Part 3

STREAMBANK STABILISATION AND CHANNEL PLUG DEVELOPMENT

compiled by Jon Wyatt,
Mondi Wetlands Programme,
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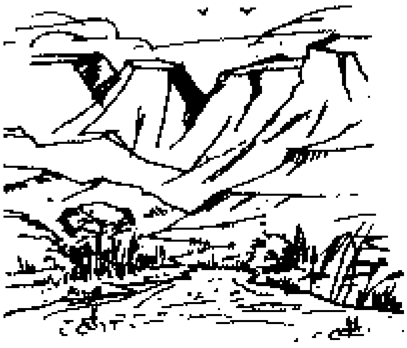
Contents

Introduction

"**C**atchments, or watersheds provide natural units for implementation of land resource management. The whole South Africa is made up of a series of catchments and each river or wetland catchment can be further subdivided into any number of smaller catchments of more convenient size. We all live and work in catchments and we depend on them for our survival. They are more than just an area of land marked on a map... There is an undeniable bond between the land and the people of an individual catchment whether it be that of a river or a wetland. Activities upstream can have major impact on the lands and people further downstream..... The readily identifiable boundaries of a catchment and the characteristic patterns of water movement within make them ideal for planning and management units." Cunningham, 1986.

"**W**etlands relate to catchments in three ways :-

1. they are affected by activities in catchments which alter the movement and quality of surface and sub-surface water,
2. they have a functional role in regulating the movement of water, sediment and chemicals through the watershed,
3. and like any other natural resource, they have a variety of values for people and wildlife which should be taken into account in catchment management ...



Wetlands cannot be regarded as anything other than integral parts of catchments. This is borne out of their varied functions in regulating processes in catchments, by their susceptibility to impacts of sometimes distant developments, and by their complimentary values with terrestrial habitats for wildlife....

"**W**etlands are subjected to various land use impacts with drainage and lowering of the water table to the extent that the '--wetland dries up being the most serious from which the wetland rarely recovers on its own accord." Cunningham, 1986."

A river is a longitudinal ecosystem and it's condition at any point is a reflection not only of all upstream activities within the river but also of all activities in the adjacent and upstream parts of its catchment.......

The rivers riparian zones are of the utmost importance in river conservation because they form part of the catchment which has a direct effect on the stream ecosystem, and on stream flow quantity and quality. The vegetation of these zones plays a vital role in the river ecosystem, by supplying food to the aquatic fauna, controlling the drainage of water, nutrients and other minerals to the stream, providing shade to decrease the deleterious effects of warm water on the biota, and stabilizing the banks, thereby keeping the water silt-free" O'Keefe 1986

Agricultural, forestry, urban, industrial and tourism development have contributed towards large scale disturbance of rivers and riparian zones. Modifying natural watercourses by the removal, or destruction of riparian vegetation can rapidly bring about the collapse of the stream and relegate it to a crude drainage system which merely serves to dispose of polluted water and top-soil into estuaries and the ocean.

"**W**etland Fix" offers some guidelines on how to restore and manage Wetlands and riparian zones.

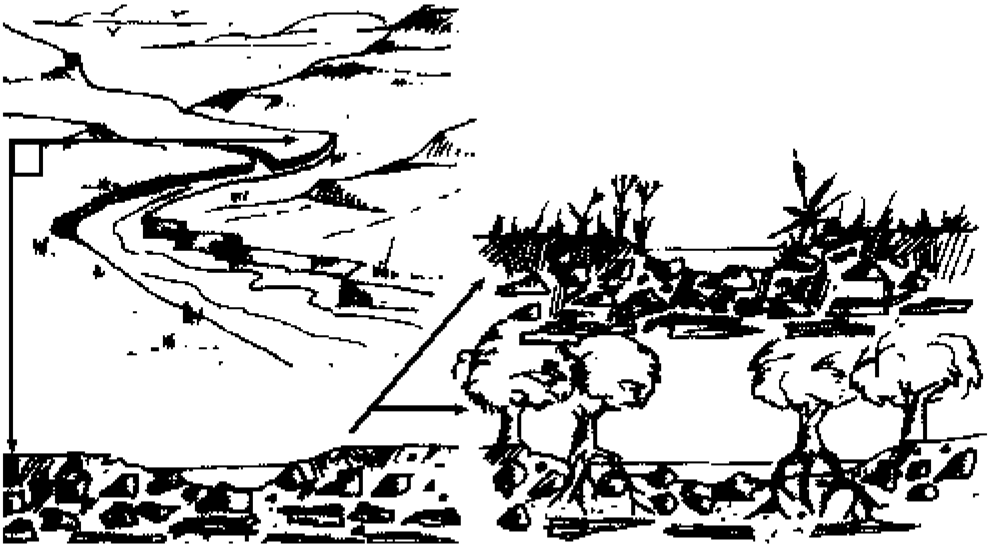
The Effects of Riparian Vegetation on Streambanks and Channels

Whilst the diagrams below depict some of the normal effects of riparian vegetation on streambanks and channels it should be noted that the "rules" do not always hold true as local land uses, storm events and upriver conditions can often change a streams natural flow behaviour and pattern quite dramatically.

A. Headwater (low order) stream with a shallow channel depth

In these headwater shallow channel depth situations, the dense near surface root mat of herbaceous plants is often more effective in enhancing bank stability than trees with their deeper but less dense root cover.

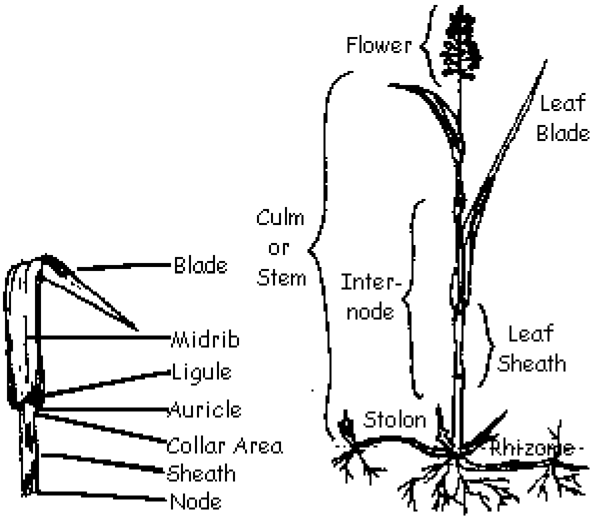
The excessive widening of streams is frequently countered by the natural confinement of streams to their steeper valleys and the effect of fire then becomes the major determining factor in choosing between encouraging a herbaceous or woody cover.



What are herbaceous plants?

Herbaceous plants are those seed plants that do not develop woody tissue and die down at the end of the growing season.

"Wetland Fix" refers to herbaceous plants such as grasses ; including reeds, sedges; including juncus, and bulrush.



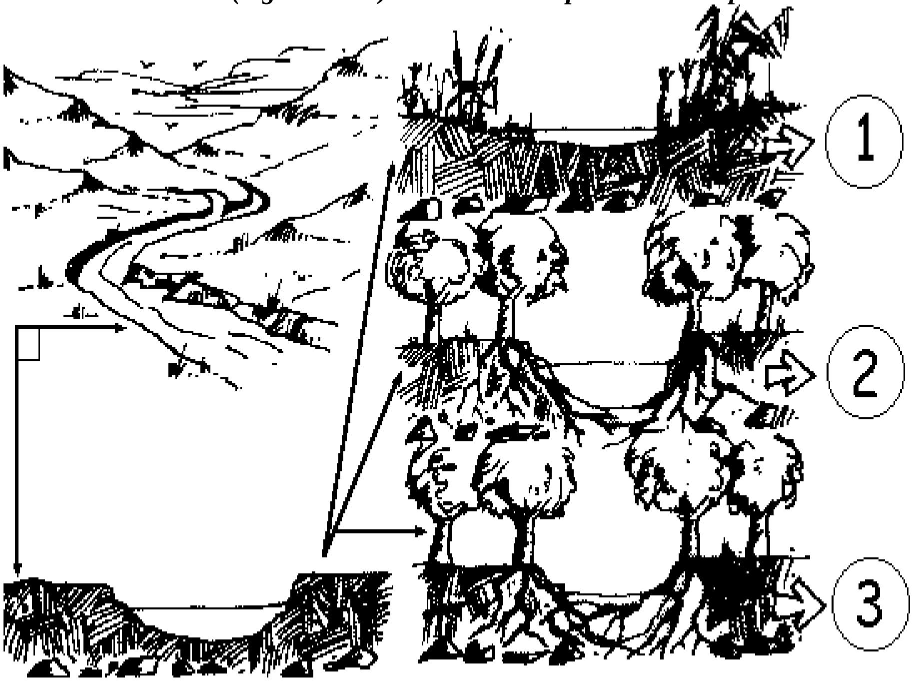
<u>GRASSES (Gramineae)</u>
Grasses resemble some sedges but, unlike most sedges all grasses have a ligule and an open leaf sheath.

<u>SEDGES (Cyperaceae)</u>
Most sedges lack a ligule and almost all sedges lack an open leaf sheath lie if present the leaf sheath is closed).

<u>JUNCUS (Juncaceae)</u>
Because juncus may be easily confused with some sedges they have been included with the sedge family.

<u>BULRUSH (Typhaceae)</u>
Typha capensis is an aquatic perennial. The flowers are male and female on the same stem-male above and female below.

B. Lower catchment (higher order) stream with deeper channel depth

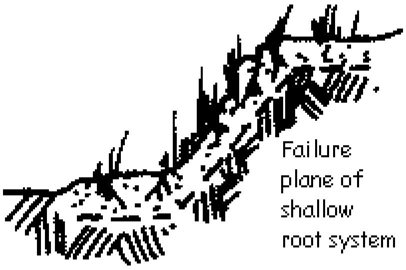


SEE 1, 2, 3 BELOW

①

A large variety of herbaceous plants with their rapidly spreading capabilities and dense near surface root mat and surface cover are effective against scour and enhancing stability on gentle and shallow banks. The plant stems induce sediment deposition thus tending to raise the floor of eroded channels, even widening the channel profile. Herbaceous plants absorb fast flowing water energy rather than reflecting it.

The combination of these factors plus the ability of many herbaceous plants to thrive in direct sunlight , of being fire tolerant and of having strong regenerative powers makes them ideal for streambank stabilization and channel plug development.



Whilst a herbaceous cover is probably most effective with respect to gentle and shallow banks, they have little effect on the stability of steep banks due to their shallow rooting depth.

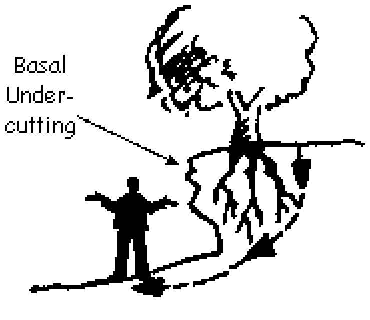
②

The growth of woody vegetation on steeper streambanks tends to lead to deeper and narrower channels with more stable banks - providing the roots reach down to full bank height.

Trees contribute cohesion and stability to steep banks- Providing the roots reach down to full bank height and the toe- hold and bank-face are protected from undercutting by tree roots and an established cover

③

In some instances such as in Natal coastal regions, certain tree species grown in narrow channels will develop entwined root weirs forming an effective channel plug.



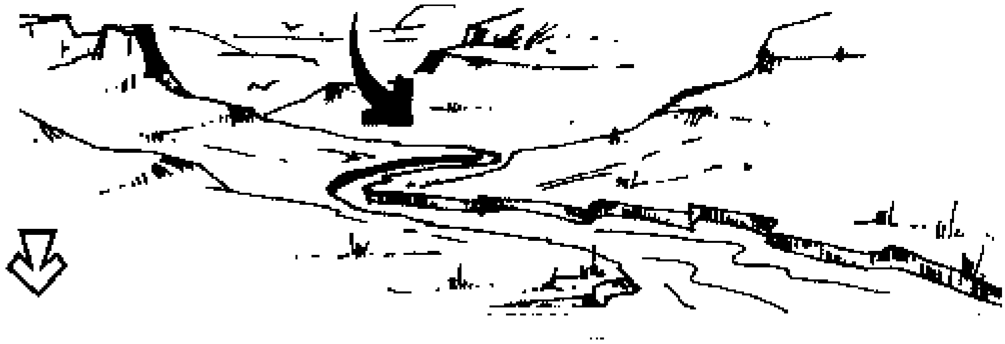
Bank undercutting and mass block failure (or rotational slumping) can occur when trees become excessively heavy and their roots do not reach down to full bank height.
Dead trees cause a loss of root associated soil strength and the dead roots provide pathways for rapid water seepage, piping and ultimately soil and bank collapse.

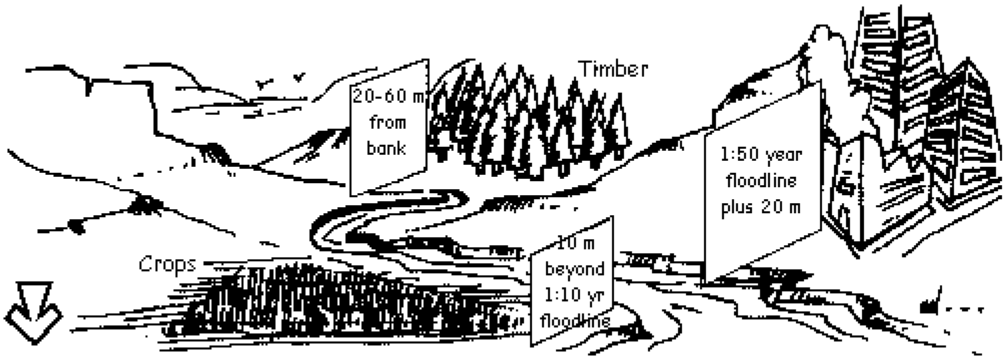
Streambank Stabilisation - Decision Key

The process of stabilizing streambanks involves a number of possible measures and a variety of options are illustrated. The following decision key assists in selecting practical management options.

PHASE 1

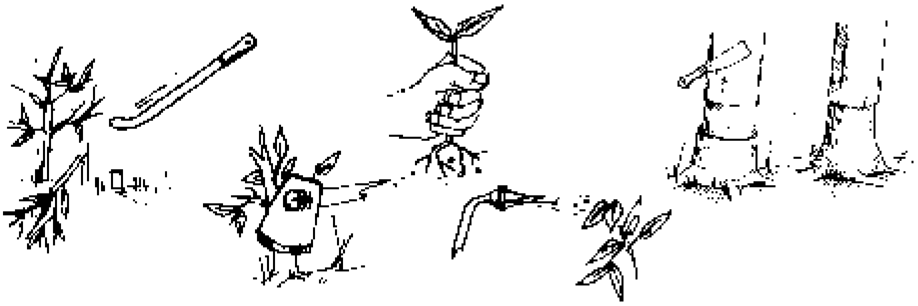
☐ Where practical initiate restoration programmes on prioritised catchments and streams.
☐ Initiate streambank restoration programmes as high up the catchment as possible and progress downstream.





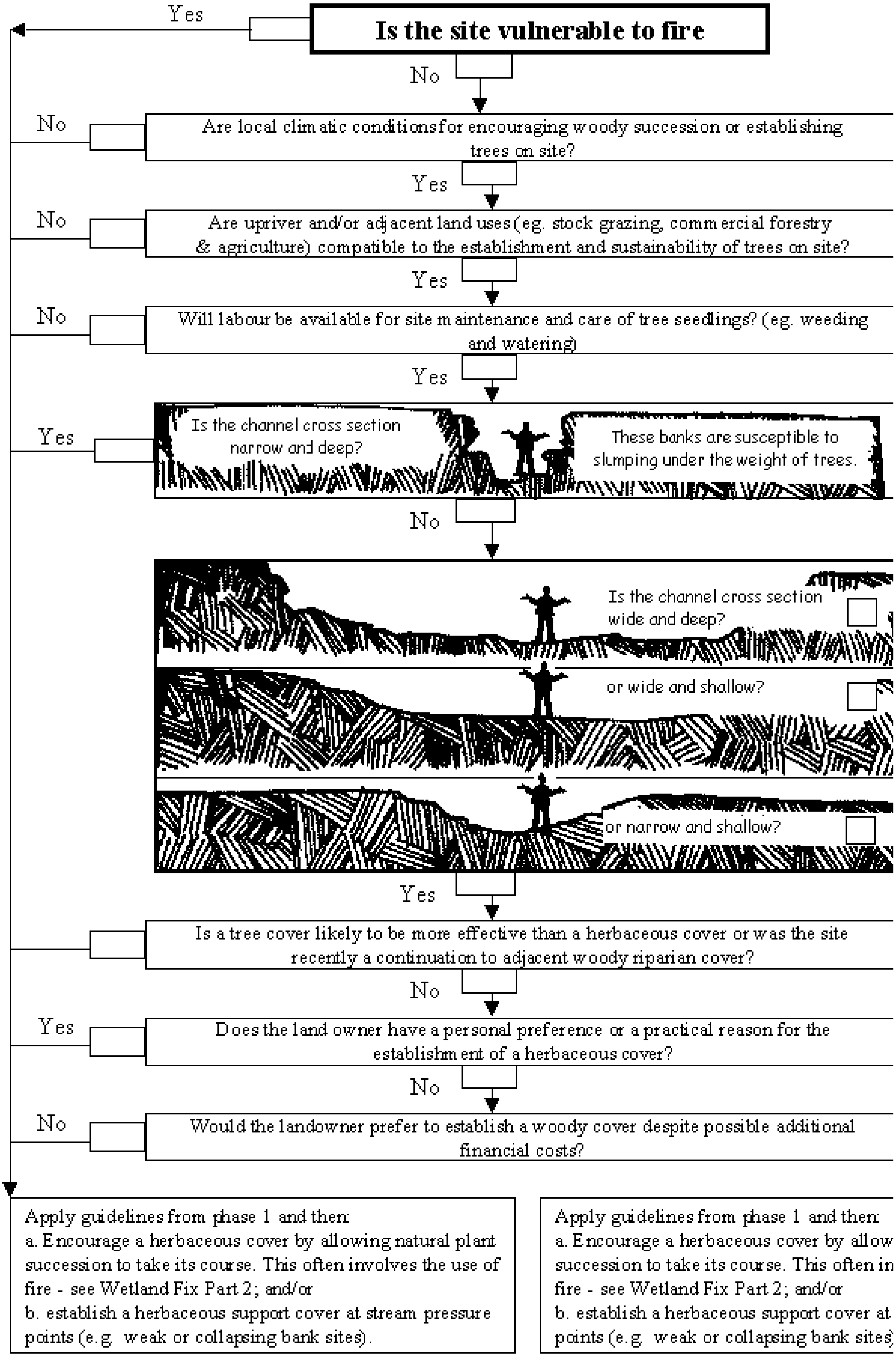
☐ Remove stock from, fence off or herd stock away from sensitive areas.
☐ Provide an alternative water source.
☐ Provide a protected stream crossing point

☐ Remove alien invasive plants in planned phases (starting upstream and working on light infestations first) and maintain control via regular follows ups. See Wetland Fix - Part 6 ????
☐ See Phase 2 for decision key selection of herbaceous or woody riparian vegetation.



Whilst initially it can be difficult to choose which techniques to use an appreciation of the principles involved comes quickly with experience gained by making a start.

PHASE 2



Is the site vulnerable to fire

Are local climatic conditions for encouraging woody succession or establishing trees on site?

Are upriver and/or adjacent land uses (eg. stock grazing, commercial forestry & agriculture) compatible to the establishment and sustainability of trees on site?

Will labour be available for site maintenance and care of tree seedlings? (eg. weeding and watering)

Is a tree cover likely to be more effective than a herbaceous cover or was the site recently a continuation to adjacent woody riparian cover?

Does the land owner have a personal preference or a practical reason for the establishment of a herbaceous cover?

Would the landowner prefer to establish a woody cover despite possible additional financial costs?

Apply guidelines from phase 1 and then:
a. Encourage a herbaceous cover by allowing natural plant succession to take its course. This often involves the use of fire - see Wetland Fix Part 2; and/or
b. establish a herbaceous support cover at stream pressure points (e.g. weak or collapsing bank sites).

Apply guidelines from phase 1 and then:
a. Encourage a herbaceous cover by allow
succession to take its course. This often in
fire - see Wetland Fix Part 2; and/or
b. establish a herbaceous support cover at
points (e.g. weak or collapsing bank sites)

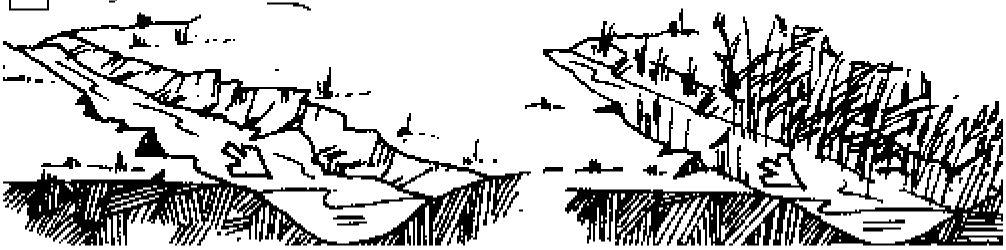
Streambank Stabilisation - Using Herbaceous Plants

1. Select from the diagrams those unstable streambank sites that resemble your situation.
2. Check for likely effects of stabilization using herbaceous plants.
3. Select planting techniques using herbaceous plants (next section).
4. See "Wetland Fix" - part 4 for selection and propagation of herbaceous plants.

Cautionary note:

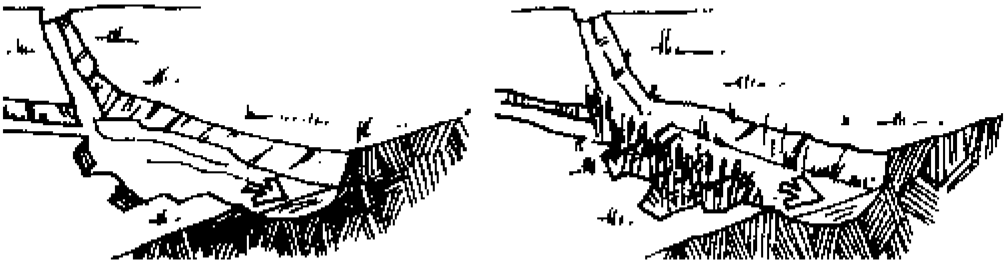
- Beware of theft of wire from gabion baskets in some districts.

☐ Straight reach of stream

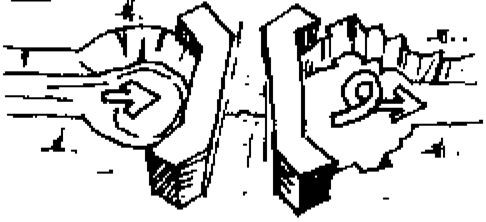


☐ Stream curve

☐ Stream confluence



☐ Stream crossing

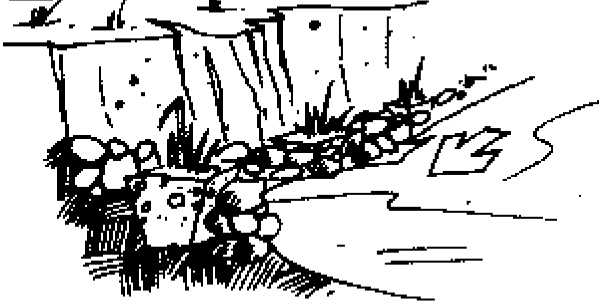


PLANTING TECHNIQUES

☐ Herbaceous 1: Root rhizome cuttings buried in rows 50 cm to 100 cm apart

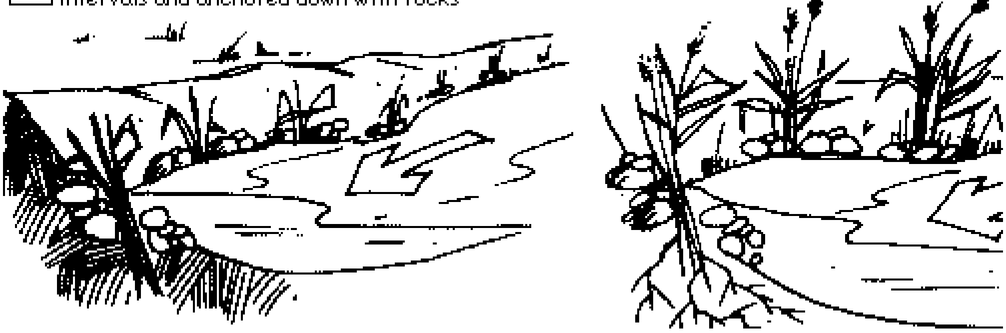
☐ Herbaceous 2: Root clumps of grass, sedge, reed or bulrush at 50 cm to 100 cm

☐ Herbaceous 3: Root clumps of grass, sedge, reed or bulrush buried at 50 cm to 100 cm intervals and anchored down with rocks

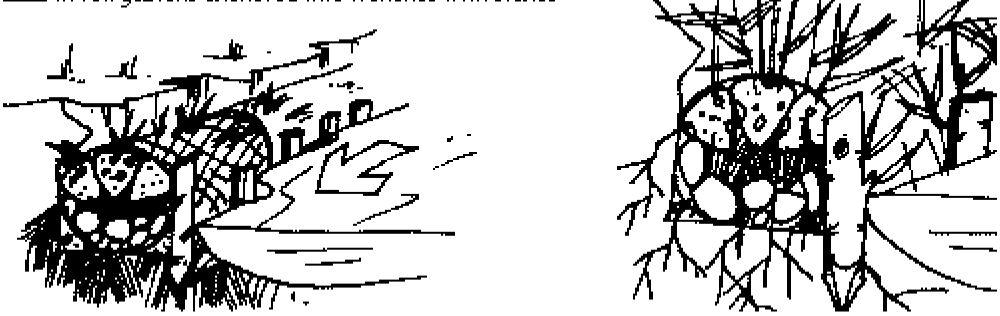


☐ Herbaceous 4: Reed culm bundles planted at 50 cm to 100 cm intervals

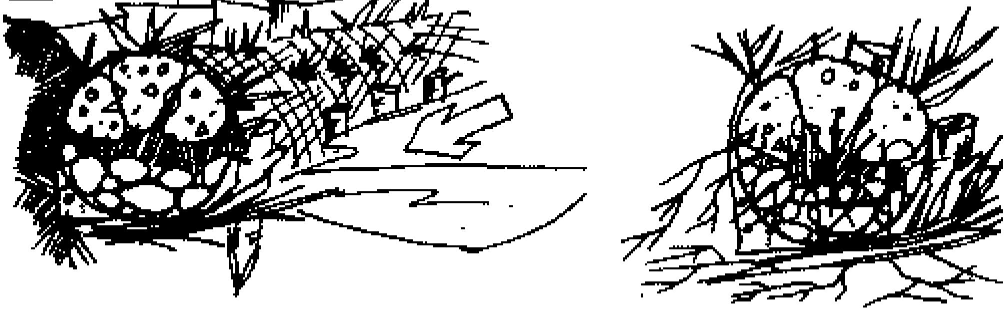
☐ Herbaceous 5: reed culm bundles planted at 50 cm to 100 cm intervals and anchored down with rocks



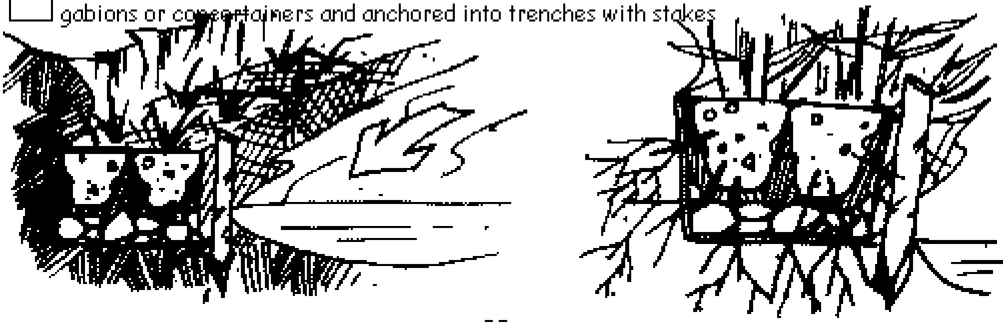
☐ Herbaceous 6: Root clumps of grass, sedge, reed or bulrush planted in roll gabions anchored into trenches with stakes



☐ Herbaceous 7: Root clumps of grass, sedge, reed or bulrush planted in roll gabions placed over silt trap layer of dead branches and anchored into trenches with stakes



☐ Herbaceous 8: Root clumps of grass, sedge, reed or bulrush planted in standard gabions or containers and anchored into trenches with stakes



Streambank Stabilisation - Using Trees

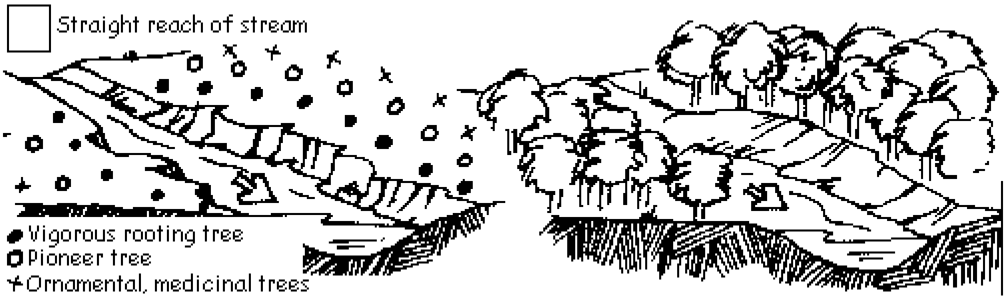
1. Select from the diagrams below those unstable streambank sites that resemble your situation.
2. Check likely effects of stabilisation using trees.
3. Select planting technique (next section).
4. See "Wetland Fix" part 4 for selection and propagation of trees.

Trees in riparian zones should not be planted in straight lines but at random with approximately 3m gaps between trees. This seems close but the aim is to try and establish a closed canopy and an extensive root system cover quickly, and furthermore, not all the trees will survive. The "front trees" should be planted as close to the stream as possible, but not on the edge of steep banks where bank " slumps" are likely to occur. Reshaping of the banks or planting far enough back from the bank edge to allow for slumping should be considered.

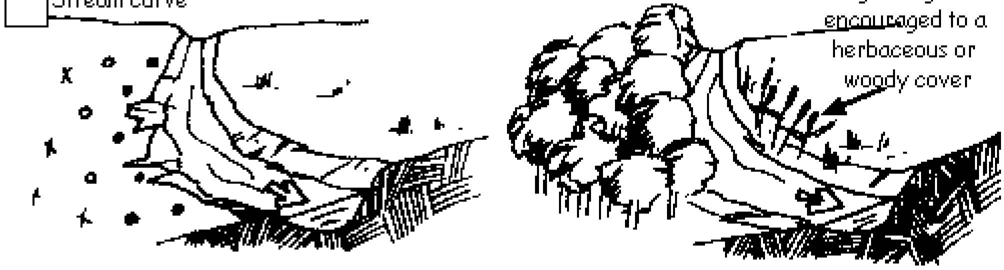
Cautionary notes:

- When restoring narrow channels with trees there is a likelihood that root "plugs" will be formed. This plug action could lead to flooding which might affect neighbouring landowners. Whilst this might be the intention of the restoration exercise, such possible flooding consequences need to be discussed with and agreed to by neighbours before allowing complete plugging to take effect.
- Beware of theft of wire from gabion baskets when working in some districts.

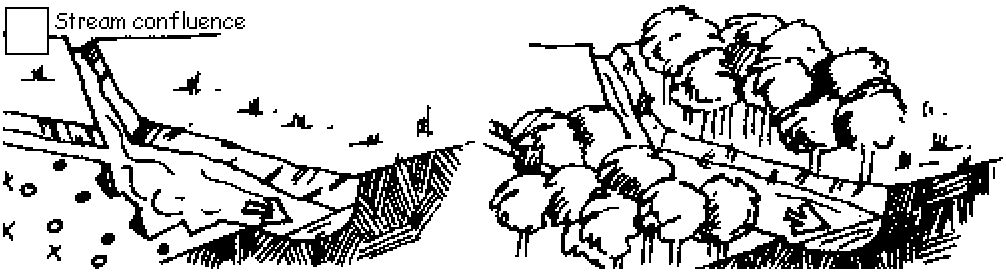
☐ Straight reach of stream



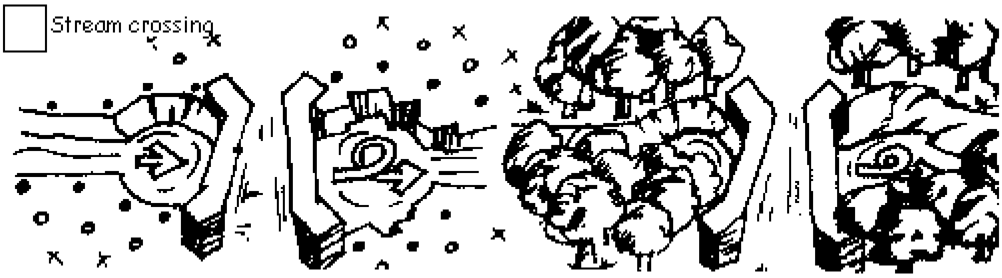
☐ Stream curve



☐ Stream confluence

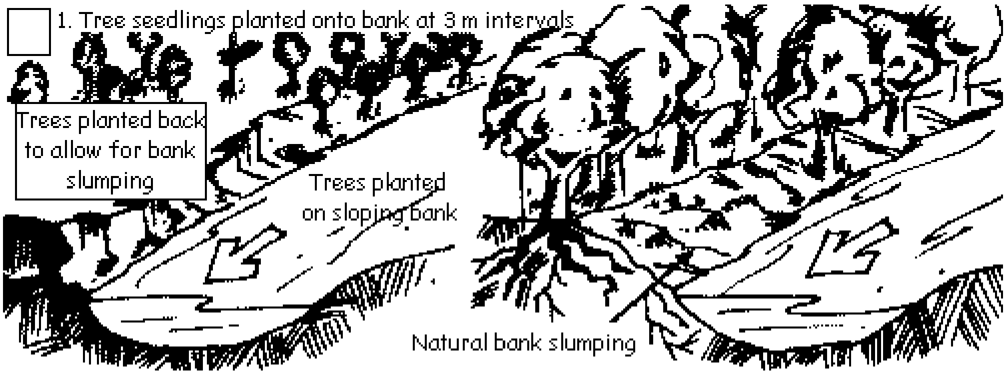


☐ Stream crossing



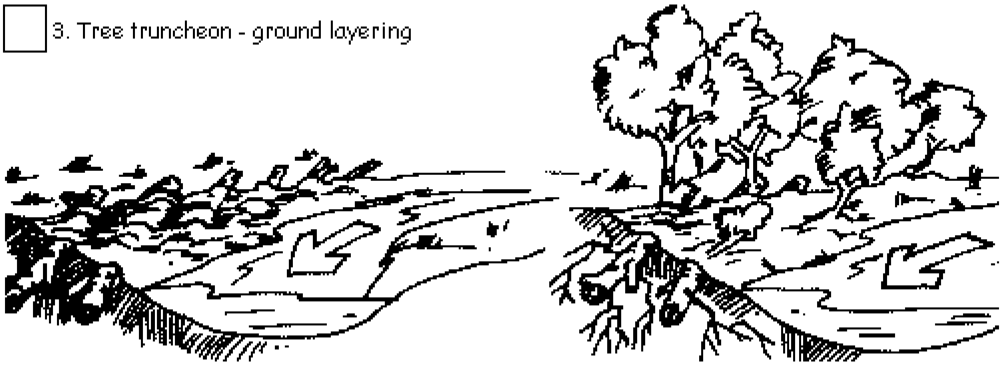
TREE PLANTING TECHNIQUES

☐ 1. Tree seedlings planted onto bank at 3 m intervals

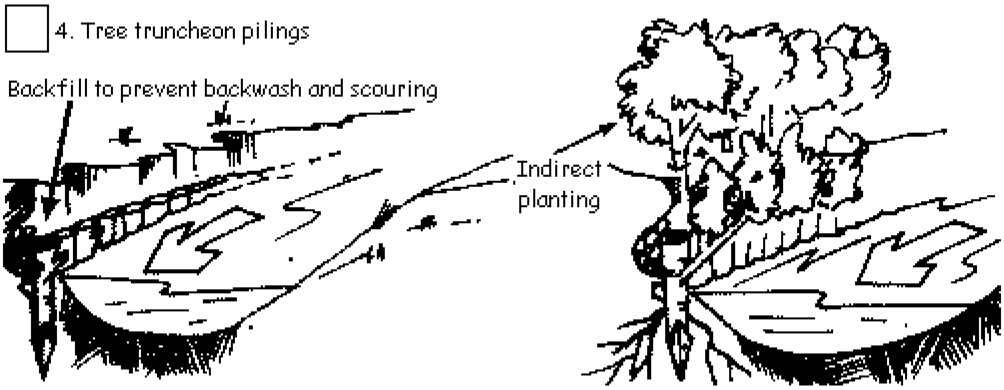


☐ 2. Tree truncheons and seedlings planted onto bank ~~at 3 m intervals~~

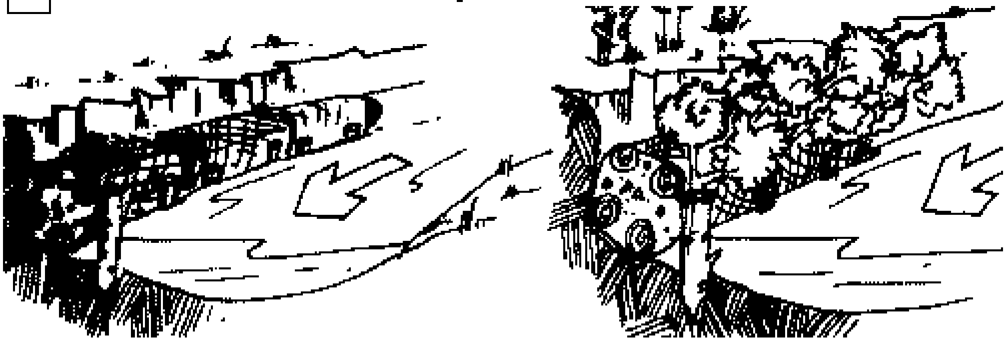
☐ 3. Tree truncheon - ground layering



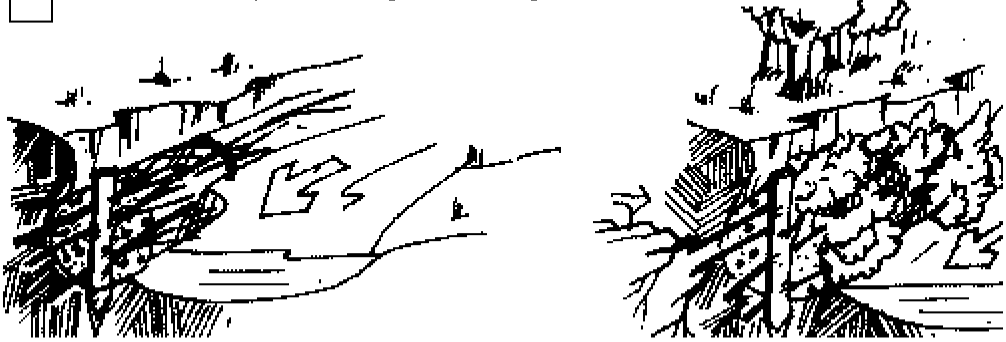
☐ 4. Tree truncheon pilings



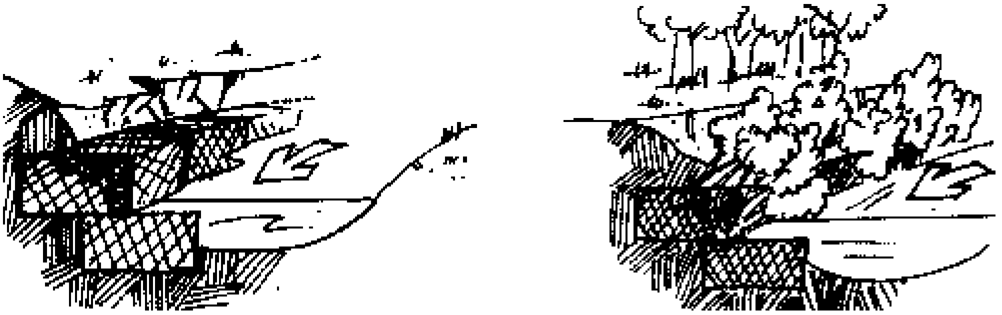
☐ 5. Tree truncheons laid into wire netting rolls anchored into trenches with stakes



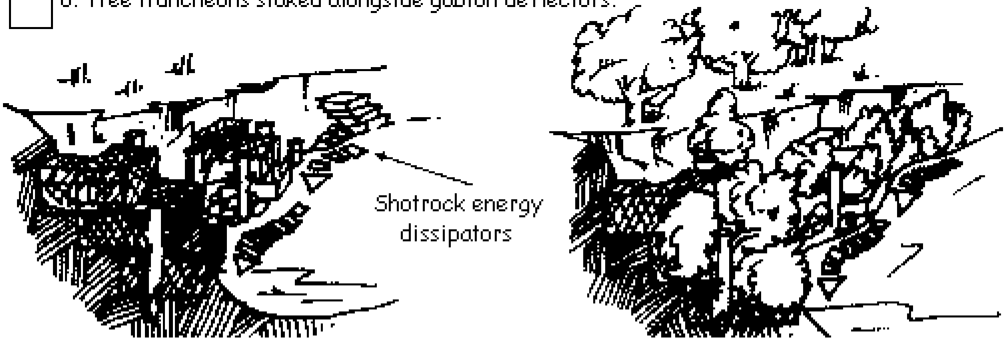
☐ 6. Tree truncheons planted through wire netting rolls anchored into trenches with stakes



☐ 7. Tree truncheons laid into front and top of gabions or concertainers filled with stone soil.



☐ 8. Tree truncheons staked alongside gabion deflectors.

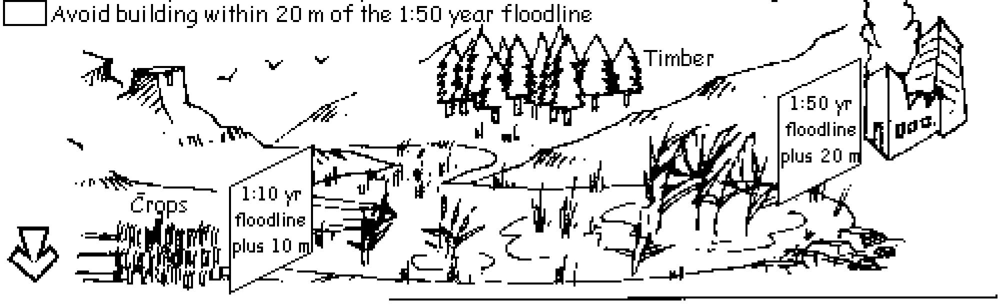


Channel Plug Development - Decision Key

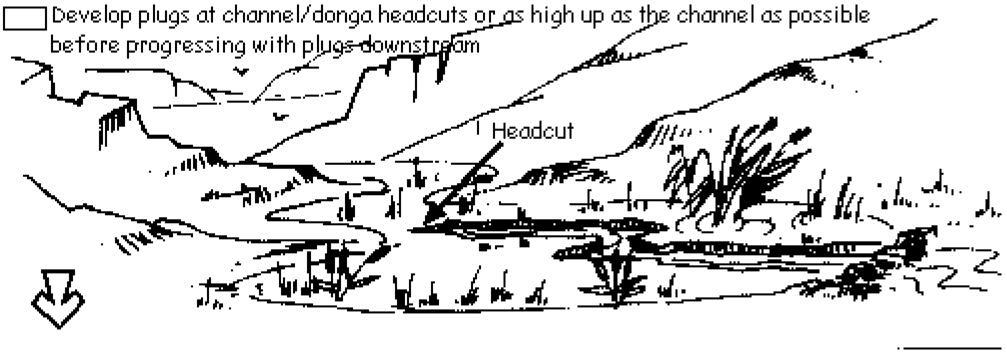
The basic concept of "developing channel plugs" is to restore or to create wetlands. The plugs might be "sills" designed to only stabilize and gently raise a channel floor, or they could be substantial structures intended to create flood storage wetlands that have the capacity to store a given volume of water and to reduce the flow velocity by forcing it through dense vegetation, then to gradually release flood waters into a stream or river for and extended period after a storm. Local conditions and anticipated flow velocities will determine the most effective structure . (for detention / retention ponds see Urban Stormwater Management)

PHASE 1

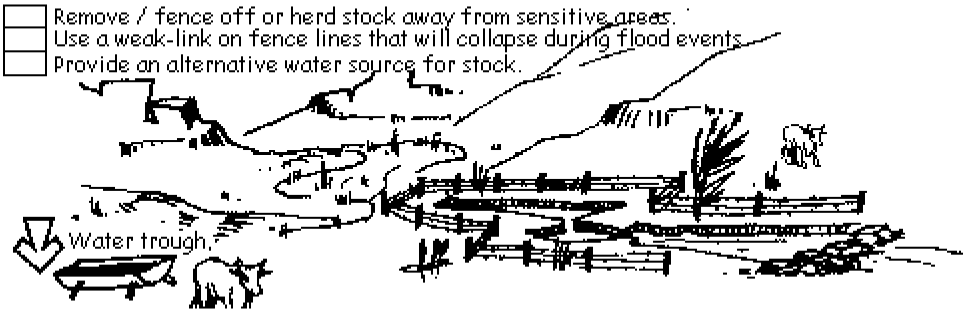
☐ Remove crops or timber to the prescribed distance from the wetland edge
☐ Avoid building within 20 m of the 1:50 year floodline



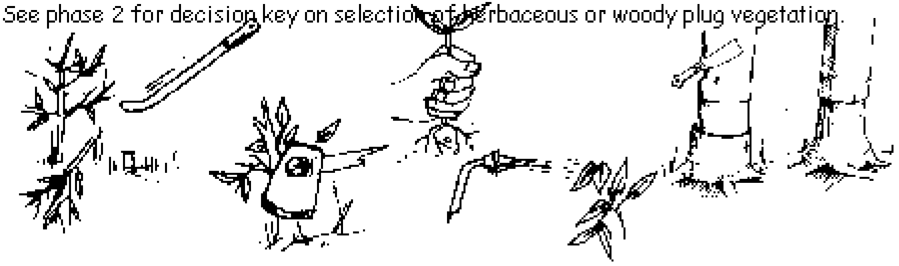
☐ Develop plugs at channel/donga headcuts or as high up as the channel as possible before progressing with plugs downstream



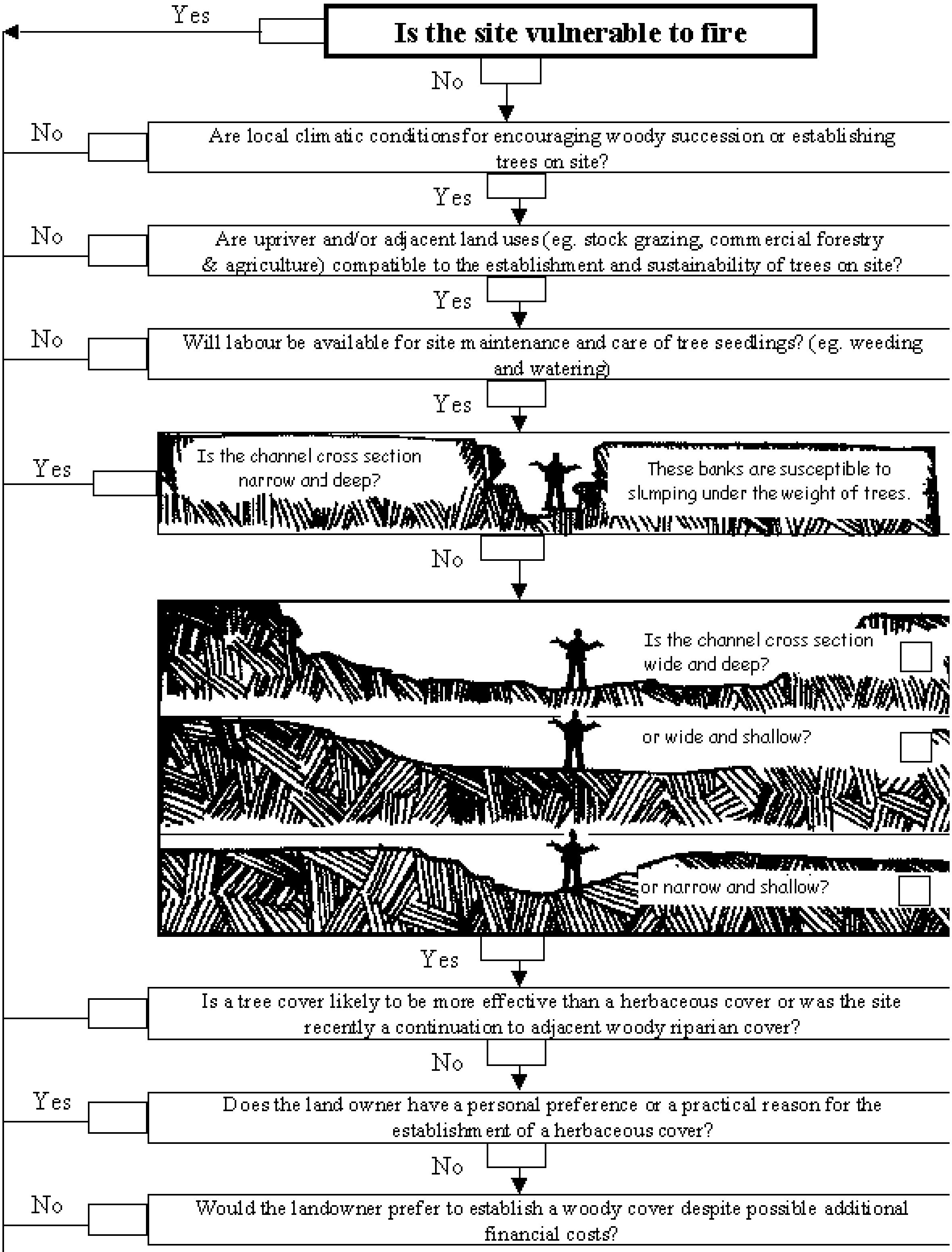
☐ Remove / fence off or herd stock away from sensitive areas.
☐ Use a weak-link on fence lines that will collapse during flood events
☐ Provide an alternative water source for stock.



☐ Remove alien invasive plants in planned phases (starting upstream and working on light infestations first) and maintain control via regular follow ups.
☐ See phase 2 for decision key on selection of herbaceous or woody plug vegetation.



PHASE 2



Apply guidelines from phase 1 and then:
a. Encourage a herbaceous cover by allowing natural plant succession to take its course. This often involves the use of fire - see Wetland Fix Part 2; and/or
b. establish a herbaceous support cover at stream pressure points (e.g. weak or collapsing bank sites).

Apply guidelines from phase 1 and then:
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b. establish a herbaceous support cover at
points (e.g. weak or collapsing bank sites)

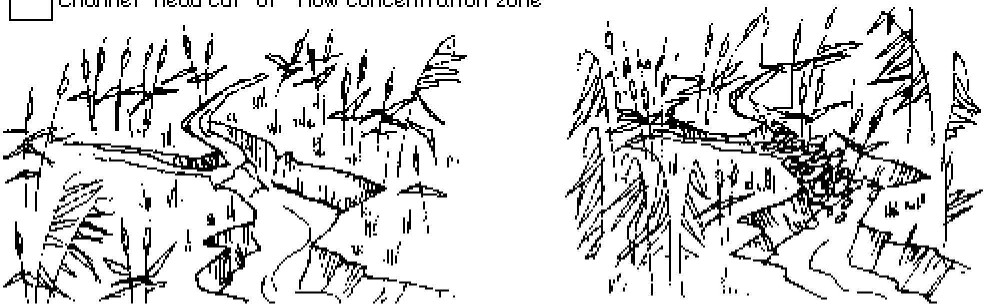
Channel Plug Development - Using Herbaceous Plants

1. Select from the diagrams those unstable "plug sites" that resemble your situation.
2. Select "plug development" techniques using herbaceous plants (next section).
3. See Wetland Fix - part 4 for selection and propagation of herbaceous plants.

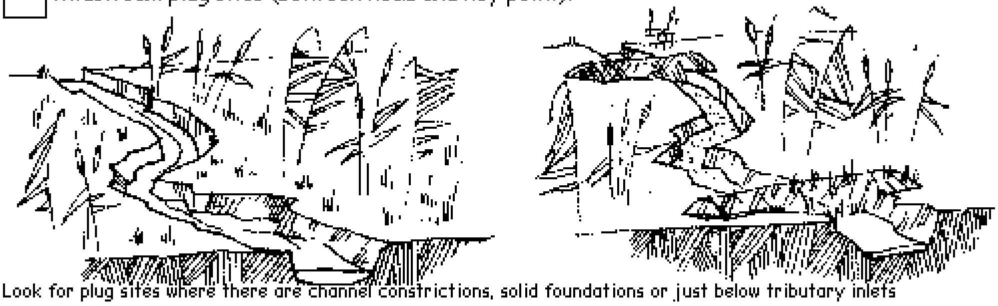
Cautionary notes:-

- Plug development could lead to flooding which might affect neighbouring landowners. Whilst this might be the intention of the restoration exercise, such possible flooding consequences need to be discussed with and agreed to by the neighbours before allowing complete plugging to take effect.
- Beware of theft of wire from gabion baskets when working in some districts.

☐ Channel "head cut" or "flow concentration zone"

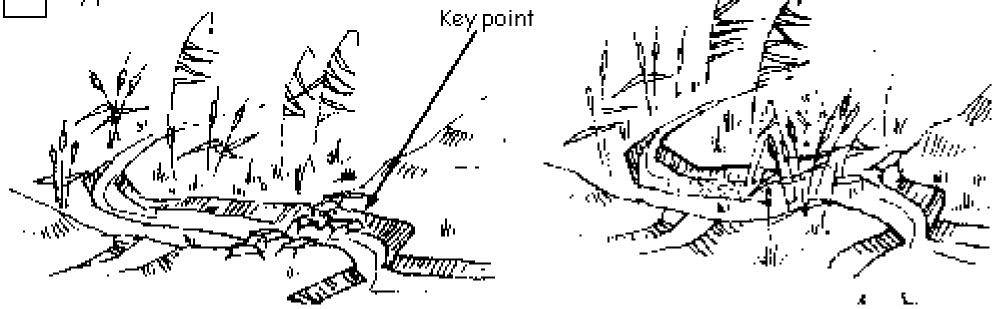


☐ Midstream plug sites (between head and key point).



Look for plug sites where there are channel constrictions, solid foundations or just below tributary inlets

☐ Key point

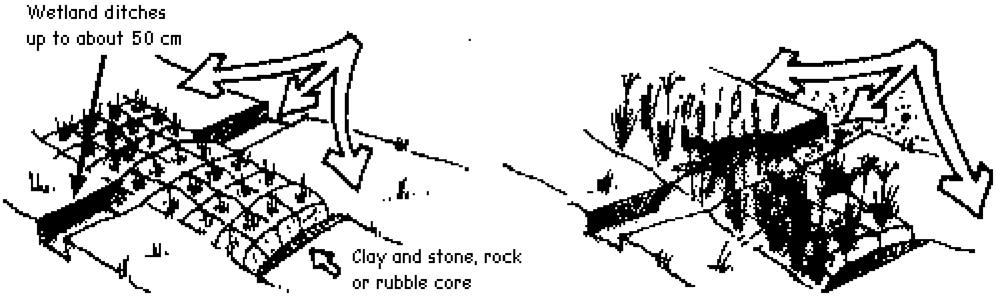


☐ Plug overflow / spillway

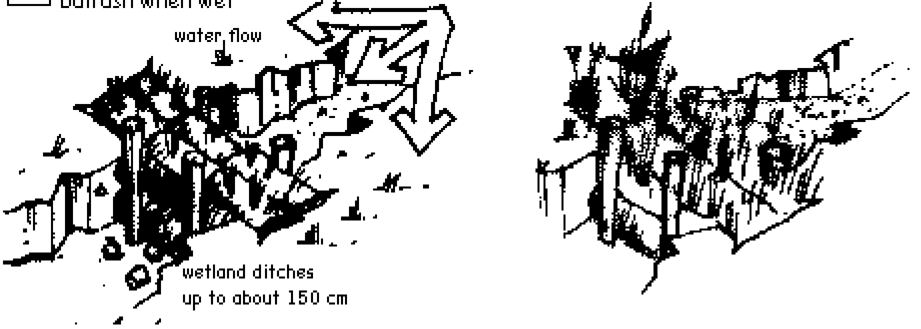
PLUG DEVELOPMENT TECHNIQUES USING HERBACEOUS PLANTS

☐ Hebaceous plug 1: Rock fill (rip-rap) at head-cut supported by root clumps of sedge, reed or bulrush

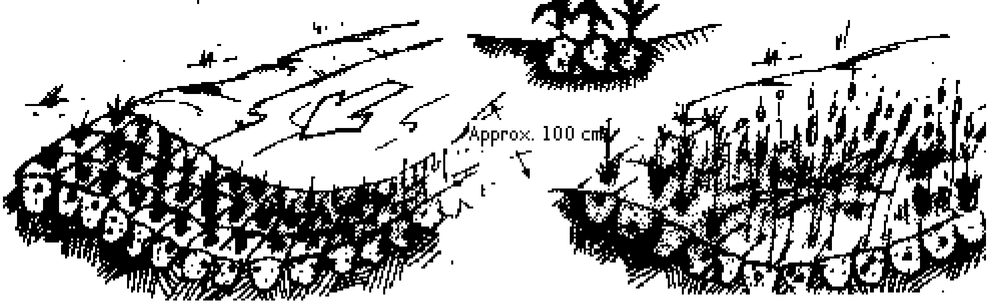
☐ Hebaceous plug 2: Soil hump diversion plug planted with rootclumps of grass, sedge, reed or bulrush



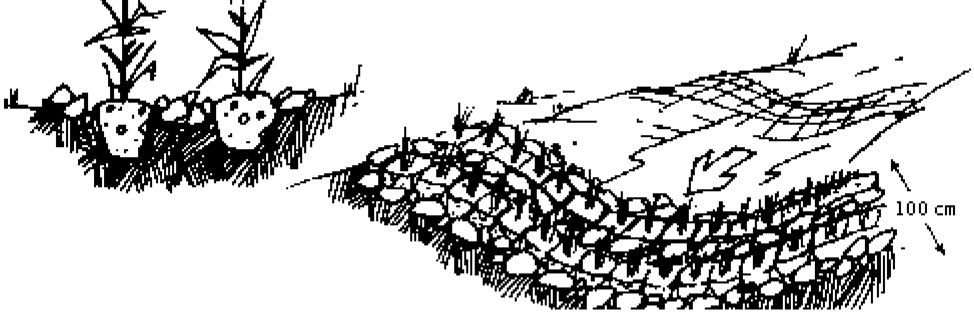
☐ Herbaceous plug 3: *Sand bag diversion plug planted with grass, sedge, reed or bulrush when wet*



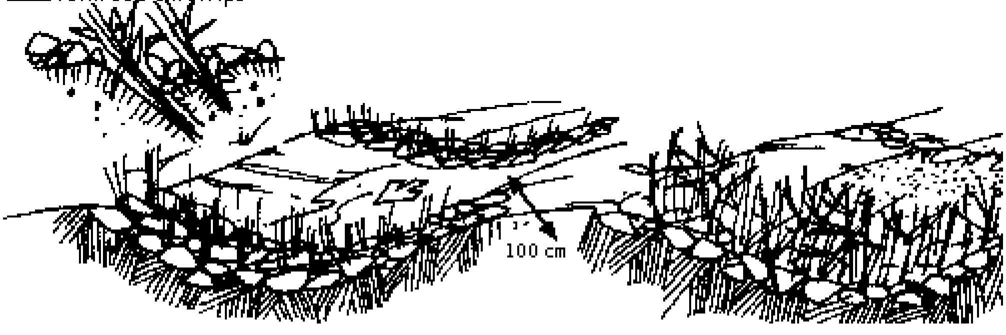
☐ Herbaceous plug 4: *Channel slits planted with root clumps of sedge, reed or bulrush in 100 cm strips*



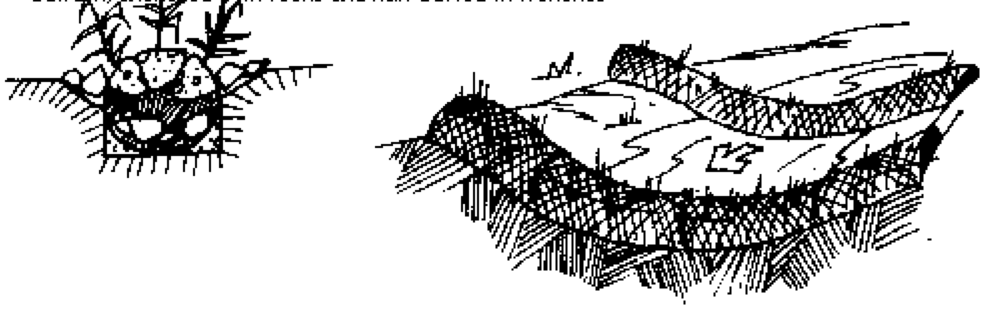
☐ Herbaceous plug 5: *Channel sills planted with root clumps of sedge, reed or bulrush in 100 cm strips and supported with rocks*



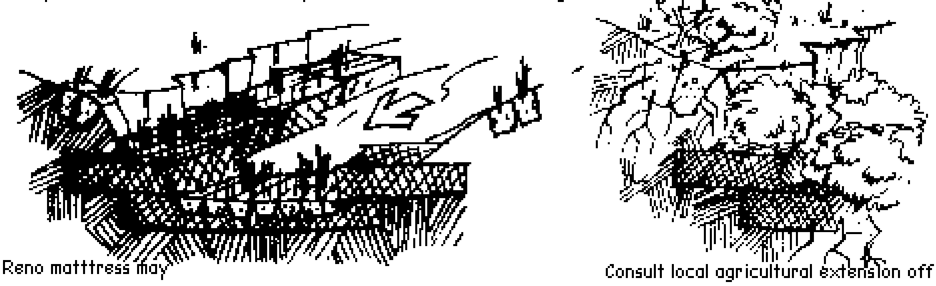
☐ Herbaceous plug 6: *Channel sills planted with reed culm bundles and anchored with rocks to form 100 cm strips*



☐ Herbaceous plug 7: Roll gabion channel sills planted with root clumps of sedge, reed or bulrush, anchored with rocks and half buried in trenches



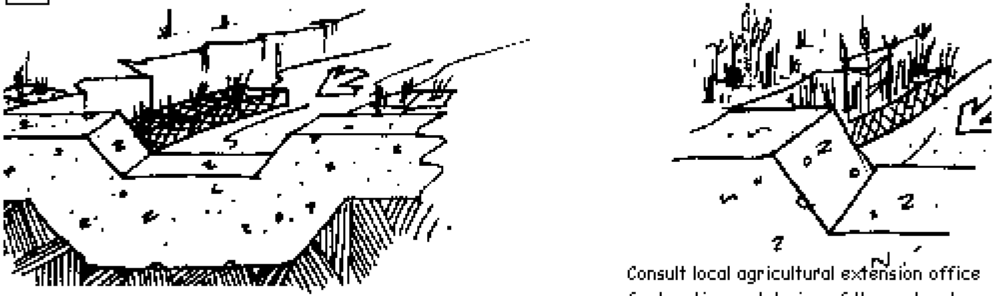
☐ Herbaceous plug 8: *Gabion or concertainer plug.* Root clumps of sedge, reed or bulrush planted in front and on top of stone and soil filled gabions



Reno matttress may be required

Consult local agricultural extension office for location and design of these structures

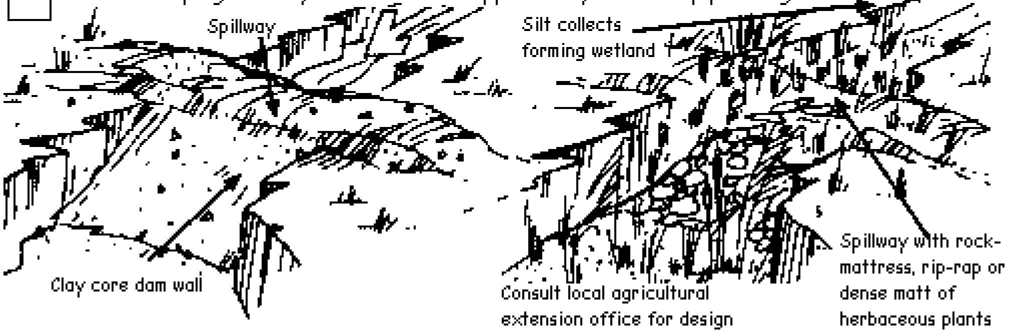
☐ Herbaceous plug 9: *Concrete weir.* Supported by root clumps or gabion / root clump planting.



Reno mattress may be required

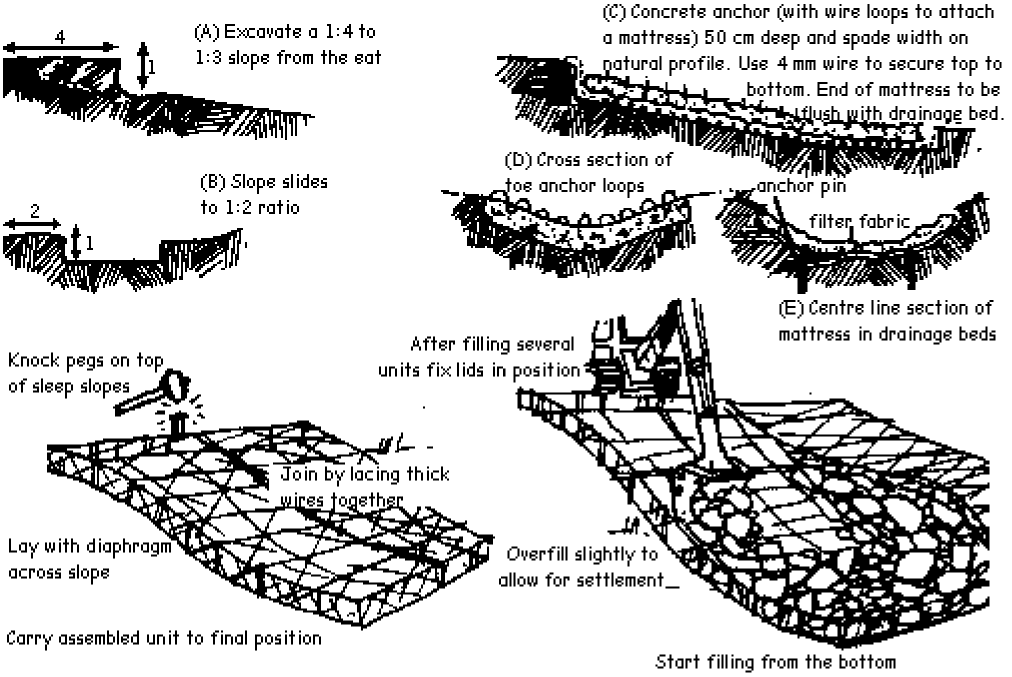
Consult local agricultural extension office for location and design of these structures

☐ Herbaceous plug 10: *Clay core dam wall supported by root clump plantings*



Consult local agricultural extension office for design

☐ Reno mattress: Long flat wire-mesh or veldspan baskets filled with rocks or stones, used to protect water overfall points against downstream scour



Channel Plug Development - Using Trees

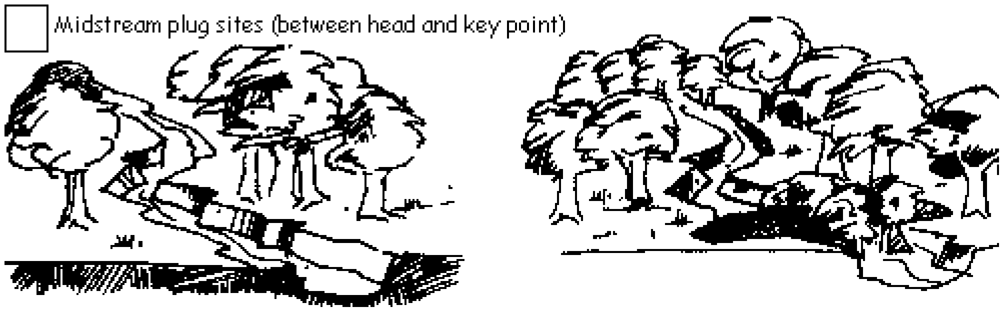
1. Select from the diagrams those unstable "plug sites" that resemble your situation.
2. Select "plug development" techniques using trees (next section).
3. See Wetland Fix - part 4 for selection and propagation of trees.

Cautionary notes:-

- Plug development could lead to flooding which might affect neighbouring landowners. Whilst this might be the intention of the restoration exercise, such possible flooding consequences need to be discussed with and agreed to by the neighbours before allowing complete plugging to take effect.
- Beware of theft of wire from gabion baskets when working in some districts.

☐ Channel head cut or flow concentration zone

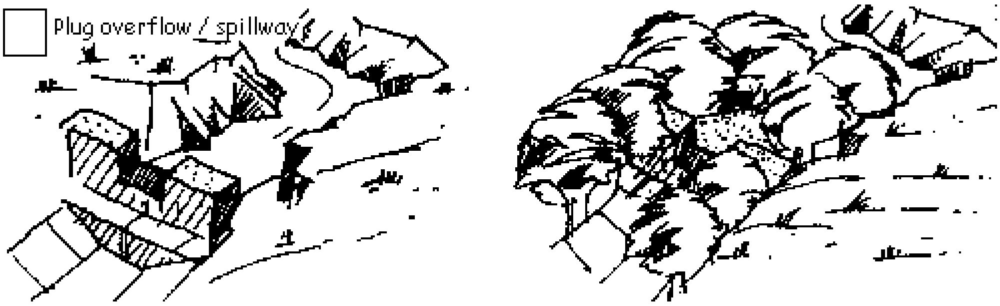
☐ Midstream plug sites (between head and key point)



Look for plug sites where there are channel restrictions, foundations or just below tributary inlets

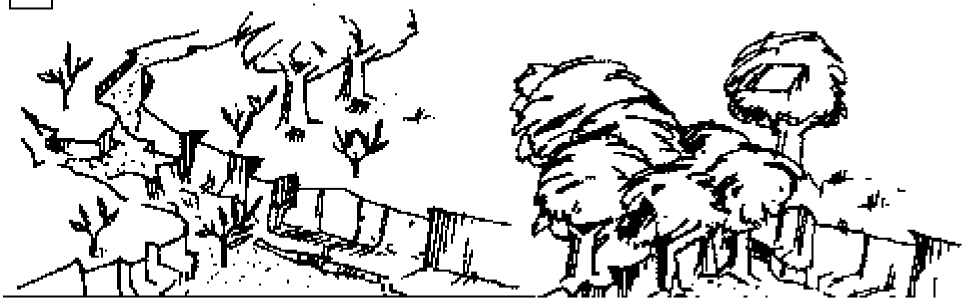
☐ Keypoint

☐ Plug overflow / spillway



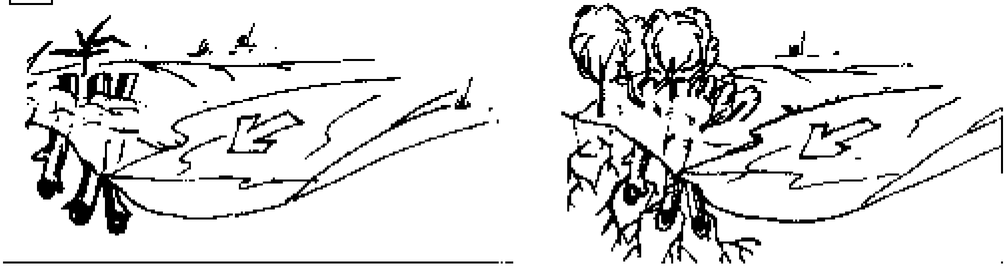
PLUG DEVELOPMENT TECHNIQUES USING TREES

☐ Tree plug 1: Head cut planted to trees

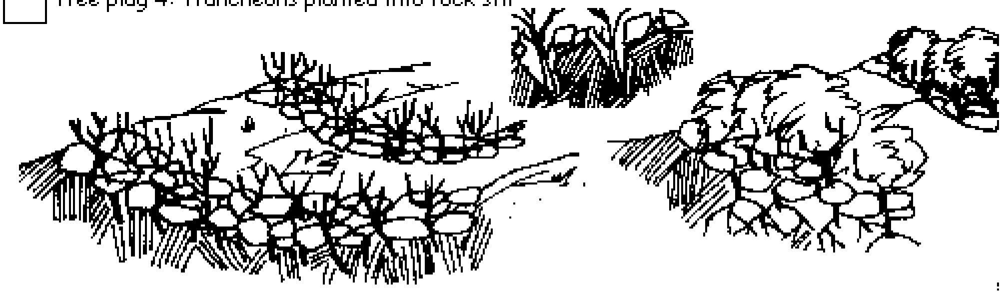


☐ Tree plug 2: Seedlings and/or truncheons planted into the channel at about 150 cm intervals

☐ Tree plug 3: Truncheons ground layered into the channel

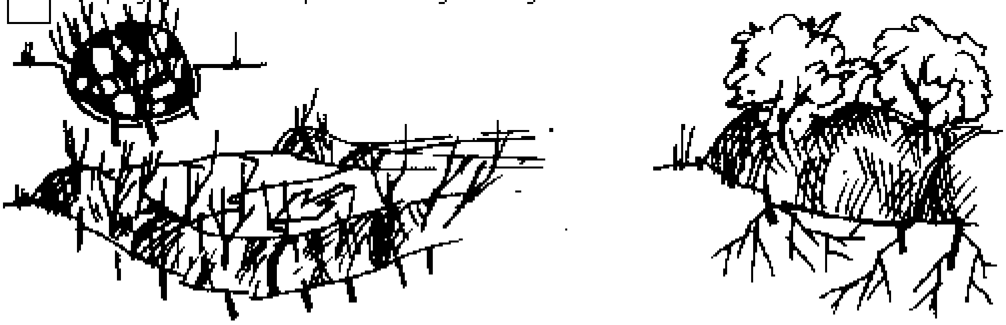


☐ Tree plug 4: Truncheons planted into rock sill

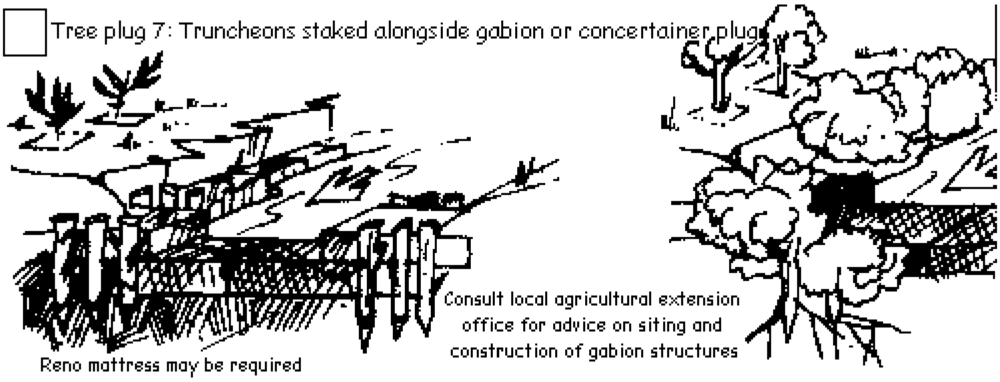


☐ Tree plug 5: Truncheons planted alongside a roll gabion sill filled with rock and soil

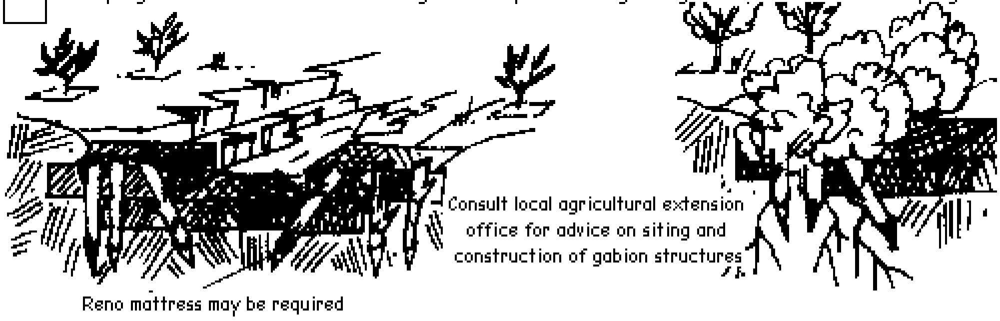
Tree plug 6: Truncheons planted through a roll gabion sill filled with rock and soil



Tree plug 7: Truncheons staked alongside gabion or concertainer plug



Tree plug 8: Truncheons staked and ground layered alongside gabion or concertainer plug



Urban Stormwater Management

Ideally the planning and design of storm water management should be a combination of engineering and biological skills. The following are not intended as guidelines but rather as illustrations of the reasoning and some possibilities of such "bioengineering".

In developed areas, the hard surfaces allow rapid run-off to occur ; run-off is the amount of water that does not soak into the ground during and after a rainstorm and which flows into streams and rivers. Buildings, roads and other hard paved surfaces prevent water soaking in thereby contributing to increased run-off that can be as much as four-fold higher than that of natural areas. These high peak flows break and scour through natural channels causing flooding and damage to property. Traditionally these water courses are modified into canals; that is, they are straightened and lined with concrete or rock filled gabions- mattresses.

Canals allow water speeds to increase which increases flow rates without having to build bigger canals. Consequently this transfers the flood problem downstream which in turn necessitates further stream straightening and hardening. Whilst managing to rid the area of floodwaters at high cost, this form of storm water concentration negates all the wetland values that a natural stream would have . Furthermore, canals are visually unappealing and biologically unproductive.

A more acceptable approach follows the principle that flow-rates can be reduced in semi-canalised watercourses if some basic principles of storm water management are followed. In heavy storms the width of a stream increases to cope with the increased volume rather than only increasing the speed of flow. This is in effect storing the excess water until the stream can cope with the flow again. The combined effects of a wide flood plain to store overflow; porous soil to soak up some water and vegetation to slow the flow and trap silt , all act together to reduce the damaging effects of floods.

- loss of former flood plains can be compensated for to some degree by constructing detention or retention dams and ponds;-
- detention dams or ponds are pervious man-made structures designed to temporarily catch flood run off, to reduce flow velocity and then to gradually release floodwaters back into the stream thereby minimising damage to watercourses and surrounding areas.
- retention dams or ponds on the other hand are impervious and only release impounded floodwaters down to a certain level, then retain some of it. Depending on the water quality this may provide recreational opportunities for fishing, sailing, boating, swimming etc.

Building these features into canals can reduce the cost of initial construction and the need for downstream canalisation whilst enhancing the biological and visual aspects.

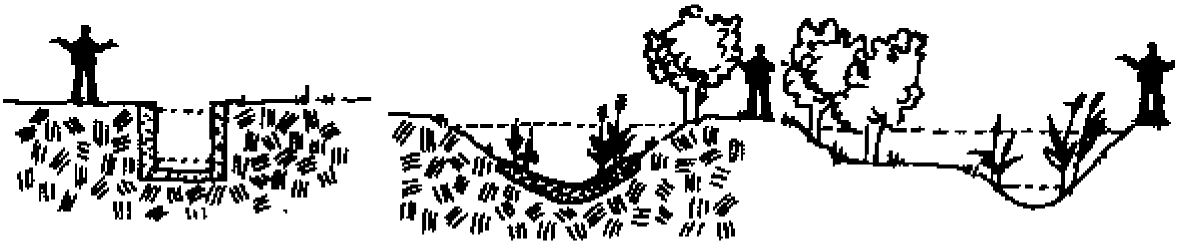
SMALL STREAMS

*A*The small stream completely converted to a concrete lined canal which confines flow within a steep sided rectangular culvert. This design is visually unappealing and biologically unproductive.

*B*An improvement on canal (A) is to retain some of the existing streams features whilst only semi-lining the stream bottom with rock-mattresses to prevent erosion. The natural vegetation would reduce the velocity of flood peaks whilst improving the visual and biological aspects.

*C*Useful additional features include a wide bench as a flood plain which can serve as a walking trail.

The increased storage capacity of this watercourse could even negate the nee to harden the canal bottom.



LARGE STREAMS AND RIVERS

*A*The large stream converted into a hydraulically efficient concrete canal.

This canal remains bare of vegetation as the V-bottom design ensures scour and will prevent any silt build up.

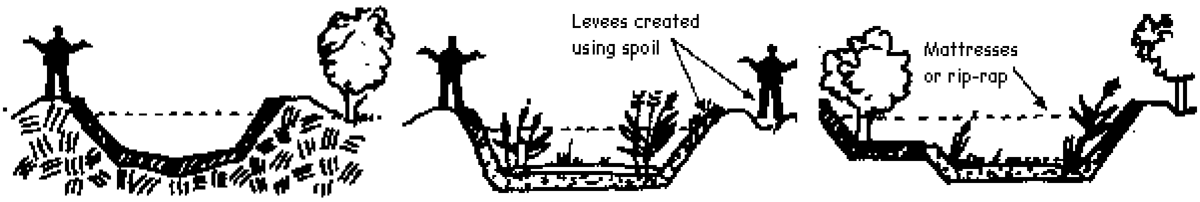
This design is visually unappealing and biologically unproductive.

*B*An improvement is to flatten the canal bottom to allow for some silt build up that will encourage plants to grow.

Rock mattresses are used on the upper sides to encourage further vegetative screening.

*C*The ideal compromise of canal engineering with natural design is the concrete flat bottomed canal together with a flood plain bench and sides semi-hardened with rock mattresses.

This design allows for flood-plain storage whilst the natural silt and vegetation build-up improves the flood attenuating and the visual and biological aspects.



Glossary of Terms

Alien	Plants or animals introduced from one environment to another, where they had not occurred previously.
Canopy (of trees)	The upper layer of woody communities where tree branches and leaves are most dense.
Channel (of water)	The bed in which a stream of water runs.
Concertainer	A collapsible steel mesh cage that is textile lined and can be filled with any material including, concrete, sand, stone, mud, gravel, and synthetic resins and is similar to a gabion (see below) in both form and use.
Dampening	See "flood attenuation".
Deposition	The settling down of material transported by water.
Flood plain	An area adjacent to streams which is periodically inundated by flood flows. Flood plain ecosystems develop in response to the flooding patterns generated.
Flood attenuation	The effect of a wetland on reducing flood peaks and water velocity.
Gabion	A wire-mesh basket filled with rocks or stones; used in reinforcing eroding banks.
Levees	Man made ridges of soil (technically "dykes") that are formed on either side of a river channel to protect the surrounding land from flooding- Levee formation is also a natural phenomenon.
Perennial (stream)	Having running water throughout the year or through many years.
Propagate(plants)	To reproduce plants by means of cuttings or seeds.
Reach (of stream)	A straight uninterrupted portion of stream or river.
Restoration	The act of enhancing the condition of degraded wetlands to a level whereby certain of the functions which the system formerly provided become replaced.
Riparian	Occurring on the banks of streams or rivers.

Rip-rap	A jumbled mass of rocks used as a simple means of controlling bank erosion.
Seasonal (stream)	Only having running water during the rainy season.
Sill (on a channel)	A horizontal structure running perpendicularly across a channel bed.
Succession (of plants)	The progressive change in composition of a community of plants towards a largely stable climax.
Truncheon	A "thick" cutting from a plant used for propagation purposes.
Woody (cover)	Covered with shrubs and trees

Further Reading

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