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Natural Heritage Trust

Water notes

Water notes for rivers management

GOVERNMENT OF WESTERN AUSTRALIA

ADVISORY NOTES FOR LAND MANAGERS ON RIVER AND WETLAND RESTORATION

Sediment in streams

This water note aims to provide readers with an introduction to sediment in streams. It discusses the origin and transport of sediment in natural systems and the influence of flow characteristics and channel shape on erosion. Human activities that influence the erosion and transport of sediment are then described. The impact of excess sedimentation on the natural streams system are discussed, and finally, some mechanisms for reducing sediment import into streams are described.

Erosion and sediment transport

Stream channels are dynamic features of the landscape, changing their size, shape and bed material with time and in accordance with changes in water flow and sediment load. The mobile material that makes up a stream's bed, banks and floodplain has been carried and deposited there by the stream and can be moved again given the right conditions.

A stream channel can be considered to be relatively stable when its water flow and sediment flux are in balance over time (see Figure 1). If there is a change in either of these two factors, then the channel will adjust its slope, depth, width, meander pattern, bed composition and vegetation density accordingly. The extent and rate of these adjustments are dependent on the extent and rate of change in the water flow and sediment load.

Some textbooks describe the transport of surface water in streams as occurring within a two-stage "channel" system. These include the "bankfull" channel, which has the capacity to carry flood flows that occur, on average, once every one to two years and the low flow channel which carries minor flows between floods, that are generated by groundwater seepage along the river valley. Low flow channels are not always present especially in the drier parts of the State. There is also the floodplain, onto which floodwaters will spill out when a flow event exceeds "bankfull" capacity. Changes to streams predominantly occur when the "bankfull" channel is full of water. This is the level at which the water has its maximum power to move sediment. When this volume of flow is exceeded the water rises above the level of the channel and spills onto the floodplain, dramatically reducing the average stream flow velocity and consequently its power. As the power of the water is reduced, so too is its capacity to carry sediment and as a consequence large quantities of sediment are often deposited on the floodplain during flood events.

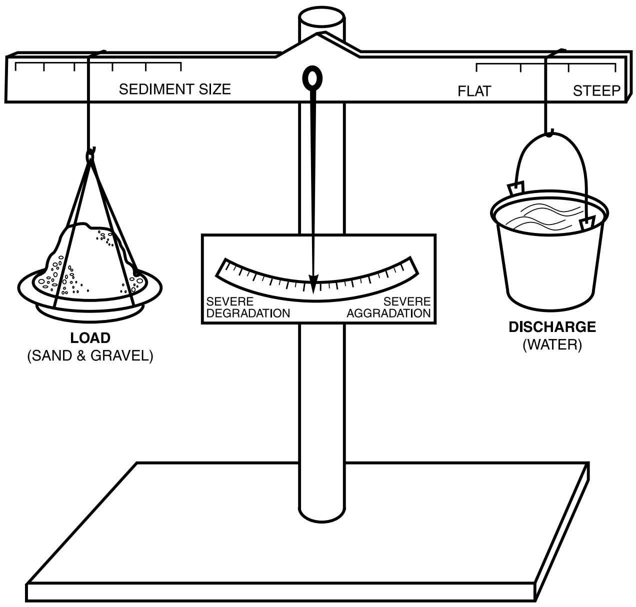
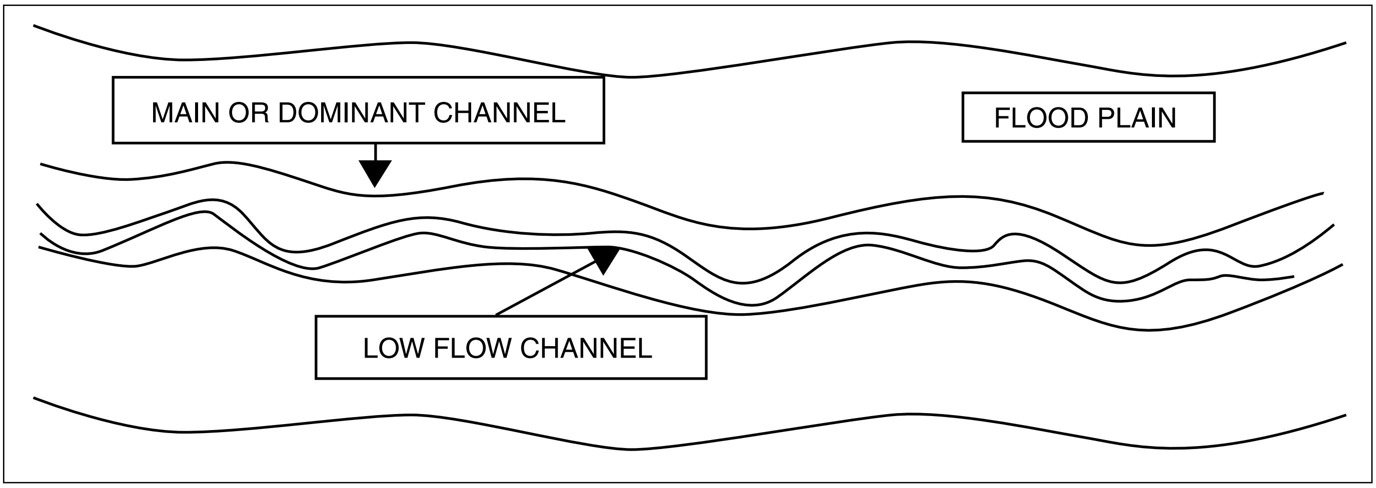


Figure 1: The Stream Balance. Adapted from McManus, J. 1985.

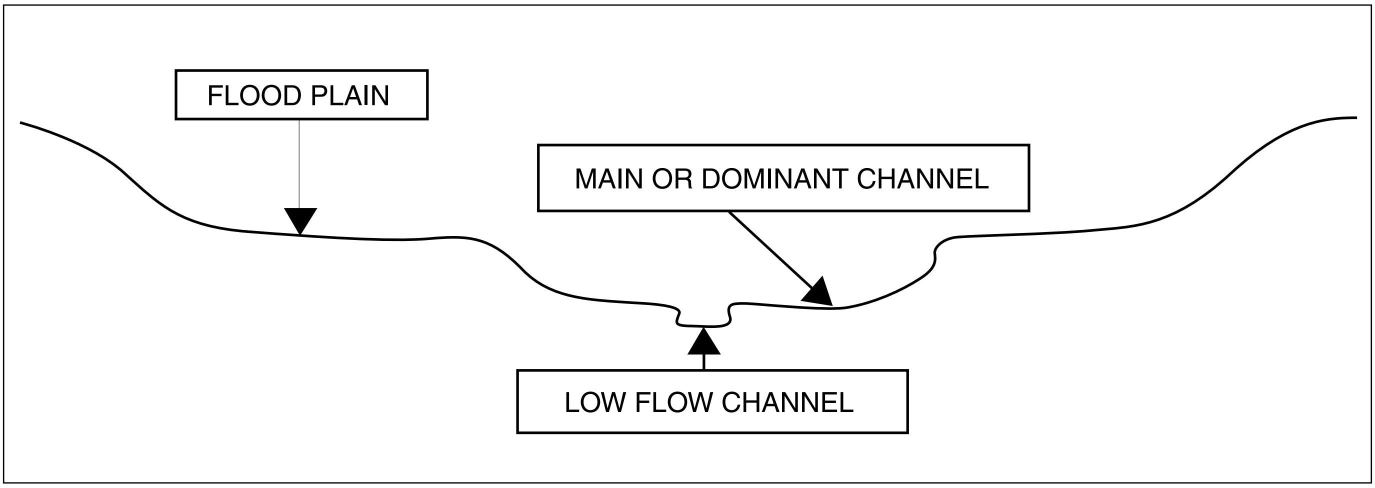
In southwest Western Australia, river systems have three zones (see Figure 2).

1. The main or "dominant" channel: This is identified by a number of factors including the presence of high water marks on the banks, changes in slope and bank vegetation, exposed root zones and bank undercutting.
2. The low flow channel: It is common in southwest Western Australia for a low (trickle) flow channel to form within the "dominant" channel. Long periods of no or low flows are typical due to a combination of hot, dry summers and low gradient terrain. The low flow channel is often being eroded and is therefore also referred to as the 'active' channel.
3. The floodplain: When the volume of flow exceeds the capacity of the "dominant" channel, the water rises above the level of the channel and spills onto the broader part of the valley that is the floodplain.

It is important to recognise all three zones to understand which one has the potential to, or has already, caused a change to stream characteristics. During periods of drought, with sustained periods of low or no flow, the "dominant" channel and floodplain can become overgrown by vegetation. This reduces the flow carrying capacity of the channel. When higher flow events return the stream may scour a wider or deeper channel or a new channel across the floodplain, along the least line of resistance. This is simply a response to the flood event and does not necessarily indicate a long-term change. Management of vegetation density on floodplains and within the dominant channel can minimise channel changes and sediment mobilisation during high flow events.



Plan view



Cross section view

Figure 2: Plan and cross sectional view showing 3 zones of Western Australian river systems.

The effect of widespread clearing

The advent of large-scale clearing and development in catchments since European settlement has initiated significant changes in water flow and sediment movement of many rivers in southwest Western Australia. The main effect of these changes on the water balance has been an increase in the amount and rate of run-off from a catchment, with more water entering river systems. Increased flow may increase erosive power and the potential to undercut the stream bank, particularly at meander bends. In addition, larger flood flows may saturate the bank, causing it to collapse under the added bulk weight of the water. This is particularly common where the root zone has been undercut. Thus, increased amount of water draining the catchment increases the potential for channel change and contributes to changes in the sediment regime.

Widespread clearing has also altered sediment regimes through the influx of fine silt and clay particles from soil erosion. In addition, de-snagging or "river training" programs, for the purpose of flood control, have resulted in the mobilisation and redistribution of sand that was otherwise held in place by fringing vegetation.

Sources and types of sediment

Catchment clearing and "river training schemes" result in the indirect mobilisation of sediment into stream systems. Sediment may also enter streams as result of other human activities such as the construction of dams and as a result of mining activity within a catchment. The construction of roads is known to be a major contributor of sediment to waterways.

In rivers and creeks, sediment exists in two forms, either as suspended or deposited material. Usually, it is the very fine sediment (silt and clay) that is suspended, and the courser sands that are deposited. Under high flow sand may enter the suspended load and under low flow silts and clays may settle onto the stream bed. Sediment that is deposited may remain in place forming long plumes and channel bars or it may be transported downstream as part of slow moving bed load.

Damaging effects of sediment in streams

Although sediment is a natural component of streams and rivers, it can be damaging when it is present in excess. There are a number of mechanisms by which this can occur.

Infilling of natural riverine pools

Riverine pools comprise areas of deeper water with slower baseflow than nearby shallower riffle or channel areas. It is natural for sediment to settle out in pools and for the sediment to remain until large floods scour it out. Large amounts of sediment may be deposited in riverine pools where the upstream catchment and watercourse are highly degraded. In southwest Western Australia, the generally low gradient landscape means that many streams do not have the power to scour out the pools, except in extreme flood events. Since these events are uncommon, sediment may remain in pools for long periods. The infilling and thus loss of riverine pools has serious consequences for the stream ecosystem.

Riverine pools provide an important habitat for aquatic fauna. The hot, dry climate of Western Australia, means that many of our rivers and creeks dry out in summer and autumn. In these systems, permanent, deep river pools provide a refuge for the aquatic fauna that do not have physiological adaptations to tolerate drought. These fauna are able to survive in the shrinking river pools until flow begins again in winter.

Pool environments can contribute to the reduction of nutrients entering our estuaries and near-shore marine areas. Where shallow pools are able to provide slow flow and a stable bed, they become suitable for the growth of benthic algae and submerged water plants. These can strip the water column of nutrients, thereby reducing the nutrient load being transported downstream.

What's happening to the river pools in the Avon

The Avon River between Beverley and Toodyay once comprised a series of deep permanent river pools separated by braided river reaches. As a result of the combined effect of extensive catchment clearing and the implementation of the River Training Scheme (1958 - 1972), the river has experienced significant sediment relocation resulting in the filling of many of the permanent river pools. Fortunately the major natural pools at Beverley, Gwambygine, York and Katrine/Glen Avon remain substantially intact.

Rehabilitation works are planned for the Avon River pools. These will involve regeneration of natural vegetation, revegetation and excavation of sediment from selected pools. The recovery of these pools is dependent upon the collaborative efforts of the community, local government, the local management authority, Aboriginal groups and state agencies.

Neridup Creek at Fisheries Road, Esperance February 1998. *Photo by S. Janicke*

Neridup Creek flood event 7 January 1999. *Photo by S. Janicke*

Neridup Creek. Aftermath of the January flooding 20 January 1999. *Photo by S. Janicke*

Time series photos showing the value of fringing vegetation in preventing erosion during flood events. Note the erosion caused by the flood in areas where vegetation was absent.

Photos showing the accumulation of sediment in Burlong Pool near Northam. The dredge is used to excavate sand with an estimated 10,000m^3 being removed from Burlong Pool annually.

Altered instream vegetation and flow dynamic

Where sediment accumulates in shallow, slow flowing areas of a river, it provides a base for the colonisation of semi-aquatic plants. Weeds, which readily colonise new habitats as well, may prevail in these areas. The colonisation of plants will slow the flow across these areas and cause further sediment to settle out. These areas may become islands within the stream channel, causing flow to divert around them and altering channel shape. The accumulation of sediment may also raise the channel bed and thereby reduce channel capacity to carry high flows.

Reduced photosynthesis

When large amounts of sediment are suspended in the water column, conditions become turbid and light penetration is reduced. Water plants and algae require light for photosynthesis. Without it they cannot survive and if light is reduced their growth rate will decline. This effect may be particularly problematic in mid-order streams where turbidity is generally low and an open canopy permits light to reach the stream bed. In these areas water plants and algae form an important component of the food web and their absence or reduced growth will affect the microbes and animals that feed upon them.

Altered macroinvertebrate communities

Aquatic macroinvertebrates are particularly vulnerable to deposited sediment as the composition of the streambed is a major factor contributing to their distribution. Typically streams subjected to increased sedimentation have a less diverse macroinvertebrate fauna. Macroinvertebrates, such as caddisflies, stoneflies and mayflies, which like to live in clean gravel beds, become less abundant. Worms and midge larvae, which prefer finer sediment, become more abundant.

Macroinvertebrates are also vulnerable to increased turbidity caused by suspended sediment. Turbidity reduces light and may confuse macroinvertebrates into sensing that it is night-time. At night, many macroinvertebrates leave their homes to seek new homes. This is called ‘drift’ because they move into the flow path and drift downstream in search of new places to live. Macroinvertebates ‘drift’ at night because they are safer from predators at that time. If macroinvertebrates are confused by turbidity they may ‘drift’ at times when they are more likely to be eaten.

Suspended sediment can be abrasive and may damage the fine gills and mouth parts of macroinvertebrates. It may also make it harder for predatory macroinvertebrates to see their food. Macroinvertebrates that feed on algae may have to spend more time feeding because fine sediment sticks to the algae, reducing its nutritional value.

Influences on fish distribution and food availability

Many of Western Australia’s native fishes ‘over-summer’ in deep river pools. The loss of these pools, because they have become filled with sediment, may cause localised extinctions of some fish species.

Excess sediment may also influence the availability of food for our fishes. Some fish species, such as gobies, feed partially on algae, while others have a diet mainly of macroinvertebrates. Changes to the abundance and distribution of algae and macroinvertebrates as a result of increased sedimentation may therefore influence fish populations in streams. Fish may also have more difficulty finding their food because of increased turbidity.

Disruption of the food web

Increased sedimentation will upset the food web by influencing the distribution and abundance of fish, macroinvertebrates, plants and algae.

Excess deposition of sediment may also slow the breakdown of terrestrial leaf litter in streams. Leaf litter forms the basis of energy supply to the stream food web. When sediment smothers leaves it reduces the availability of oxygen to the leaf surface. As a result the leaves are not available to the oxygen loving microbes and macroinvertebrates that break leaves into finer particles so that they then become food for other animals downstream.

What can be done to reduce sediment transport in streams

Once sediment has entered waterways it is difficult and expensive to remove, requiring engineering solutions and heavy equipment. Preventative measures aimed at reducing further sediment transport are the best approach. The revegetation of river banks will go a long way toward reducing sediment transport as healthy riparian vegetation is effective in reducing bank erosion. Riparian vegetation will also filter sediment being transported in surface water runoff. It is important to have riparian zones of adequate size for this purpose. Current research indicates that zones of between 30 and 50 m may be sufficient, depending on the slope of the land. On-farm retention of water through the use of dams and contour banks will also help to reduce the erosive power of water leaving catchments and thereby reduce the amount of sediment transported to and mobilised within stream systems. Techniques for sediment management will be detailed in the water note (in preparation) titled 'Techniques for management of excess sediment in streams'.

Further reading

Available from the Water and Rivers Commission

Water note WN12, The value of the riparian zone

Available from other sources

Waters, T. F. 1995, *Sediment in Streams*, American Fisheries Society, Maryland.

Wood, P. J. & Armitage, P. D. 1997, *Biological effects of fine sediment in the lotic environment*, Environmental Management 21(2): 203 –217.

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