REPORT

Maitai River - Gibbs-Dennes Reach

Geomorphic Assessment and Reach Management Options

Prepared for
Nelson City Council
Prepared by
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Glossary

Term	Definition/Description
Active channel	The width of the stream channel that is wider than the low-flow channel, narrower than the bankfull channel and carries frequent flow events (i.e. seasonal rainfall).
Aggradation	The process of general bed raising by deposition of sediment.
Armoured/Armour layer	A layer of large sized bed material (cobbles or boulders) which cover the river bed. The amour layer can only be moved in very large floods, and so protects the river bed beneath it from erosion.
Bank	The land beside a river channel that contains the flow of the river.
Bankfull	The junction between the floodplain and the channel, where the river is at its fullest flow contained entirely within the channel without spilling onto the floodplain.
Bed	The bed of a river is referred to as the base of the wetted channel, including the thalweg, and excluding the banks.
Bed material	The sediment that sits on, or forms, the bed of a river (sand, gravel, cobbles, boulders).
Benches	Flat surfaces in a channel above the average water level but below bankfull point. Typically created through repeated deposition of fine-grained material on the river bank.
Chute	High-flow channel that dissects a bar surface.
Degradation	General lowering of a stream bed by erosional processes.
Deposition	The laying down of sediment that is carried by water.
Erosion	When material is removed from the bed or bank of a river. Several types of erosion exist including block failure, gullying, rilling, mass wasting, slumps, slips, flaking, slaking, scour
Erosion susceptibility	How susceptible a river's bed or banks are to erosion.
Flood	An overflow of a large amount of water beyond a body of water's normal limits, especially over what is normally dry land.
Flood flows	Periods of elevated flow, when the river level is higher than an assumed base flow level
Floodplain	Typically, a flat area of land beside a river, above the bankfull level, which has been formed through the repeated deposition of sediment by the river itself.
Fluvial geomorphology	How rivers shape the world, and is the interaction between sediment, water and vegetation.
Geology	The earths physical substance and structure.
Imbricated	Sediment particles on a river bed have overlapping edges with their largest faces dipping upstream into the direction of water flow, essentially locking them into place.
Incision	The downward erosion (vertical lowering) of a river bed.
Lateral bar	Elongated sediment deposit attached to the river bank along a relatively straight channel.
Meandering	A type of river planform that is highly sinuous, or winding.
Partly confined stream	10-90% of the channel abuts the valley margin (Brierley and Fryirs 2005).
Point bar	Area of deposited sediment on the inside of a meander bend.
Riparian vegetation	Vegetation on the banks of a river/stream (usually more broadly defined as a strip of land up to tens of metres wide along the banks of a stream).
Scour	A concentrated type of erosion, where particles are removed from a surface by swift flowing water.
Sediment	A solid material that is moved and deposited in a new location. Sediment can consist of rocks and minerals, as well as the remains of plants and animals.
Sediment transport	The way that sediment is moved through a river system. This usually refers to when (as in what sized flows) sediment is eroded or moved by water.

Term	Definition/Description
Stratigraphy	The sequential layers of sediment that have been deposited by a river (or volcanic event) that have been preserved in a depositional surface such as a river bank or a floodplain.
Unconfined stream	Less than 10% of the channel abuts the valley margin (Brierley and Fryirs 2005).

1 Introduction

Nelson City Council (NCC) have engaged Tonkin & Taylor Ltd (T+T) to undertake an assessment of options for the ongoing management of the section of Maitai River between Gibbs Bridge and Dennes Hole (Gibbs-Dennes Reach). Particularly, in response to the long-term evolution of this reach. The property owner along the true right bank of this reach has raised their concerns regarding the erosion of the true right bank with NCC and has expressed a desire for it to be remedied.

T+T has previously undertaken a Geomorphology and Ecology assessment of the full length of the Maitai River[1,2]. These reports, issued as draft, found that Gibbs-Dennes Reach is critical for the flood management of Nelson City. The current study identifies the geomorphic characteristics of the Gibbs-Dennes Reach and discusses options for reach management, with a focus on minimising further erosion. The current study draws on findings from the site-specific geomorphic assessment undertaken in November 2023 (part of the current scope of works and summarised in this report) and the findings of the Geomorphology and Ecology assessments of the Maitai River prepared as part of previous scopes of work (T+T Ref: 1006675.0561.v1 and 1006675.0564.v2).

Our work has been carried out in accordance with the scope of works and under the terms and conditions of our variations (T+T Ref: 1089395.2012, titled “VO No: Maitai_2”).

2 Site description

The Gibbs-Dennes Reach is located from Gibbs Bridge to Dennes Hole (Figure 2.1, Figure 2.2), approximately 1.1 km up the Maitai Valley Road from the Nile Street junction. The Maitai River has actively been eroding and depositing sediment in this reach, where the river bends, and the flow direction changes from north to west. Figure 2.3 shows the evolution of the Gibbs-Dennes Reach from 1940s to 2022, with both deposition and erosion occurring at the site. Figure 2.4 shows the active river channel migration overtime, with the active river channel delineated from aerials, overlaying the August 2022 aerial.

Presently, there are not assets or infrastructure at risk due to erosion; however, the land to the north of the river on the true right bank is currently proposed to be developed as a residential subdivision. The land to the south of the river on the true left bank is Maitai River Esplanade, beyond which is rural residential property. The nearest residence is estimated to be 80 m from the river channel.

[1] Tonkin & Taylor. (2022). Maitai Flood Management Options – Geomorphology and Ecology Assessments. T+T Ref: 1006675.0561.v1, prepared for Nelson City Council.
[2] Tonkin & Taylor. (2023). Addendum report to the Maitai flood management options. T+T Ref: 1006675.0564.v2, prepared for Nelson City Council.

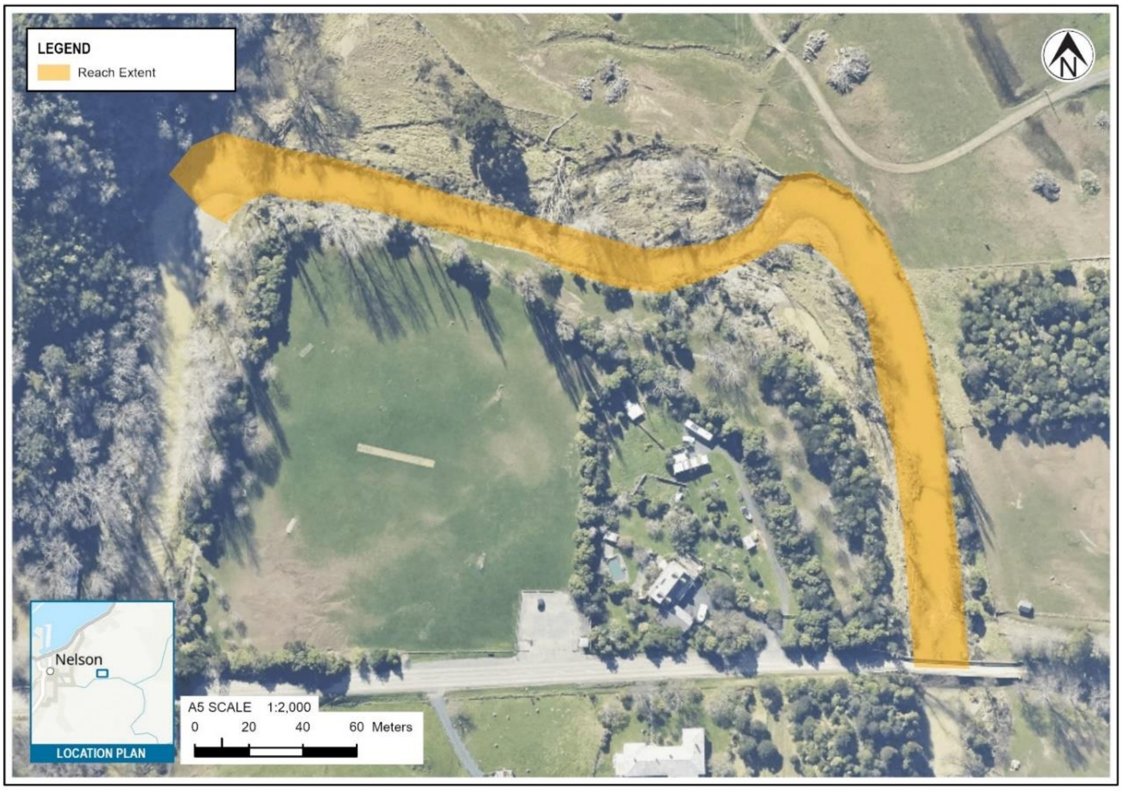

Figure 2.1: The Matai River Gibbs-Dennes Reach from Gibbs Bridge to Dennes Hole.

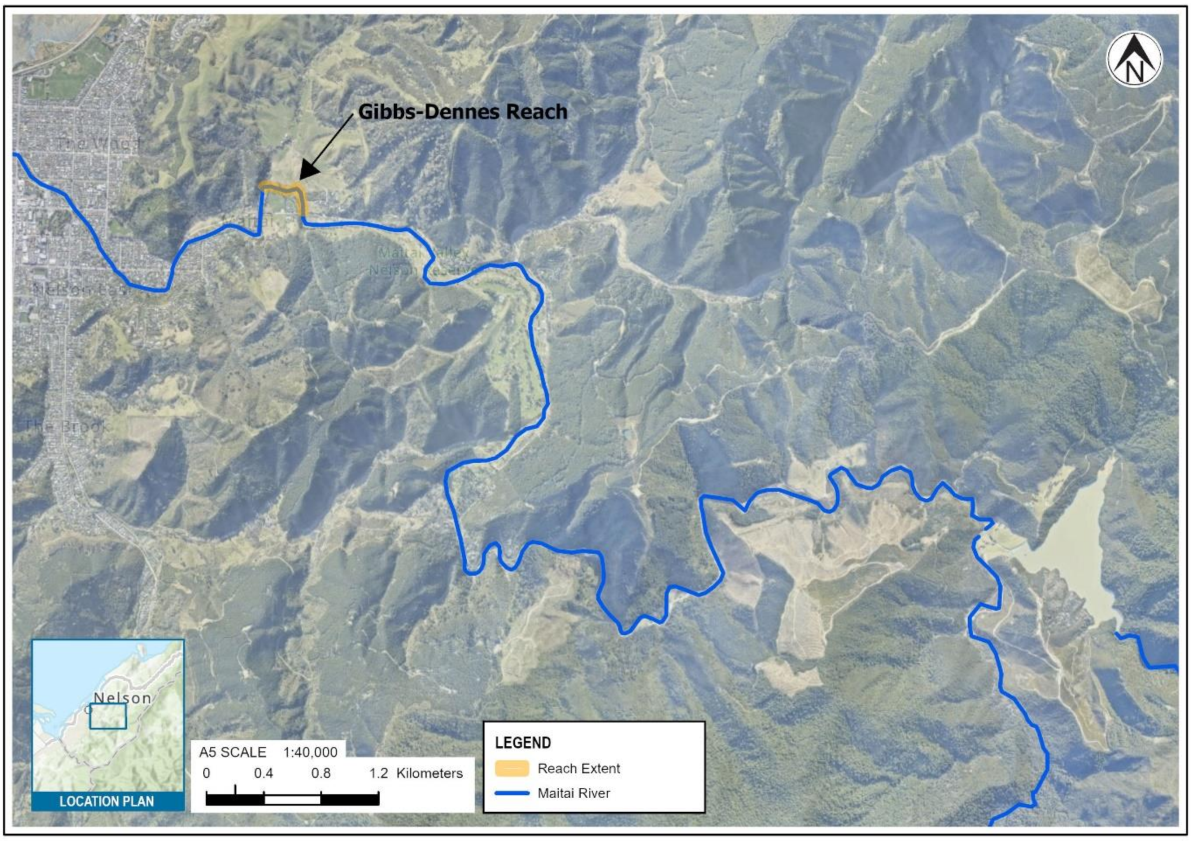

Figure 2.2: The Gibbs-Dennes Reach in context to the Maitai River, with Nelson City downstream.

	
1940-1949 Aerial imagery (Top of the south maps)	1980-1989 Aerial imagery (Top of the south maps)
	
January 2022 Aerial imagery (LINZ)	September 2022 Aerial imagery (LINZ)

Figure 2.3: Evolution of the Maitai River from Gibbs Bridge to Dennes Hole, 1940s – 2022.

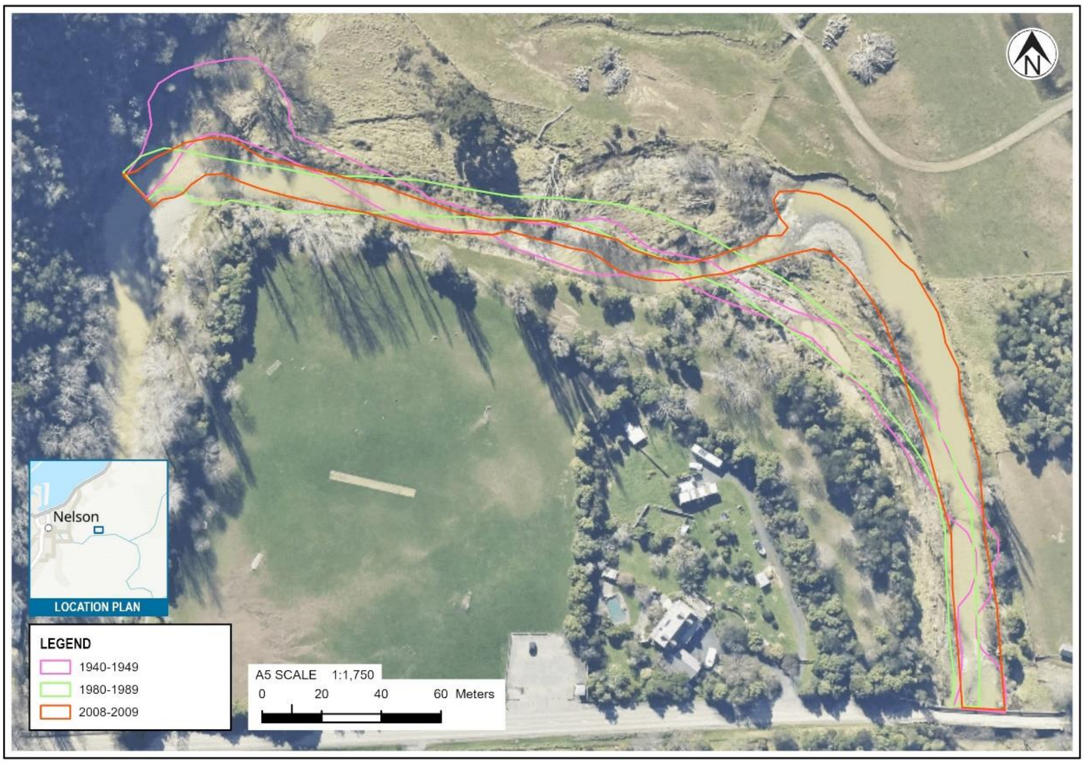

Figure 2.4: Delineated river channels from the 1940-1949 aerial (pink), 1980-1989 aerial (green) and the 2008-2009 aerial (orange) overlaying the August 2022 aerial.

2.1 Geologic setting

The geology at the Gibbes-Dennes Reach is Kaka formation (Brook Street Volcanics Group) comprising breccia, tuff and basalt, forming the valley walls. Bedrock was observed at and upstream of Gibbs bridge on the true left and at Dennes Hole on the true right of the river. Holocene and recent deposits comprising well sorted river gravels overlain by fine sediments (sands and silts) have infilled the valley floor and form the floodplains on the true left and true right of the river between the bedrock outcrops. Erosion of these deposits produces a composite bank stratigraphy (gravel overlain by fines in the bank profile) (Figure 2.5).

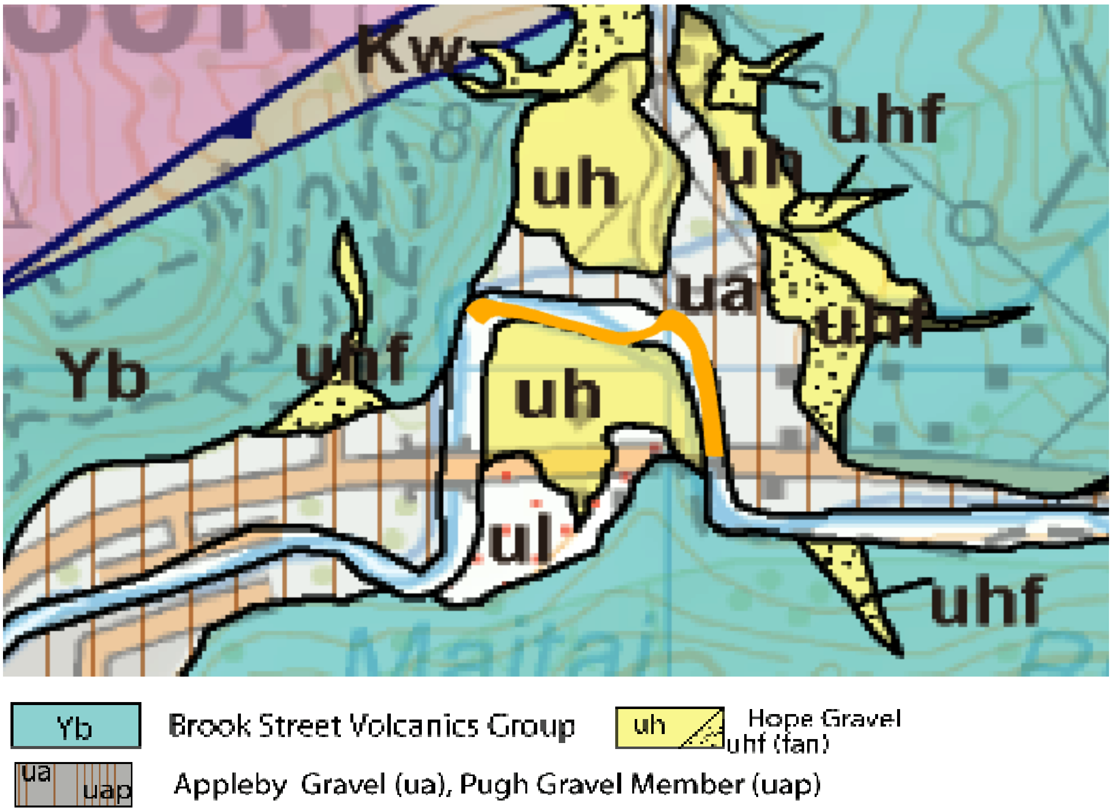

Figure 2.5: Geology of the reach and the surrounding area. The yellow polygon outlines the Gibbs – Dennes Reach3.

2.2 Geomorphic assessment

T+T undertook a site visit in November 2023 to carry out a geomorphic assessment of the Gibbs-Dennes Reach.

The Gibbes-Dennes Reach is partly confined, with a floodplain pocket. It is a meandering cobble bed channel with point bars and vegetated lateral bars. The Maitai River in this reach is dynamic, particularly in flood events. Erosion of sediment deposits (point and lateral bars) and composite banks typically occurs on the outside of the river bends (Figure 2.3, Figure 2.4) where flow velocities and shear stress are greatest. Deposition occurs on the inside of bends, forming point bars. Lateral bars have formed in areas of flow expansion, which reduces the transport capacity of flow, leading to deposition along the (lateral) margins of the wetted channel.

[3] M.R. Johnston, F. Ghisetti, P.Wopereis (2022) – Revised Geological Map of the Nelson-Richmond Urban Area (v3). DOI: https://doi.org/10.6084/m9.figshare.21259419

Chute channels have formed on the inside of the bend as a result of channel migration, shown in Figure 2.6. There is a point bar between the chute and the main river channel, which has been developing with river migration (Figure 2.6). There are also lateral bars in the reach. Both are temporary sediment storage features of the river, which become sediment sources when activated during high flow events, where erosion and re-working are prevalent. However, vegetation is establishing on the point and lateral bars, "locking" sediment in place, which limits and will continue to limit sediment re-working.

Figure 2.6: Plan of the upper Gibbs – Dennes reach, showing the lateral bar and chute channel.

The banks of the stream in this reach are typically vegetated, although at the corner where the river bends west, a face of the bank was exposed (Figure 2.7). The bank is composed of topsoil (300 mm thick, silt dominant), overlying sandy silt (500 – 700 mm thick), overlying imbricated moderately sorted gravels with some sand in 1.5-2 m high banks (Figure 2.7). The soil is tightly packed and has a high friction angle as the banks are near vertical and are currently stable in normal flows. These riverbanks are a source of sediment in the Gibbs-Dennes Reach.

Figure 2.7: Panoramic view of the corner where the Maitai river flows west. It shows the composition of the river bank, the floodplain on the true right of the river and the riparian vegetation.

Upstream and downstream of the bend, the banks were vegetated; dominated by exotic trees (e.g. willow), native scrub and shrubs species (including lowland native broadleaved forest and Harakeke), and herbaceous and grassy weed species present where disturbance has historically occurred.

Floodplains are located on the true left and true right of the river between Gibbs Bridge to just upstream of Dennes Hole. Floodplains are key for downstream attenuation of flow and sediment load by storing both water and sediment. Analysis of the 2015 and 2022 Land Information New Zealand (LINZ) Digital Elevation Models (DEMs) was undertaken to identify erosion and deposition trends in the reach. Figure 2.8 shows the difference between the 2022 DEM from 2015 DEM. There was an overall net volumetric loss within the reach, which was estimated to be 980 m^3. However, it is possible this is an overestimation from where LiDAR couldn't penetrate the vegetation canopy in the 2015 dataset.

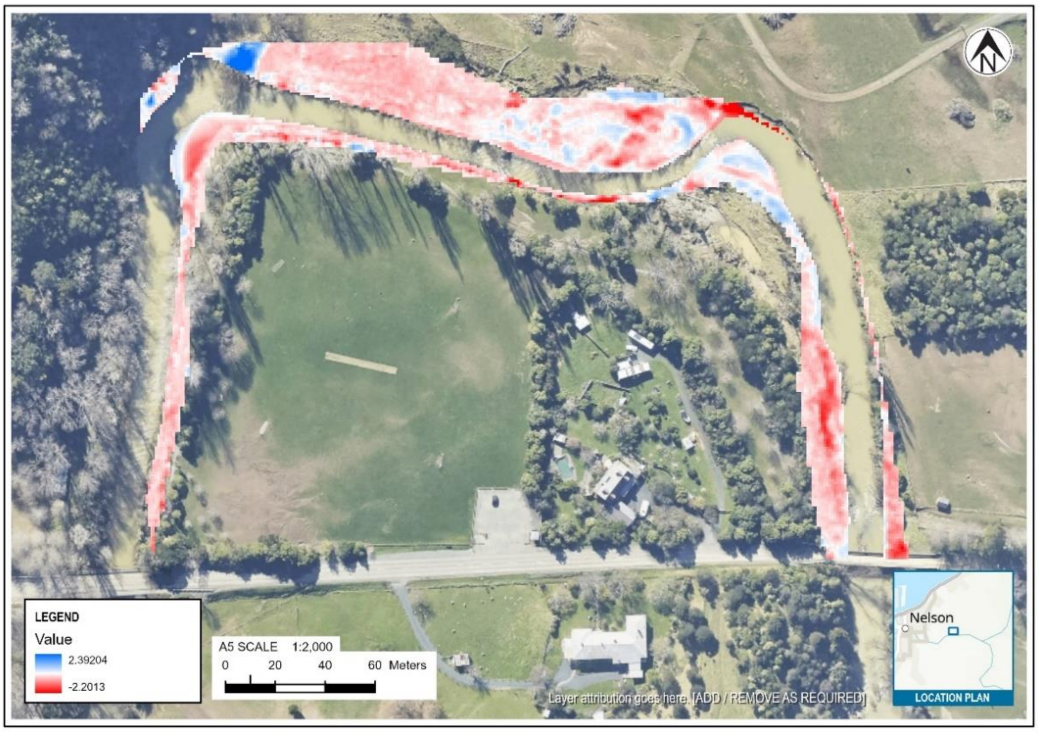

Figure 2.8: The difference between the 2022 DEM and the 2015 DEM. Red indicates erosion and blue indicates deposition.

Between the January and September 2022 aerials, 5 m of lateral erosion was measured on the outside of the bend where the river flows from north to west (Figure 2.3, Figure 2.8) and an over loose bed (Figure 2.9) comprising poorly sorted river gravels has developed at the point bar. This deposit is poorly structured and armoured as it is above the normal flow of the river, so it has not (yet) been reworked by the river. It is likely that this erosion and deposition occurred in this reach during the August 2022 storm.

Figure 2.9: Over-loose bed at the point bar with the Gibbs-Dennes Reach.

The river in this reach appears to be in sediment deficit, with more sediment eroded than deposited in recent years. T+T (Ref: 1006675.0564.v1) previously identified that the long-term geomorphic trends in the Maitai River appear to be degradational with an overall loss of sediment over time. T+T (2022) attributed this long-term degradational trend to a natural depletion in sediment supply and a history of over extraction of gravel from the Maitai River. This, combined with the composition of the riverbanks, means the bank erosion susceptibility is high.

3 Options assessment

3.1 Project objectives

The following project objectives were considered in the selection and assessment of options to manage the Gibbs-Dennes reach:

- Address erosion of the true right bank at the bend,
- Maintain or enhance the downstream attenuation of sediment load and flow, thereby reducing risk to downstream areas; and
- Maintain, or enhance, ecological values of the reach.

3.2 Previous report recommendations

Morphum Environmental Ltd (Morphum) undertook an ecological restoration plan for the Maitai River Esplanade[4] and noted that the Gibbs-Dennes Reach (North-east Cricket Ground Boundary in their report) as an erosion hotspot that had been investigated in 2018 by Christensen Consulting. Two corrective actions were presented by Christensen Consulting (option MA and MB below) and one alternative option was presented by Morphum (Option MC below). These corrective actions are quoted from the Morphum report as follows:

- Option MA: Remove the willows on true left bank and cut a channel to relocate the river to its previous alignment. The high degree of sediment accumulation makes it likely that substantial excavation will be required to dig the new channel.
- Option MB: Leave current river alignment unchanged and plant a 15 m wide willow buffer on the true right bank to slow erosion. Rock groynes may be installed if additional erosion protection is required. This would allow for the restoration and enhancement of willow area on the true left bank following further investigation and investment.
- Option MC (preferred option): Regrade sections of the true right bank and install rock groynes to deflect high energy flows from this side. Replant with native species Selected for strong root structure including dense underplanting of *carex* species.

T+T does not consider option MA as a feasible option for the management of the Gibbs-Dennes Reach. Option M1 requires relocating the river, this is a temporary solution and the Maitai River will eventually avulse or work its way back into the current active channel. However, a variation of this option (reactivation of the chute channels on the true left and true right bank in addition to the main channel) has been considered further below.

Option MB recommends planting the bank with willows. T+T considers riparian planting an option for management of the reach and is discussed in Section 3.3 below.

Option MC involves re-grading sections of true right riverbank and installing rock groynes. T+T does not recommend re-grading the true right riverbank as the river gravels comprising the bank will be re-worked, causing the riverbank to steepen over time. However, redirecting the river using rock groynes as suggested in option MC (and in option MB) to is discussed in Section 3.3 below as an option.

3.3 Reach management options

Based on our site observations, gravel assessment and understanding of the project objectives, we have identified seven concept options to be considered for the management of the Gibbes-Dennes Reach of the Maitai River from Gibbs Bridge to Dennes Hole. These are as follows:

- **Option 1 – Do nothing** would involve allowing the Maitai River to continue naturally reworking some of its floodplain promoting floodplain engagement. Floodplain engagement in this option allows natural bend development to continue through reworking of the (coarse) sediment in the riverbank on the outside of the bend and results in (coarse) sediment replenishment of the river in this reach. Bend development increases storage capacity on the inside of the bend for sediment deposition. Floodplain engagement dissipates higher flood flows (and some fine sediment) across the floodplain. It is unlikely that the migration of the Maitai River north at this bend would continue perpetually since river bends naturally cutoff over time as part of a cycle of planform development. This option could include utilising the

[4] Morphum Environmental Ltd. (2020). Ecological Restoration Plan – Matai River. Job ref P02534. Prepared for Nelson City Council

floodplain to create a wetland environment and/or floodplain revegetation for an ecological benefit.

- **Option 2 – Riparian Planting** would comprise planting of the banks that are not vegetated (particularly the true right bank). This option will require regrading of vertical riverbanks in some locations. Riparian planting has the potential to stabilise banks and slow run-off if done appropriately. However, to be effective, the marginal vegetation and / or root zone must extend to at least the low water level, otherwise flow will undercut the root zone. The type of vegetation needs to be considered carefully:
  - Toe of the bank and bench zone – should include flexible sedges, rushes and grasses that do not impede flood conveyance, provide erosion control, can filter contaminants and sediments, and provides instream and spawning habitat.
  - Mid bank zone – small native shrubs as well as flexible sedges, rushes, grasses and ferns that do not impede flood conveyance, provide erosion control, can filter contaminants and sediments, and provides instream and spawning habitat.
  - Upper bank zone – a diverse range of native trees, shrubs and groundcovers that provide bank stability, soil erosion control, shade, and habitat.
- **Option 3 – Gravel management** would involve removal of gravel from the current active channel within the reach. Gravel extraction currently occurs in the Maitai River by NCC generally after flood events to maintain conveyance capacity. Gravels stored in point and lateral bars in the reach are a sediment source which is likely to become activated in high flows. A variation of this option (Option 3a) would involve removing gravel from the inactive river channel, such as the chute channels. It should be noted that this reach is in sediment deficit so removing gravel in either the low-flow channel or chute channels will exacerbate this trend contributing to increased bed and bank erosion rates.
- **Option 4 – Rock armouring** would involve grading susceptible banks to a 1.5H:1V (34°) to 1H:1V (45°) slope, then placing rip rap. This option would reduce the risk of further bank erosion but also reduce floodplain engagement as the river is unable to rework the sediment stored in the riverbank, likely exacerbating the sediment deficit in the river. A variation to this option would be to armour the toe of the true right bank and grade and plant the upper portion of the bank.
- **Option 5 – Groynes** would involve installation of a series of rock groynes that are angled to the downstream flow, perpendicular to the bank, on the outside of the bends. The intention of rock groynes is to divert the main flow of the river away from the bank where it is susceptible to erosion.

The key considerations for each option are summarised in Table 3.1 below.

Table 3.1: Summary of considerations for each option

Consideration	Option 1 – Do nothing	Option 2 – Riparian Planting	Option 3 – Gravel management	Option 3a – Gravel management (inactive channels)	Option 4 – Rock armouring	Option 5 – Groynes
Upstream/downstream impacts	Sediment transport and deposition maintained at current rates within the reach.	Riparian planting will trap fine sediment, will be some reduction in fine sediment transported and deposited downstream.	The river is in a sediment deficit, so further removal of gravel will increase erosion rates across all storm events.	Chute channels are a sediment store. By removing gravels, the stream power and erosive potential increases downstream. At the site, it's possible that the bed and bank erosion at the bend to initially be alleviated but will potentially result in scour in the chute channels.	Disengages floodplain, reducing sediment storage and potentially elevating transport capacity. The river is in a sediment deficit, rock armouring susceptible banks will redirect the river energy and encourage incision and increased bed erosion rates.	Disengages floodplain, reducing sediment storage and potentially elevating transport capacity. There is also potential for further erosion to occur downstream.
Bed and bank stability and channel capacity	No change, however, river migration north is unlikely to continue perpetually as river bends naturally cutoff over time as part of a cycle of planform development.	Planting an active bank is still at risk of failing, especially during plant establishment. Will reduce erosion in small floods. Vegetation is at risk of being stripped in a flood of higher magnitude, but this does not negate its ability to reduce, delay or prevent erosion from occurring.	Removal of gravel disturbs the bed armour, creating an unstable bed which leads to unstable banks causing further erosion and channel widening.	Potential for river to reactivate chute channels (bend cut-off is a natural process), diverting flows away from the bend would initially decrease the erosion at the bend. However, in bank full flood events, the bed and banks in the reach and downstream are at risk of further erosion as sediment has been removed from the system so the river has more erosive power. Erosion potential downstream is influenced by the amount of gravel removed.	Stabilises banks where constructed. However, the bed and banks downstream are at further risk of erosion as less energy will be dissipated in this reach due to bank protection so the river will have more energy to erode downstream. Where banks consist of basalt/volcanic rock outcrops (erosion resistant materials), bed erosion is likely to occur.	Reduce risk of bank erosion on the bank they are installed, may cause erosion on the opposite bank and local bed scour.

Consideration	Option 1 – Do nothing	Option 2 – Riparian Planting	Option 3 – Gravel management	Option 3a – Gravel management (inactive channels)	Option 4 – Rock armouring	Option 5 – Groynes
Ecological value	Maintains terrestrial ecological habitat, additional planting would enhance habitat.	Provides further habitat and encouragement of bird life, shades river water.	Potential negative impact – quite disruptive works, reduces channel heterogeneity and geomorphic diversity.	Potential negative impact – quite disruptive works, although the geomorphic diversity of the active channel is maintained.	Potential to plant rock armouring to provide a habitat, forced pools develop adjacent to rock.	Potential to plant rock groynes to provide a habitat, forced pools at groyne tips.
Design/ Consenting/constructability	No design required. No construction. If wetland is implemented, some design required and easily constructed.	Design required, consent potentially required. Easily constructed – planting.	Consent required.	Consent required.	Consent and design required, minimal earthworks, may require temporary stream diversion. Not as easy to construct as other options.	Consent and design required, may require temporary stream diversion. The most difficult of the options to construct.
Maintenance	No maintenance required. If wetland planting in the floodplain is included removing sediment build up and planting maintenance may be required	Little to no maintenance required once plants are established.	High probability that this needs to be ongoing, since likely that resulting void will be re-filled.	High probability that this needs to be ongoing, as the channels may aggrade back to their current levels or degrade.	Little maintenance required.	Little maintenance required.
Constraints	The floodplain on the true right is private property and the floodplain on the true left is a recreational reserve.	Time for vegetation to establish.	Is best done when the riverbed is disturbed, and an armour layer hasn't been established, or the focus is on dry extraction (effectively removing bars).	Does not directly impact the active channel at low flows.	Potential that works will encroach onto neighbouring land (private and a public reserve).	Narrows the river channel and there is the potential for further erosion to occur downstream.
Qualitative comparison of costs	No cost (assuming no property purchase is part of this option).	$	$$	$$	$$$	$$$
Other comments	There is an expectation that NCC actively manage erosion on the true right bank of this reach.	Regrading of the banks is recommended before planting. Planting must extend beyond the low water level to stabilise banks. Alternatively toe	The reach is in sediment deficit so removing gravel will exacerbate the erosion trend. T+T (Ref: 1006675.0564.v2) states that before gravel is	See Option 3	A variation of this option is to rock armour the toe of the bank. This variation would allow for some floodplain engagement while protecting against	Most effective when the river has a reasonably stable bed. The river bed in the Gibbs –Dennes reach is mobile and so there is a

Consideration	Option 1 – Do nothing	Option 2 – Riparian Planting	Option 3 – Gravel management	Option 3a – Gravel management (inactive channels)	Option 4 – Rock armouring	Option 5 – Groynes
		protection may be required to prevent further erosion where planting cannot be done.	removed from this reach in the river that an assessment is undertaken to determine if there is immediate risk of adverse erosion to downstream buildings or lifeline structure and that gravel removal is only undertaken if the risk is high.		undercutting of the bank. This variation is likely to be less expensive than rock armouring to the 1% AEP flow or top of bank.	scour risk at the toe of the groynes. Potential for bank erosion to occur, leading to the outflanking of groyne structures.

3.4 Discussion of options and option combinations

The Gibbes-Dennes Reach is integral for the flood management of Nelson City, located approximately 1.5 km downstream, as it is one of the last reaches where the river can dissipate energy in the floodplain prior to the channelisation of the river in the urban area. NCC is also managing the expectation that river migration north and resulting erosion of the true right bank is addressed. The most appropriate option would be one that satisfies adjacent property owners while not compromising the flood risk for Nelson City and residential development downstream. As such the following options and combinations are proposed to be considered by NCC and discussed with relevant stakeholders:

Option A – Option 1 – Do Nothing: This option consists of no intervention and letting the river stabilise the true right bank naturally, recognising there is a limit to how far north the river will continue to migrate. While this option does not halt the erosion currently occurring on the true right bank, it is a nature-based solution that allows natural river processes to mitigate the erosion of the true right bank in time. This option has the least amount of negative effect to downstream areas and has the potential to increase the ecological value of the reach.

Option B – Options 2 + 3a – Riparian planting and chute channel gravel removal: This option consists of planting the banks to help reduce erosion and removing gravel from the chute channels (see Figure 2.6) to reduce erosive potential on the outside bend. Riparian planting includes the removal of willows and targeted planting on the gravel bars as appropriate to lock in sediments, as well as the planting of regraded banks on the true right. Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows. This option would minimise erosion of the true right bend in the most frequent storm events, but after larger (infrequent) events would require repair (replanting) and some tolerance for river movement in the bend and erosion. This option has minimal effects to downstream areas and would increase the ecological value of the reach.

Option C – Options 2 + 3a + 4 – Riparian planting, chute channel gravel removal, and rock armouring: This option is like Option B above with the addition of rock armouring the true right toe of the bank. This option would be more protective of erosion of the true right bend in the designed to storm events and in large events the armoured toe would protect against undercutting of the bank and resulting mass bank loss. Planting the upper portion of the bank would provide some ecological value to the reach and help dissipate energy in larger bank full or over bank events. There may be some replanting required after larger (infrequent events). This option would potentially have a greater effect on downstream areas than Option A and Option B as stream energy is increased through the armouring of the bend.

Option D – Options 2 + 3a + 4 + 5 – Riparian planting, chute channel gravel removal, rock armouring, and groynes: This option is the same as Option C but with the addition of rock groynes to change the course of the river and divert flow away from the true right bank. The river bed in this reach is mobile, so rock armouring the toe of the bank where groynes are installed would be necessary to protect against scour/erosion risk. This option would be more protective of erosion of the true right bend than Option A and Option B and perform similar to Option C. This option may potentially have a greater effect to downstream areas than any of the above options as stream energy is increased through the armouring of the bend, redirection of the river, and greatest degree of floodplain disengagement.

All options involve relatively straightforward construction methodologies, with some options easier to construct than others. Section 3.5 below summarises a high-level cost estimate for Options A through D.

When selecting an option to progress consideration should be given to NCC's priorities of the above stated objectives (Section 3.1), NCC's risk tolerance for each of the above stated objectives, opportunity to work with adjacent property owners, and available budget for the project.

3.5 High-level cost estimates

High-level construction cost estimates have been prepared for each option above. We understand that NCC will use these estimates for the purposes of determining the preferred option to progress to preliminary design (not determining budgets for implementation). As such, the cost estimates are based on high level concepts only (refer Appendix A) and no design of the options has been undertaken.

Table 3.2 summarises the high-level construction cost estimate for each option.

Table 3.2: Option construction cost estimates

	Option A Do nothing	Option B Riparian planting and chute channel gravel removal	Option C Riparian planting, chute channel gravel removal, rock armouring	Option D Riparian planting, chute channel gravel removal, rock armouring & groynes
Contractor's Preliminary and General (15%)	$0	$41,000	$58,000	$65,000
Construction stage engineering and observation	$0	$20,000	$30,000	$40,000
Construction Estimate	$0	$276,000	$386,000	$431,000
Subtotal	**$0**	**$337,000**	**$474,000**	**$536,000**
Contingency (45%)	$0	$152,000	$213,000	$241,000
Engineering design fees (15%)	$0	$51,000	$71,000	$80,000
Total estimate, rounded	$0	$540,000	$758,000	$857,000
Total estimate range, rounded (-20%, +40%)	**$0**	**$430,000 - $760,000**	**$610,000 – 1,060,000**	**$690,000 – 1,200,000**

The construction cost estimates provided are based on conceptual figures, estimated quantities and a combination of recent rates from Nelmac, the NCC cost rate database, and QV Cost Builder database. These rates are based on information and data as of August 2024 and do not include allowance for any cost escalation. This may need to be considered depending on when the solutions are likely to be implemented.

The estimates are based on estimated quantities for key elements (e.g. earthwork volumes, planting, rock armouring) and unit rates, with allowances for non-itemised components and construction overheads (e.g. Contractor's preliminary and general). Key quantities are presented in the cost estimate detail provided in Appendix B.

A significant margin of uncertainty exists on the cost estimate given that no design has been undertaken and the costs are based on high level concepts only. Therefore, the contingency we have allowed should be considered as part of the cost rather than a potential add on. A contingency of 45% has been adopted. An accuracy range of -20% to +40% has been estimated for the current project stage (conceptual options) as per AACE 56R-08.

In particular, we have not made any attempt to allow for the potential impact of COVID-19 in this estimate. Also, supply chain disruptions are currently having quickly-changing effects on construction costs and schedules. We recommend NCC seek up-to-date specialist economic advice on what budgetary allowances you should make for escalation, including for any potential changes in construction costs and timing in relation to both COVID-19 and supply-chain issues.

The following items are not included in the construction cost estimate and should be allowed for separately and additionally:

- Inflation
- Land purchase and easements
- Government taxes
- Insurance
- Environmental offsets and compliance
- Consenting and approvals
- Construction cost volatility due to changes in costs of commodities subject to currency exchange fluctuations or world demand such as fuel; the degree of depend for relevant potential contractors in the market at the time of bidding; and other global market forces.
- Operation and maintenance

4 Conclusions and next steps

Previous T+T Geomorphology and Ecology assessments of the full length of the Maitai River and the geomorphic assessment of the Gibbs-Dennes Reach conducted as part of this report, find that this reach is in a sediment deficit, with more sediment eroded than deposited in recent years. Between 2015 and 2022 there has been estimated sediment loss of 980 m^3. The reach being in a sediment deficit, combined with the composition of the river banks means that bank erosion susceptibility is high.

Options to manage the Gibbs-Dennes Reach were selected and assessed using the following objectives as a framework:

- Address erosion of the true right bank at the bend,
- Maintain or enhance the downstream attenuation of sediment load and flow, thereby reducing risk to downstream areas; and
- Maintain or enhance ecological values of the reach.

We recommend that NCC undertakes discussions with the stakeholders, particularly adjacent landowners prior to proceeding to design, if necessary, for the option/combination of options chosen.

5 Applicability

This report has been prepared for the exclusive use of our client Nelson City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

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Water Engineer

Authorised for Tonkin & Taylor Ltd by:

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Josh Hodson
Project Director

Technical review undertaken by Prof. Ian Fuller, Principal Fluvial Geomorphologist

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Appendix A Conceptual figures

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NOTES:
Top of the South Flood 0.15m Aerial Photos (2022): . NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.
Maitai River aerial from UAV survey carried out by Staig & Smith on 15/12/2023 and 20/12/2023.

REVISIONS	NO.	BY
First version (07/08/2024)	0	AMHO

PROJECT No. 1089395.2012

DESIGNED	AMHO	AUG.24
DRAWN	AMHO	AUG.24
CHECKED	AMHO	AUG.24

APPROVED DATE

CLIENT **NELSON CITY COUNCIL**
PROJECT **MAITAI RIVER - GIBBS-DENNES REACH**
TITLE OPTION A - NO INTERVENTION

SCALE (A4) 1:1,500 FIG No. FIGURE 1. REV 0

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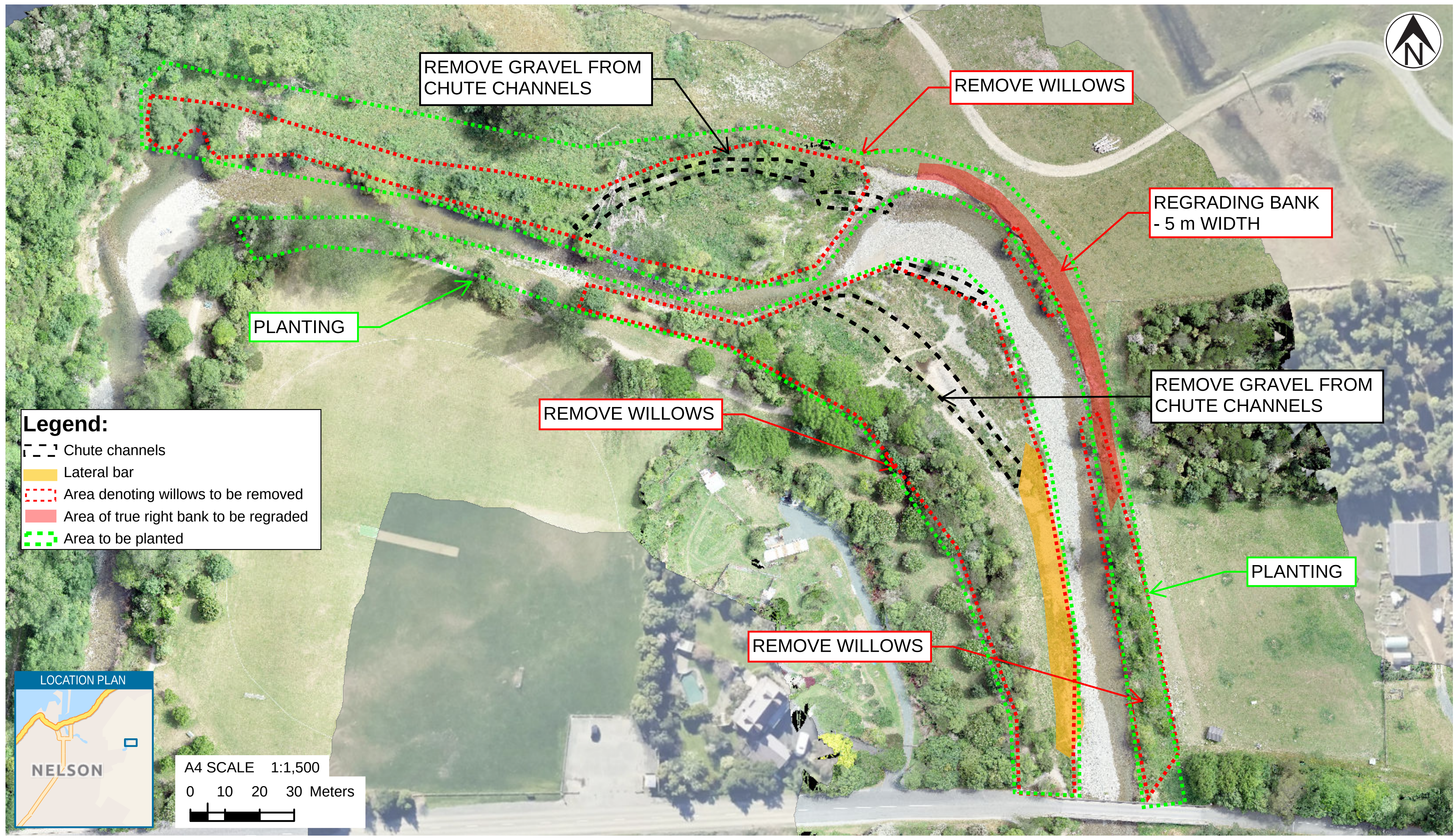

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CLIENT **NELSON CITY COUNCIL**
PROJECT **MAITAI RIVER - GIBBS-DENNES REACH**
TITLE OPTION B - RIPARIAN PLANTING AND CHUTE CHANNEL GRAVEL REMOVAL
SCALE (A4) 1:1,500 FIG No. FIGURE 2. REV 0

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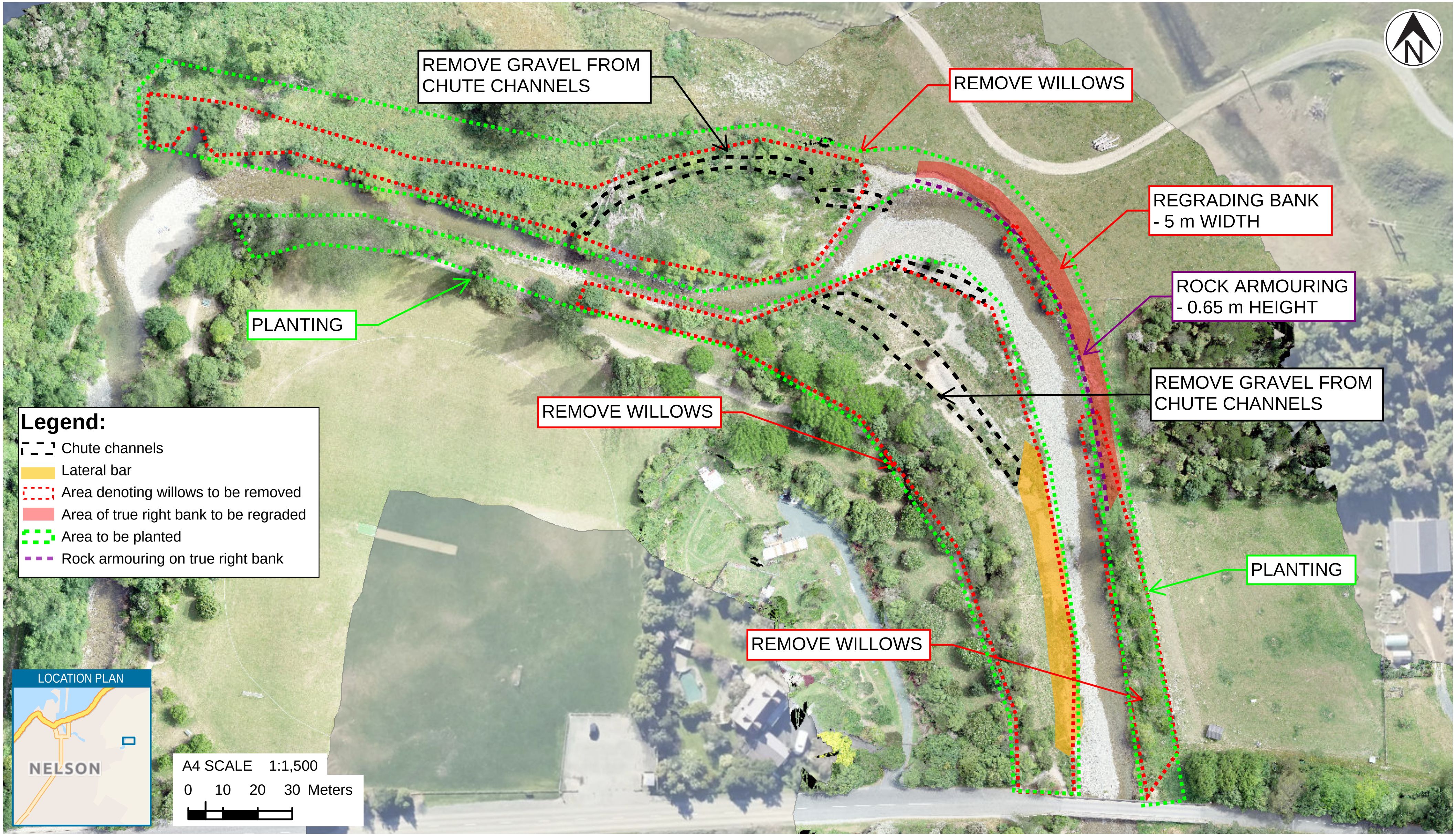

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APPROVED		DATE

CLIENT **NELSON CITY COUNCIL**
PROJECT **MAITAI RIVER - GIBBS-DENNES REACH**
TITLE OPTION C - RIPARIAN PLANTING, CHUTE CHANNEL GRAVEL REMOVAL AND ROCK ARMOURING

SCALE (A4) 1:1,500 FIG No. FIGURE 3. REV 0

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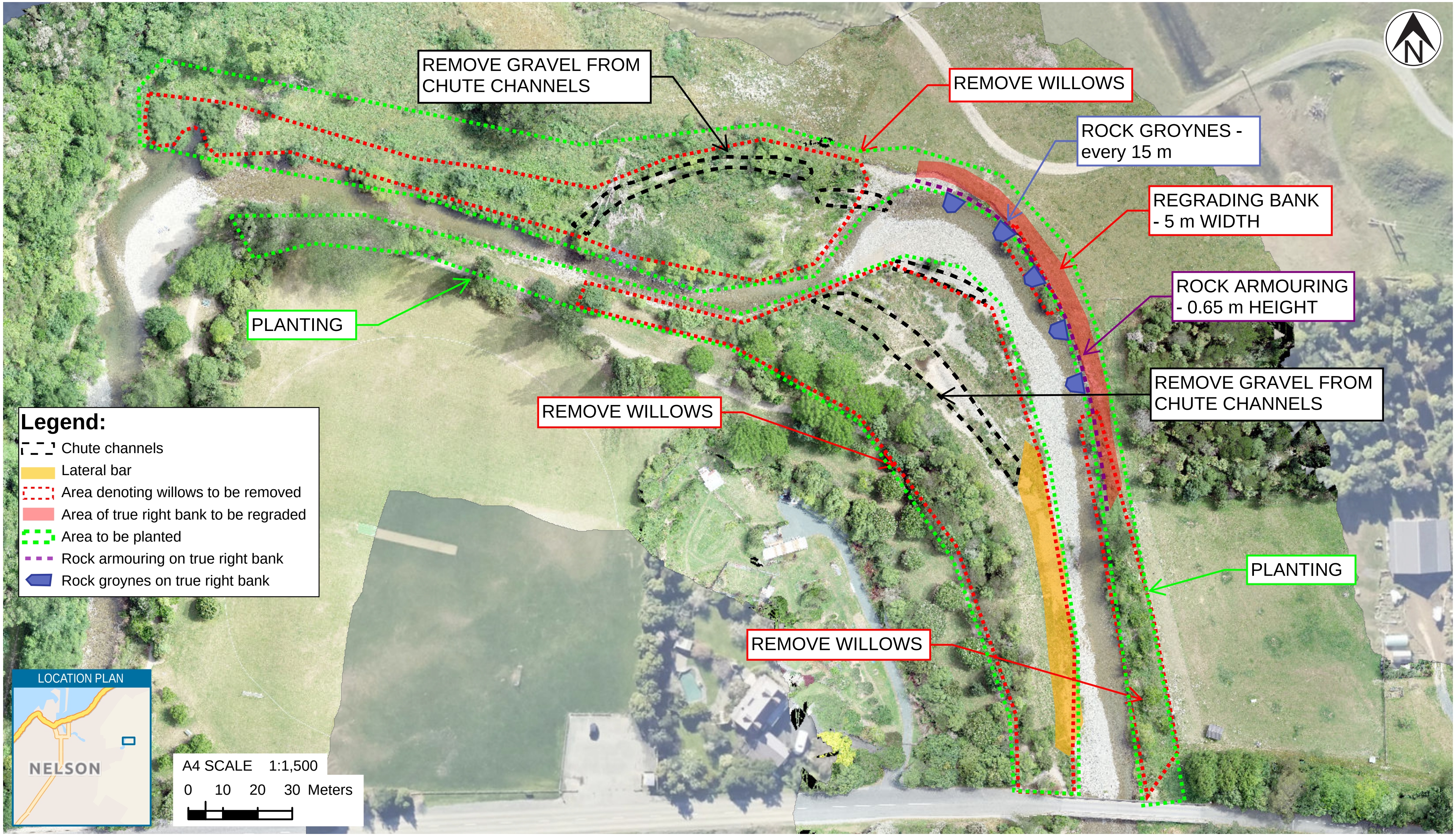

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Maitai River aerial from UAV survey carried out by Staig & Smith on 15/12/2023 and 20/12/2023.

REVISIONS	NO.	BY
First version (07/08/2024)	0	AMHO

PROJECT No.	1089395.2012	
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CHECKED	AMHO	AUG.24
APPROVED		DATE

CLIENT **NELSON CITY COUNCIL**
PROJECT **MAITAI RIVER - GIBBS-DENNES REACH**
TITLE OPTION D - RIPARIAN PLANTING,CHUTE CHANNEL GRAVEL REMOVAL, ROCK ARMOURING AND GROYNES

SCALE (A4) 1:1,500 FIG No. FIGURE 4. REV 0

Appendix B Construction cost estimates quantity detail

Option A: Do Nothing

Description of option:

No intervention and letting the river stabilise the true right bank naturally, recognising there is a limit to how far north the river will continue to migrate. While this option does not halt the erosion currently occurring on the true right bank, it is a nature-based solution that allows natural river processes to mitigate the erosion of the true right bank in time. This option has the least amount of negative effect to downstream areas and has the potential to increase the ecological value of the reach.

Tasks:	Description	Assumption	Unit	Quantity	Rate	Cost Estimate
N/A		River will have room to move across the floodplain	-	-	-	$0

Option B: Riparian Planting and Chute Channel Gravel Removal

Description of option:

This option consists of planting the banks to help reduce erosion and removing gravel from the chute channels to reduce erosive potential on the outside bend. Riparian planting includes the removal of willows and targeted planting on the gravel bars and planting of regraded banks on the true right. Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows. This option would minimise erosion of the true right bend in the most frequent storm events, but after larger (infrequent) events would require repair (replanting) and some tolerance for river movement in the bend and erosion. This option has minimal effects to downstream areas and would increase the ecological value of the reach.

Tasks:	Description	Assumption	Unit	Quantity	Rate ($/Unit)	Cost Estimate ($)
Unscheduled items		10%				25,000
Removing willows/site clearing	Remove willows by cutting them down individually, including poisoning of stumps. Clear site for planting. Not included is associated ecological work, e.g. bat / lizard investigation.	Total area = 10,730m2.	LS	1	20,000	20,000
Regrading true right banks		5 m width of regrading, approximate volume of 600 m3, assumes cartage within Nelson.	m3	600	60	36,143
Removing gravel from chute channels	Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows. Chute channels are dug down to the level of Mean Annual Flow (MAF)	Total area = 930m2, Depth = 0.4m	m3	372	40	14,880
Planting banks and gravel bars	Targeted planting on the gravel bars as appropriate to lock in sediments, as well as the planting of regraded banks on the true right and where willows are removed.	Two plants per m2	m2	16,400	11	180,400
					Total (excluding GST):	**276,423**

Option C: Riparian Planting, Chute Channel Gravel Removal, Rock Armouring

Description of option:

This option consists of planting the banks to help reduce erosion, removing gravel from the chute channels to reduce erosive potential on the outside bend and rock armouring the true right toe of the bank. Riparian planting includes the removal of willows, targeted planting on the gravel bars and planting of regraded banks on the true right. Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows. This option would be more protective of erosion of the true right bend in the designed to storm events and in large events the armoured toe would protect against undercutting of the bank and resulting mass bank loss. Planting the upper portion of the bank would provide some ecological value to the reach and help dissipate energy in larger bank full or over bank events. There may be some replanting required after larger (infrequent events).

Tasks:	Description	Assumption	Unit	Quantity	Rate ($/Unit)	Cost Estimate ($)
Unscheduled items		10%				35,000
Removing willows/site clearing	Remove willows by cutting them down individually, including poisoning of stumps. Clear site for planting. Not included is associated ecological work, e.g. bat / lizard investigation.	see Option B	LS	1	20,000	20,000
Regrading true right banks		see Option B	m3	600	60	36,143
Removing gravel from chute channels	Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows.	see Option B	m3	370	40	14,800
Excavating rock armour toe		Toe depth and width of 1.3m for length of armouring	m3	408	40	16,320
Rock armour toe	placing of double-layered rock armour at the toe of the true right bank to the level of mean flow.	120m length, to 0.65m height, D50 = 650mm Rate assumes sheet piling and/or dewatering is not required at site.	m3	540	150	81,000
Bidim behind rock armouring	placing a layer of bidim across the newly graded true right bank before placing the rock armour		m2	360	6	2,230
Planting banks and gravel bars	targeted planting on the gravel bars as appropriate to lock in sediments, as well as the planting of regraded banks on the true right and where willows are removed.	see Option B	m2	16,400	11	180,400
					Total (excluding GST):	**385,893**

Option D: Riparian Planting, Chute Channel Gravel Removal, Rock Armouring, and Groynes

Description of option: This option consists of planting the banks to help reduce erosion, removing gravel from the chute channels to reduce erosive potential on the outside bend, rock armouring the true right toe of the bank, and rock groynes along the true right to change the course of the river and divert flow away from the true right bank. Riparian planting includes the removal of willows, targeted planting on the gravel bars and planting of regraded banks on the true right. Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows. This option would be more protective of erosion of the true right bend in the designed to storm events and in large events the armoured toe would protect against undercutting of the bank and resulting mass bank loss. Planting the upper portion of the bank would provide some ecological value to the reach and help dissipate energy in larger bank full or over bank events. There may be some replanting required after larger (infrequent events).

Tasks:	Description	Assumption	Unit	Quantity	Rate ($/Unit)	Cost Estimate ($)
Unscheduled items		10%				39,000
Removing willows/site clearing	Remove willows by cutting them down individually, including poisoning of stumps. Clear site for planting. Not included is associated ecological work, e.g. bat / lizard investigation.	see Option B	LS	1	20,000	20,000
Regrading true right banks		see Option B	m3	600	60	36,143
Removing gravel from chute channels	Maintenance of the chute channels would be required to ensure they can be activated at the appropriate flows.	see Option B	m3	370	40	14,800
Excavating rock armour toe		See Option C	m3	408	40	16,320
Rock armour toe	placing of double-layered rock armour at the toe of the true right bank to the level of mean flow.	see Option C	m3	540	150	81,000
Bidim behind rock armouring & groynes	placing a layer of bidim across the newly graded true right bank before placing the rock armour		m2	535	6	3,315
Rock groynes	Stones for rock groynes (up to bank height, lower towards the center of the river. Reaching ca 1/4 to 1/3 into the river, every ~20 m) including placing of stones.	5 groynes, approximately 5m length (into river), height 2m-1m, max width 9 m, D50 = 650mm. Rate assumes sheet piling and/or dewatering is not required at site.	m3	270	150	40,500
Planting banks and gravel bars	Targeted planting on the gravel bars as appropriate to lock in sediments, as well as the planting of regraded banks on the true right and where willows are removed.	see Option B	m2	16,400	11	180,400
					Total (excluding GST):	**431,478**