4 Fluvial Processes and Causes of Erosion

The following sections summarise the major physical processes that determine the shape of the river and the potential bank erosion mechanisms.

4.1 Tidal Hydraulics

The South Pine River discharges into the North Pine River and Moreton Bay, which experiences a predominantly semidiurnal tide (i.e. two high tides and two low tides in a little over 24 hours). These tides propagate into the connected rivers and their tidal tributaries. The speed of propagation of the tide up the estuary is primarily dependent on:

(1) Depth of the river; and

(2) Friction losses due to the roughness of the bed and banks and the non-uniformity of the river cross-section.

The tidal prism at a particular location is the volume of water that passes this location during the rise or fall of a tide. Therefore the tidal prism decreases from a maximum at the mouth of the river to zero at the limit of tidal propagation.

Most rivers which flow through alluvial coastal plains develop a tidal regime equilibrium in the lower estuary areas, in which:

- There is a balance between tidal flow (expressed in terms of the tidal prism) and the cross-section area at each part of the river; and
- There is a balance between the width and depth of the river.

The cross-section of the lower South Pine River is therefore governed predominantly by tidal processes. Clearly, bedrock and/or stiff cohesive clays may restrict the ability of a river to achieve this equilibrium in certain areas, sometimes affecting other adjacent areas. Furthermore, if dredging or reclamation works are undertaken which change 'natural' tidal hydraulics, this equilibrium can be upset with scour and/or deposition occurring until a new equilibrium is reached.

4.2 Flood Hydraulics

The South Pine River is subject to infrequent major flooding. There is a transition zone in the upper estuary in which the shape and nature of the river channel, meander patterns and bank erosion cease to be dominated by tidal flow and become predominantly a function of flooding processes.

The location of this zone is usually not obvious, but can be identified by investigation of the tidal hydraulics and river channel characteristics.

In areas dominated by flood processes, the following factors are important:

- The river may be experiencing natural long-term meandering, with erosion on the outer bank and accretion on the inner side of bends.
- A balance of bed sediment transport along the river during floods is important to preserve quasi-stable equilibrium. Dredging, which creates a major 'sink' for fluvial sediment, may starve

downstream areas of sediment supply, leading to progressive bed and bank erosion until the bed becomes armoured with coarser material after finer material has been carried downstream.

- The river channel will be larger than that required for tidal equilibrium, tidal velocities will be low and there will be a tendency for the deposition of fine sediments from the catchment during the final stages of flooding.

Australia's rainfall climate is influenced by global inter decadal, decadal and multi decadal cycles. These cycles result in significant variations in rainfall conditions, with some years or groups of years experiencing significantly greater rainfall volumes than others. Periods of above average rainfall are likely to result in increased catchment runoff, causing increased occurrences of high flow velocities and higher erosion potential.

Figure 4-1 reports the historic flood events in the South Pine River since 1960. The flood data highlights three periods of increased flood occurrence:

- 1960 – 1975;
- 1988 – 1992; and
- 2009 – Present.

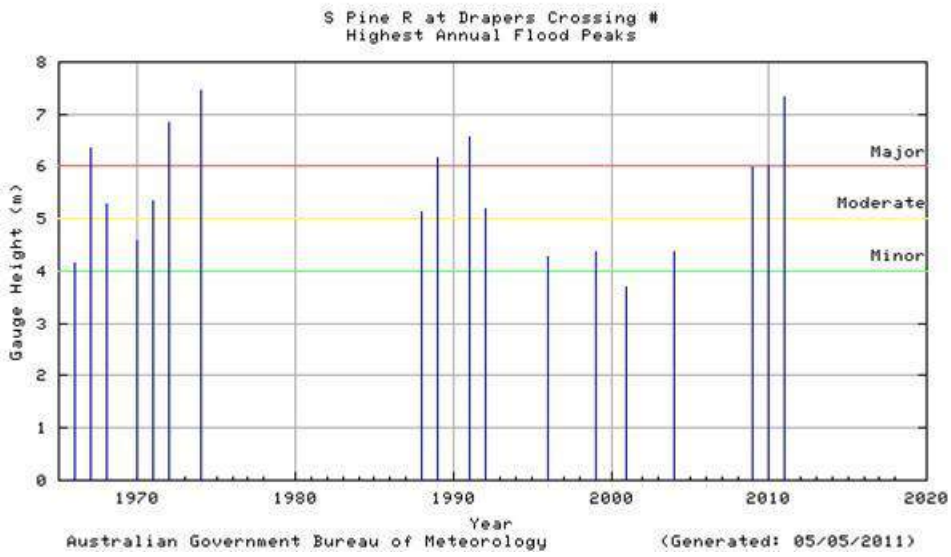

Figure 4-1 South Pine River Historic Flood Events[7]

The Bureau of Meteorology provides a measure of the rainfall variability using rainfall decile plots. Three year rainfall decile figures indicate that rainfall within the South Pine River catchment has been 'very much above average' since 2009. The period between March 2010 and 2013 represents the highest recorded three year rainfall totals in the South Pine River catchment, shown in Figure 4-2.

[7] Major flooding also occurred in January 2013

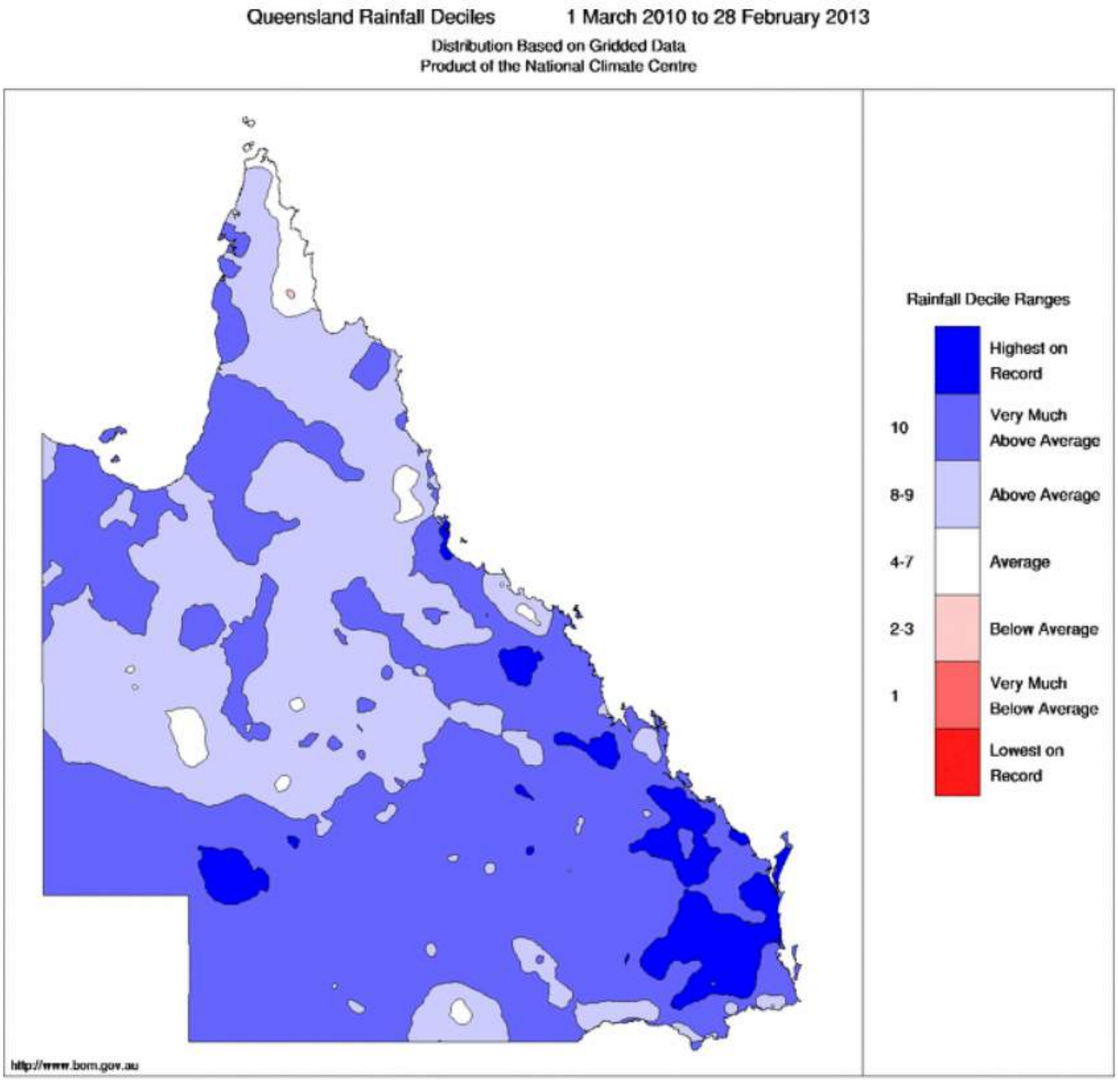

Figure 4-2 Queensland Rainfall Decile Measure (March 2010 to February 2013)

4.3 Sediment Transport

The sediment (sand, gravel, silt etc) present in the river is a product of transport from the eroding catchment and incision of the river into alluvial plains deposited during prehistoric times of higher sea level. The transport of this sediment along the estuary is a complex process, with major influences from tidal and flood hydraulics.

Floods result in the sediment bed load becoming dynamic for a short period of time (a matter of days or hours), producing a markedly different distribution of sediment depending on the size of the flood. Generally, floods tend to scour out beds and banks on the outside of bends where flow velocities are highest and severe turbulence and a lateral flow component occurs towards the inner side of the bend. These scoured materials are then deposited downstream in straight sections and more often on the inside of bends where velocities are lower.

Tides also result in a redistribution of sediment but, due to the typically lower velocities involved, the rate of change is much slower and more gradual, with the timeframe being much greater (of the order of months - years). In a similar mechanism to that for floods, sediment is transported when velocities reach a critical value and are deposited when velocities drop below another critical value. This process will continue until equilibrium is obtained or other external forces interfere (floods, dredging etc.). In the absence of these external forces, there is a tendency for a sediment balance to be established. That is, the sediment supply from the upstream catchment is matched by the discharge of sediment through the river's mouth.

In a localised area of a river, a deeper section of the river can cause disturbance to this equilibrium by starving downstream areas of sediment supply. This may lead to progressive downstream bed and bank erosion.

4.4 Potential Bank Erosion Mechanisms

As well as the abovementioned natural mechanisms for sediment transport, there are also changes introduced by man's activities, including sand and gravel extraction, navigation channel dredging, canal development and boat wash. These have the potential to influence bank stability either directly or indirectly through changes to the sediment transport processes. The full range of mechanisms potentially affecting the South Pine River estuary is detailed below.

- Natural meandering often exacerbated by floods: A river has a natural tendency to meander by scouring the outside bank and allowing a build up of sediment on the inside bank. These natural tendencies may result from tidal flows or freshwater (flood) flows.
- Natural slumping after flood events: Rapid drawdown as floodwater recede can lead to high groundwater pressures behind the banks with subsequent instability and slumping.
- Natural wind waves: Wind blowing across an open water body will generate waves. In the case of a river, these will be of limited height and period, but may still be responsible for bank erosion.
- More persistent freshwater runoff because of development and catchment clearing: Development/clearing of the catchment may contribute to more persistent and more frequent freshwater runoff and increased flood flows for a given rainfall event. This would intensify normal meandering processes by increasing the power of the river to remove scoured sediment.
- Increased tidal compartment: Enlargement of the tidal waterway, resulting from the construction of canals, marinas, flood-control channels or other enlargement of the tidal volume, will result in increased tidal flows and potential channel readjustment.
- Sand and gravel extraction: Dredging for sand or gravel extraction for navigation or other purposes, may contribute to lessening the stability of the adjacent bank, that can then slump or fail during flood drawdown or surcharge loading conditions. It may also generate a major 'sink' for fluvial sediment, starving downstream areas of sediment supply, leading to progressive bed and bank erosion. Armouring of the bed with coarser material after finer material had been carried away may limit such impacts.
- Dredging for navigation: Dredging of river channels, while not directly enlarging the tidal waterway area, can make the river channel more efficient at carrying tidal or flood flows; therefore, more tidal water flows in and out of the river during each tidal cycle. The increased

cross sectional area within the dredged channel may be sufficient to accommodate the extra flow without increasing the velocities there. However, velocities and scour potential could increase outside the dredged areas as a result of the additional flow, which may intensify normal erosion processes or create separate problem areas.

- Natural shoreline vegetation cleared: Rural and urban development often involves clearing a large percentage of the natural vegetation along a riverbank. In particular, mangroves are often not valued because of the silts they trap and as they are seen to 'obscure' water views. However, they are effective at slowing shoreline recession due to the high level of energy dissipation in their exposed root system. Also, clearing of larger timbers along a riverbank exposes the water body to higher winds and hence higher waves, which can cause shoreline erosion.
- Boat wash: Boat generated waves are a significant problem in most rivers where population/boating density has increased. However, the physical causes are still being understood and not all boats contribute to erosion. Almost all soil types are affected to some degree by boat wash, with clays being undercut and sandy materials transported away from the banks.