

# Clive River Sediment

## 1. Introduction

Sediment accumulation in the Clive River is an ongoing issue that the Hawke's Bay Regional Council monitors regularly. It is an issue for iwi who desire a return to the days when gathering kai and swimming in the awa was a common occurrence, carried out in clear water on a gravel bed, not a silt and weed laden bed as exists today.

Prior to the late 1960's the Ngaruroro River flowed down the same channel as the river now known as the Clive River (but still referred to by hapu as the Ngaruroro Awa). The river bed was gravel, built-up by successive floods and flows sufficient to transport the gravel all the way to the coast. In the late 1960's the Ngaruroro River was diverted down its current channel, leaving the old riverbed, the Clive River to continue to carry the flow from the Karamu Stream catchment, one quarter the size, a flatter gradient, less rainfall and little or no gravel sediment supply. In addition the runoff was silt laden and carried contaminants associated with urban development and intensive rural agriculture.

Over the decades, without a supply of gravel, much reduced flows, warmer water with lower dissolved oxygen and fine sediment input, the stream ecology changed from a gravel bottom ecology to a muddy bottom ecology as the fine sediments gradually accumulated over the top of the gravel. Aquatic weeds thrived in these conditions and anecdotally the larger fish species declined.

The recreational values of the awa also declined to a stage where non-contact recreation is now the safest option. Although this paper is not about the water quality, the focus is on reducing sediment input, maintaining low flows and keeping water temperatures down. These are all factors in improving water quality as is upstream control of contaminants entering the system. In order to improve the recreational values, particularly for the rowers, the river bed over a limited area has been dredged twice to date to deepen it, at considerable cost and questionable value, given that the sediment build-up is not a concern for flood control purposes.

As part of the TANK process the issue of sediment in the Clive River was examined in more detail in order to present to the group explanations as to what was happening and what the impact of some possible interventions might be on reducing the sediment problem. The following sections describe what was addressed in the study and relayed to the group.

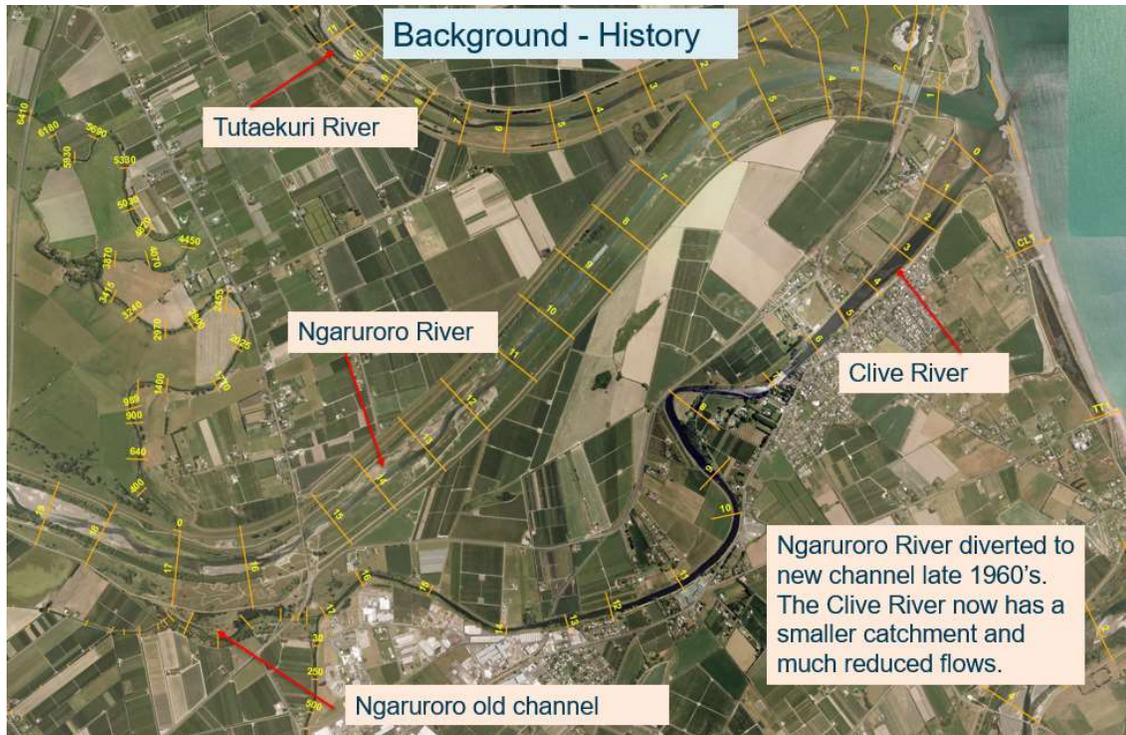


Figure 1: Location of Ngaruroro River and the Clive River

## 2. Sediment Accumulation

This section addresses the matter of the amount of sediment and where it accumulates in the river reach.

The Ngaruroro diversion in the late 1960's was via a pilot cut through silts and clays. The plan was for the channel to fully develop by itself although this has not happened to any great degree. Of interest is that gravel has not progressed in the new channel much below the Chesterhope Bridge in the past 5 decades. The reasons for this are not necessarily because of upstream gravel extraction. Recent sediment transport modelling (*reference: Modelling gravel transport, extraction and bed level change in the Ngaruroro River, NIWA October 2012*) showed that although extraction reduced the amount of gravel propagating downstream, even with no extraction there was no gravel transport within 1.8 km of the sea. This was modelled over a 35 year simulation time based on actual flow data.

The 1931 Napier earthquake uplifted an area around Napier of 1500 km<sup>2</sup> with a maximum of 2.7 m of uplift and a 1m subsidence in Hastings. Near Napier the coastline was raised reducing the grade of the lower reaches of the Esk, Tutaekuri and Ngaruroro Rivers so that these rivers only deliver silt and sand to the coast. In the Ngaruroro River the effect was twofold, a raising of the reach near the mouth and a lowering of the bed upstream. This would have had a significant effect on the transporting power of the river, with only very large flood events being capable of mobilising the gravels, and for such floods the old channel would not have been able to contain such flows resulting in widespread flooding.

A conclusion from this and the modelling is that even without the diversion, it is likely that no new gravel would have been mobilised and transported in the Clive River for similar flow conditions as the simulation. But the loss of significant flushing flow has meant that the

smaller sized sediment (sand and silt) has not been flushed out to sea. Weed growth in the sediment has caused it to bind together, worsening the problem.

Since the Ngaruroro River diversion in the late 1960's, two dredging operations have been carried out. These were in 1997 and 2009. The dredge reach was from near the river mouth (XS 1) to 660 metres above the SH2 Bridge (XS2). Figure 2 below shows the dredged volume in 1997 was 69,000 m<sup>3</sup> and in 2009 it was 57,000 m<sup>3</sup>.

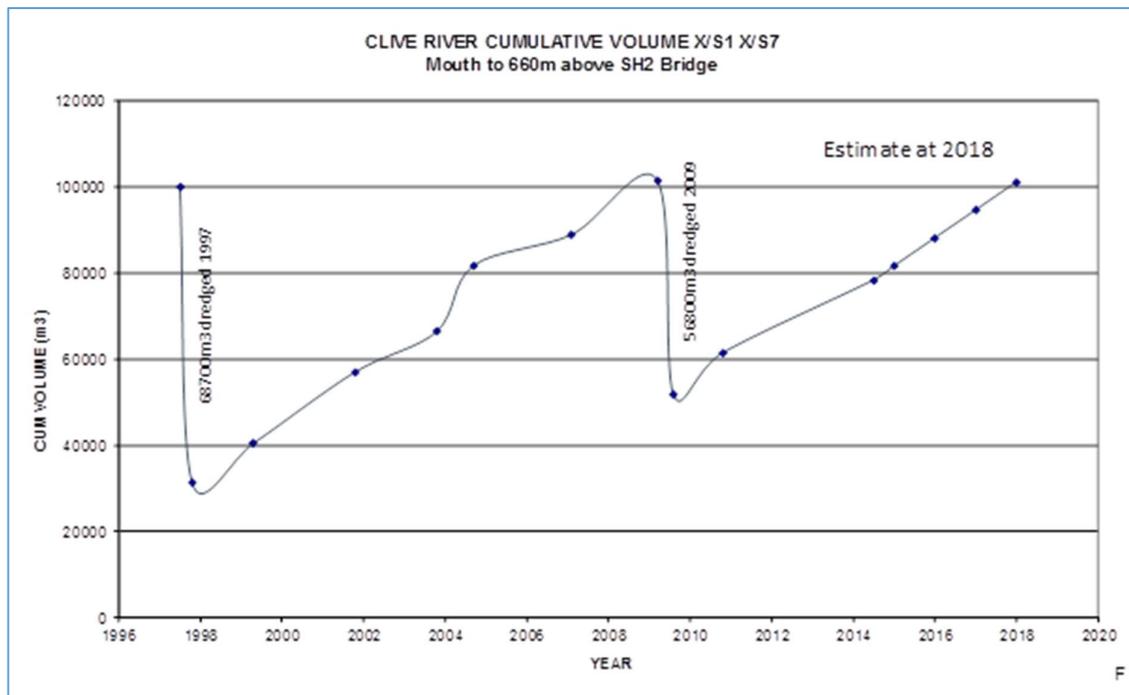


Figure 2: sediment accumulation volumes for successive surveys 1998 to 2018 (2018 estimate)

In the lower reach, 2.0 to 2.5 km from the confluence with the Ngaruroro River sediment accumulates at a rate of 30 to 35 mm/year (depth). Refer Figure 3.

In the upper reach, 2.5 to 7.5 km from the confluence with the Ngaruroro River sediment accumulates at a rate of 6 to 7 mm/year (depth).

In the lower reach the sediment accumulates at 5 times the rate of that in the upper reach. Likewise sediment accumulation further upstream than the study reach and into the Karamu Stream is at a lower rate than downstream. The reasons for the higher rates of sediment accumulation in the lower reach are:

- The grade flattens out and the river widens
- There is a strong tidal influence
- Backwater from the Ngaruroro River (possibly, see note)

Note: backwater from the Ngaruroro River when in flood is thought to exacerbate the sediment deposition in the lower Clive River. However this may not be as much of a cause as believed. Examination of the photographs in Figure 5 below where the Ngaruroro River is discoloured by floodwater indicates that there is very little mixing with the Clive River with

flow from the Ngaruroro heading directly out the mouth to sea. Although this is anecdotal evidence and more study on this effect may be required, there is sufficient explanation in what follows to be confident that other reasons for the siltation prevail.



Figure 3: Longitudinal mean bed level plot

### 3. Sediment Mobilisation

This section addresses the flow that is required to move sediment through the system, down the Clive River and out to sea.

To address this it is helpful to look at shear stress which is the stress caused by friction between fluid particles due to the fluid viscosity. Simply for this purpose, it is a measure of the amount of force required by the river to mobilise a soil particle and move it downstream. This is the applied shear force. There are a number of factors that influence the shear stress and the key ones are listed below. First there is some terminology to explain within the context of this discussion the factors that make up the applied shear stress.

**The slope:** This is the slope of the channel bed. Uniform flow is when the water surface slope is parallel to the bed slope and for the purpose of what follows the water surface slope is used.

**The hydraulic radius:** This is the ratio of the flow area to the wetted perimeter and can be taken as the depth for wide channels.

**The specific weight:** This is the weight of water ( $\text{kN/m}^3$ ) including particles entrained in the water.

- The greater the slope the greater the shear stress
- The greater the depth the greater the shear stress.

- The greater the specific weight the greater the shear stress

Of these factors the slope and depth are the most influential. The bed form also plays a part and this is another complication but not essential to consider here.

When a force is applied to an object (particle) there is also a reaction or in this case a resisting shear stress. Of interest is when the particle (sediment) becomes mobile. Resisting stress is defined as the stress at initiation of particle motion.

Its determination is based on theory, laboratory and field studies. It depends on the relationship between a dimensionless shear stress (Shields parameter) and grain size (Reynolds Number). For this the specific weight of the sediment and the particle diameter are required.

Some typical shear stress (resisting) values are: (Pa = Newtons/mm<sup>2</sup>)

- Silt:** Range 2 to 10 Pa (depends on the void ratio (how compact) and cohesion)
- Sand:** Range 10 to 14 Pa
- Gravel:** Range 14 to 33 Pa or more
- Cobbles:** Range 56 Pa or more

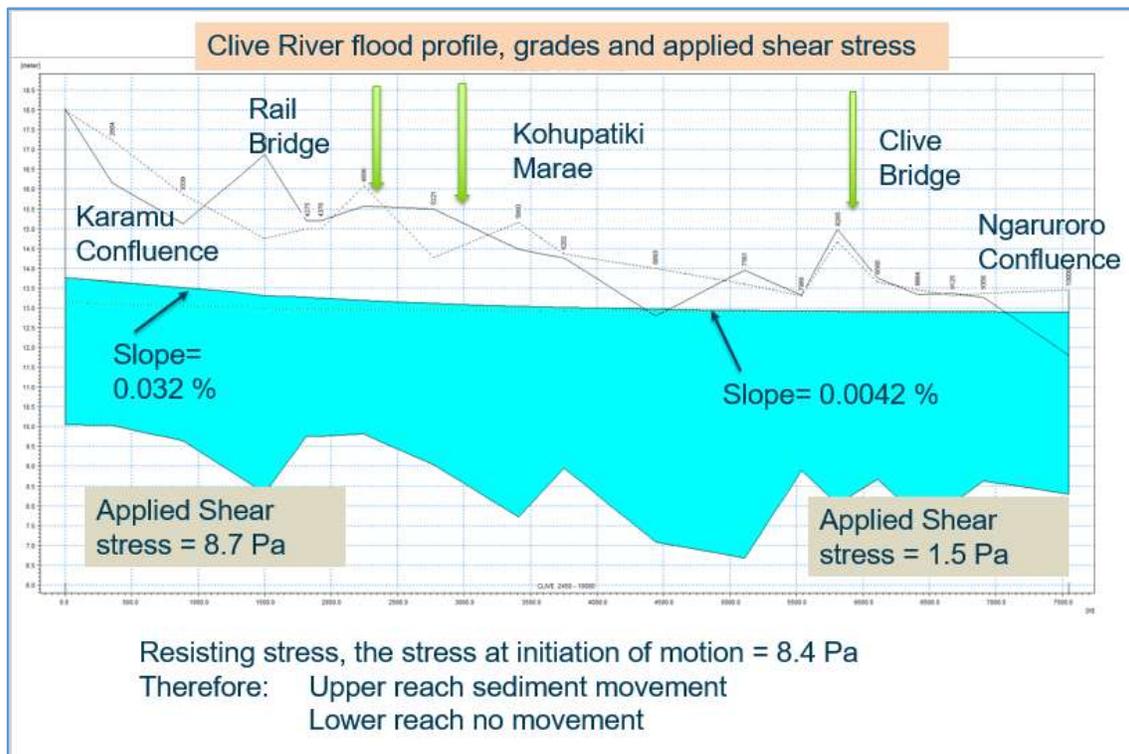


Figure 4: Clive River flood profile with applied shear stress values and grades.

Figure 4 above shows the results of analysis simplified so that the shear stress discussion is able to be visualised to provide an explanation as to why there is a different rate of sediment build-up and how the shear stress affects the movement of sediment. In the upper reach above Kohupatiki Marae the slope is much steeper than the lower reach and thus has

an applied shear stress greater than the resisting stress. The depths between the upper and lower reach do not vary significantly compared to the slopes.

The key point of this is that the upper reach has much more ability to overcome the resisting stress and mobilise the sediments to keep them moving downstream.

#### 4. River mouth alignment

This section addresses the question of whether fixing the river mouth to one location will help with moving the sediment.



Figure 5: Google images of the Ngaruroro River mouth 2003 to 2017

Figure 5 shows some of the natural characteristics of the combined Tutaekuri, Ngaruroro and Clive river mouth.

- The location of river mouth is determined by the river flows and the coastal processes.
- The Hawke's Bay coast has a predominant northerly drift.
- This tends to push the river mouth to the north, but not always.
- It is mechanically opened several times a year when there is sufficient flow in the rivers and sea conditions allow a successful opening.

Questions that arise with the river mouth are:

What effect does the river mouth have on sediment mobilisation in the Clive River?

Can river mouth training walls help mobilise sediment from the bed of the river? Note that river training walls are expensive to construct and maintain and have a significant influence on the coastal processes. There would need to be some strong positive benefits before even contemplating such action.



*Figure 6: Image of river mouth training walls of the type considered for this discussion*

In order to examine the effect of training walls on sediment movement in the Clive River a 2 dimensional computer model was used to determine the changes in shear stress in the rivers. Two cases were considered for the comparison. The first case (Option 1) was to examine the existing case with no training walls. The second case (Option 2) included the training walls. Comparing the shear stresses at selected locations between the two options will give an indication if there is any significant effect on sediment movement.



*Figure 7: Shear stresses in the Ngaruroro and Clive rivers the lighter colours show higher shear stresses*

Figure 7 is for Option 2 and it shows the training walls. It can clearly be seen that there are higher shear stresses at the river mouth and bridge openings. For the range of flows considered these were up to 27 Pa, capable of moving gravel. At the Clive Bridge there were much lower shear stresses in the range of 1 to 3 Pa. For Option 1 with no training wall at the mouth the shear stress at the Clive Bridge is 3 Pa. For Option 2 with the training wall the shear stress reduces to 1 Pa.

## Shear Stress in Clive River near SH2 bridge

Depth increases due to tide,  
but slope reduces and has the  
greater effect, hence shear  
stress reduces.

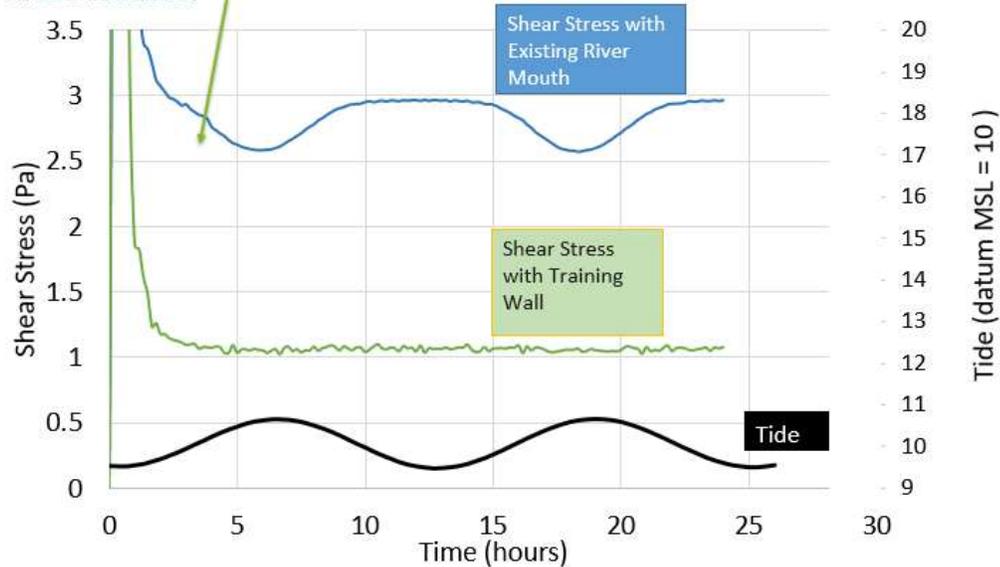


Figure 8: Plot of shear stress including tidal effects in Clive River near SH2 Bridge

The explanation for what is depicted in Figure 8 is that the training walls, being of fixed spacing, form a flow constriction. Water then heads up to pass through the constriction. This in turn results in a depth increase in the Clive River, but more significantly the water slope decreases at a much larger rate than the increasing water level and hence the shear stress decreases.

Although this is not an exhaustive study, and was never meant to be, it does nevertheless show that having training walls doesn't actually improve the ability of the Clive River to increase shear stresses and reduce sedimentation. There would need to be a far more convincing increase in shear stress in the Clive River to promote training walls, even if the coastal processes issues could be resolved.

### 5. Flow Augmentation

This section addresses the question of whether adding extra flow from another source will help move the sediment through the system?

Flow augmentation is the process of introducing flow from another source (another river or a bore) for the purpose of improving environmental flows or improving minimum flows for example.

The Clive River was examined to determine if there was a suitable flow increase that would initiate sediment movement on the bed and help to keep the bed from silting up. The flow source was from the Ngaruroro River to be introduced at approximately the location where it was first diverted back in the late 1960's.

The study found that flow augmentation isn't a solution, for the reasons already described previously. That is, there was little or no change to the shear stress generated to effectively remove the sediment.

Large flows were required to overcome the effects of the tide and increase the water slope and hydraulic radius to gain any increase in shear stress. Large augmentation flows would require correspondingly large intake control structures at high cost for little or no benefit.

In addition, the act of diverting flood flows from the Ngaruroro River would include increased sediment load to the Clive. The effects on the loss of these larger flows on the Ngaruroro River was not examined.

## 6. Summary

This work was carried out to inform the TANK process about the issue of sediment in the Clive River and options for removing or reducing the sediment. No solutions were found that would make any difference. Limiting the sediment input through land management controls would provide the most benefit. It is also a fact that due to the diversion of the Ngaruroro River for flood control purposes the Clive River ecology and biodiversity has changed and it will never be the same gravel bottom river as it was prior to the diversion.

Weed control is another big issue that was not specifically included in this study yet it remains an issue to look at different means of control.

The management regime of the future for this section of river should be to value the muddy bottom ecology for what it is; concentrate on reducing sediment input from the catchment and work on improving water quality, starting with shading to reduce temperatures and increase dissolved oxygen.

Ir Gary Clode

August 2018