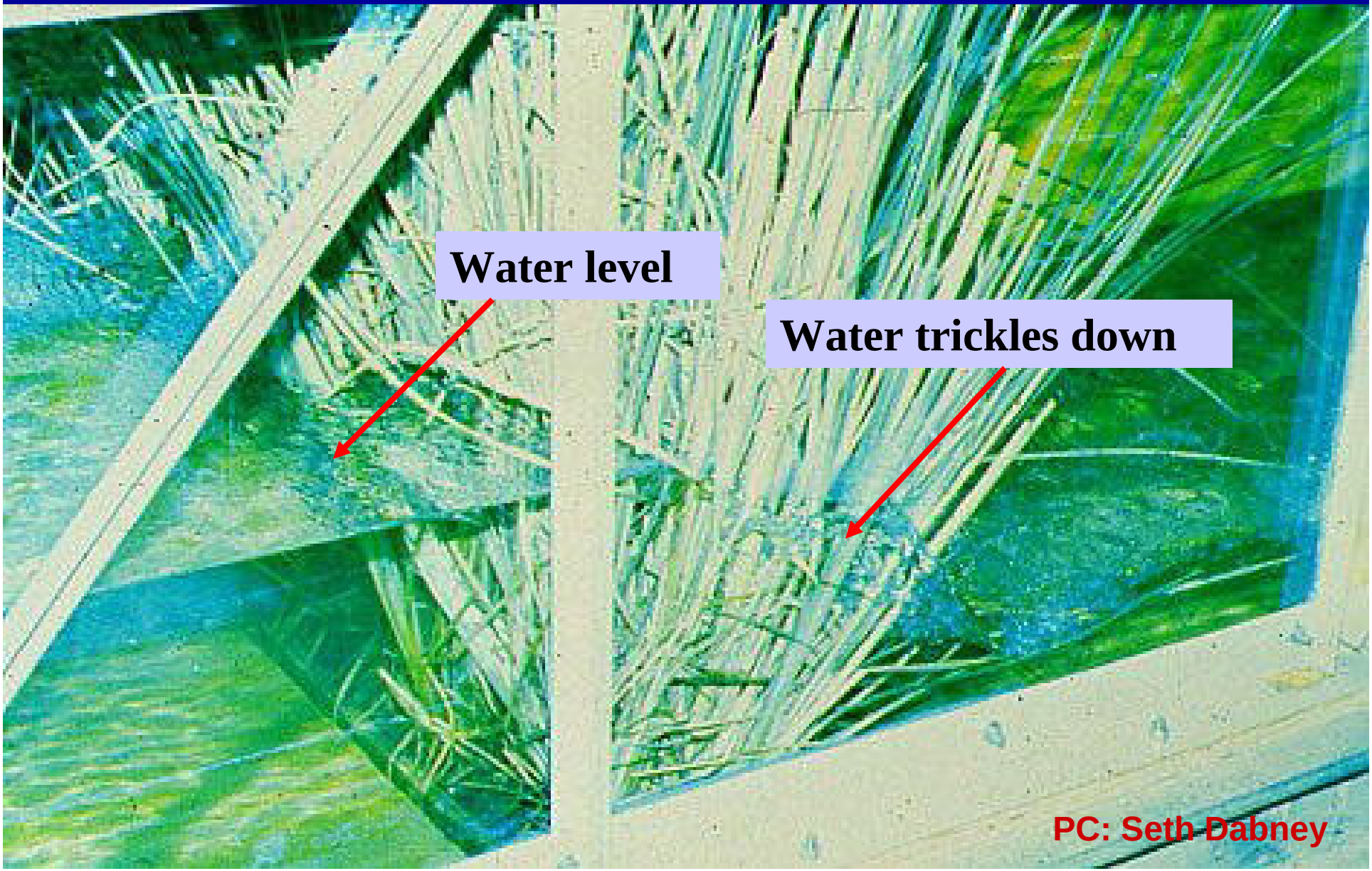
1. As in the case of dry land slopes the stability of stream bank is based on the interplay between the driving forces which promote down slope movement, while resisting forces deter movement.

2. However, erosion of water retaining structures are more complicated. it increases driving forces by:
    - Eroding the base of slopes by wave action, which removes the support.
    - Loading, that is, filling previously empty pore spaces and fractures, which adds to the total mass subjected to gravitational force.
    - Reducing the shear strength of the slope material
    - Interacting with surface rock and soil, slowly weakening slope material, and reducing its shear strength. This interaction reduces resisting forces.
3. Failure occurs when erosion of the bank toe and the channel bed have increased the height and angle of the bank to the point that gravitational forces exceed the shear strength of the bank material.

Special Characteristics of Vetiver Suitable for Stream Bank Erosion Control

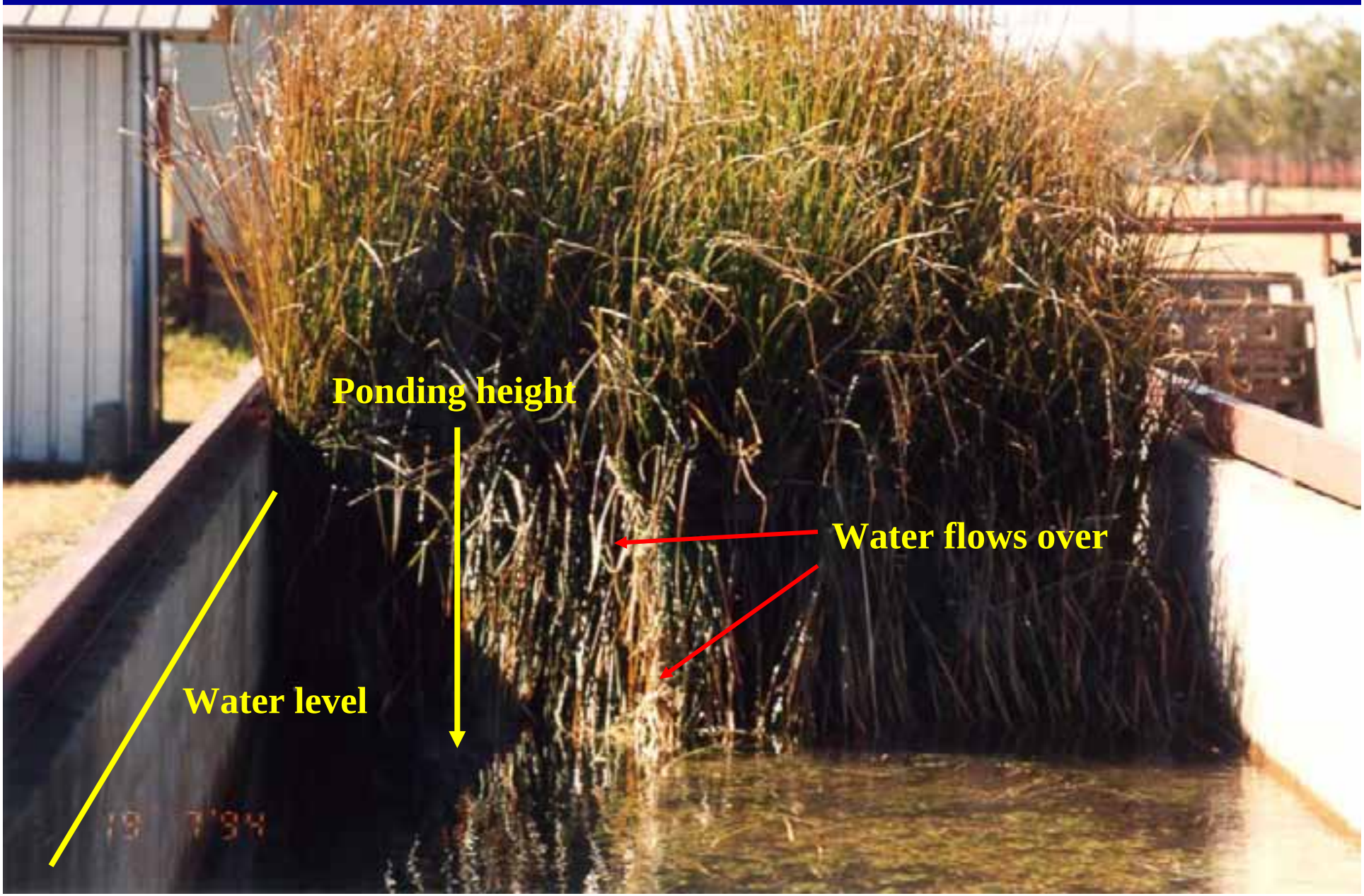
- As a wetland plant, Vetiver withstands prolonged submergence. In Cambodia, Vetiver survived longer than five months under the muddy Mekong River water.
- Given its extraordinary root depth and strength, mature Vetiver is extremely resistant to washouts from high velocity flow.
- Under shallow or low velocity flow, the erect and stiff stems of Vetiver act as a barrier that reduces flow velocity and traps eroded sediment. It can maintain its erect stance in a flow as deep as 0.6-0.8m.
- Vetiver leaves will bend under deep and high velocity flow, providing extra protection to surface soil while reducing flow velocity.
- When planted on dams or dikes, Vetiver hedgerows help reduce the flow velocity, decrease wave run-up.
- These hedgerows also help reduce retrogressive erosion that often occurs when the water flow or wave retreats after it rises.

Indoor flume test



In flume test a mature hedge can bank up water to 600mm depth

Water flows over bent leaves and stems



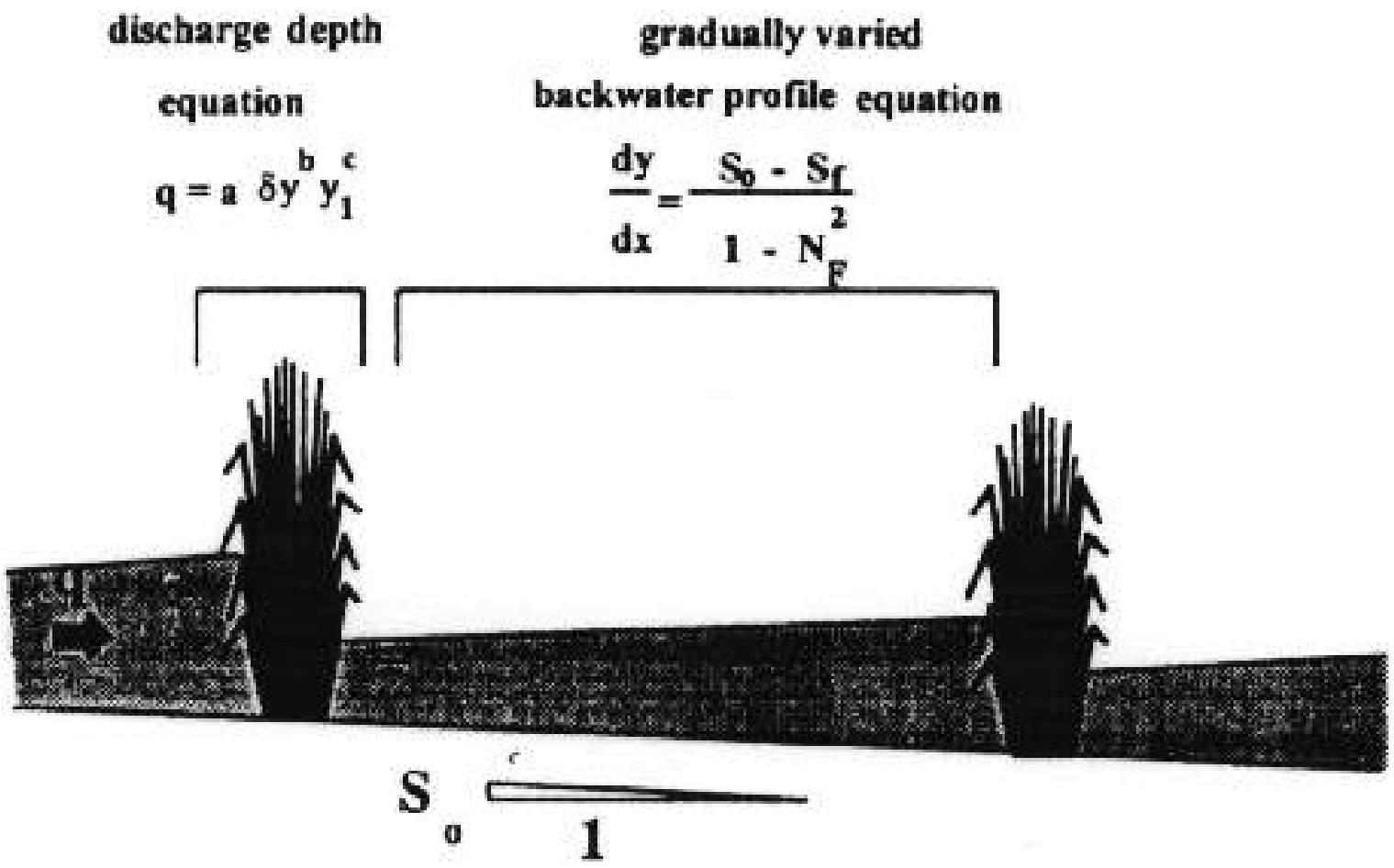


Figure 1: Hydraulic model of flooding through vetiver.

Where:

q = discharge per unit width

y = depth of flow

y1 = depth upstream

So = land slope

Sf = energy slope

Nf = the Froude number of flow.

Appropriate Designs and Techniques

As in dry land erosion control, appropriate designs and techniques should be adhered to for successful stream banks erosion control.

For flood mitigation and coastal, riverbank and dike/embankment protection, the following layout specifications are recommended:

- Maximum bank slope should not exceed 1.5(H):1(V).
- Recommended bank slope is 2.5:1.
- Vetiver rows should be planted in two directions, one parallel to flow direction (horizontal), for bank stabilisation and the other right angle to the flow to reduce flow velocity
- The first horizontal row should be planted at the crest of the bank and the last row should be planted at the low water mark of the bank.

Some examples of failures of traditional river bank protection in Vietnam

Soft structure:

Using the water hyacinth barrier. But Erosion continues behind it

Trees are of not much help either.

Native grass is equally ineffective.

Soft structure

Phragmites spp

From the front it looks like this bank is well protected. But erosion continues as waves from unprotected section upstream got behind it.

Some examples of river bank and coastal erosion control with bamboo, casuarinas and coconut trees

Hard structure:

Concrete plate cover on river dike

River and Canal Bank Erosion Control in Australia

- ***Bridge Abutment***
- ***Drainage channel at Laidley***

Stream bank erosion control in Australia: Bridge abutment

Severe erosion on the abutment of the Coolumboola Creek

Severe erosion on the abutment of the Coolumboola Creek

Vetiver planted after reparation

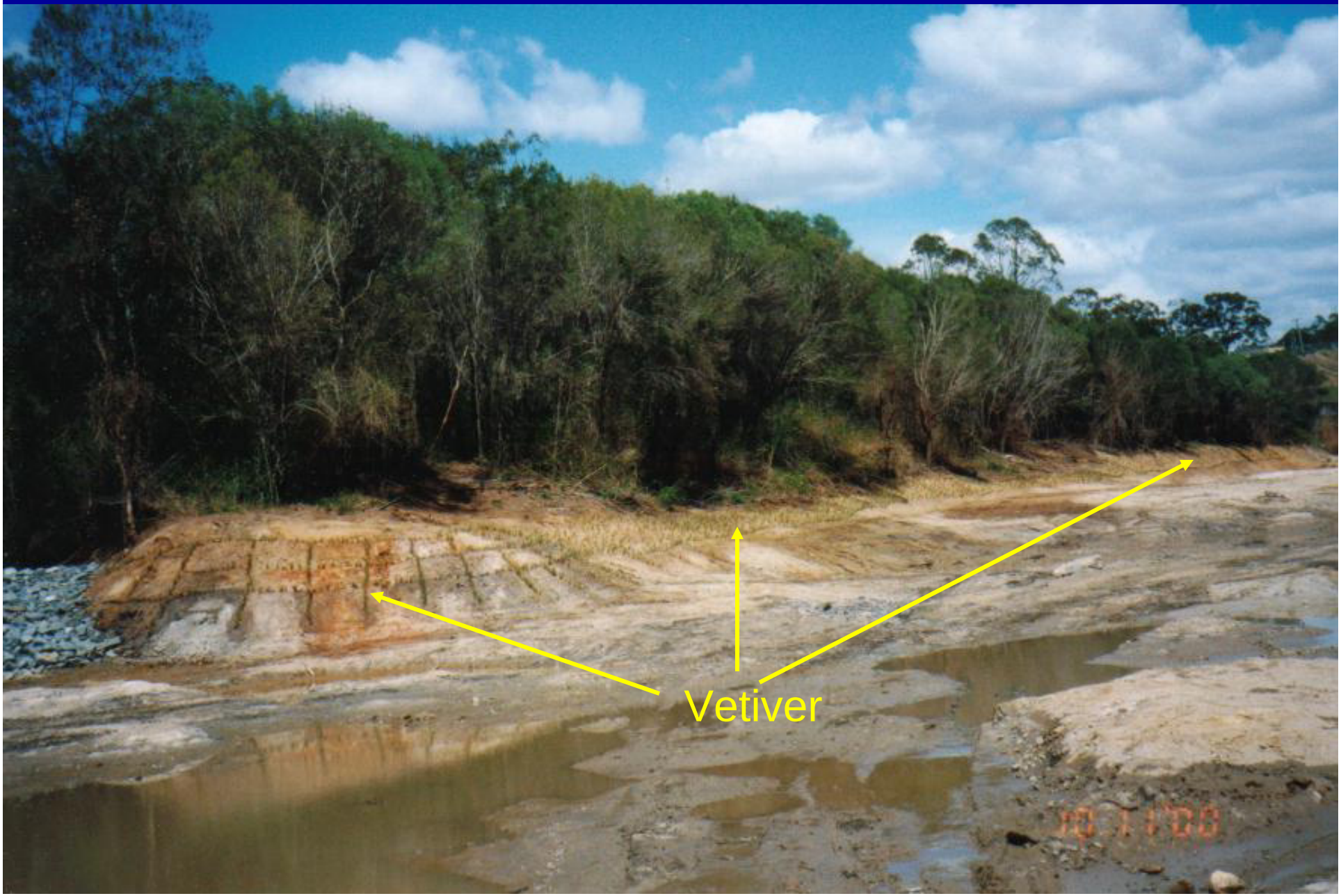
18 months after planting, no more erosion on the whole site

Five years after planting and after several flash floods

Yellow leaves due to winter frost

Note the bare area between rows. No other plants have survived

Stabilisation of creek bank of a Dam spillway




One year after planting
The water is brackish
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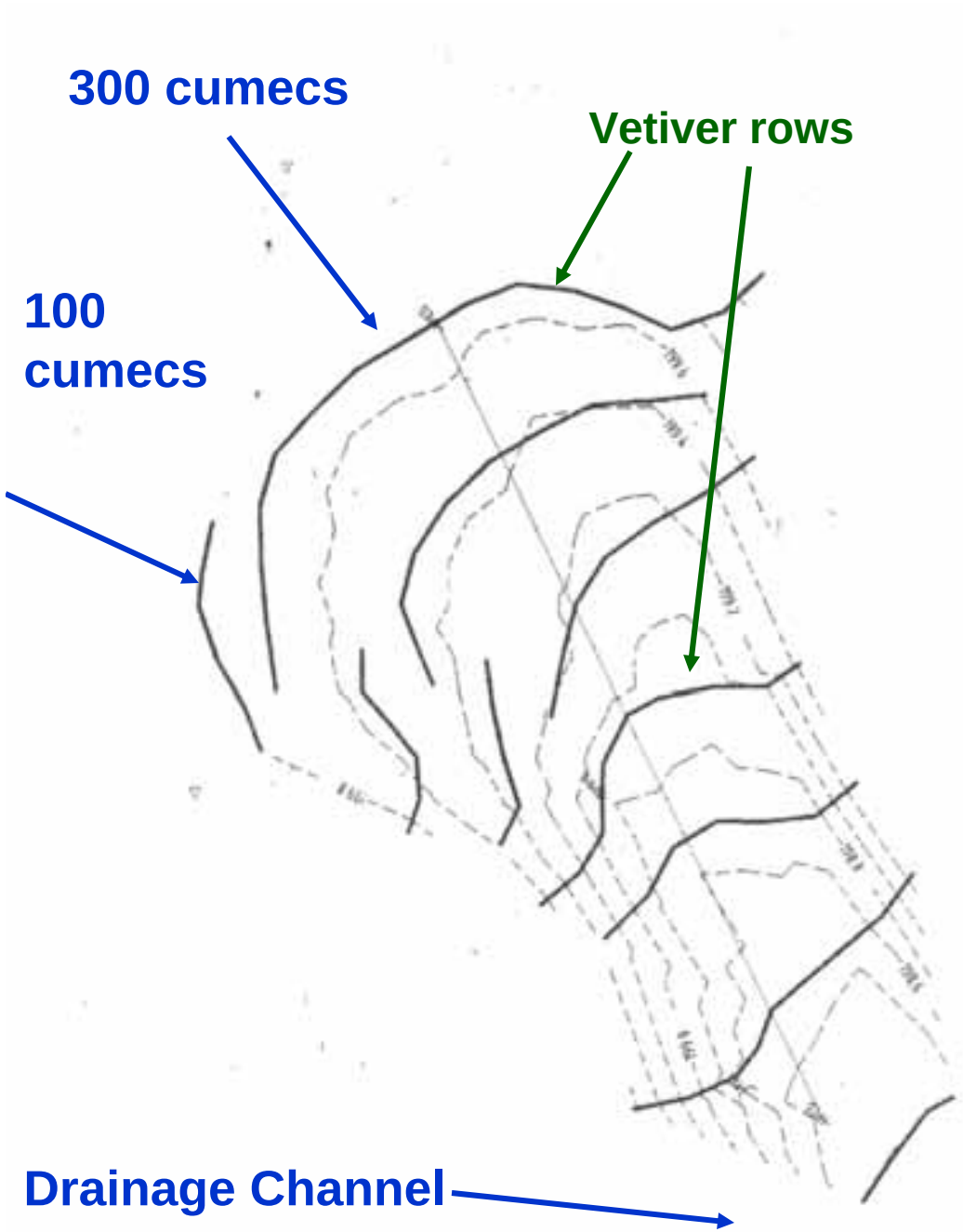


Flood erosion control in drainage channel

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

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


bmerged Vetiver
dges
Drainage channel

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

General view of channel seven weeks after flooding

River and Canal Bank Erosion Control in Vietnam

- *Failure of rock basket and gabion technique*
- *Success of the Vetiver System*

THE VERY COSTLY ALTERNATIVE

- Rock walls, rock baskets or rip rap are traditional methods used for riverbank stabilisation in Asia, particularly in China and Vietnam.
- These methods are high-tech engineering structures, requiring special skill and high maintenance costs
- These methods are much more expensive, may be several thousand times more in the case of the Mekong delta as rock is not available locally and some imported materials are required
- But most importantly they are not effective as they are not stable themselves on the alluvial plains of Asia. The following photos show their ineffectiveness and high costs.

Viet Nam: The levee bank of the Red river in Hanoi

Gabions and rock baskets are being used to repair recent flood damages which threatened the levee bank of the Red River

A very elaborate and costly engineering structure, these rocks came from far away quarries

But this method provided no protection as this bank had been previously covered by similar rock baskets. Remnants of the old rocks which collapsed in the last flood, were still visible in the river.

Consultant Report on costs of riverbank stabilisation in Australia

Summary of the Impacts and Costs Associated of Various Options

Options	Estimated Cost ($)	Environmental Impacts
Native vegetation	10 000	Low
Vetiver grass	15 000	Low
Dumped riprap	195 000	Low
Rock mattresses	272 500	Medium
Rock groyne	251 250	Low
Concrete pile wall	1 700 000	Medium

Flash flood protection

Levee bank protection in central Vietnam

An irrigation canal in bad shape in central Vietnam

The same site at planting and after several months.

Prawn farm (Brackish water) dike protection in central Vietnam

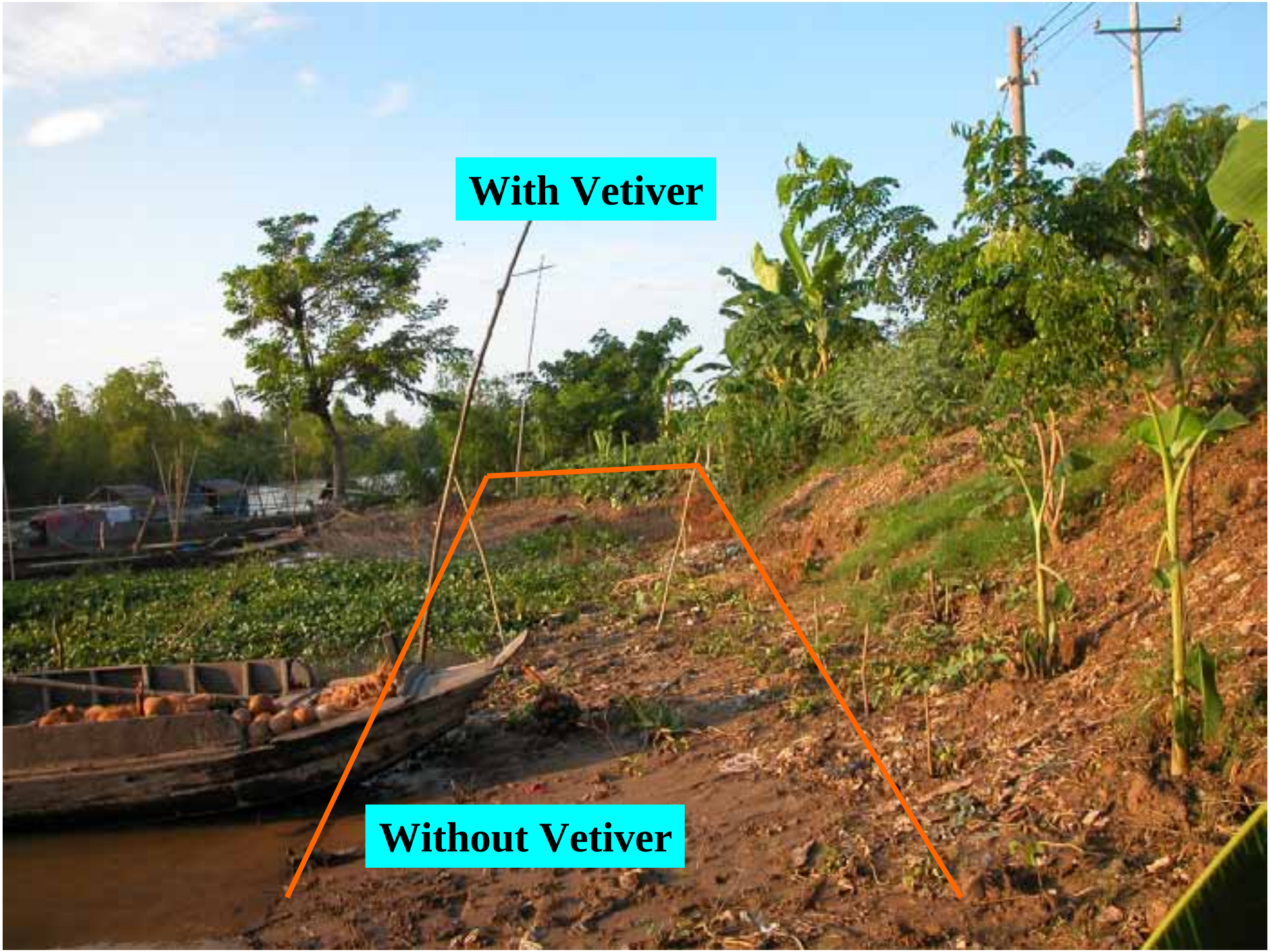
The same site after several months.

Flood protection

Flood control dike protection in the Mekong Delta Vietnam

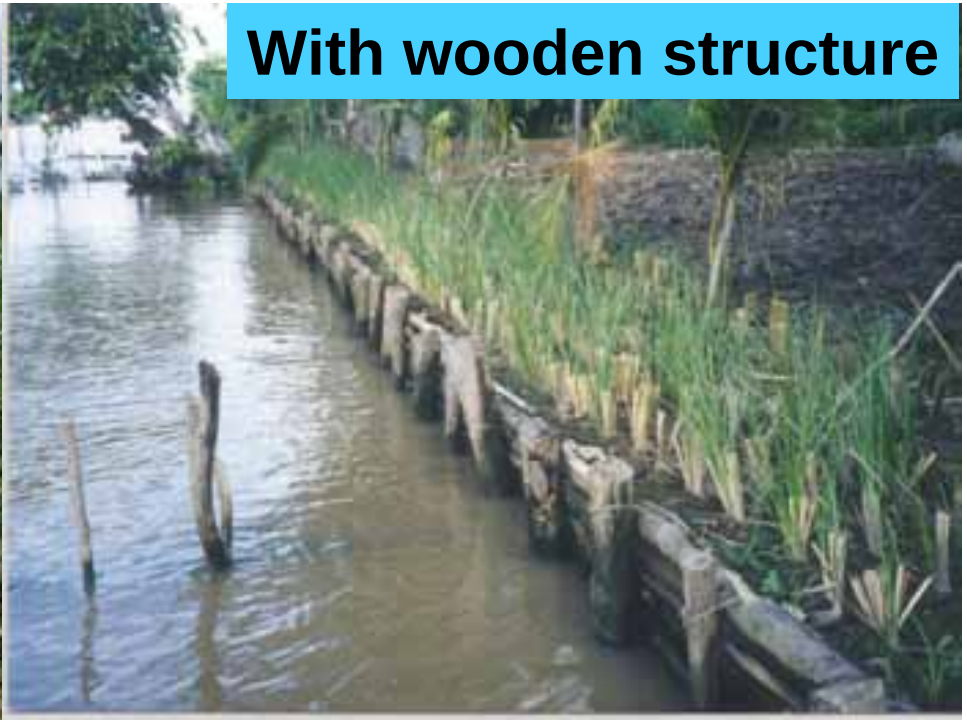
Dike during flood

A precious piece of land 5m wide is kept intact due to Vetiver


With Vetiver
Without Vetiver

Eucalyptus is not effective

Can act alone



With wooden structure

Or with concrete/rock rip-rap structures.

Sea Dikes in north Vietnam

Sea Dikes in south Vietnam

Vetiver protecting sea dike behind the mangrove.

Riverbank Erosion Control in Other Countries

Some examples of VS used in riverbank stabilisation in Cambodia, China, Malaysia, the Philippines, South Africa.

Cambodia

Erosion on the bank of the Mekong river

Cambodia Vetiver planting following earth shaping

Cambodia Eight month after planting

Cambodia

Annual flooding with depth level between 15-20m

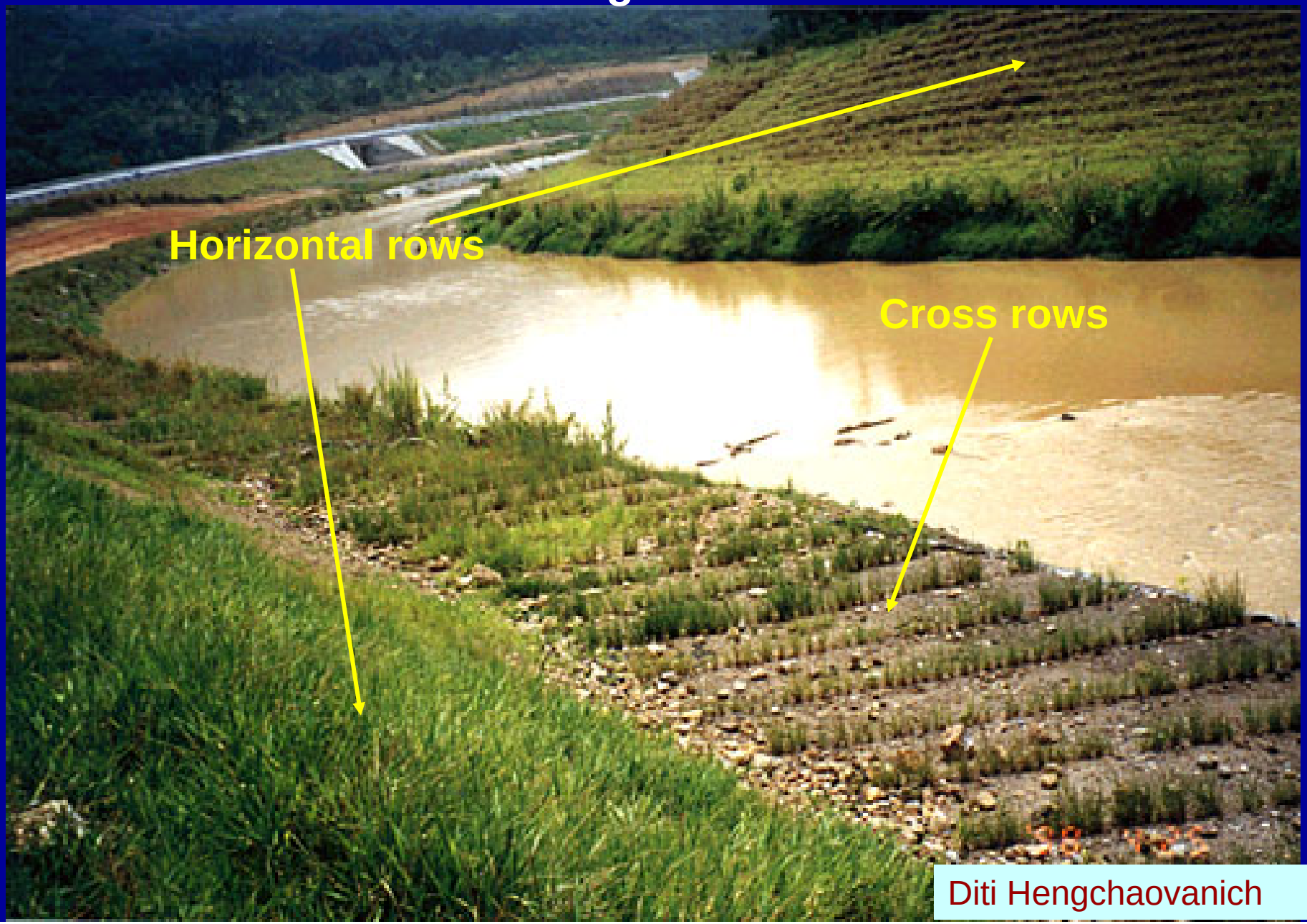
Cambodia

Water receded 5 months after flooding:

- the lowest rows (15m) was dead but its roots remain intact and stop erosion

- the mid section (8m) survived and resume growth after water receded

Malaysia: An outstanding success, several floods did not damage this river



Diti Hengchaovanich

South Africa: A very well layout provided complete protection against erosion

China: Highly erodible and badly eroded of the often flooded shore line of Lake Evergreen in Guangdong

This section of the bank has been successfully stabilised by vetiver grass in a trial

Philippines: Vetiver was planted to protect the bank of Abra River against flood erosion

Ed Balbarino

One year after planting, the bank was successfully stabilised


THANK YOU
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