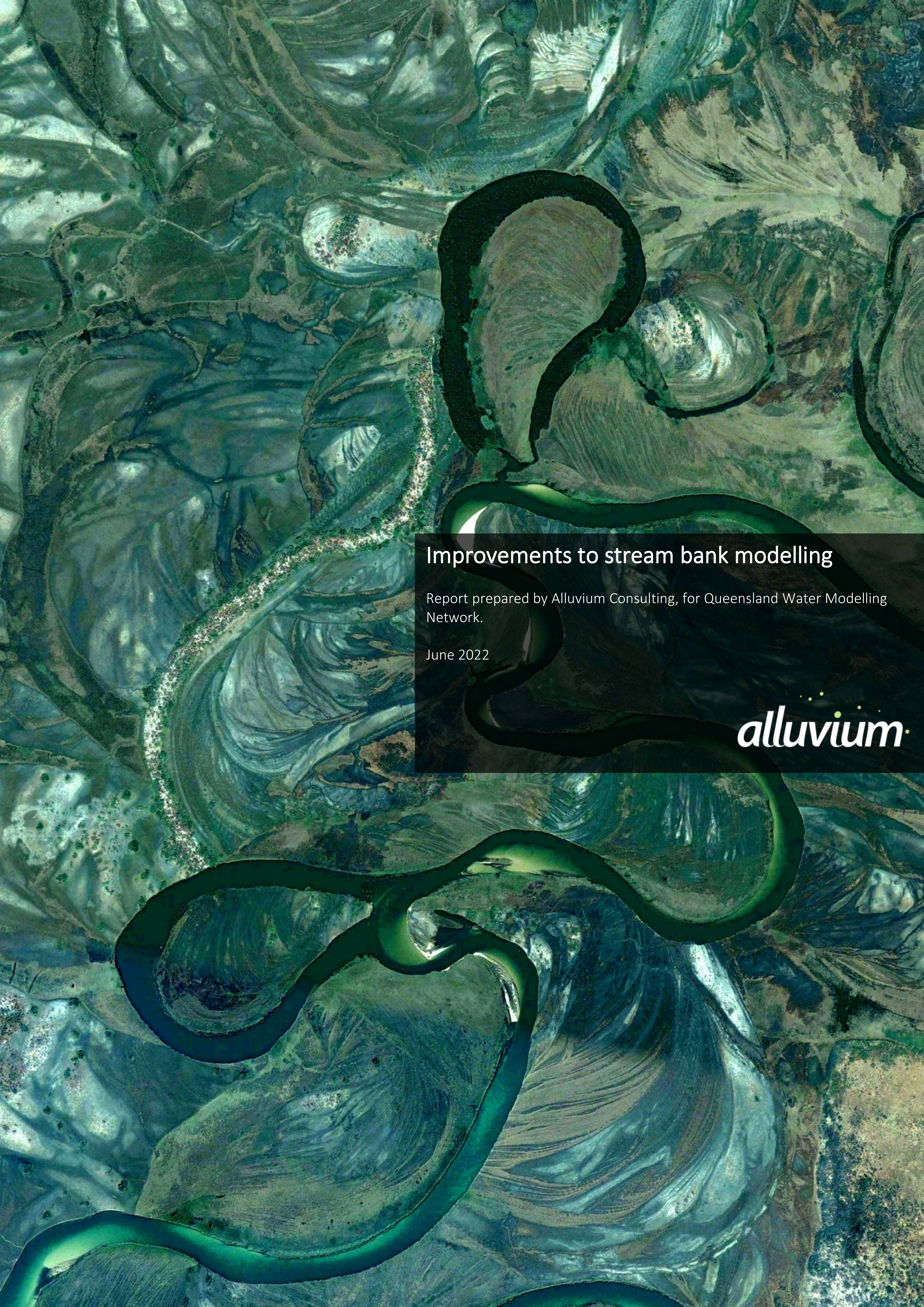

Improvements to stream bank modelling

Report prepared by Alluvium Consulting, for Queensland Water Modelling Network.

June 2022

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Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

The Queensland Water Modelling Network (QWMN) is an initiative of the Queensland Government that aims to improve the state's capacity to model its surface water and groundwater resources and their quality. The QWMN is led by the Department of Environment and Science with key links across industry, research and government.

Prepared by Misko Ivezich and Marnina Tozer (Alluvium Consulting)

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1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) have been engaged by the Department of Environment and Science (DES) to investigate and assess options and opportunities for stream bank erosion modelling within the Great Barrier Reef (GBR) catchments. An initial investigation assessed a range of stream bank erosion modelling approaches and their applicability to GBR streams (Alluvium, 2020a and Alluvium, 2020b). A key finding of this study was the difficulty in accurately predicting stream bank erosion in all river typologies that exist within the GBR catchments.

This study aims to consolidate the previous QWMN projects undertaken by Alluvium to help the Paddock to Reef team improve the linkages between their models and actual river form and processes. The main outputs of this project are a decision support framework, and case study assessments to help inform Paddock to Reef streambank models.

1.1 Project background

Stream bank erosion represents a major source of sediment to the GBR lagoon. Erosion is a natural and essential process in alluvial systems; however human activities such as land clearing, removal of riparian vegetation or grazing pressure that limits reestablishment of vegetation can result in accelerated rates of stream erosion resulting in damaging channel change. These erosion processes provide a pathway for sediments and nutrients, such as nitrogen and phosphorous, to enter waterways. Land use changes within the GBR catchments have resulted in significant increases in sediment and nutrient loads to the GBR lagoon. As a result, stream bank erosion has been identified as a major sediment and particulate nutrient delivery process impacting on the GBR (Figure 1).

Figure 1. *Stream bank erosion along the O'Connell River (left) and Mary River (right).*

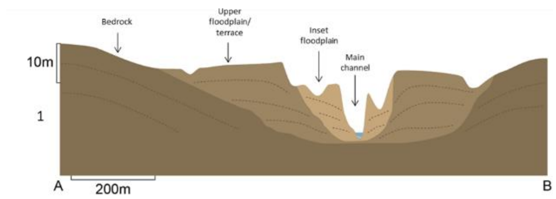
The Dynamic SedNet model is currently used within the GBR Source Catchment Modelling framework to assess end-of-catchment loads and to estimate pollutant load reductions due to adopted improved management practices. The Dynamic SedNet model is also used to run scenarios to provide comparison of potential reef water quality outcomes arising from a range of theoretical investment strategies. Bank erosion is currently one of the processes modelled within the Dynamic SedNet model.

The model, and the data inputs currently utilised, is a reasonable tool for estimating the relative contribution of bank erosion at large, whole-of-catchment, scales. However, its applicability at smaller spatial scales (i.e. reach or sub-catchment) to estimate erosion rates and undertake prioritisation is limited due to the coarse datasets used, size of the model links and sub-catchment areas, and modelling assumptions. In 2020 Alluvium Consulting investigated and assessed options and opportunities for stream bank modelling within the Great Barrier Reef (GBR) catchments (Alluvium, 2020a). The review assessed four different stream bank erosion prediction approaches:

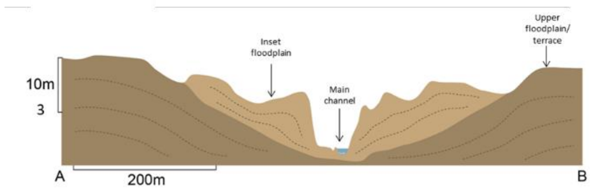
1. The Dynamic SedNet stream bank erosion model (the current approach)
2. Bank Assessment of Non-point Source Consequence of Sediment approach (BANCS)
3. The Bank Stability and Toe Erosion Model (BSTEM)
4. Stream type based approach and multi-temporal analysis

The review highlighted the difficulties in predicting stream bank erosion across the broad catchments of the GBR. Stream bank erosion processes are complex, often non-linear, and involve a range of diverse and interrelated variables. As a result, selecting an appropriate predictive model is very challenging, especially at the scale of the GBR catchments where data availability is limited.

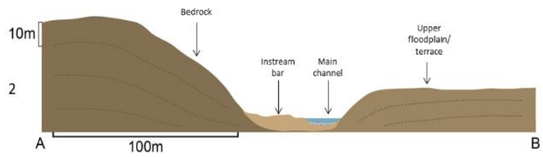
Within the GBR catchments there are a huge diversity of river typologies ranging from classic self-formed meandering systems, anatomising systems, entrenched compound channel systems which are confined by resistant floodplain/terrace material with contemporary (i.e. Holecene) inset deposits, bedrock constrained, semi-alluvial channels and typical incised channels as defined by Schumm et al (1984) (typically in smaller secondary channels). The erosional processes within the channel will differ significantly for each type of river system. Some examples of different river channels within the GBR catchments are highlighted in Figure 2. Each of these channels have very different morphology and channel erosion processes. However, the current Dynamic SedNet stream bank erosion model assumes the river systems have a similar channel form and erosional mechanisms. Accurately predicting stream bank erosion will be difficult without an understanding the spatial distribution of each river type and processes that impact erosion in each system.



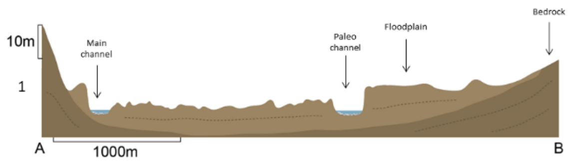
Entrench, compound channel confined by terraces with narrow inset floodplain and bench units



Compound channel with limited terrace confinement and broad inset floodplain units



Partly confined gravel bed channel with abundant coarse bedload sediment



Unconfined meandering channel with paleo channels within broad floodplain

Figure 2. *A range of different river types which exist within Great Barrier Reef catchments*.

Based on recommendations in Alluvium (2020a) a study was undertaken to assess the parameterisation of the Dynamic SedNet model in a range of different river types within the GBR catchments (Alluvium, 2020b). The case study areas were selected on the basis of good pre-existing data availability in order to assess the geomorphology and hydro-geomorphic processes.

The case study assessment identified erosion areas are significantly more prevalent when the channel is bound by certain geomorphic units (i.e. inset floodplains) and are often concentrated within small areas. Given the length of modelled links (often 10-15 km) an understanding of the type and prevalence of channel bounding geomorphic units within each link, and their relative erodibility, would greatly enhance stream bank erosion prediction.

The assessment also identified major issues with the parameterisation of the models. Despite the good predictive power of the model there were very large errors in the variables which drive the process-based component of the model in several case study areas. Given there were such large errors in some of the input parameters it was not possible to assess the process-based components of the model performance in the different river types assessed in this study.

1.2 Project objective

Building on findings in Alluvium (2020b) the key objective of this project was to develop a decision support framework to help the Paddock to Reef modelling team understand the geomorphic properties at the modelled link scale. The purpose of the framework is to:

- Provide guidance on identifying the critical geomorphic units and channel features which contribute to streambank erosion at the modelled link scale.
- Provide recommendations on which geomorphic parameters to adopt for link streambank erosion parameterisation with the aim of improving model parameterisation.

It is hoped that improved model parameterisation will allow more conclusive assessments of model performance. To assist in the assessment of model performance the modelled links in each of case study assessed in Alluvium (2020b) have been broken into smaller segments and parameterised as part of this study.

1.3 Report structure

The report has the following structure:

- Section 1 provides an overview of the project background and project objectives.
- Section 2 provides an overview of the Dynamic Sednet Stream Bank Erosion Model.
- Section 3 provides a summary of a key geomorphic controls on channel adjustment and form.
- Section 4 introduces a decision support framework which has been developed to provide guidance on identifying the critical geomorphic units and channel features which contribute to streambank erosion at the modelled link scale.
- Section 5 provides an overview of reach scale geomorphic characteristics within five case study areas. To inform parametrisation, Dynamic SedNet links (within the case study areas) have been split into unique hydro-geomorphic reaches, primarily based on degree of confinement.

2 Overview of Dynamic SedNet Stream Bank Erosion Model

Overview of model

Dynamic SedNet is a daily time-stepping sediment budget model which is implemented within the Source integrated modelling system. The model simulates spatial patterns in primary erosion processes at a catchment scale using data relating to terrain, land use, riparian vegetation cover, soils and rainfall. Dynamic SedNet is used within GBR catchments to model sediment transport processes and the impacts of river management practices.

Dynamic SedNet a is semi-distributed spatial model used to assess end of catchment loads. It is structured around river reaches (described as links) and their associated sub-catchments. Within sub-catchments the model uses Functional Units (FU) to represent different hydrological and pollutant generation responses based on land use (Figure 3). The model uses a daily rainfall-runoff model to predict runoff for each FU in each sub-catchment, and subsequently to predict daily flow in each stream link (Wilkinson et al., 2014). Flow data is used in the subsequent modelling of daily fine sediment budgets for each link in the river network. Dynamic SedNet is comprised of multiple models, with each component modelling a specific process (i.e. stream bank erosion, floodplain deposition, gully erosion etc.).

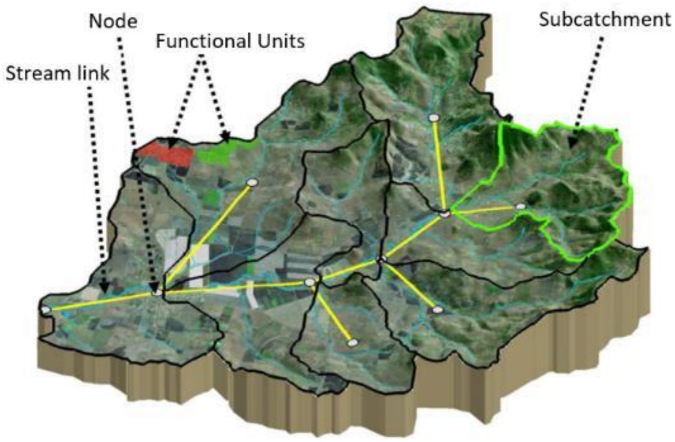


Figure 3. Example of a Dynamic *SedNet functional node and link network implemented within Source (adapted from Hateley, 2014).*

The Stream Bank Erosion component of Dynamic SedNet models bank erosion along stream links represented in the node-link (stream) network. The Stream Bank Erosion component models mean annual sediment supply from bank erosion along a link as a function of bankfull stream power in a hypothetical rectangular channel, and the extent of riparian vegetation adjacent to the channel and level of bedrock confinement as represented by available geological maps (as proxies for erosion resistance) (Figure 4). The bank erosion algorithm calculates the erosion rate over the entire length of the link. The erosion rate is then scaled down based on the proportion on the reach (link) with intact riparian vegetation cover (Prosser, 2018). Mean annual bank erosion (t/y) is calculated as shown in Figure 4 and discuss further below.

Mean annual bank erosion (t/y) = Lateral retreat rate (m/y) × Mass Conversion × Bank erodibility

Figure 4. *Mean annual bank erosion equation.*

Lateral retreat rate

The lateral retreat rate (RR) is the product of total bankfull stream power, and the bank erosion calibration and management factors:

$$\mathbf{RR = (k\ \rho_w\ g\ S_l\ \ Q_{bf}\ )M_f}$$

Where:

ρ_w = density of water (1000 g/m^3)
g = acceleration due to gravity (9.81 m/s^2)
S_l = link stream bed slope (dimensionless)
Q_{bf} = bankfull discharge (m^3/s)
k = bank erosion calibration coefficient
M_f = bank erosion management factor

The bank erosion calibration coefficient is adjusted (according to available monitoring data e.g. measured bank retreat, erosion volumes, end of system loads) to ensure predicted long term erosion rates are comparable with observed bank erosion rates (Wilkinson et al, 2009). Consequently, good quality monitoring data is required to calibrate the model. Previous SedNet studies based in Australia employed K values in the range 0.00001 – 0.0001. The bank erosion management factor, introduced to allow proportional manipulation for Reef Plan, allows for adjustment of retreat rate based on proposed management actions.

Mass conversion

Mass Conversion (MC) is determined by bank height and soil density:

$$\mathbf{MC\ =\ F_b\ \ \rho_s h\ L_l}$$

Where:

Fb = proportion is fines in bank materials
ρ_s = stream bank soil dry bulk density (t/m^3)
h = bank height (m) ('bank'= erosion contributing feature)

L_l = river length represented by link (m)

Bank erodibility

Bank erodibility (BE) is considered riparian vegetation cover and bank material erodibility:

$$\mathbf{BE = \big(1 - MIN\ (RipVeg, MaxVegEffectiveness)\big) \times SoilErod}$$

Where:

RipVeg = proportion of intact riparian vegetation
MaxVegEffectiveness = cap on the effectiveness of riparian vegetation
SoilErod = stream bank material erodibility (0-1 with 0 for bedrock and 1 for highly erodible alluvial sediments)

MaxVegEffectiveness acknowledges that stream bank erosion occurs in fully vegetated riparian zones.

Daily bank erosion

The mean annual erosion is then converted to daily bank erosion using a disaggregation function based on daily stream flow (Figure 5). Daily stream bank erosion is calculated as shown in Figure 5.

$$\text{Daily bank erosion (kg/day)} = \frac{1}{365.25} \times \text{Mean annual bank erosion (t/y)} \times \text{Stream link discharge factor} \times 1000$$

Figure 5. *Disaggregation mean annual bank erosion to daily bank erosion.*

$$\textbf{Stream link discharge factor} = \frac{Q_i^b}{\frac{1}{n}\sum_{i=1}^{n} Q_i^b}$$

Where:

Q_i = daily flow rate (m^3/s)
n = number of days in the long term historical daily flow record

b = adjustable Daily Flow Power Factor (default 1.4)

Model input parameters

Several raster data layers and parameter values are used to build the Dynamic SedNet Bank Erosion model. A Digital Elevation Model (DEM) is used to define both the sub-catchments and the stream network. To determine sub-catchment and stream networks an area threshold for first-order river links must be determined (Wilkinson et al., 2014). Often this area threshold is specified based on computational efficacy and gully erosion mapping. Input raster layers are used to calculate eight raster data sets used in parameterisation (slope, flow direction, contributing area, ephemeral streams, stream order, stream confluences with main channel and stream buffers) (Hateley et al., 2014), although some of these do not contribute directly to stream bank parameterisation. The modelling period is defined by the daily precipitation and potential evapotranspiration data available for input into the daily rainfall-runoff model.

Input parameters required for the Dynamic SedNet Bank Erosion component, and geomorphic consideration for parameterisation, are outlined in Table 1. The framework outlined in the next section aims to help modellers further consider the geomorphic consideration when parameterising modelled links.

Table 1. Dynamic SedNet Bank Erosion input parameters, potential data sources and geomorphic considerations.

Parameter	Units	Description	Data source	Geomorphic consideration
k (bank erosion coefficient)	[0.00001, 0.0001]	Bank erosion calibration coefficient (default 0.00004)	Based on empirical data sets	-
S_l (river link slope)	m/m	Link stream bed slope	Included in Dynamic SedNet plugin, based on DEM and links	Slope can vary along the link length due to structural works (i.e. weirs), sediment supply and vertical and lateral controls within the valley.
Q_{bf} (bank full discharge)	m^3/s	Bank full discharge (m^3/s) based on the selected ARI (default 1.58 yrs)	Derive ARI discharge (m^3/s) based on long run of hydrology in Source model	There are often multiple depositional units within river valleys which makes it difficult to determine the active flow channel and define bankfull flow. In bedrock confined reaches it is difficult to define bank height and as a result bankfull flow.
ρ_s (soil bulk density)	$tonnes/m^3$	Stream bank subsoil dry bulk density	Best available soils data	-
h (bank height)	m	Function of catchment area and slope	Dynamic SedNet spatial parameteriser calculates average height at link level	Often the bank height is not straightforward as there may be an inset channel and wider compound channel.
RipVeg	[0, 1]	Proportion of vegetation in riparian zone (1 for complete cover, 0 for no cover)	Vegetation cover mapping e.g. Queensland 2014 Foliage Projective Cover (FPC) layer. Clipped using a 100 – 200 m stream network buffer	The position of riparian vegetation within the channel plays a critical role in limiting erosion. For example, vegetation within the channel bed may be less effective at limited channel erosion as opposed to vegetation on streambanks abutting erodible floodplains.
MaxVegEffectiveness	[0, 1]	Sets limit for effectiveness of riparian vegetation in mitigating erosion	Set as 0.95 (Wilkinson et al., 2009)	-
SoilErod	[0, 1]	The erodibility of stream bank material (0 for rock, 1 for erodible soil). Or based on floodplain width (1 within mapped floodplain area, 0 elsewhere)	Floodplain mapping	Different geomorphic units can have significantly different stratigraphy and erodibilities.
p_f (proportion fine)	[0, 100%]	Proportion of fine sediment in bank subsoil	Best available soils data	Often the portion of fine sediment is linked to the erodibility. Increased fine content leads to increased cohesive properties and lower erodibility.

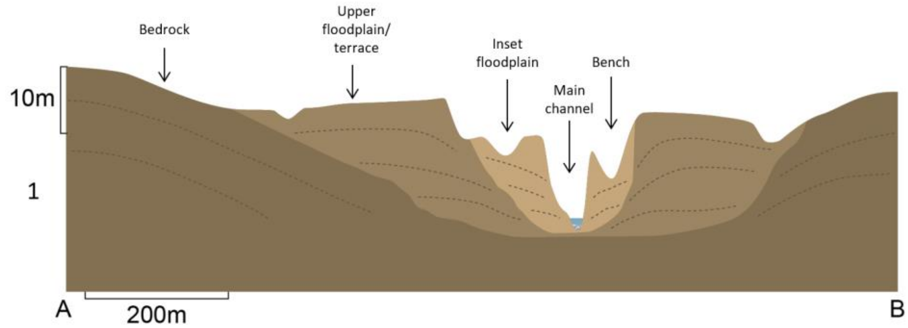
3 Channel morphology

This section provides an overview of a key control on channel adjustment and form – channel confinement and channel boundary material. The degree to which a river channel is confined between the valley walls and/or resistant substrate and the presence, or absence, of in-channel features impacts erosional mechanisms within a reach.

An understanding of the type and prevalence of channel bounding geomorphic units within each link, and their relative erodibility, would greatly enhance stream bank erosion prediction. Terminology used in the decision support framework to help the Paddock to Reef modelling team understand the geomorphic properties at the modelled link scale is defined below.

Some examples of different river channels (and erosion considerations) within the GBR catchments are provided in Figure 6.

River type | **Erosion considerations**

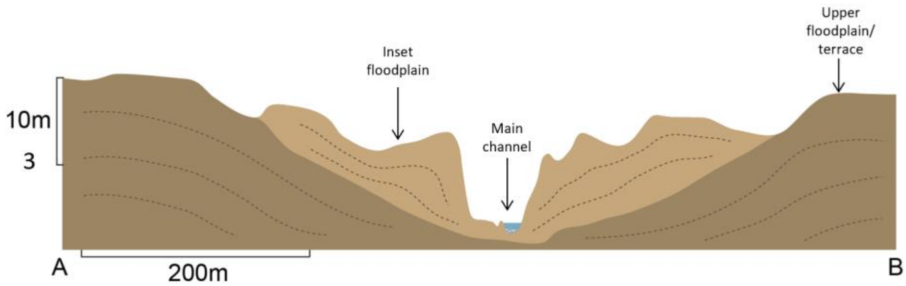


a. Entrenched compound channel confined by terraces with narrow inset floodplain and bench units.

Erosion is often concentrated on inset floodplain units. Older terrace units are often very resistant to erosion.

Limited planform adjustment or meandering.

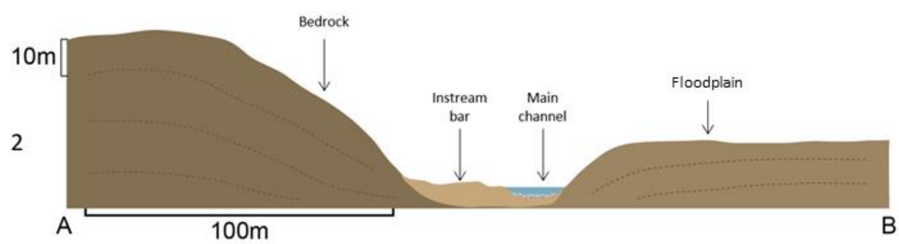
Vegetation on inset floodplain units more critical for erosion resistance than vegetation on terrace units.



b. Compound channel with limited terrace confinement and broad inset floodplain units.

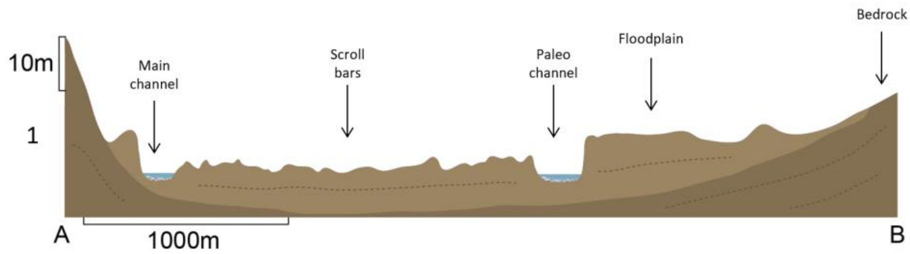
Extensive lateral planform adjustment is possible when riparian zones are disturbed.

Meander migration and development common.



c. Partly confined gravel bed channel with instream bar and abundant coarse bedload sediment.

Abundant coarse sediment can drive lateral migration of the channel and meander migration where there are erodible floodplains.



Extensive lateral planform adjustment is possible when riparian zones are disturbed.

Meander migration and development common.

d. Unconfined meandering channel with scroll bars and paleo channels within broad floodplain.

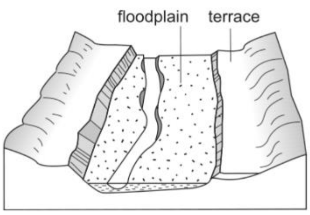
Figure 6. *Examples of different river types (and erosion considerations) within Great Barrier Reef catchments*.

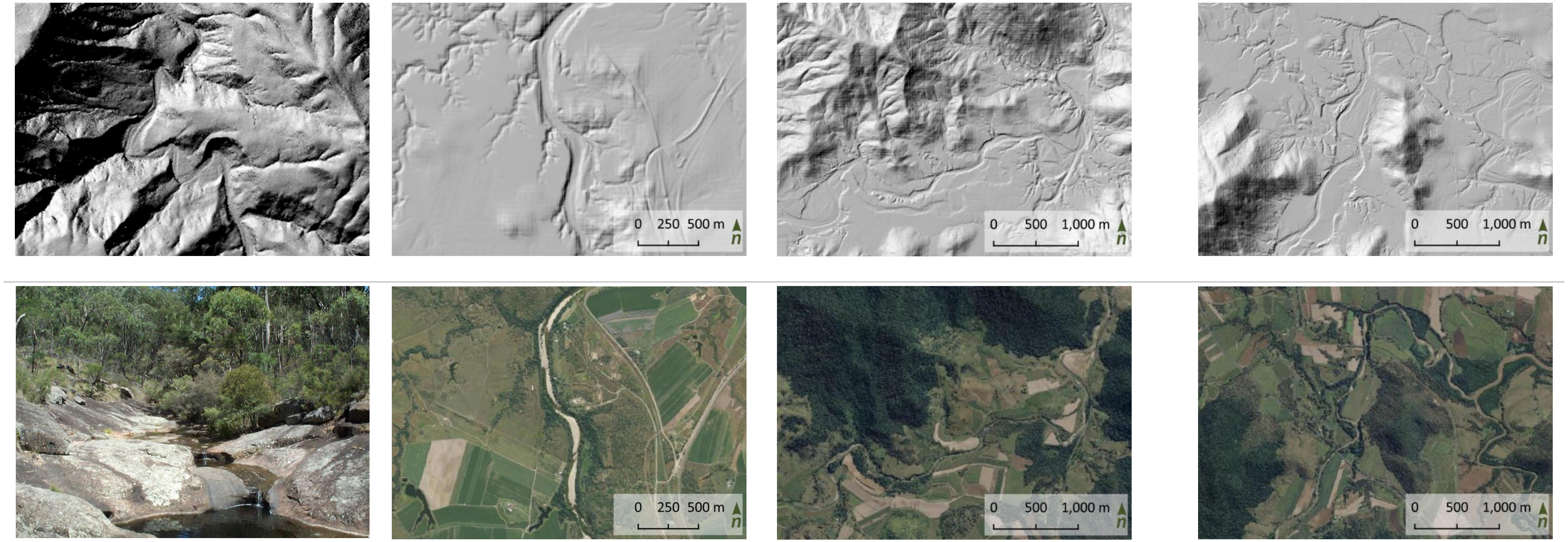
Degree of confinement and confinement media

The degree of confinement is the degree to which the channel is confined and, as a result, impacts its ability to laterally adjust within contemporary timeframes. The channel can be confined by either bedrock/hillslopes or floodplain/terraces which comprises of highly resistant sediments.

Key confinement/channel boundaries are described in Table 2. Examples of different ranges of confinement, within GBR catchments, are shown in Figure 7. Three ranges of confinement are considered in this study, based on the percentage of channel which abuts the confinement boundary.

Table 2. Summary of key confinement/channel boundaries (Charlton, R., 2007 and River Styles, 2022).

Term	Conceptual diagram	Description
Bedrock channel		A channel formed directly in the underlying rock, rather than in alluvium (sediment deposited by fluvial processes).
Terrace		Typically, a relatively flat (planar), valley marginal feature that is perched above the contemporary channel and/or floodplain. These abandoned floodplains are no longer active. Terraces often confine the contemporary channel, in a manner that is analogous to bedrock valley margins.
Floodplain		A relatively flat alluvial depositional landform that border river channels and is periodically inundated by floodwater. Formed from lateral accretion (within channel) and vertical accretion (overbank) deposits.



Confined bedrock
>90% of channel abuts bedrock/ hillslope

Confined terrace – O'Connell River
>90% of channel abuts terrace/upper floodplain

Partly confined – Murray Creek
10 - 90% of channel abuts confinement boundary

Unconfined - Lower Murray Creek
>90% of channel abuts floodplain/inset floodplain

Figure 7. *Examples of each confinement type. Showing LiDAR and aerial/oblique.*

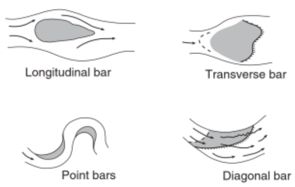
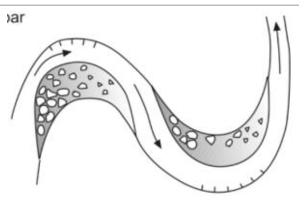
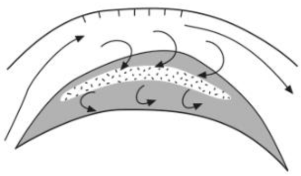
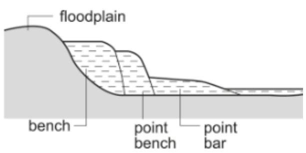
Compound channels

Many rivers in GBR catchments have an entrenched compound channel morphology bounded by resistant old floodplain/terrace deposits (Croke et al. 2013; Brooks et al. 2014; Fryirs et al. 2015;Daley et al. 2018)) (Figure 6a and Figure 6b). These compound channels are relics from past sea level, flow and sediment regimes. As a result, they do not behave as true self-formed alluvial channels. Within the confines of the alluvial terraces more contemporary alluvial floodplains and benches have formed during the current Holocene period. Within the compound channel, an inset channel and a range of geomorphic units (e.g. bars, benches, islands, inset floodplains) can be found. Research indicates the majority of channel erosion occurs from these inset units in macrochannel systems (Brooks et al, 2014; Croke et al., 2013). Within these entrenched channel systems, there is minimal lateral planform adjustment of the main channel and the main channel is effectively ‘confined’ by the floodplain/terrace (Fryirs et al., 2015).

3.1 In-channel geomorphic units

Erosion areas are significantly more prevalent when the channel is bound by inset floodplains and are often concentrated within small areas (Alluvium, 2020b). Key in-channel geomorphic unit, found within GBR catchments are outlined in Table 3.

Table 3. Summary of key in-channel geomorphic units (Charlton, R., 2007 and River Styles, 2022).

Term	Conceptual diagram	Description
Bar		Bars are in-channel accumulations of sediment. Bars may be formed from boulders, gravel, sand or silt.
Point bar		Bank-attached bar that forms along the convex banks of meander bends. Result from lateral shift in channel position associated with deposition on the convex bank and erosion on the concave bank.
Scroll bars / meander scrolls		Deposits formed by the migration of meander across the floodplain which are laid down to produce concentric ridges separated by lower elevation troughs, or swales.
Bench		A distinctly stepped, elongate, straight to gently curved feature that is inset along one or both banks. Formed by oblique- and vertical-accretion of bedload and suspended load materials during small to moderate floods within widened channels. Benches are a major agent of channel contraction in over-widened channels.
Inset floodplains		Inset floodplains (also incipient floodplains) are floodplain benches at an elevation above the channel bed but below a higher floodplain/terrace.

4 Decision support framework

A decision support framework has been developed to:

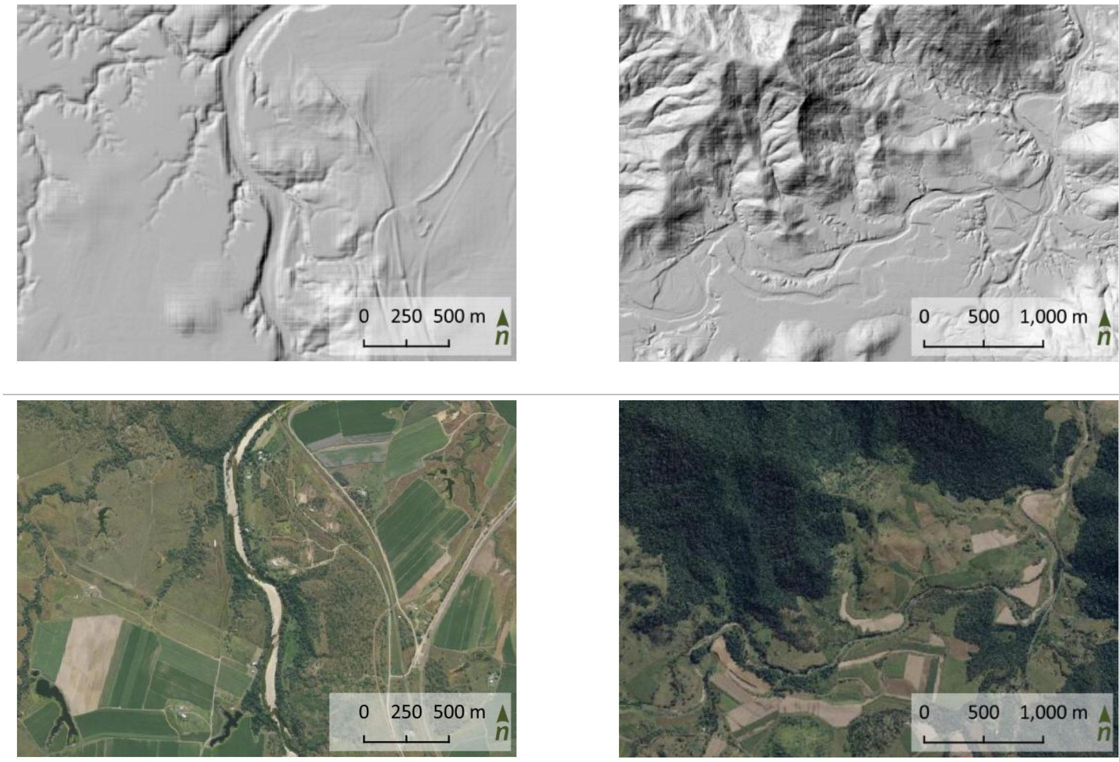
- Provide guidance on identifying the critical geomorphic units and channel features which contribute to streambank erosion at the modelled link scale.
- Provide recommendations on which geomorphic parameters to adopt for link streambank erosion parameterisation with the aim of improving model parameterisation.

The decision support framework consists of three levels (Figure 9). Each step in the decision support framework is outlined below.

4.1 Level 1: Is the reach geomorphically homogeneous?

A geomorphically homogeneous reach is a stretch of waterway where the channel controls are sufficiently uniform to allow a consistent set of landforms to be maintained. Variables that control channel form include the flow regime, sediment regime, degree of valley confinement, channel slope, channel substrate and riparian vegetation. For the decision support framework, a reach would be considered geomorphically homogeneous if >90% of the channel abuts a consistent geomorphic unit. Whereas a reach would be considered geomorphically heterogeneous if, for example, 70% of the channel abuts terrace/upper floodplain, 30% of the channel abuts inset floodplains with evidence of recent lateral adjustments.

Examples of homogenous and heterogeneous reaches, within GBR catchments, are shown in Figure 8.



Homogeneous – O'Connell River	Heterogeneous – Murray Creek
>90% of channel abuts terrace/upper floodplain	70% of channel abuts floodplain, 30% of channel abuts terrace/upper floodplain.

Figure 8. *Example of a geomorphically homogenous (terrace/upper floodplain confined) reach on the O'Connell River (left). Example of a geomorphically heterogenous (70% floodplain/30% bedrock) reach on the Murray Creek (right).*

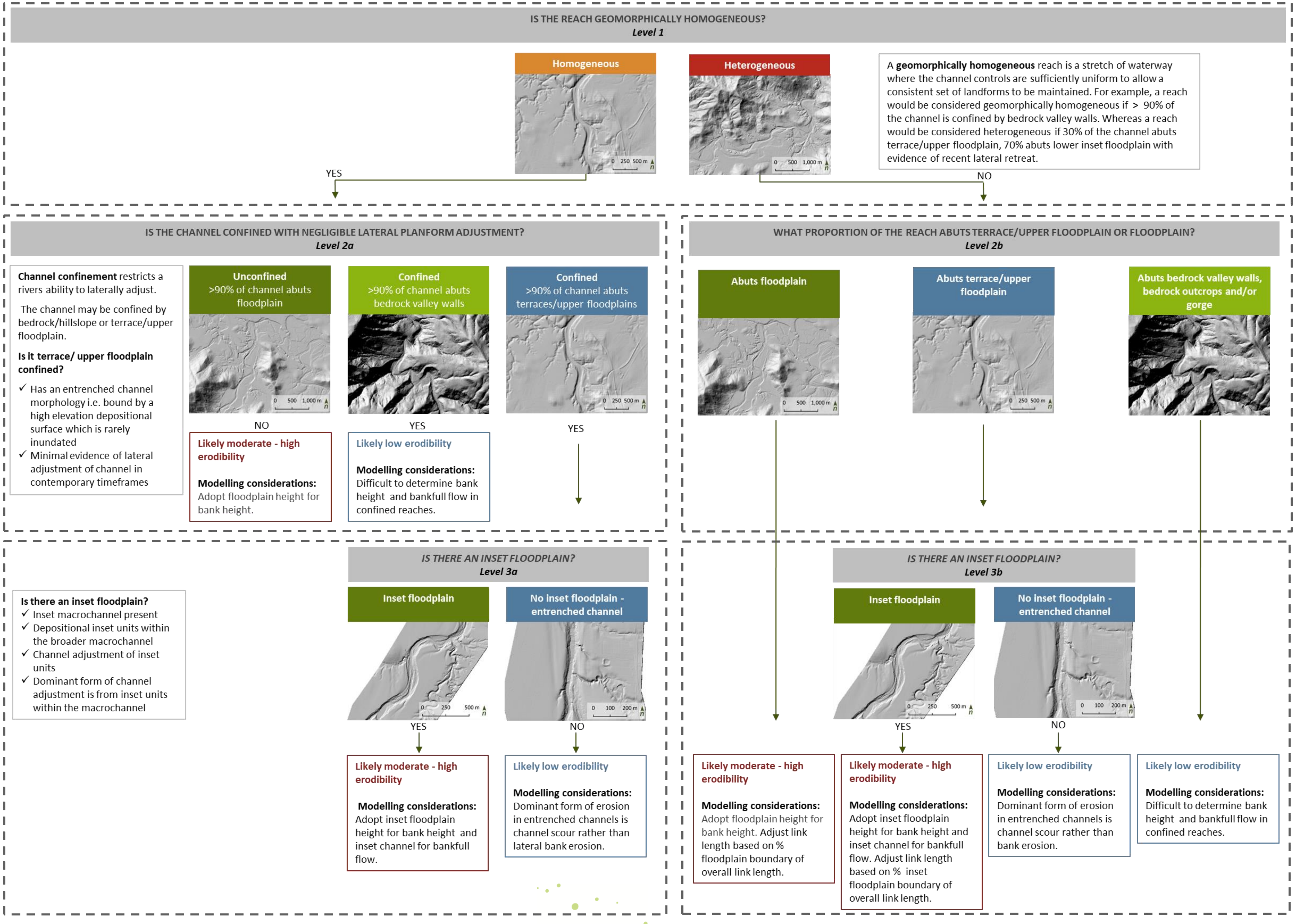


Figure 9. *Decision support tree to assist identification of the critical geomorphic units and channel features and to inform Dynamic SedNet parameterisation.*

4.2 Level 2a (homogeneous): Is the channel confined with negligible lateral planform adjustment?

The degree of confinement is the degree to which the channel is confined and, as a result, its ability to laterally adjust within contemporary timeframes. The channel can be confined by either bedrock/hillslopes or upper floodplain/terraces.

The following criteria can be used to determine if the channel is confined by bedrock/hillslope:

- Channel bound by bedrock/hillslope (determined from LiDAR data and/or field observations).
- Minimal evidence of lateral adjustment of channel in contemporary timeframes (determined from LiDAR data and/or aerial imagery).

The following criteria can be used to determine if the channel is 'confined' by upper floodplain/terraces:

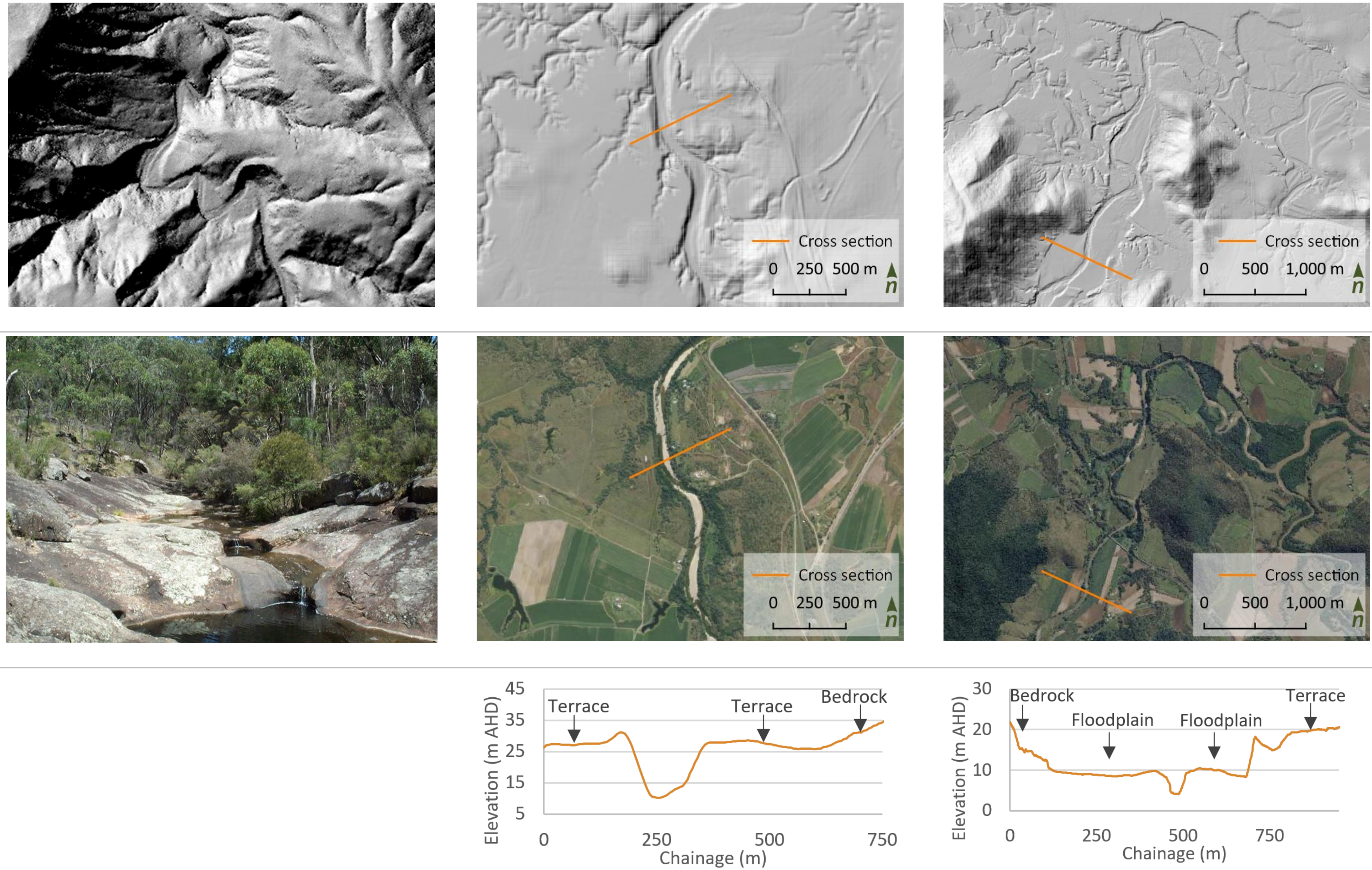
- Entrenched compound channel morphology present i.e. bound by a high elevation depositional surface which is rarely inundated (determined from LiDAR data and/or field observations).
- Minimal evidence of lateral adjustment of macrochannel in contemporary timeframes (determined from LiDAR data, aerial imagery and field observations).

Where a reach is classed as a homogeneous confined reach the bank erodibility (SoilErod) is likely to be low. This does not mean that no erosion may occur, but in comparison to other river types, the contribution to bank erosion is likely very low.

Modelling considerations:

Unconfined meandering floodplain channel	Confined bedrock channel
Adopt floodplain height for bank height.	Difficult to determine bank height and bankfull flow in confined reaches. However, erosion rates likely negligible.

This assessment helps determine the likelihood of lateral adjustment and the potential erodible zone. Different examples of confinement, within GBR catchments, are shown in Figure 10.



Confined: >90% of channel abuts bedrock valley walls

O'Connell River - Confined: >90% of channel abuts terraces/upper floodplains

Lower Murray Creek - Unconfined: >90% of channel abuts floodplain

Figure 10. *Examples of each confinement types in GBR catchments. Showing LiDAR, aerial and cross section*.

4.3 Level 3a (homogeneous): Is there an entrenched compound channel with inset floodplain?

The following criteria can be used to determine if there is an entrenched compound channel with inset floodplain:

- Inset channel present within macrochannel (determined from LiDAR data and/or field observations).
- Depositional inset units (e.g. inset floodplain) occur within the macrochannel (determined from LiDAR data and/or field observations).
- Dominant form of channel adjustment is from inset units within the macrochannel (determined from aerial imagery and/or field observations) .

An example of a macrochannel system with a broad inset floodplain is shown in Figure 11. An entrenched compound channel with inset floodplain, along the Mary River, can be seen in Figure 19.

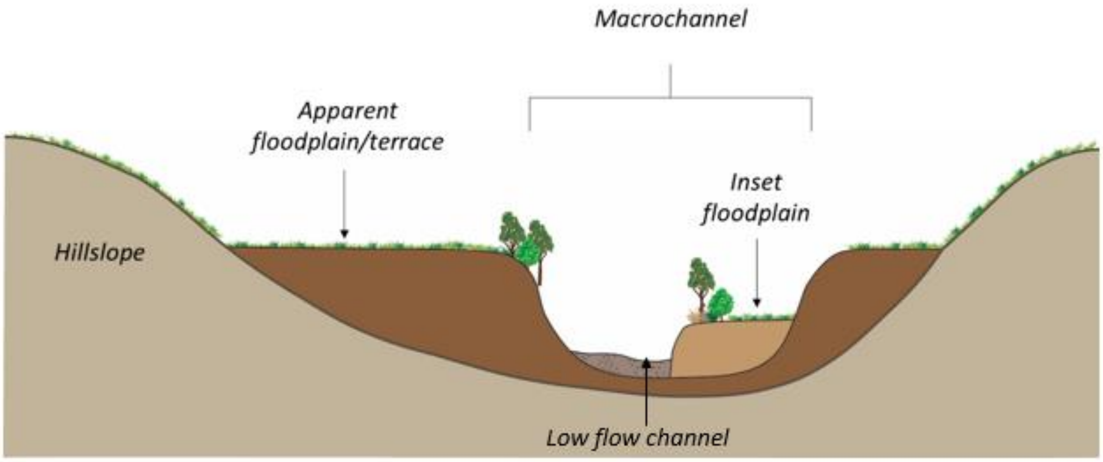


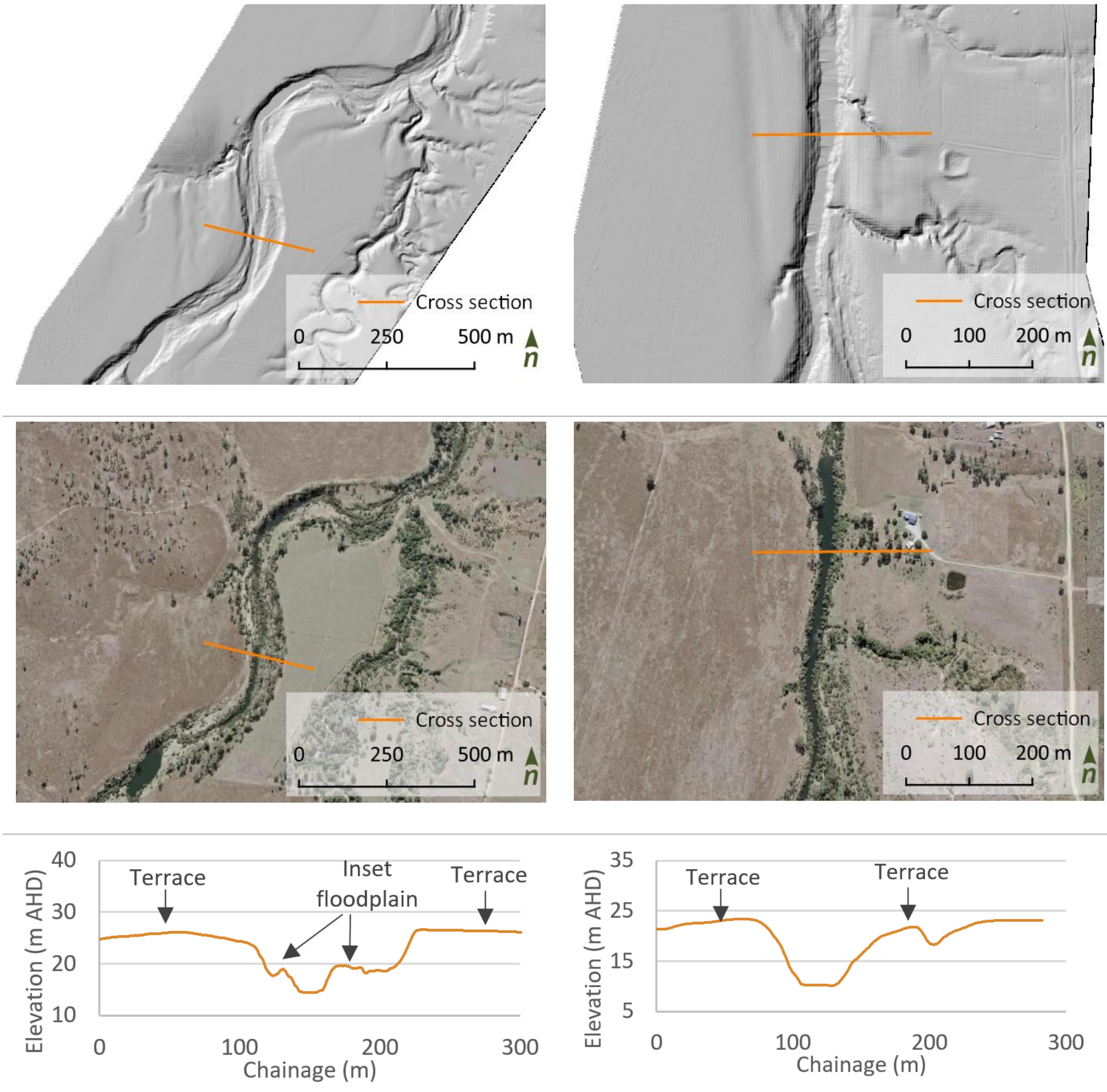
Figure 11. *Macrochannel with a broad inset floodplain.*

Figure 12. *Oblique view south along Mary River showing the higher terrace and inset floodplain unit.*

Examples of compound channels, with and without inset floodplains, in GBR catchments are shown in Figure 13.

Modelling considerations:

Entrenched compound channel with inset floodplains or in-channel units	Entrenched compound channel without in-channel units
Adopt inset floodplain height for bank height and inset channel for bankfull flow.	Adopt upper floodplain/terrace height for bank height and bankfull flow.
Vegetation on inset floodplain units more critical for erosion resistance than vegetation on terrace units.	Dominant form of erosion in entrenched channels is channel scour rather than bank retreat – likely low erodibility of bank surface.



Raglan Creek - Entrenched compound channel with inset floodplains	Raglan Creek - Entrenched compound channel without in-channel units

Figure 13. *Examples of compound channel in Great Barrier Reef catchments.*

4.4 Level 2b (heterogeneous): What proportion of the reach abuts floodplain, terrace/upper floodplain, or bedrock?

This assessment helps determine the proportion of the channel which abuts floodplain, terrace/upper floodplain and bedrock are therefore the proportion of reach which is likely suspectable to erosion.

If 70% of a link (reach) length abuts floodplain and 30% abuts bedrock, scale the link length based on the percentage floodplain boundary of overall link.

Where the reach abuts bedrock the bank erodibility (SoilErod) is considered low. This does not mean that no erosion may occur, but in comparison to the floodplain section, the contribution to bank erosion is likely very low.

Modelling considerations:

Floodplain boundary	Bedrock boundary
Adopt floodplain height for bank height.	Difficult to determine bank height and bankfull flow in confined reaches
Adjust link length based on % floodplain boundary of overall link length.	

4.5 Level 3b (heterogeneous): Is there an entrenched compound channel with inset floodplain?

The following criteria can be used to determine if there is an entrenched compound channel with inset floodplain:

- Inset channel present within macrochannel (determined from LiDAR data and/or field observations).
- Depositional inset units (e.g. inset floodplain) occur within the macrochannel (determined from LiDAR data and/or field observations).
- Dominant form of channel adjustment is from inset units within the macrochannel (determined from aerial imagery and/or field observations).

An example of a macrochannel system with a broad inset floodplain is shown in Figure 11. An entrenched compound channel with inset floodplain, along the Mary River, can be seen in Figure 19.

Modelling considerations:

Entrenched compound channel inset floodplain /in-channel units	Entrenched compound without in-channel units
Adopt inset floodplain height for bank height and inset channel for bankfull flow.	Adopt upper floodplain/terrace height for bank height and bankfull flow.
Vegetation on inset floodplain units more critical for erosion resistance than vegetation on terrace units.	Dominant form of erosion in entrenched channels is channel scour rather than bank retreat – likely low erodibility of bank surface.
Adjust link length based on % inset floodplain boundary of overall link length.	

4.6 Framework summary

This decision support framework has been developed to help the Paddock to Reef modelling team understand the geomorphic properties at the modelled link scale. Currently modellers are trying to parameterise modelled links which stretch across geomorphically diverse sections of river. This makes correct parameterisation problematic and difficult. The framework aims to provide modellers assistance in undertaking this difficult task by:

- Providing guidance on identifying the critical geomorphic units and channel features which contribute to streambank erosion at the modelled link scale.
- Providing recommendations on which geomorphic parameters to adopt for link streambank erosion parameterisation with the aim of improving model parameterisation.

The framework is very high level and given the diversity of river types in Queensland there are likely many modelled links which cannot be easily classified with the steps provide in the framework. However, the process outlined in the framework can assist modellers in analysing the geomorphic variability of their modelled rivers.

It is hoped that improved model parameterisation will allow more conclusive assessments of model performance. To assist in the assessment of model performance the modelled links in each of case study assessed in Alluvium (2020b) have been broken into smaller segments and parameterised as part of this study. The outcomes of this updated case study assessment are provided in Section 5.

5 Case study assessments of geomorphic reaches

5.1 Case study background

A study was undertaken to assess the parameterisation of the Dynamic SedNet model in a range of different river types within the GBR catchments (Alluvium, 2020b). Five case study areas were selected on the basis of good pre-existing data availability in order to assess the geomorphology and hydro-geomorphic processes. The five case study areas are located within the Mary River catchment, Fitzroy River catchment and Mackay-Whitsundays region. The case studies are shown in Figure 14 and summarised in Table 4.

Figure 14. *The location of the five case study areas.*

Table 4. Summary of the case study areas.

Stream	Description
Mary River	A 40 km section of Mary River which extends from the Yabba Creek confluence to Six Mile Creek, just upstream of Gympie.
Raglan Creek	A 73 km section of Raglan Creek which transitions through a steeper upper catchment with various degrees of bedrock control before emerging into the estuarine plains. Tortuous and active meandering through lower estuarine reach.
Fitzroy River	A 65 km section of the Fitzroy River upstream of the tidal barrage in Rockhampton.
Murray Creek	A 23 km section of Murray Creek upstream of the Bruce Highway.
O'Connell River	A 17 km section of the O'Connell River which extends from the Andromache River confluence to Bloomsbury.

The case study assessment-identified erosion areas are significantly more prevalent when the channel is bound by certain geomorphic units (i.e. inset floodplains) and are often concentrated within small areas. Given the length of modelled links an understanding of the type and prevalence of channel bounding geomorphic units within each link, and their relative erodibility, would greatly enhance stream bank erosion prediction.

The previous assessment (Alluvium, 2020b) found large errors in some of the input parameters in each case study area. This made it difficult to assess the process-based components of the model performance in the different river types assessed. To improve parametrisation the GBR catchments study catchment Dynamic SedNet links have been further split into unique hydro-geomorphic reaches. This will enable improved parameterisation of each river segment which can help assess the performance of the process-based components of the model.

The reaches have been divided primarily based on degree of confinement. Channel confinement categories are summarised below:

- Abuts floodplain
- Abuts estuarine floodplain
- Abuts inset floodplain
- Abuts upper floodplain/terrace
- Abuts bedrock/hillslope
- Gorge/bedrock confined

Each of the five case study areas are discussed below.

5.2 Case study 1 - Mary River

Overview

The Mary River case study extends for 40 kilometres, from the Yabba Creek confluence to Six Mile Creek, just upstream of Gympie (Figure 15). The floodplains along this reach support improved pasture for numerous dairies as well as general grazing. The upper slopes support grazing as well as irrigated perennial horticulture, with some quarrying and rural residential development.

The case study area is shown in Figure 16 and Figure 17. In this area the Mary River flows through a spurred valley setting which controls the planform alignment to varying degrees. The extent of alluvial development varies in accordance with valley confinement, but generally ranges from 500 to 2,000 m wide. The alluvial development includes:

- Extensive fill terraces which sit 15-18 m above the channel bed.
- Inset floodplain and bench units which sit 10-12 m above the channel bed (mapped in Figure 16 and Figure 17).

Variations in the degree of channel entrenchment and geomorphic units can be seen in the three typical section shown in Figure 18. The main geomorphic units are also visible in Figure 19.

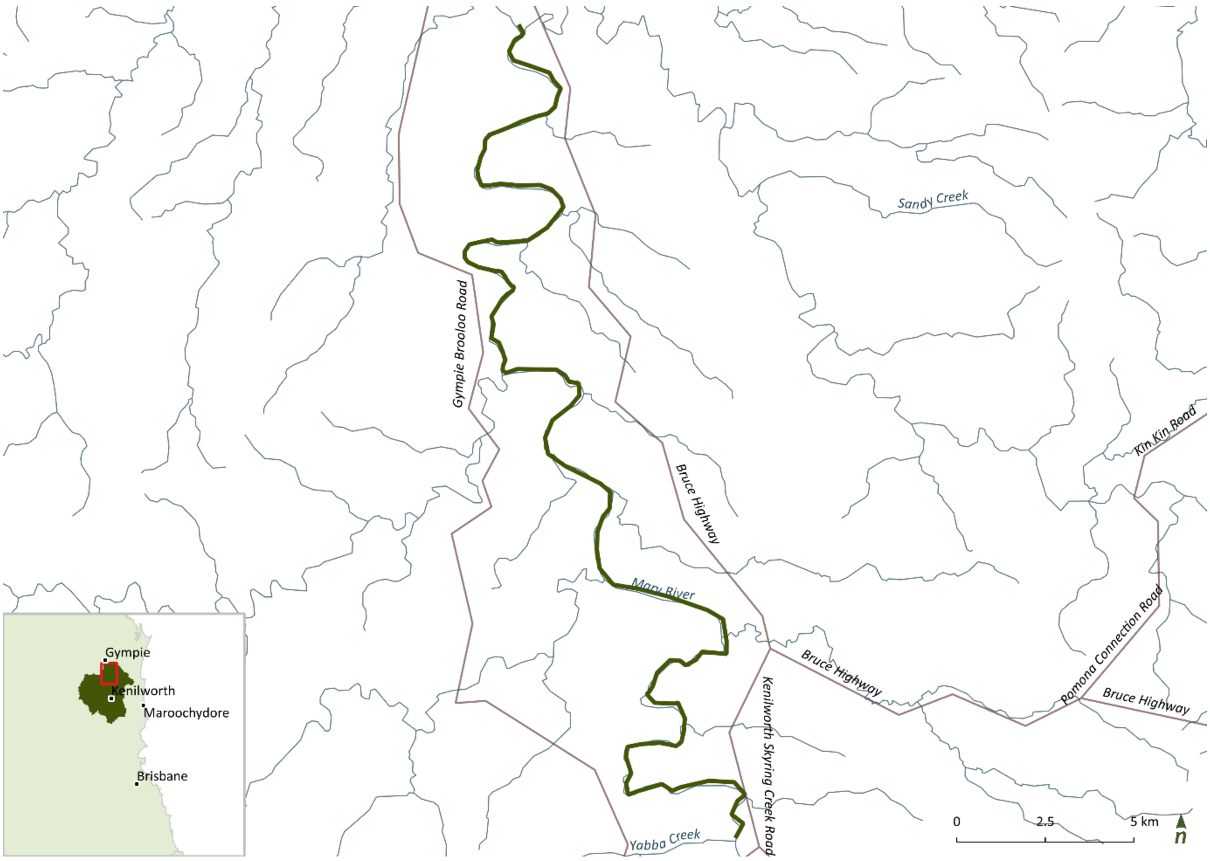


Figure 15. *The Mary River case study area.*

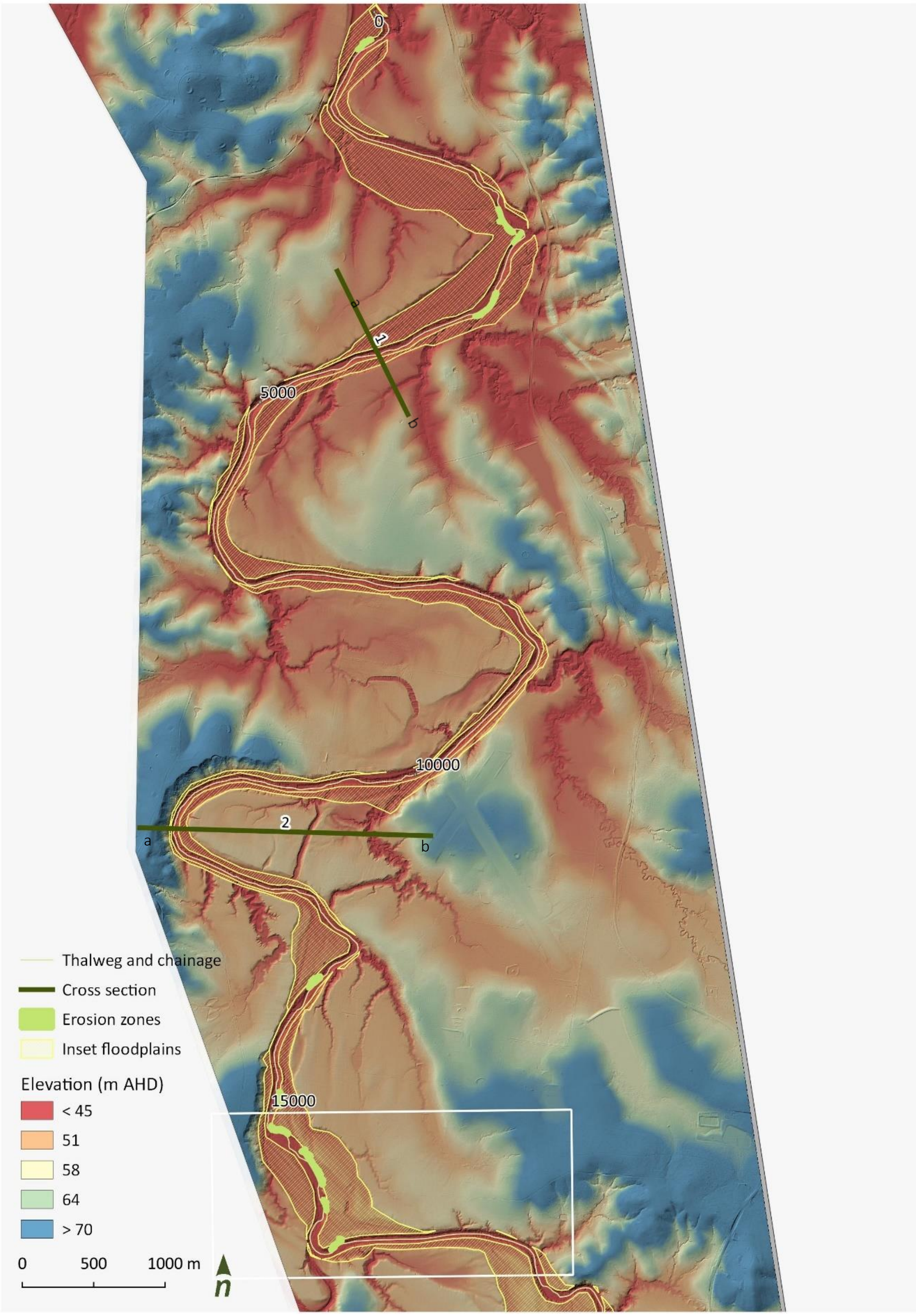


Figure 16. *The downstream portion of the Mary River case study showing elevation, inset floodplains, erosion areas and representative cross section locations*.

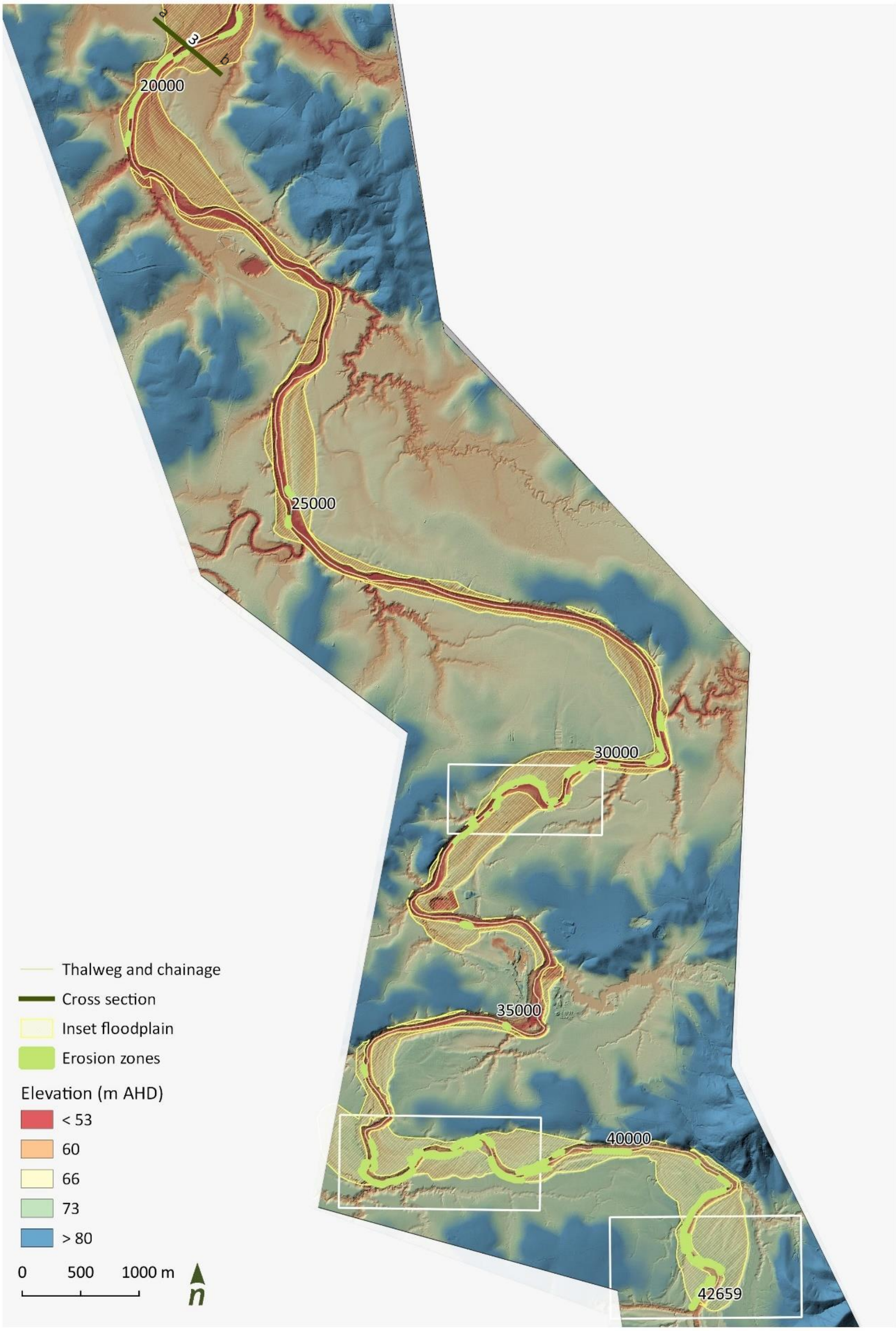


Figure 17. *The upstream portion of the Mary River case study showing elevation, inset floodplains, erosion areas and representative cross section locations*.

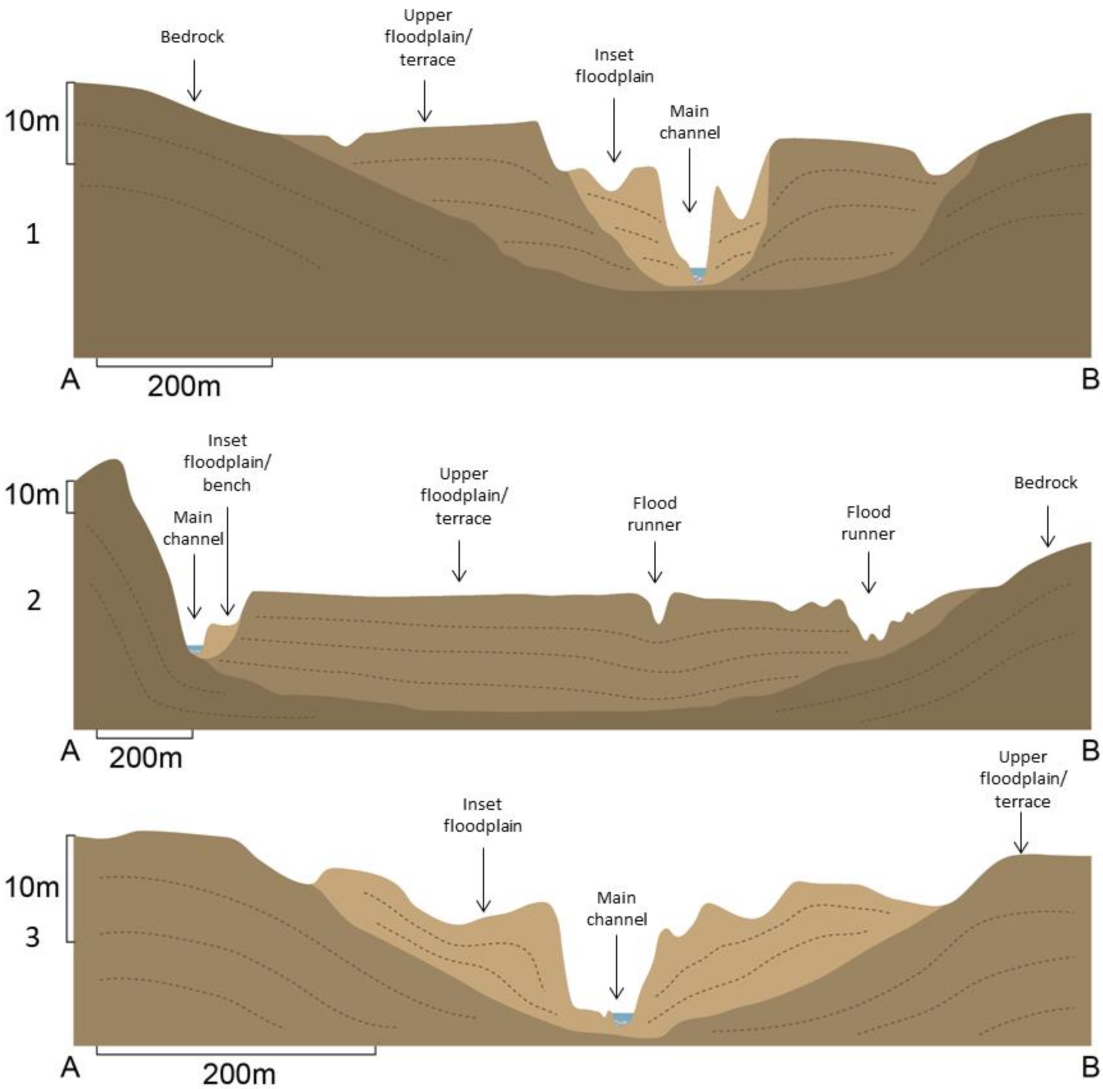


Figure 18. *The three typical sections in the Mary River case study area (shown in Figure 16 and Figure 17) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

Figure 19. *View south along Mary River showing the higher terrace and inset floodplain unit.*

The streambed generally consists of sand and gravel deposits while the banks consist of predominately fine sands, silts and clays. The channel forms a series of shallow pools broken by riffles attached to sand and gravel points and bank attached bars and localised instream wood. In-channel bedrock exposures occur where the channel abuts the valley margins (Figure 20).

Figure 20. *Bedrock exposure at the spurred valley margins within the Mary River.*

Remnant riparian vegetation mainly comprises of eucalyptus and casuarina fringing woodland. Patchy stretches of gallery rainforest remain within the riparian zone along the upstream two thirds of the case study area. Pockets of remnant eucalyptus 'Of concern' woodland also persist on confining valley margins. Regrowth of riparian species is occurring along lower banks where stock access is limited (Figure 22).

Figure 21. *A section of improved riparian longitudinal connectivity in the upper section of the Mary River case study area.*

Figure 22. *Establishing riparian vegetation is typically protected where bank slope limits cattle access.*

Riparian longitudinal connectivity diminishes in extent towards Gympie. Recent riparian vegetation establishment is predominantly occurring along bank toes where steep bank profiles limit stock access. Where cattle access is facilitated by gentler slopes, riparian vegetation coverage is significantly less, featuring predominantly casuarina regrowth as opposed to the greater species diversity observed in protected areas (Figure 23). Overall, bank condition is severely degraded, with steep, exposed and unstable bank slopes particularly on poorly vegetated inset floodplain and bench units.

Figure 23. *A section of the Mary River downstream of Traveston Crossing Road where there is regeneration along the lower bank on one side and unrestricted stock access on the opposite bank.*

Geomorphic reaches

The Mary River study area consists of four Dynamic SedNet modelled links. The Dynamic SedNet links do not align well with the geomorphic features within the study area. Across each link there are variations in channel bounding geomorphic units and channel controls. This is particularly evident across the link for SC #503 which covers the lower 16 km of the case study area. The lower section of this link contains an expansive area of inset floodplains while within the upper portion the channel is relatively entrenched with bedrock controls and minimal inset floodplain development. To improve Dynamic SedNet parametrisation the Mary River study area has been split into six reaches, primarily based on degree of confinement (Figure 24).

A summary of key hydro-geomorphic parameters for each of the six reaches, is provided below. The reach extent and a representative cross-section with each reach is shown in Figure 25 to Figure 36. Key hydro-geomorphic parameters for each reach (based on LiDAR analysis and hydraulic modelling) are provided in Table 5 to Table 10.

Key input parameters used in the Dynamic SedNet model for each link within the Mary River case study area are shown in Table 11. A summary of key hydro-geomorphic parameters for each of the six reaches within the Mary River study area is provided in Table 12.

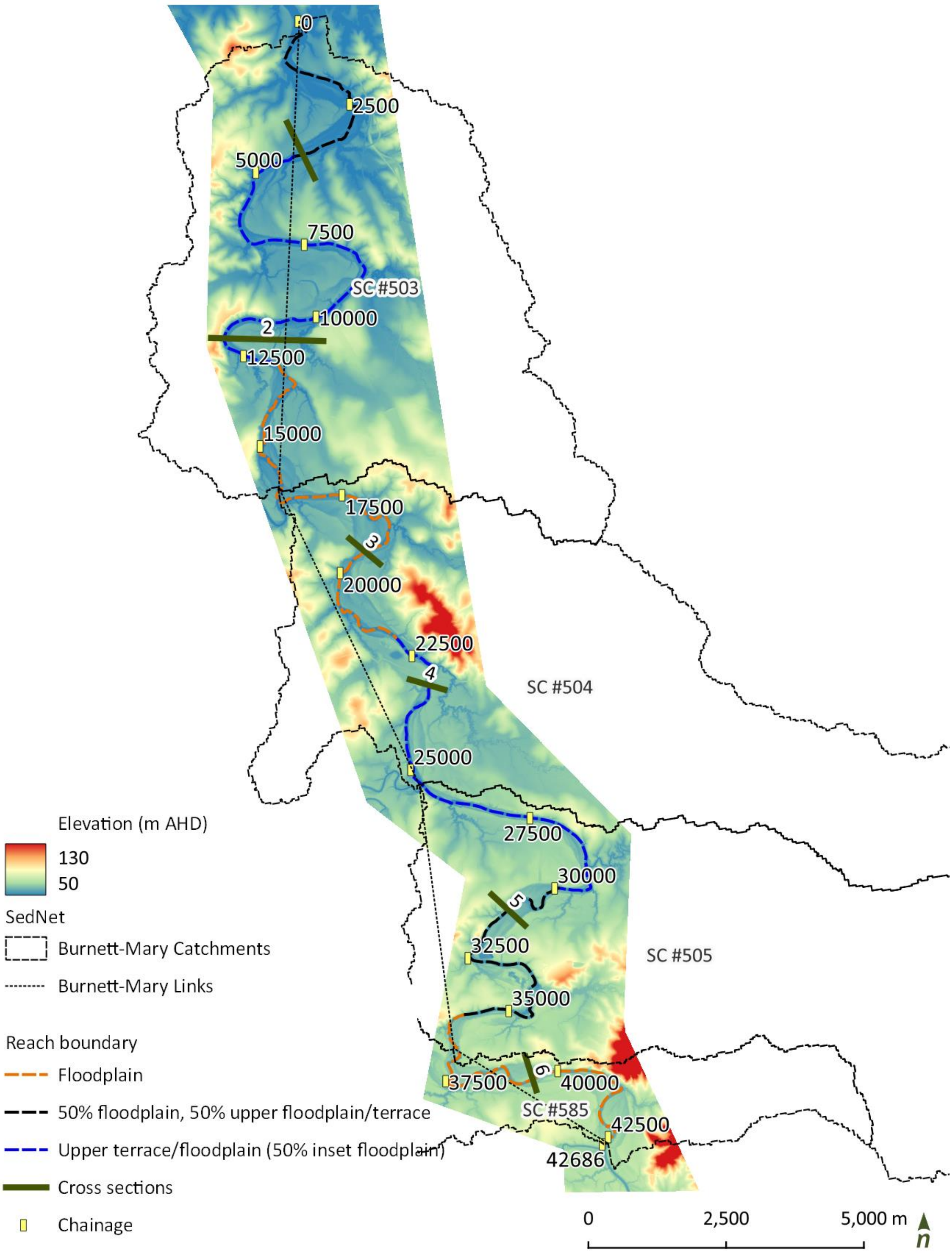


Figure 24. *Mary River case study area. Showing six reaches and representative cross-section locations for each reach. Dynamic Sednet sub-catchments are shown in black.*

Mary River Reach 1

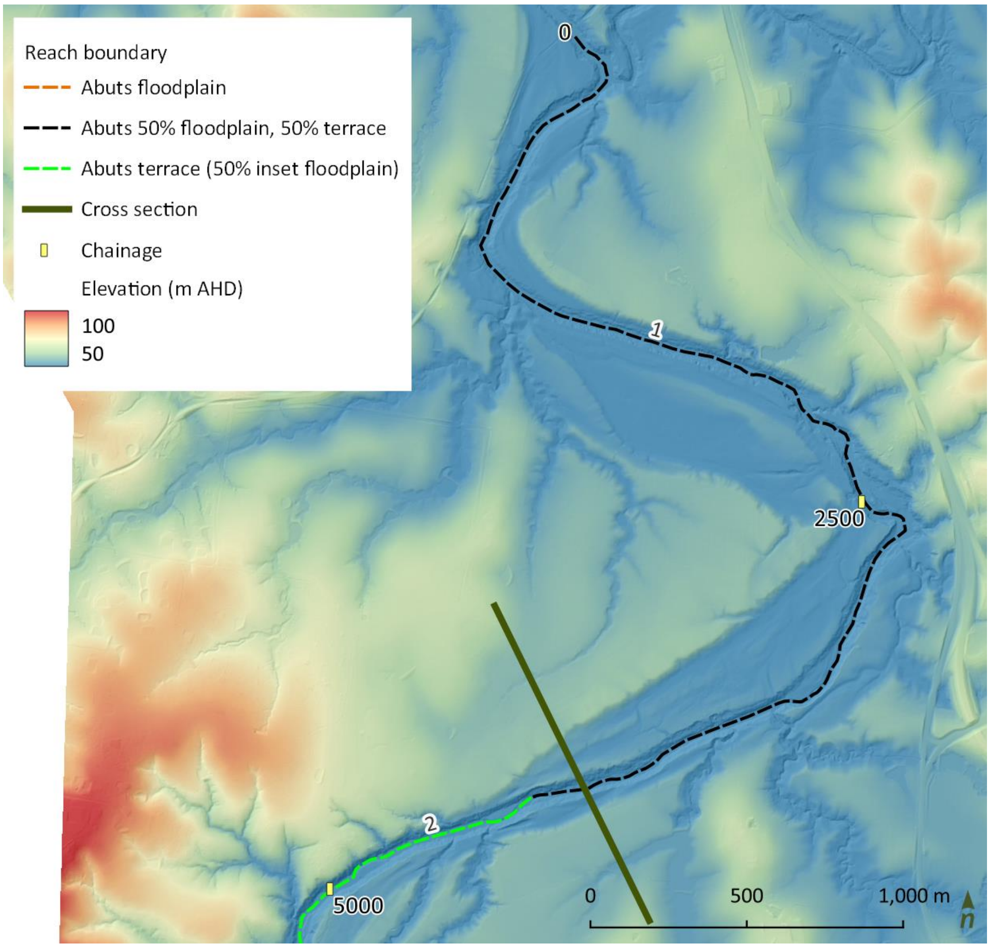


Figure 25. *Reach 1 within the Mary River study area.*

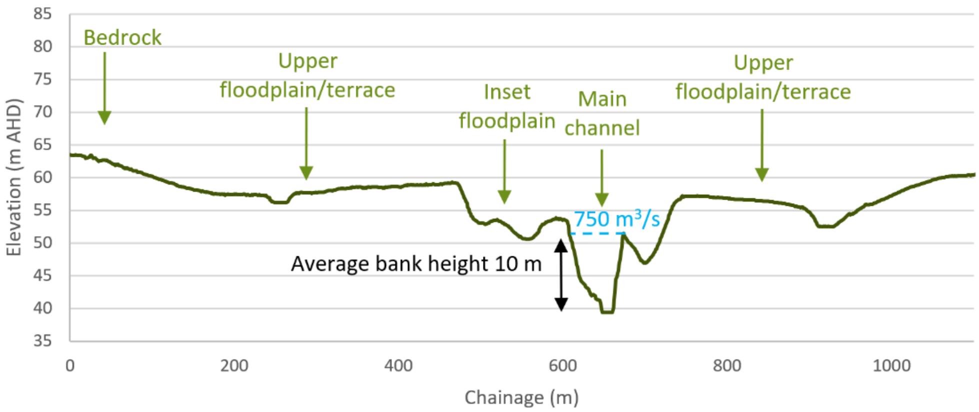


Figure 26. *Representative cross-section within the Mary River reach 1 (cross-section location shown in Figure 25).*

Table 5. Key hydro-geomorphic parameters – Mary River reach 1.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
1	750	0.00012	4286	69	10.0	50% floodplain, 50% terrace/upper floodplain	50% high, 50% low	36,493

Mary River Reach 2

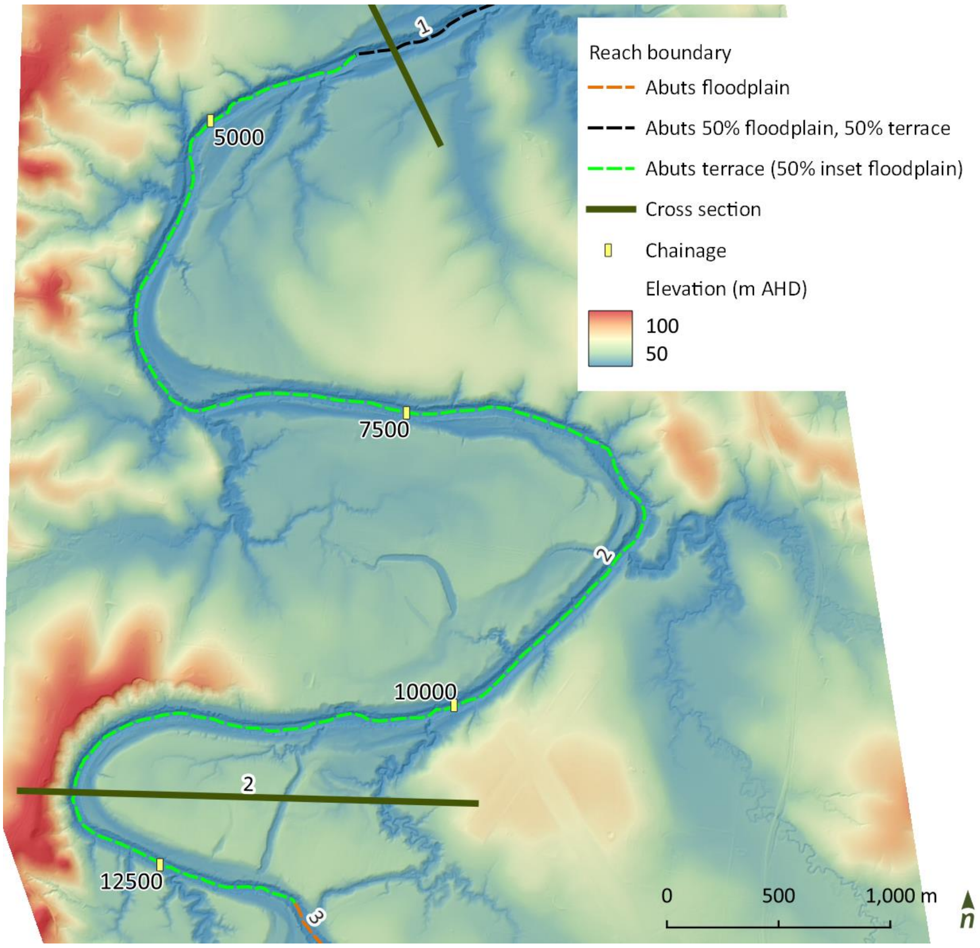


Figure 27. *Reach 2 within the Mary River study area.*

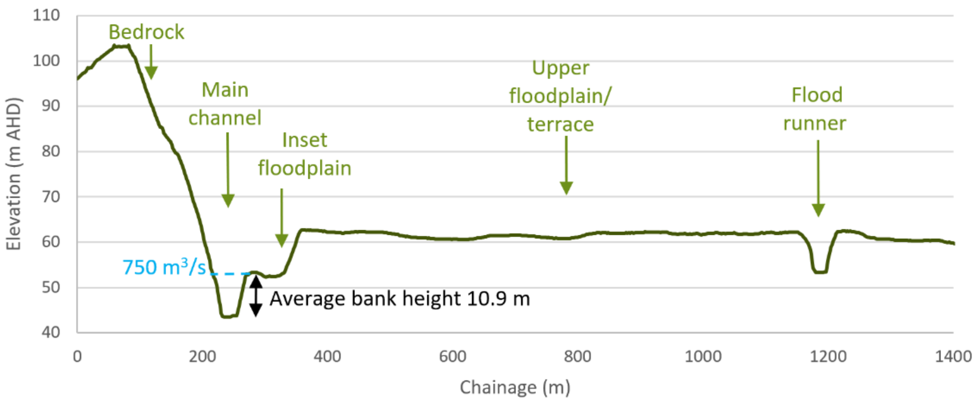


Figure 28. *Representative cross-section within the Mary River reach 2 (cross-section location shown in Figure 27).*

Table 6. Key hydro-geomorphic parameters – Mary River reach 2.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m3) (2009 – 2018)
2	750	0.00050	8886	68	10.9	Upper floodplain/terrace (50% inset floodplain)	50% very high, 50% low	49,404

Mary River Reach 3

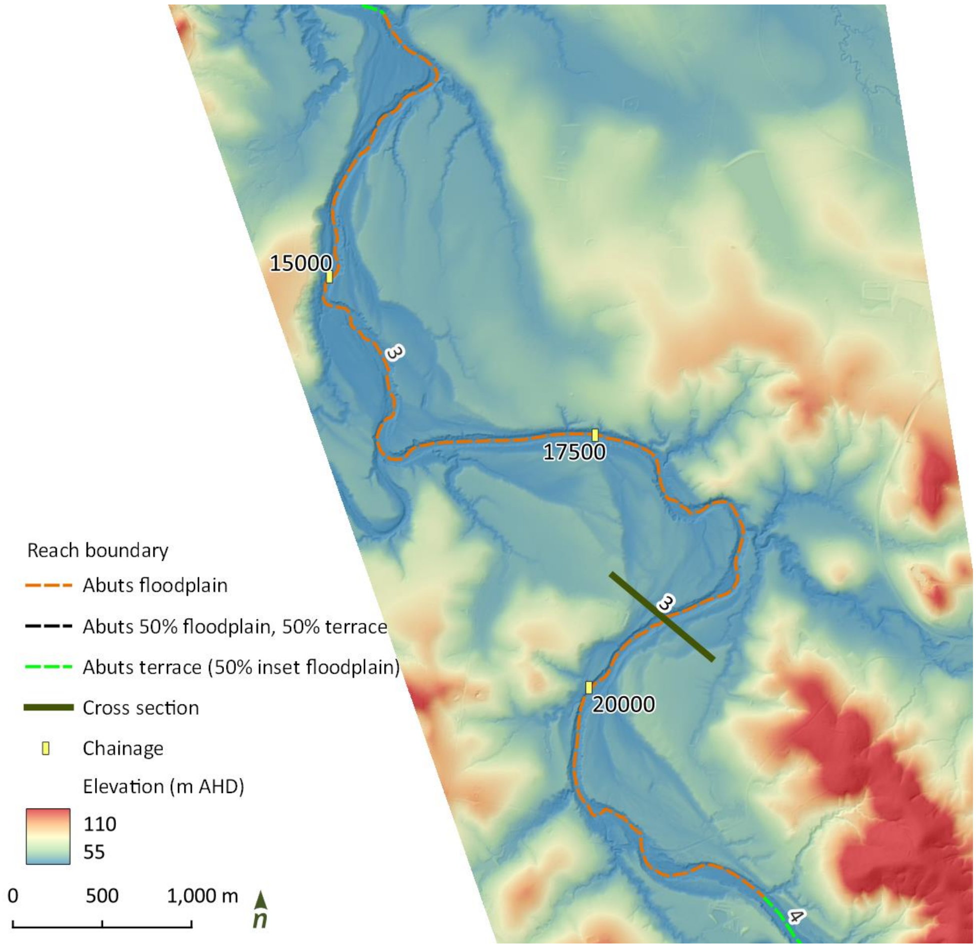


Figure 29. *Reach 3 within the Mary River study area.*

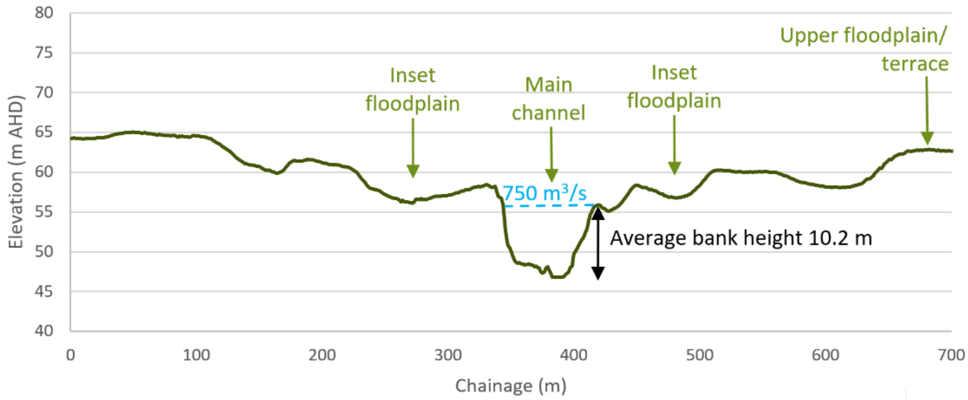


Figure 30. *Representative cross-section within the Mary River reach 3 (cross-section location shown in Figure 29).*

Table 7. Key hydro-geomorphic parameters – Mary River reach 3.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
3	750	0.00023	8890	84	10.2	Floodplain	High	154,207

Mary River Reach 4

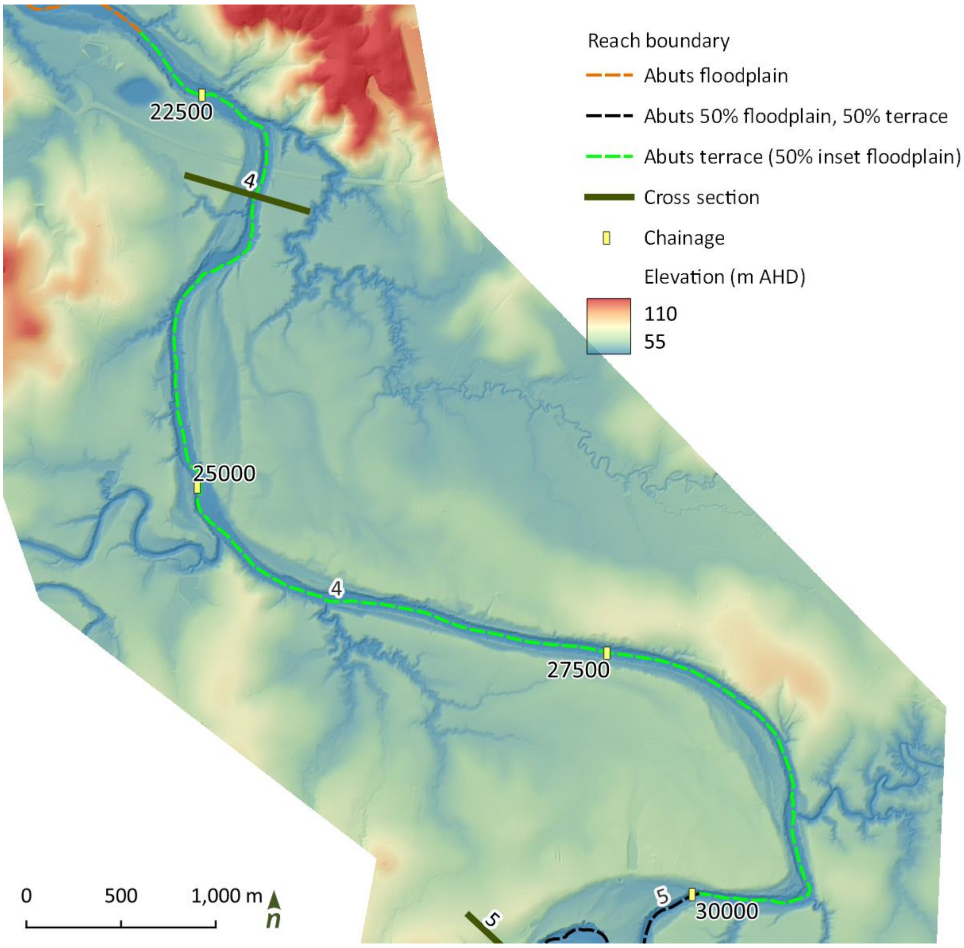


Figure 31. *Reach 4 within the Mary River study area.*

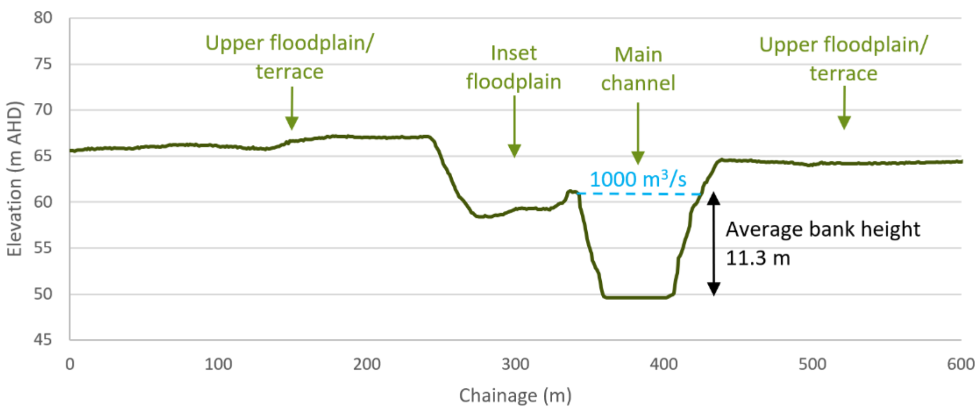


Figure 32. *Representative cross-section within the Mary River reach 4 (cross-section location shown in Figure 31).*

Table 8. Key hydro-geomorphic parameters – Mary River reach 4.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
4	1000	0.00026	8016	88	11.3	Upper floodplain/terrace (50% inset floodplain)	50% very high, 50% low	41,071

Mary River Reach 5

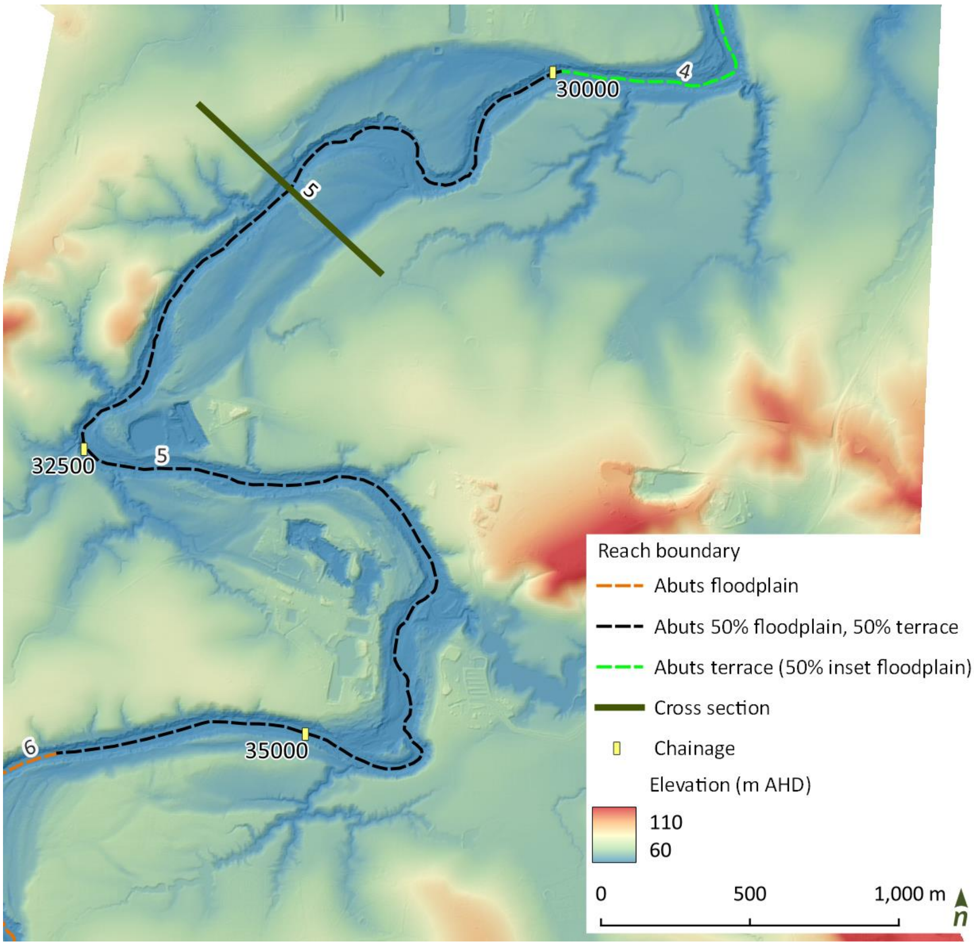


Figure 33. *Reach 5 within the Mary River study area.*

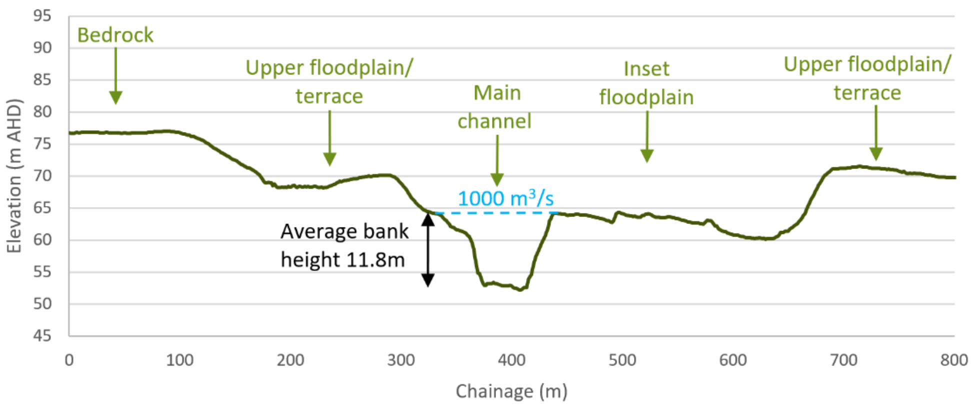


Figure 34. *Representative cross-section within the Mary River reach 5 (cross-section location shown in Figure 33).*

Table 9. Key hydro-geomorphic parameters – Mary River reach 5.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
5	1000	0.00043	5902	103	11.8	50% floodplain, 50% terrace/upper floodplain	50% high, 50% low	75,954

Mary River Reach 6

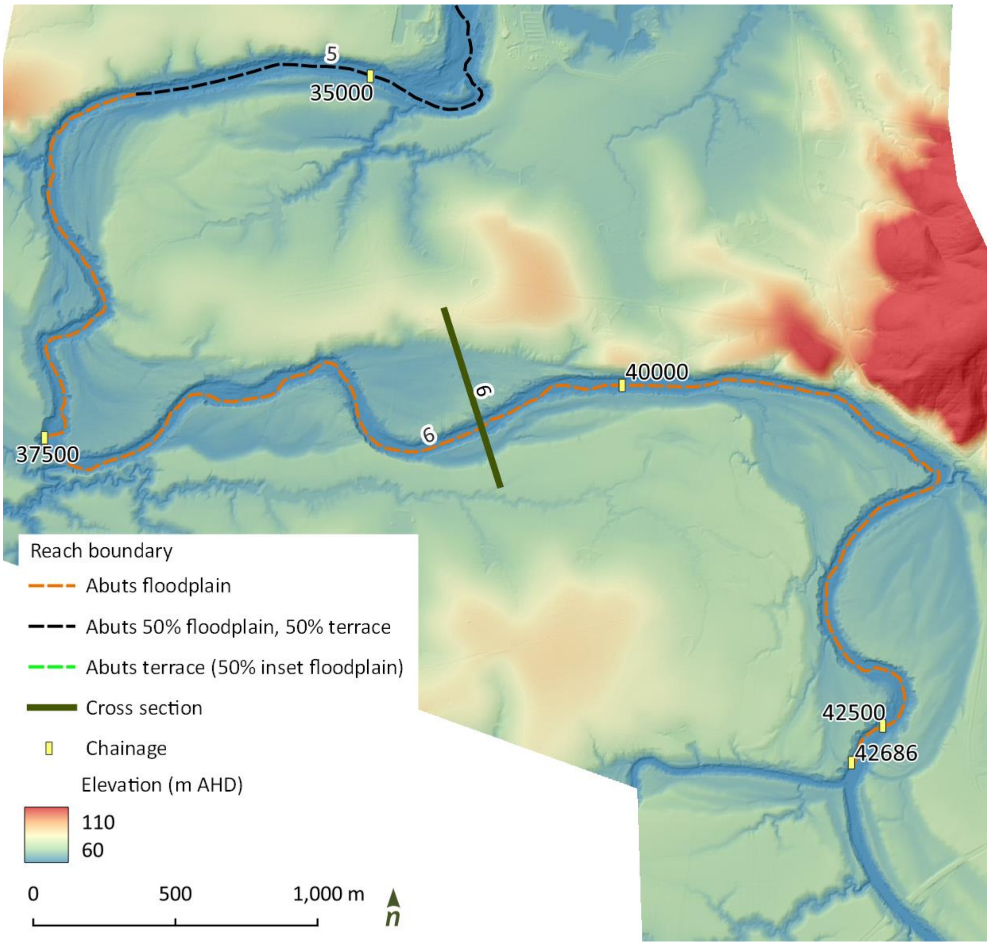


Figure 35. *Reach 6 within the Mary River study area.*

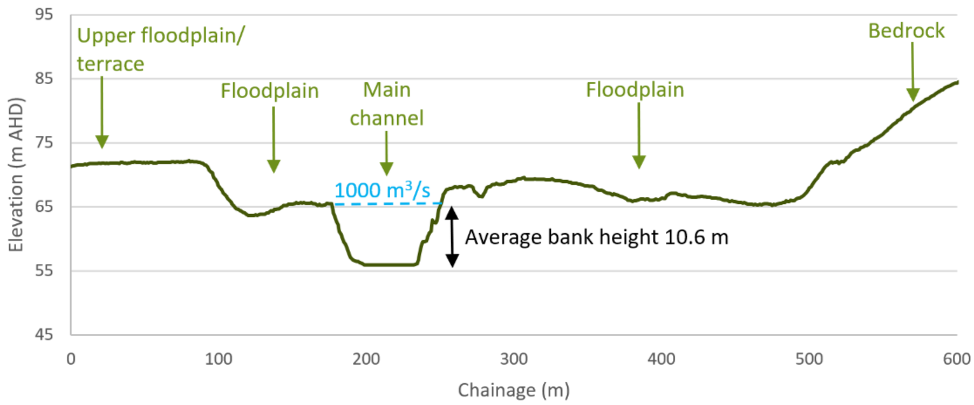


Figure 36. *Representative cross-section within the Mary River reach 6 (cross-section location shown in Figure 35)*

Table 10. Key hydro-geomorphic parameters – Mary River reach 6.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
6	1000	0.00058	6853	80	10.6	Floodplain	High	184,387

Table 11. Dynamic SedNet Bank Erosion key input parameters – Mary River case study area.

Link (Sub-catchment)	Bank Full Flow (m^3/s)	Link Slope (m/m)	Link Length (m)	Channel Width (m)	Bank Height (m)	Riparian Vegetation Percentage (%)	Maximum Riparian Vegetation Effect. (%)	Stream bank material erodibility (%)	Bank Erosion Coeff.	SedNet sediment loss (m^3) (2009 – 2018)*
SC #503	3744	0.00035	16035	154	16.8	59.3	95	97.7	1.7E-06	25,613
SC #504	3543	0.00069	8959	148	16.2	58.7	95	99.0	4.6E-06	73,205
SC #505	3209	0.00025	10869	139	15.5	59.5	95	95.4	2.0E-05	112,688
SC #585	3232	0.00095	5281	137	15.3	46.3	95	88.8	2.0E-05	254,171

*Note: in 2018 Dynamic SedNet data was only available from January to June.

Table 12. Summary of hydro-geomorphic parameters – Mary River case study area.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018) LiDAR	Sediment mobilised **per km (m^3/km) (2009 – 2018)**
1	750	0.00012	4286	69	10.0	50% floodplain, 50% terrace/upper floodplain	50% high, 50% low	36,493	8,514
2	750	0.00050	8886	68	10.9	Upper floodplain/terrace (50% inset floodplain)	50% very high, 50% low	49,404	5,560
3	750	0.00023	8890	84	10.2	Floodplain	High	154,207	17,346
4	1000	0.00026	8016	88	11.3	Upper floodplain/terrace (50% inset floodplain)	50% very high, 50% low	41,071	5,124
5	1000	0.00043	5902	103	11.8	50% floodplain, 50% terrace/upper floodplain	50% high, 50% low	75,954	12,869
6	1000	0.00058	6853	80	10.6	Floodplain	High		26,906

5.3 Raglan Creek

Overview

The tributaries of Raglan Creek rise on the eastern slopes of the Ulma Ranges and flow in a north-easterly direction before draining directly into Keppel Bay, approximately 40 km south-east of Rockhampton. The case study area is approximately 73 km in length, extending from the steep upper catchment to the outlet at Keppel Bay (Figure 37). The reach includes the tributary Six Mile Creek, in the upper catchment. The catchment predominantly supports livestock grazing, except surrounding the tidal flats of the lower sub-catchment, which are marshland/wetlands.

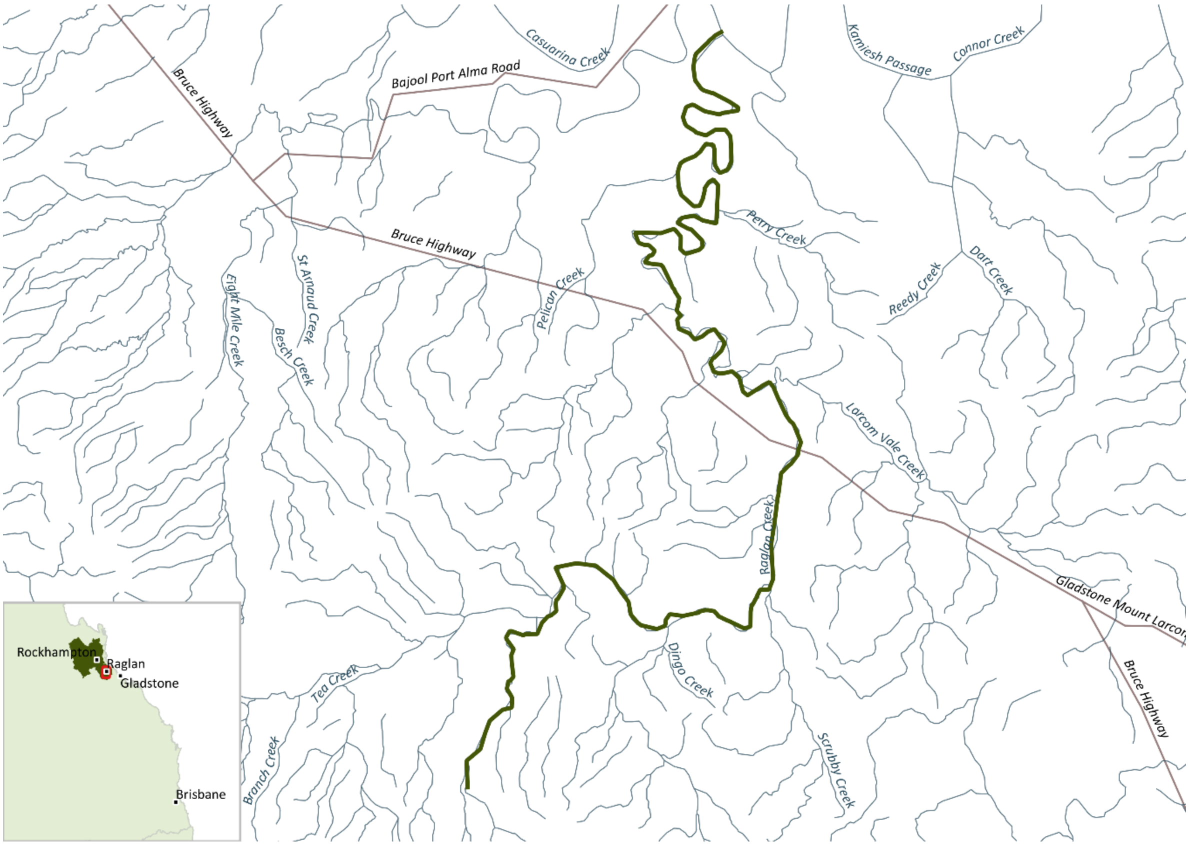


Figure 37. *The Raglan Creek case study area.*

Through the upper portion of the case study area, between chainage 60,000 m and 80,000 m, the system flows through a partly confined valley setting, where the system meanders across the floodplain intermittently abutting the valley margins (see Figure 40). Through this section the channel has a wide and shallow morphology with abundant instream gravels (see cross-section 3 in Figure 41). Between chainage 40,000 m and 60,000 m the channel has a low-sinuosity planform and an entrenched channel morphology – through this section the channel has incised into older floodplain units (See Figure 39 and cross-section 2 in Figure 41). The system transitions to an unconfined valley setting downstream of Raglan, where the low relief channel meanders across the tidal flats (Figure 38) within a broader compound channel (see cross-section 1 in Figure 41). Alluvial areas are up to several kilometres wide in the upper reaches (i.e. upstream of chainage 70,000 m), narrowing to 500 m through the mid-reaches (between chainage 40,000 m and 60,000 m), before expanding again surrounding the tidal flats. The lower reaches of Raglan Creek are at or below sea level and hence are subject to tidal influences.

Figure 38. *The downstream portion of the Raglan Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

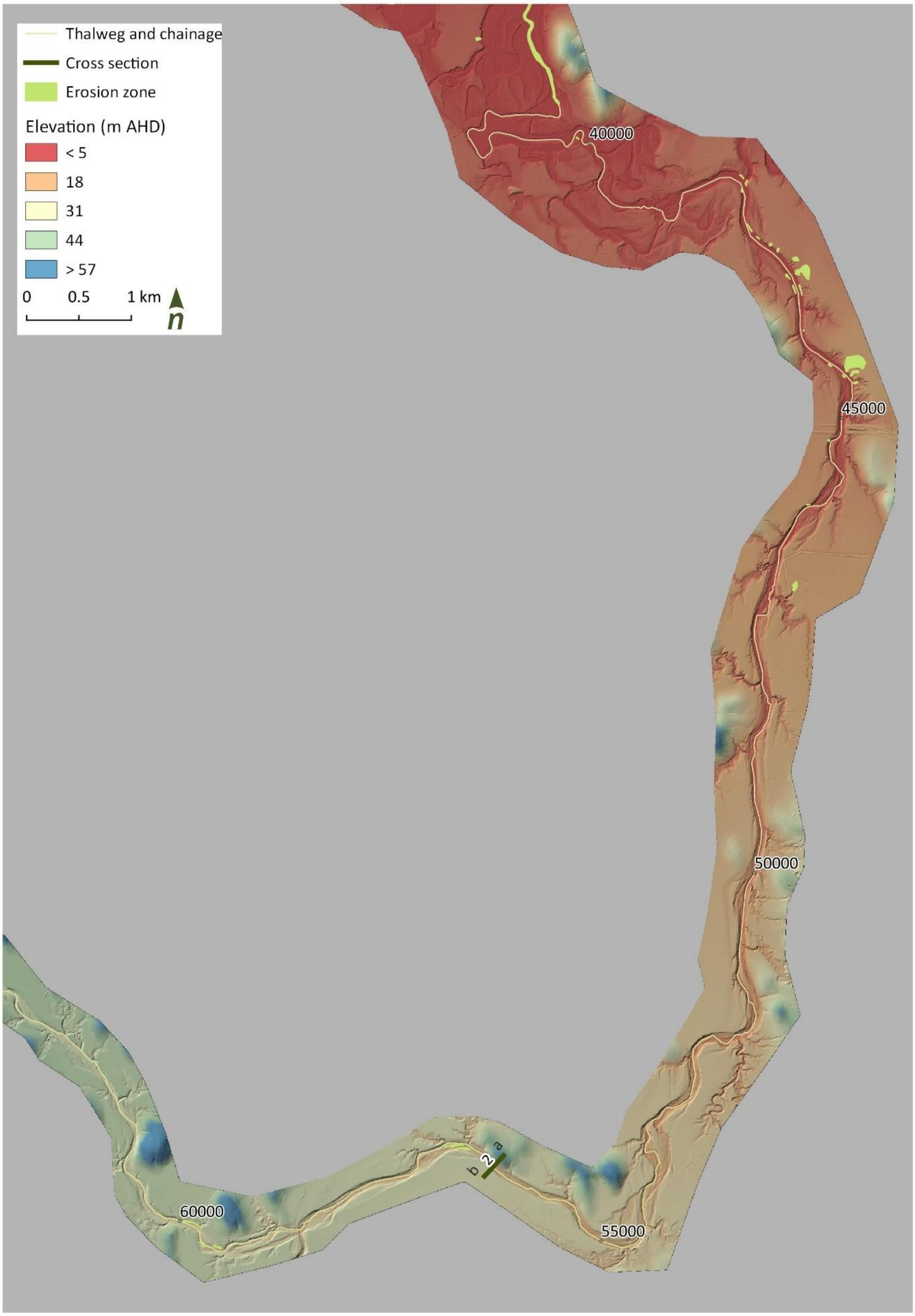


Figure 39. *The middle portion of the Raglan Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

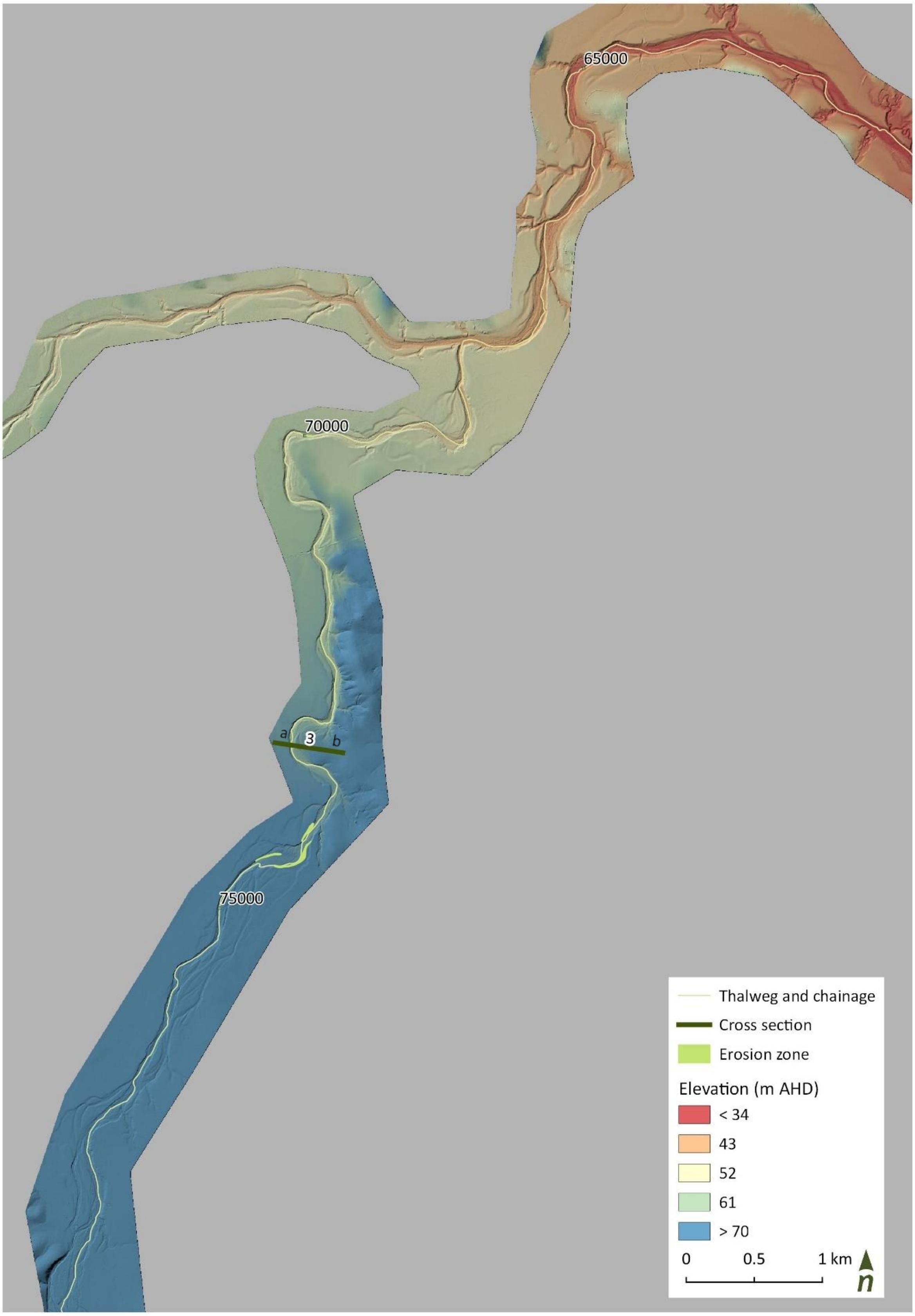


Figure 40. *The upper portion of the Raglan Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

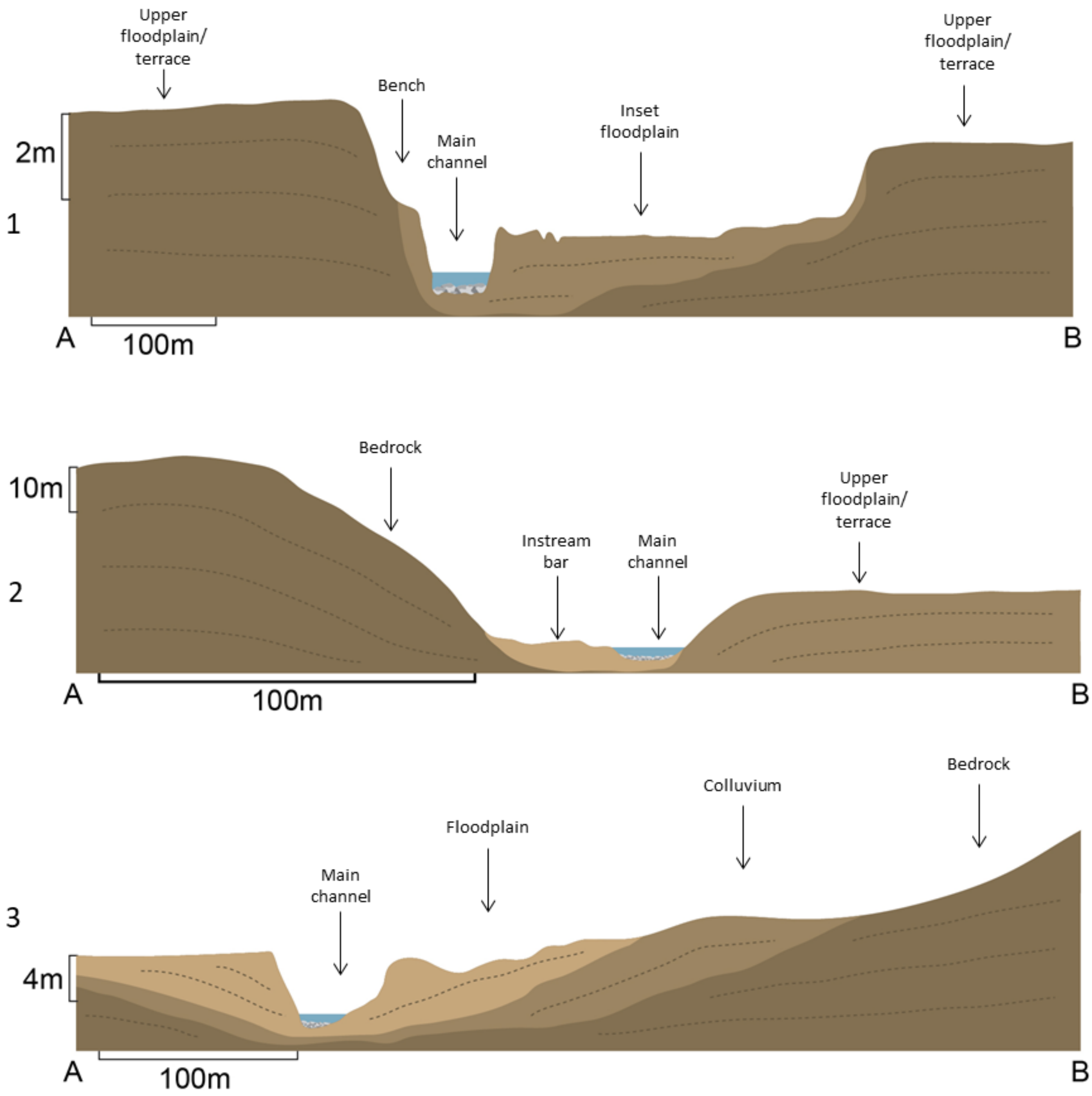


Figure 41. *The three typical sections within the Raglan Creek case study area (shown in Figure 38, Figure 39 and Figure 40) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

Six Mile Creek and the upper reaches of Raglan Creek flow through dispersive sodosol soils. The bed material consists of sands, gravels and cobbles, with occasional bedrock outcrops (Figure 42). Many stream banks within this region have vertical, steep or irregular morphology with exposed soils indicating lateral adjustment. Bedrock outcrops may be limiting large scale vertical and lateral adjustment. Riparian vegetation extent and condition is typically poor and is significantly impacted by cattle grazing (Figure 43 and Figure 44).

The mid reaches (between chainage 40,000 m and 60,000 m) appear to be relatively stable which is likely due to the resistant older floodplain deposits. Reasonable vegetation coverage is typically maintained within the entrenched channel which limits stock access. The reach includes sections in good geomorphic condition, with stable bed and banks and good instream diversity (Figure 45 and Figure 46). The tidal reaches of Raglan Creek contain stream banks that are typically steep/vertical and devoid of vegetation. This is particularly prevalent on the outside of the meanders.

Figure 42. *An example of abundant sandy/gravelly bed material, poor riparian vegetation and cattle impacts within Six Mile Creek which is in the upper portion of the Raglan Creek case study area.*

Figure 43. *Limited riparian vegetation, stock impacts and stream bank instabilities in the lower reaches of Six Mile Creek within the Raglan Creek case study area.*

Figure 44. *An example of a steep and eroding bank in Raglan Creek.*

Figure 45. *An example of a stable section of the mid-reaches Raglan Creek with good riparian vegetation extent and instream diversity.*

Figure 46. *An example of good vegetation in the mid-reaches of Raglan Creek.*

Geomorphic reaches

The Raglan Creek study area consists of four Dynamic SedNet modelled links. The Dynamic SedNet links align relatively well with the geomorphic features within the study area. However, the downstream SednNet link has been split into two reaches. To improve Dynamic SedNet parametrisation the Raglan Creek study area has been split into five reaches, primarily based on degree of confinement (Figure 47).

A summary of key hydro-geomorphic parameters for each of the five reaches is provided below. The reach extent and a representative cross-section within each reach is shown in Figure 48 to Figure 57. Key hydro-geomorphic parameters for each reach (based on LiDAR analysis and hydraulic modelling) are provided in Table 13 to Table 17.

Key input parameters used in the Dynamic SedNet model for each link within the Raglan Creek case study area are shown in Table 18. A summary of key hydro-geomorphic parameters for each of the 5 reaches within the Fitzroy River study area is provide in Table 19.

Multitemporal LiDAR analysis (2009 and 2018) was only available for the downstream area (Reach 1 & Reach 2).

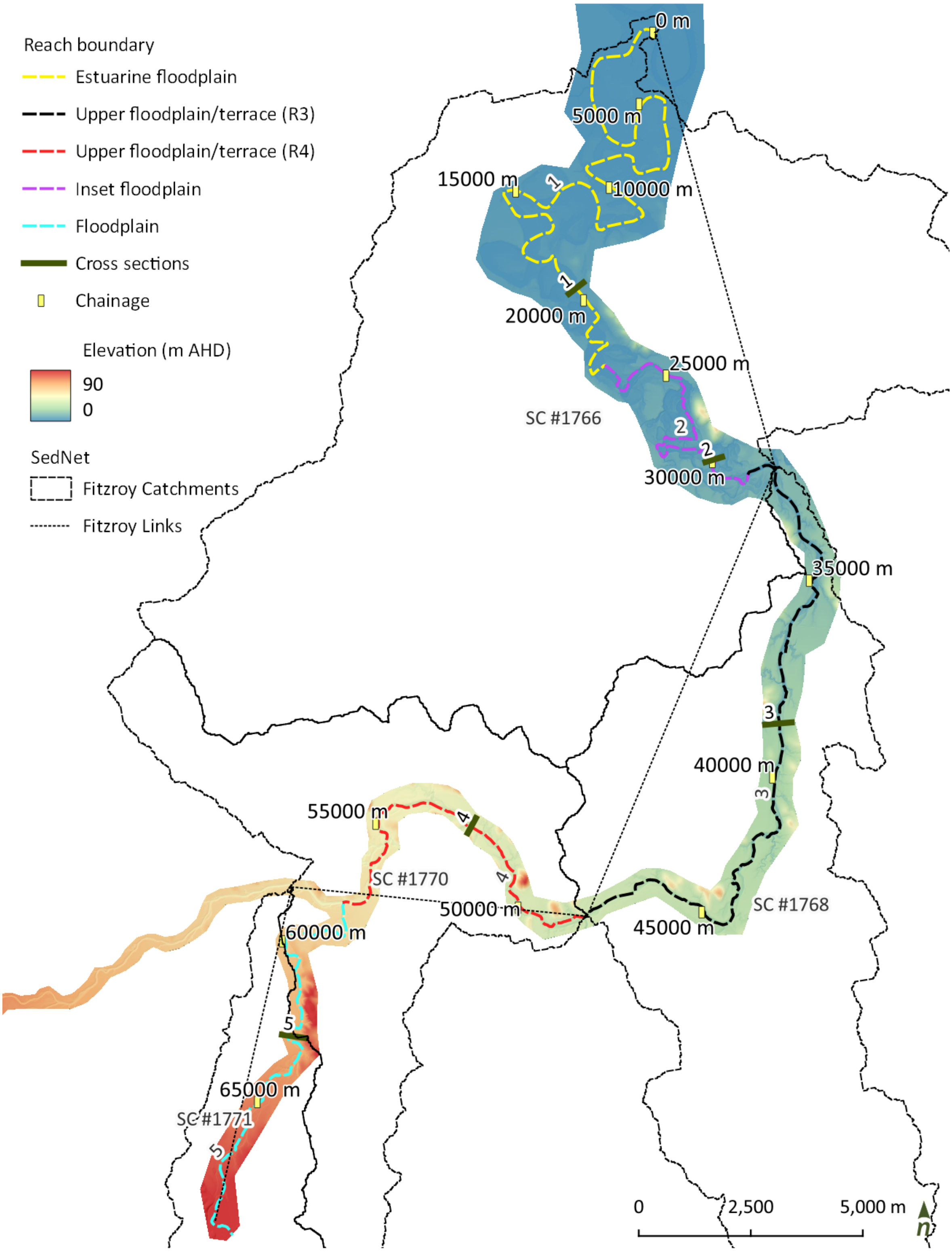


Figure 47. *Raglan Creek case study area. Showing five reaches and representative cross-section location for each reach. Dynamic SedNet sub-catchments are shown in black.*

Raglan Creek Reach 1

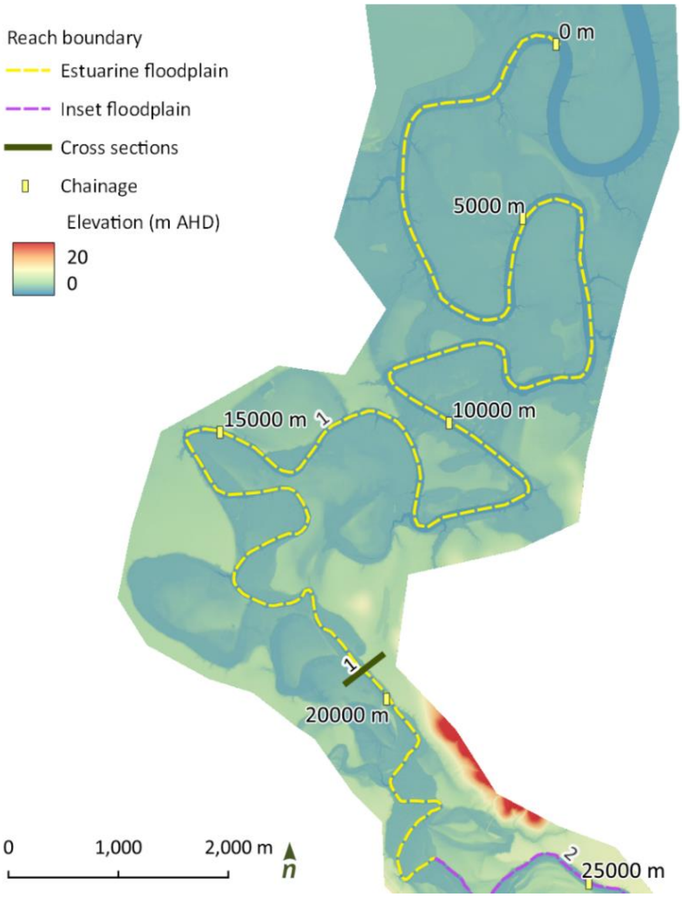


Figure 48. *Reach 1 within the Raglan Creek study area.*

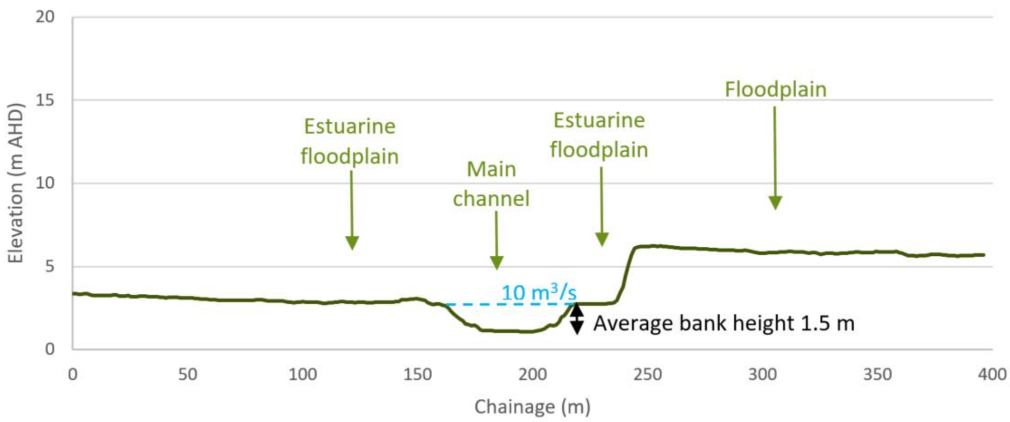


Figure 49. *Representative cross-section within the Raglan Creek reach 1 (cross-section location shown in Figure 48).*

Table 13. Key input parameters – Raglan Creek reach 1.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
1	10*	0.0000	22723	92	1.5*	Estuarine floodplain	Very high	61,313

*Bank height derived from LiDAR data which is flat within the tidally influenced channel. Bank height, and bank full flow, likely influenced by water level at time of LiDAR capture.

Raglan Creek Reach 2

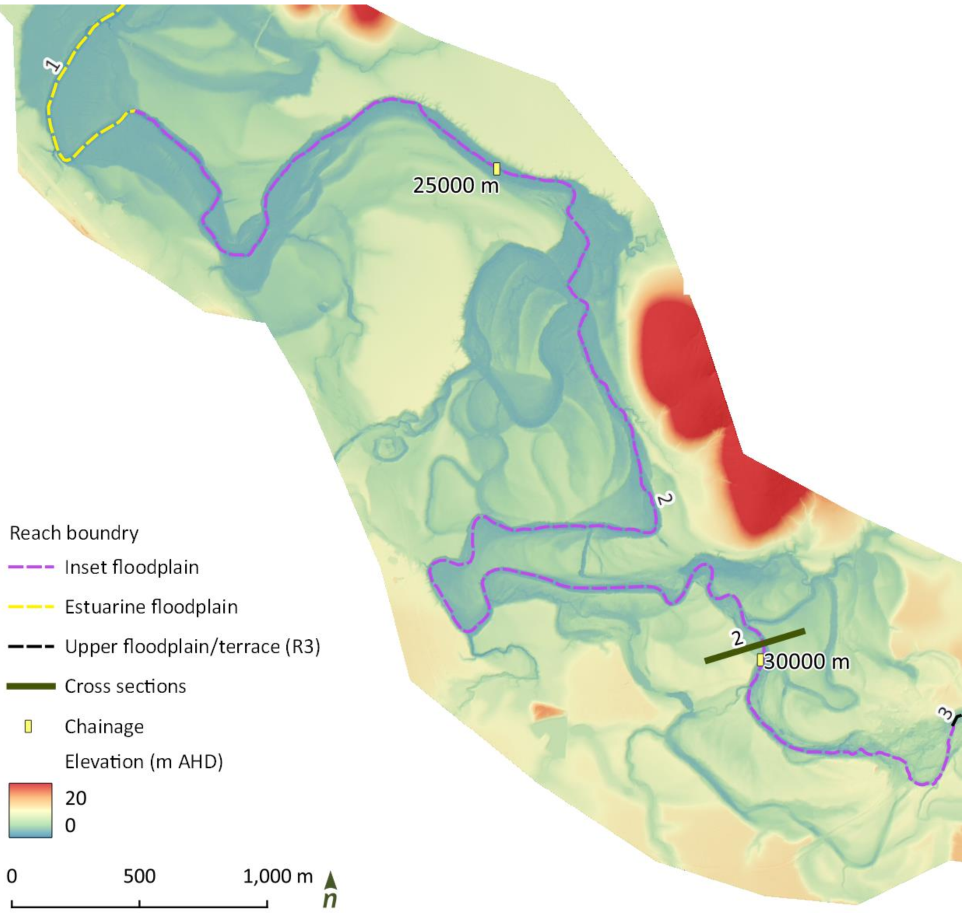


Figure 50. *Reach 2 within the Raglan Creek study area.*

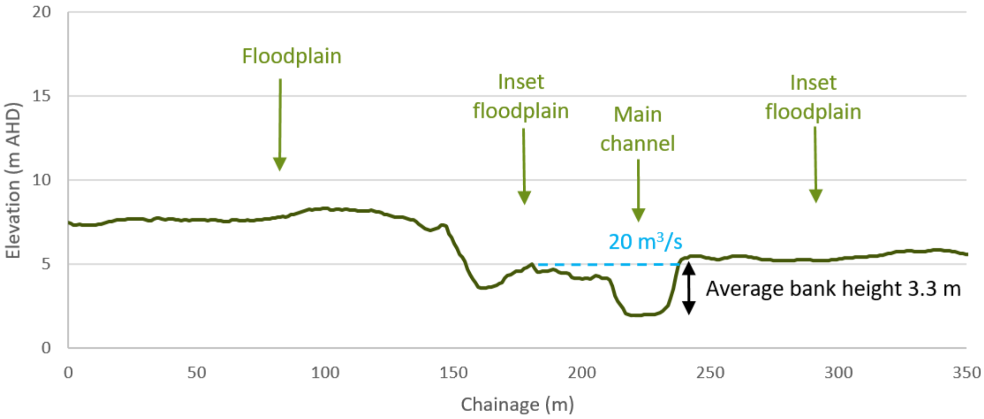


Figure 51. *Representative cross-section within the Raglan Creek reach 2 (cross-section location shown in Figure 50).*

Table 14. Key input parameters – Raglan Creek reach 2.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
2	20*	0.0003	8610	102	3.3*	Inset floodplain	Very high	290

*Bank height derived from LiDAR data which is flat within the tidally influenced channel. Bank height, and bank full flow, likely influenced by water level at time of LiDAR capture.

Raglan Creek Reach 3

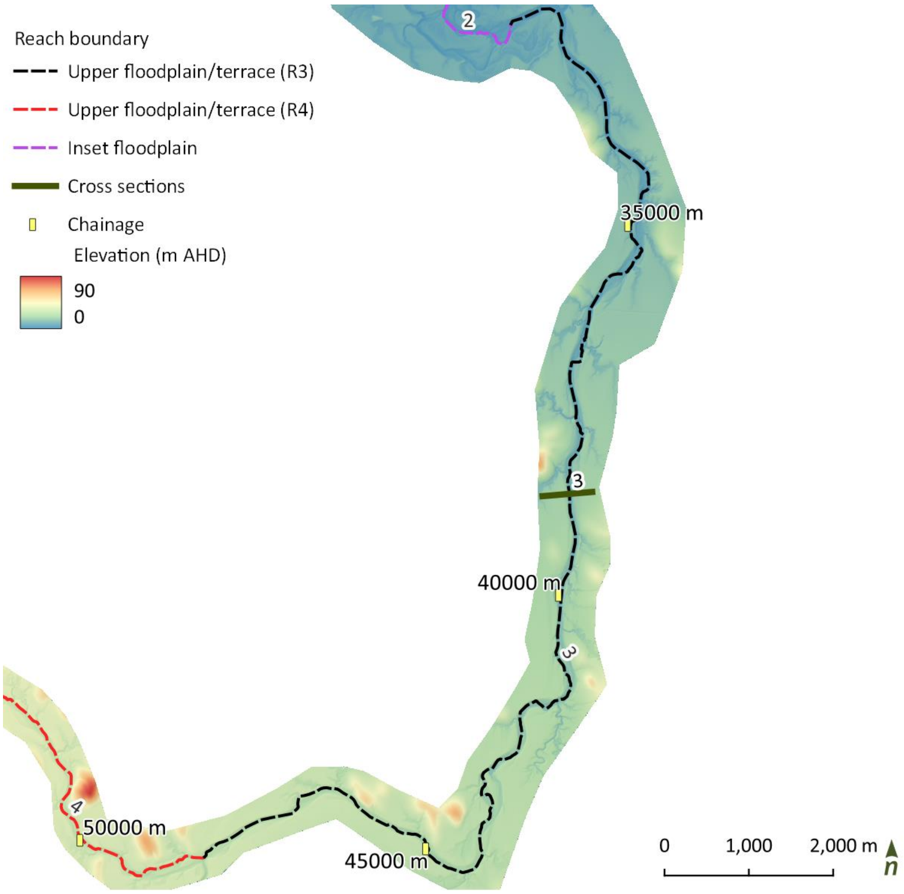


Figure 52. *Reach 3 within the Raglan Creek study area.*

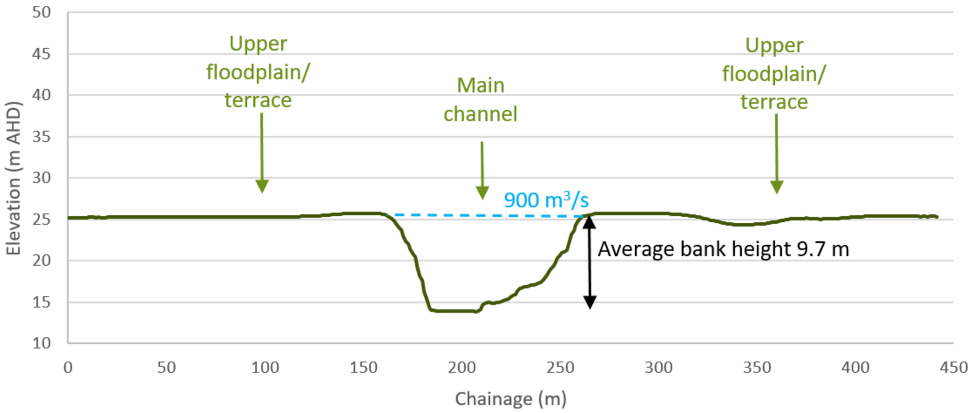


Figure 53. *Representative cross-section within the Raglan Creek reach 3 (cross-section location shown in Figure 52).*

Table 15. Key input parameters – Raglan Creek reach 3.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
3	900	0.0012	16954	129	9.7	Upper floodplain/terrace (20% inset floodplain)	20% very high, 80% low	-

Raglan Creek Reach 4

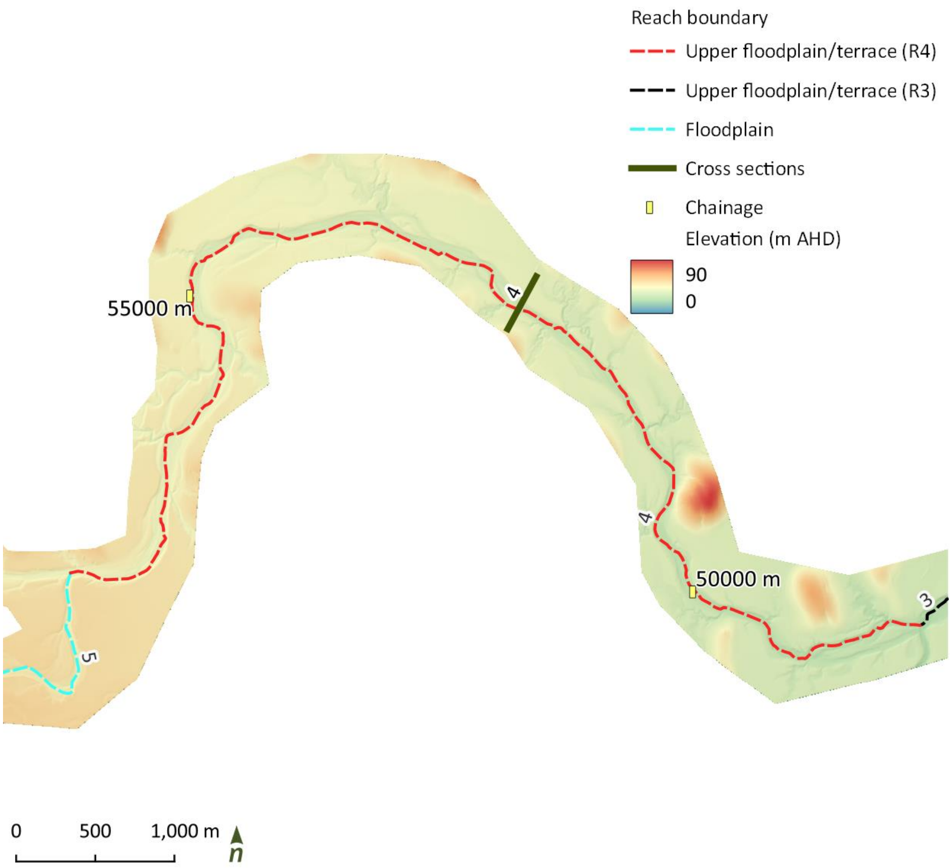


Figure 54. *Reach 4 within the Raglan Creek study area.*

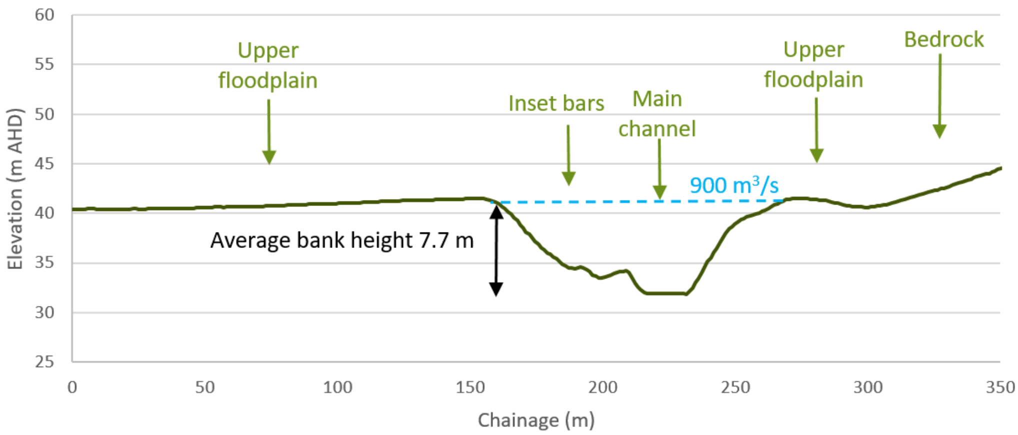


Figure 55. *Representative cross-section within the Raglan Creek reach 4 (cross-section location shown in Figure 54).*

Table 16. Key input parameters – Raglan Creek reach 4.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
4	900	0.0022	9310	104	7.7	Upper floodplain/terrace (20% inset floodplain)	20% very high, 80% low	-

Raglan Creek Reach 5

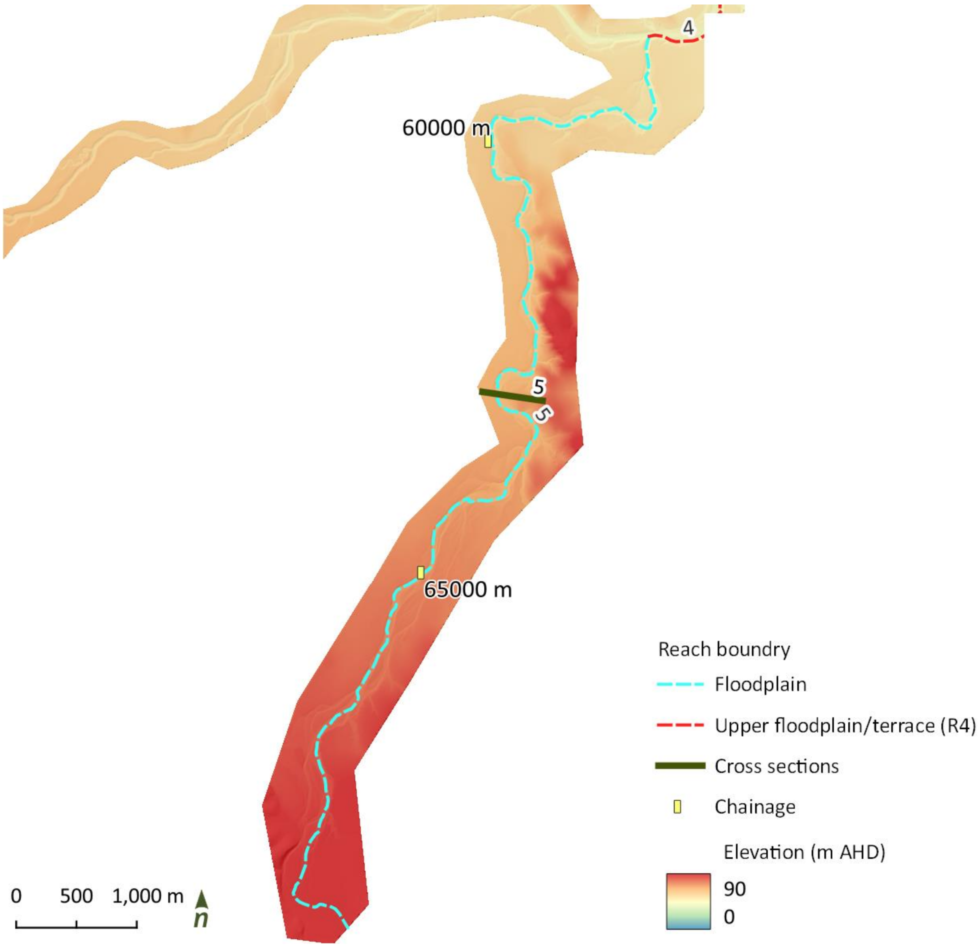


Figure 56. *Reach 5 within the Raglan Creek study area.*

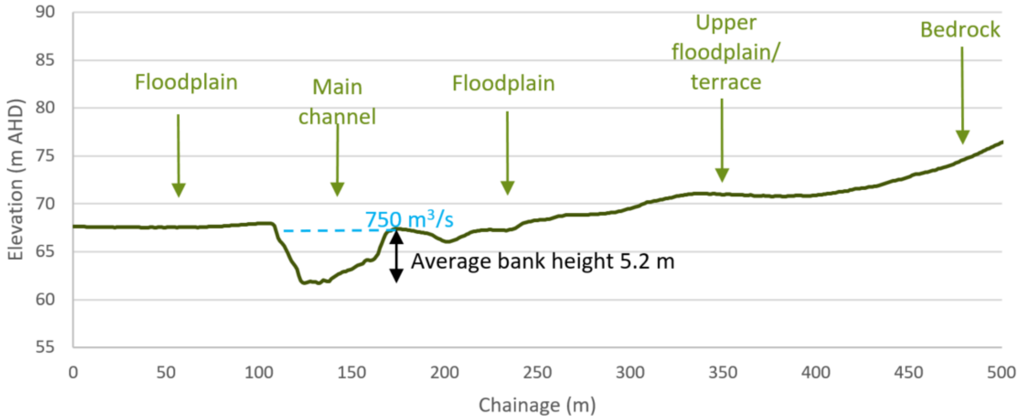


Figure 57. *Representative cross-section within the Raglan Creek reach 5 (cross-section location shown in Figure 56).*

Table 17. Key input parameters – Raglan Creek reach 5.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
5	750	0.0043	11148	83	5.2	Floodplain	High	-

Table 18. Dynamic SedNet Bank Erosion key input parameters – Raglan Creek case study area.

Link (Sub-catchment)	Bank Full Flow (m^3/s)	Link Slope (m/m)	Link Length (m)	Channel Width (m)	Bank Height (m)	Riparian Vegetation Percentage (%)	Maximum Riparian Vegetation Effect. (%)	Stream bank material erodibility (%)	Bank Erosion Coeff.	SedNet sediment loss (m^3) (2009 – 2018)*
SC #1766	880.5	0.0036	31199	60	5.0	65.3	95	75	2.0E-06	57,745
SC #1768	220.7	0.0186	15720	43	4.4	62.6	95	50	2.0E-06	23,360
SC #1770	182.8	0.0202	15041	25	3.8	57.7	95	75	2.0E-06	29,029
SC #1771	58.04	0.0110	5296	20	2.5	50.6	95	75	2.0E-06	1,379

*Note: in 2018 Dynamic SedNet data was only available from January to June.

Table 19. Summary of hydro-geomorphic parameters – Raglan Creek case study area.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018) LiDAR	Sediment mobilised **per km (m^3/km) (2009 – 2018)**
1	10	0.0000	22723	92	1.5	Estuarine floodplain	Very high	61,313	2,698
2	20	0.0003	8610	102	3.3	Inset floodplain	Very high	290	34
3	900	0.0012	16954	129	9.7	Upper floodplain/terrace (20% inset floodplain)	20% very high, 80% low	-	-
4	900	0.0022	9310	104	7.7	Upper floodplain/terrace (20% inset floodplain)	20% very high, 80% low	-	-
5	750	0.0043	11148	83	5.2	Floodplain	High	-	-

Note: Multitemporal LiDAR analysis (2009 and 2018) was only available for the downstream area (Reach 1 & Reach 2).

5.4 Fitzroy River

Overview

The Fitzroy River case study reach extends for 65 km upstream of the tidal barrage in Rockhampton (Figure 58). The upper extent of the reach is approximately 20km downstream of the Eden Bann Weir. The floodplains predominantly support livestock grazing, with some cropping in the lower reaches and the urban centre of Rockhampton.

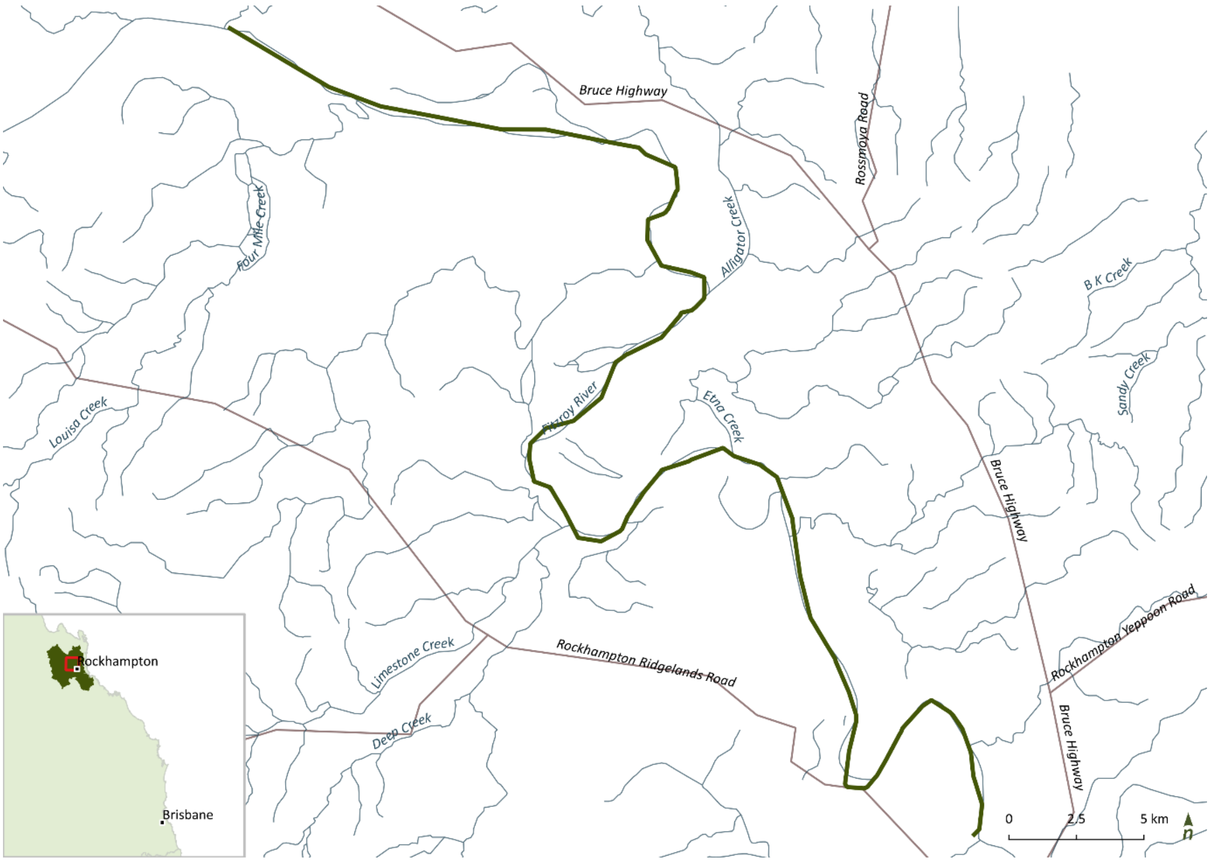


Figure 58. *The Fitzroy River case study area.*

The case study area is shown in Figure 59 and Figure 60. The reach flows through a broad floodplain (up to 12 km wide) with thick alluvial deposits that have undergone extensive reworking by the river over geologic time. There are many paleo landforms (including former channel alignments) present that are unrelated to the present-day river but do influence its behaviour (see cross-sections 1 and 2 in Figure 61). The scroll-bar topography in certain locations indicates significant lateral migration of the channel. The reach is partly confined by bedrock valley margins, which limit the ability of the channel to migrate laterally across the valley in some locations. The reach is classified as meandering (Croke et al, 2011), however it contains several higher-angle bends separated by sections that are near straight.

The channel through the reach is wide and extends over 500 m in some locations. Geomorphic units within the channel include:

- wide inset bars, which sit approximately 2 to 5 m above the channel bed (see cross-section 3 in Figure 61, and Figure 62), and
- inset alluvial units including benches, which sit approximately 5 to 10 m above the channel bed (see cross-section 3 in Figure 61).

Both the tidal barrage and the Eden Bann Weir have impacted river hydraulics, sediment transport and bank saturation processes within this area.

The reach is predominantly underlain by quaternary alluvium, comprised of clays, silts, sands and gravels. Riparian vegetation is typically present on the stream banks, but does not extend beyond the top of bank and is generally heavily impacted by cattle grazing. It lacks the structural diversity and density to provide significant erosion protection functions. In-channel bars are typically devoid of vegetation and are impacted by cattle grazing. Riparian vegetation predominantly includes open Acacia forests (R.E. 11.3.1) or open eucalypt woodlands (R.E. 11.3.3).

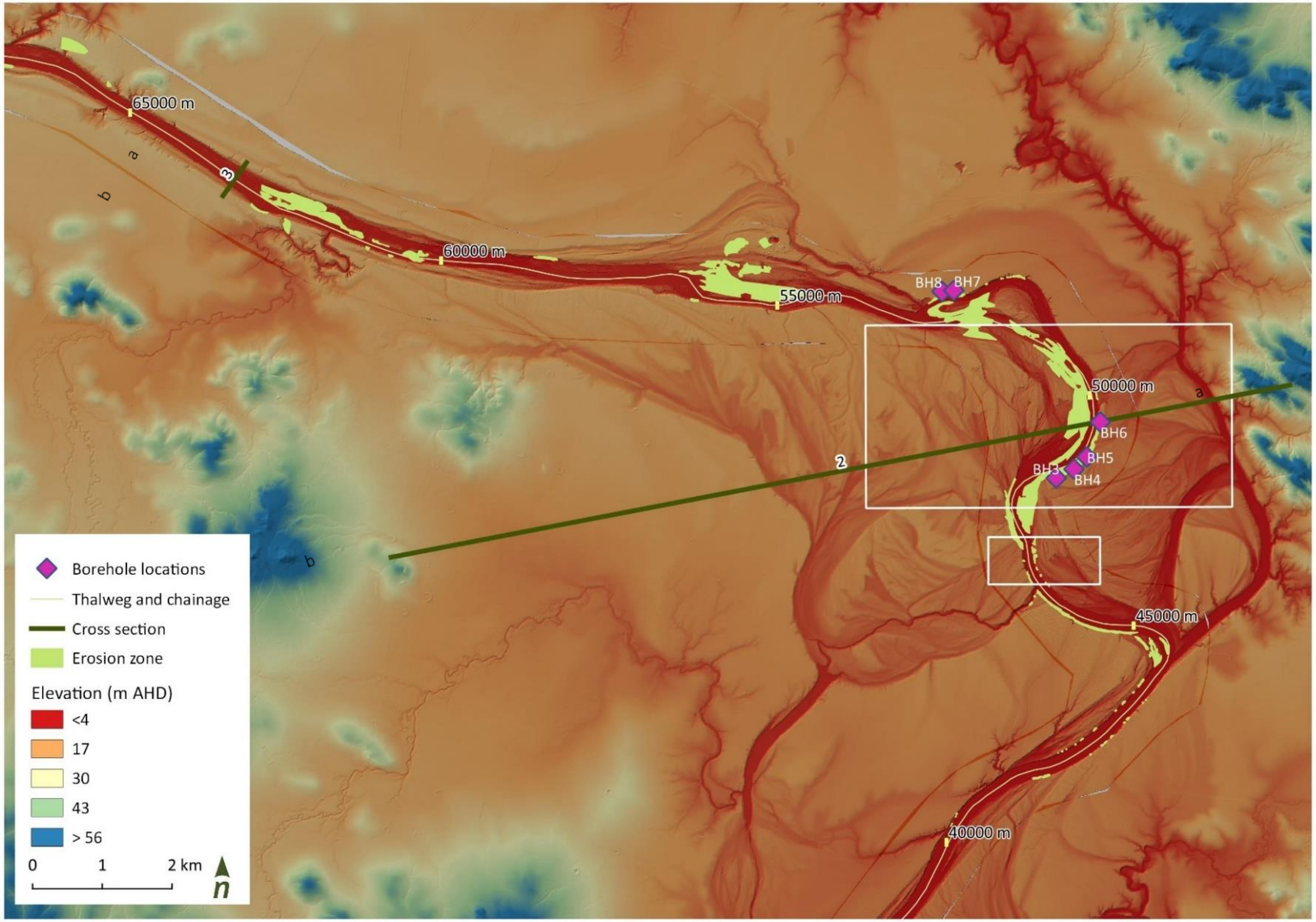


Figure 59. *The upper portion of the Fitzroy River case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

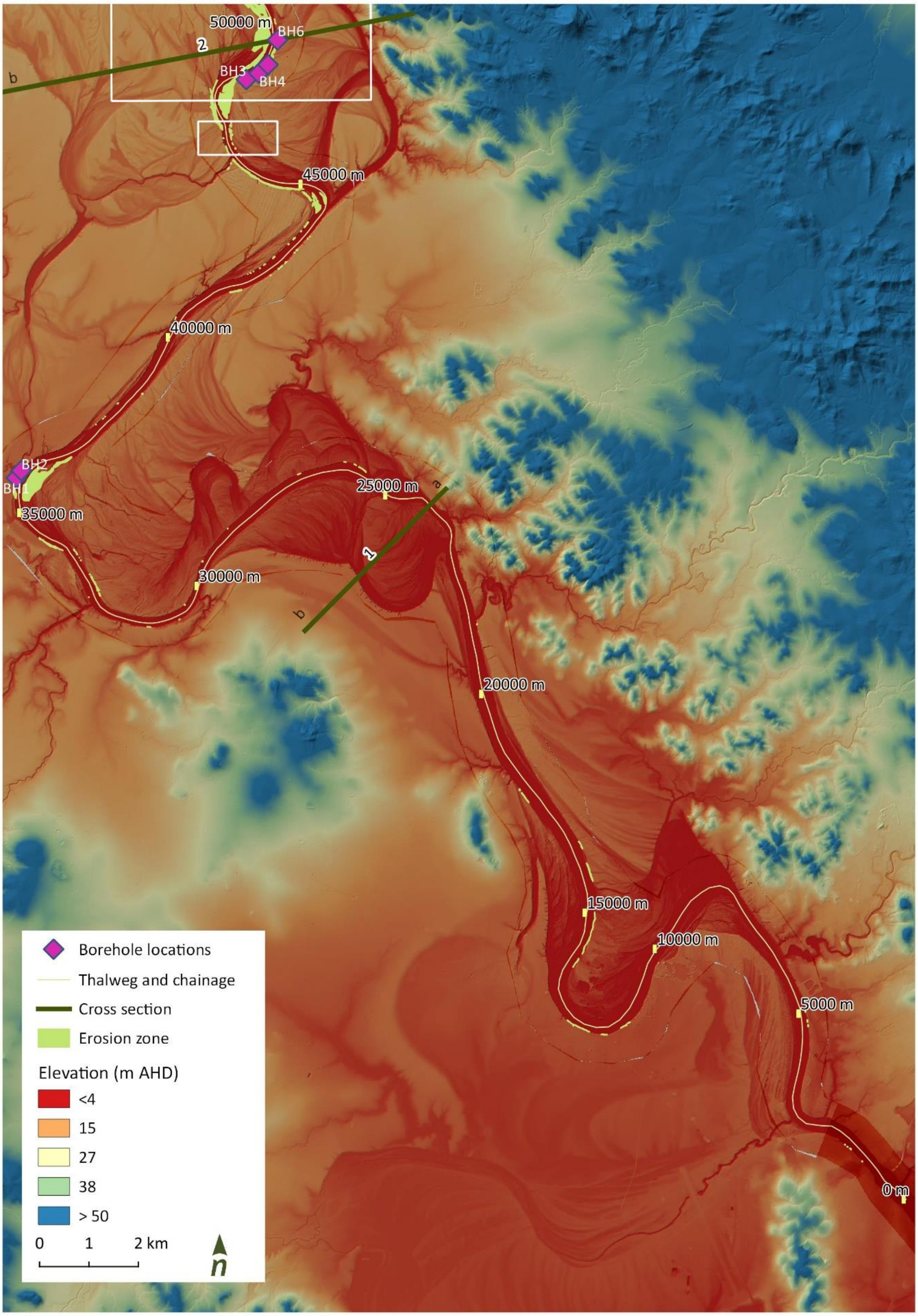


Figure 60. *The downstream portion of the Fitzroy River case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

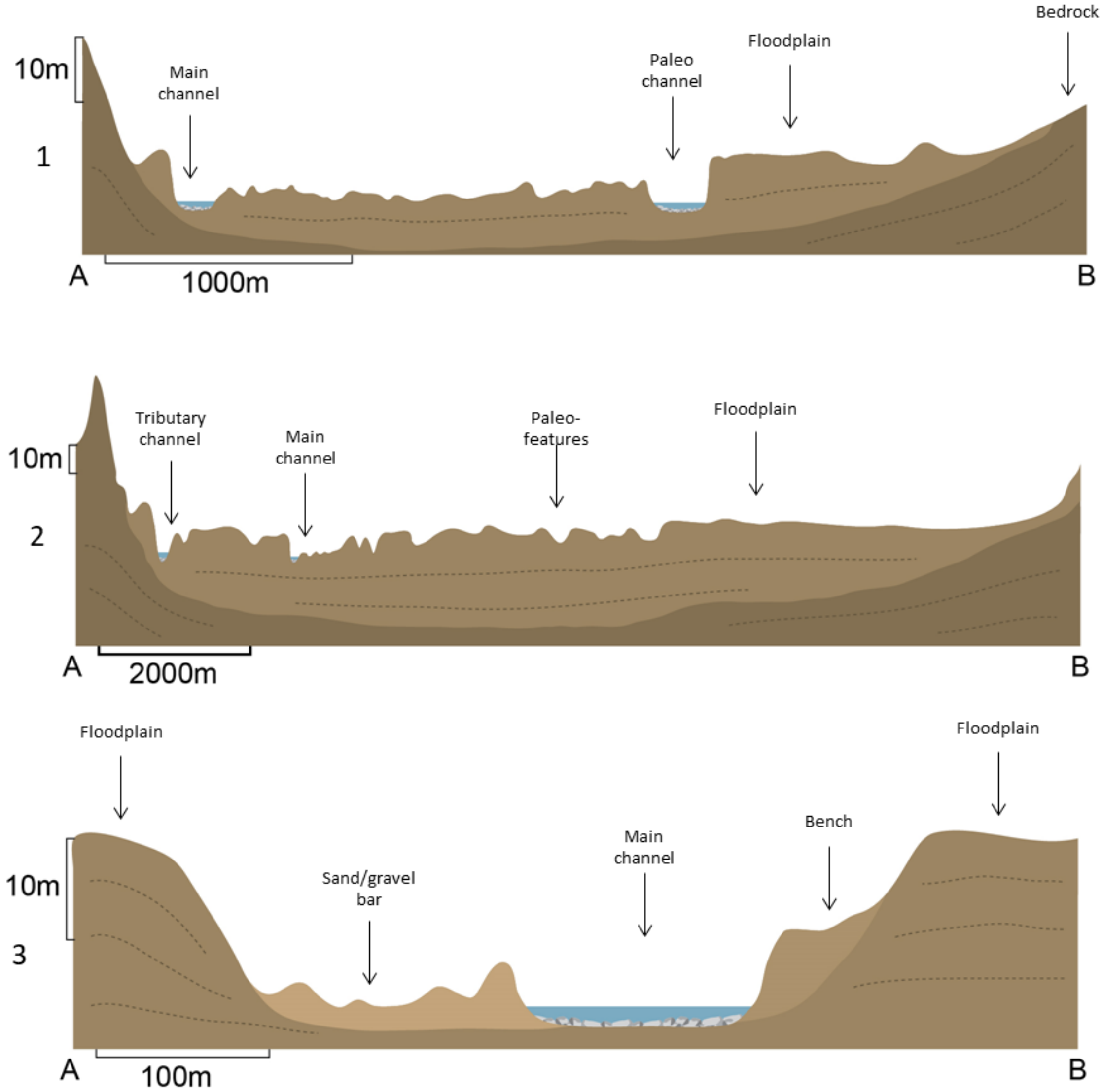


Figure 61. *The three typical sections within the Fitzroy River case study area (shown in Figure 59 and Figure 60) with the key geomorphic units - note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

Figure 62. *A wide in-channel bar within the Fitzroy River case study area.*

Geomorphic reaches

The Fitzroy River study area consists of seven Dynamic SedNet modelled links. The Dynamic SedNet links align relatively well with the geomorphic features within the study reach. To improve Dynamic SedNet parametrisation the Fitzroy River study area has been split into six reaches, primarily based on degree of confinement (Figure 63).

A summary of key hydro-geomorphic parameters for each of the six reaches, is provided below. The reach extent and a representative cross-section with each reach is shown in Figure 64 to Figure 74 . Key hydro-geomorphic parameters for each reach (based on LiDAR analysis and hydraulic modelling) are provided in Table 20 to Table 25

Key input parameters used in the Dynamic SedNet model for each link within the Fitzroy River case study area are shown in Table 26 . A summary of key hydro-geomorphic parameters for each of the 6 reaches within the Fitzroy River study area is provide in Table 27.

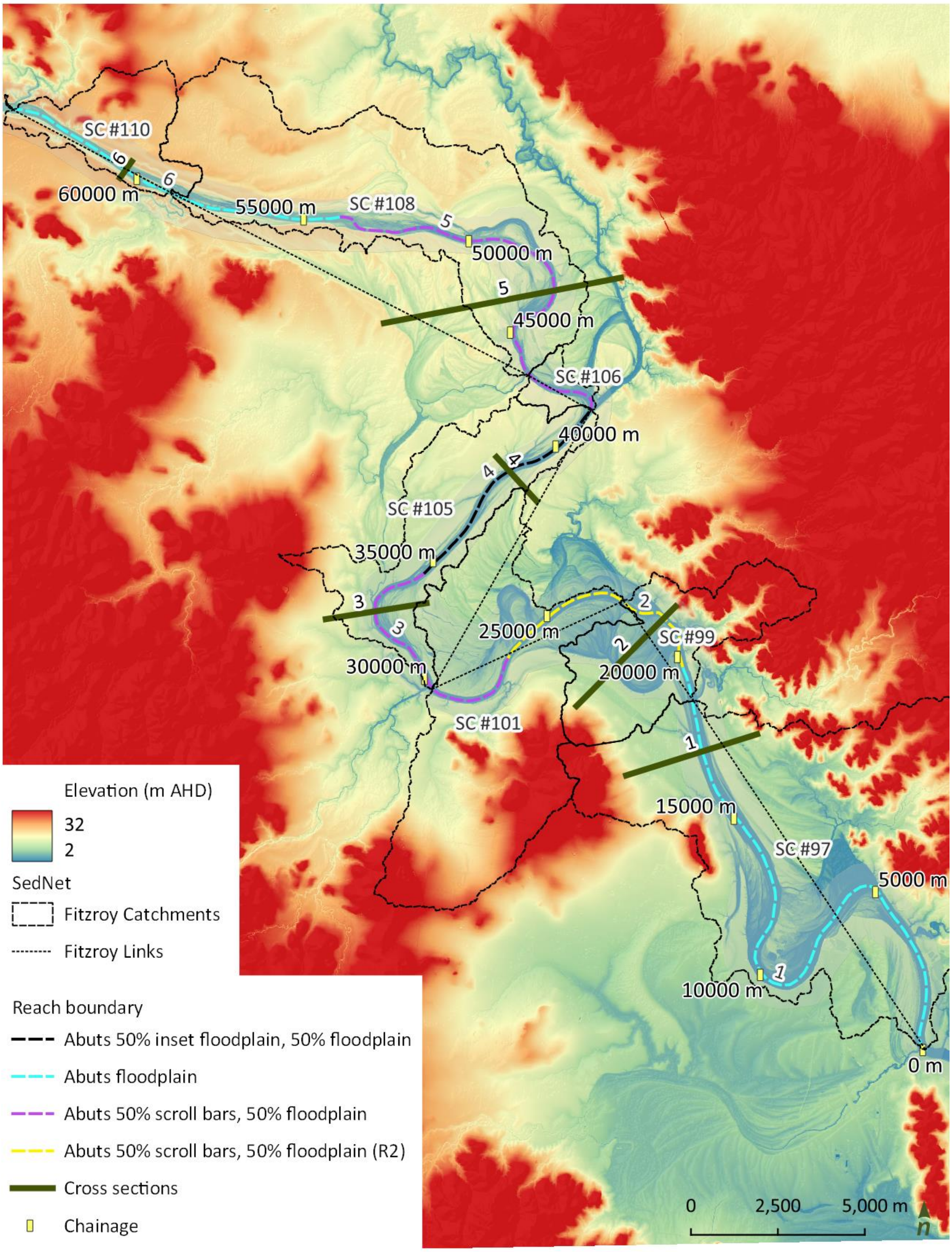


Figure 63. *Fitzroy River case study area. Showing six reaches and representative cross-section location for each reach. Dynamic SedNet sub-catchments are shown in black.*

Fitzroy River Reach 1

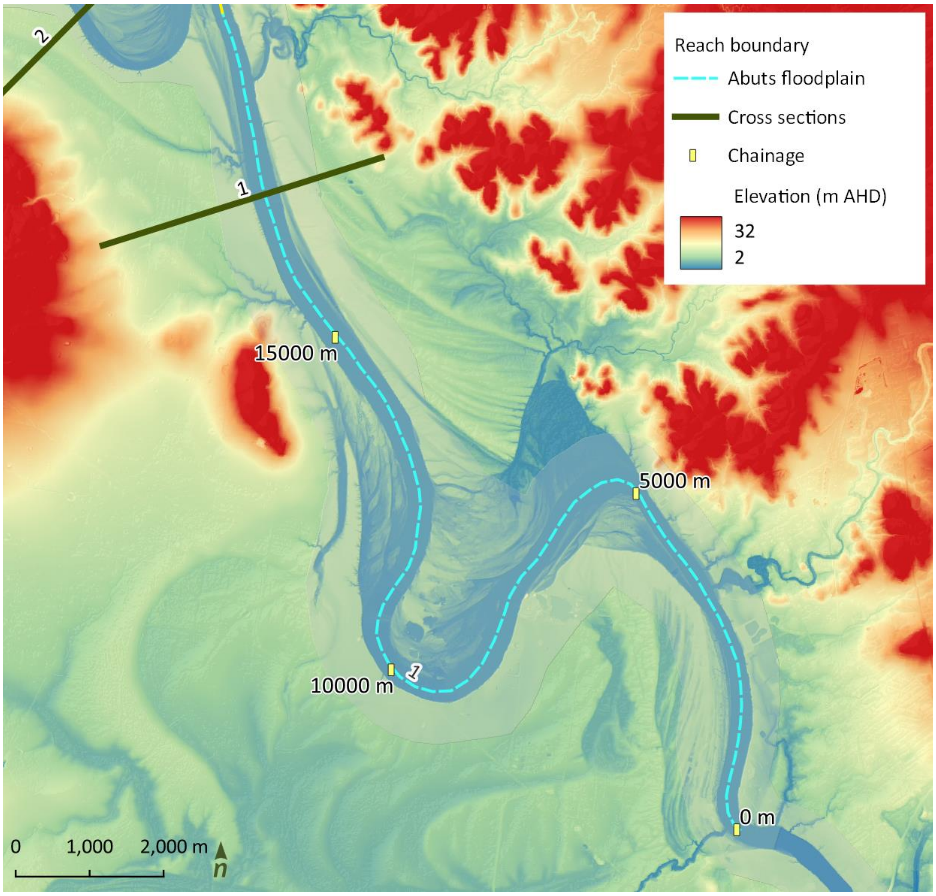


Figure 64. *Reach 1 within the Fitzroy River study area.*

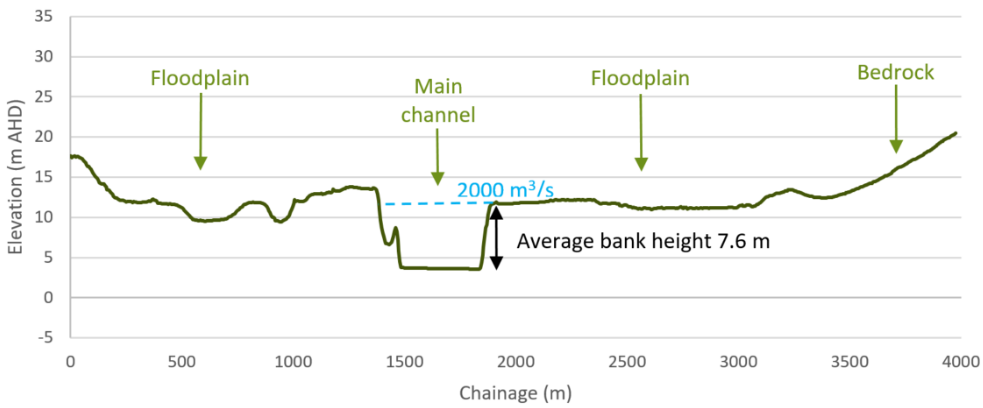


Figure 65. *Representative cross-section within the Fitzroy River reach 1 (cross-section location shown in Figure 64).*

Table 20. Key hydro-geomorphic parameters – Fitzroy River reach 1.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
1	2000	0.00000*	19724	881	7.6	Floodplain	High	48,868

*Slope derived from LiDAR data which is flat within the weir pool

Fitzroy River Reach 2

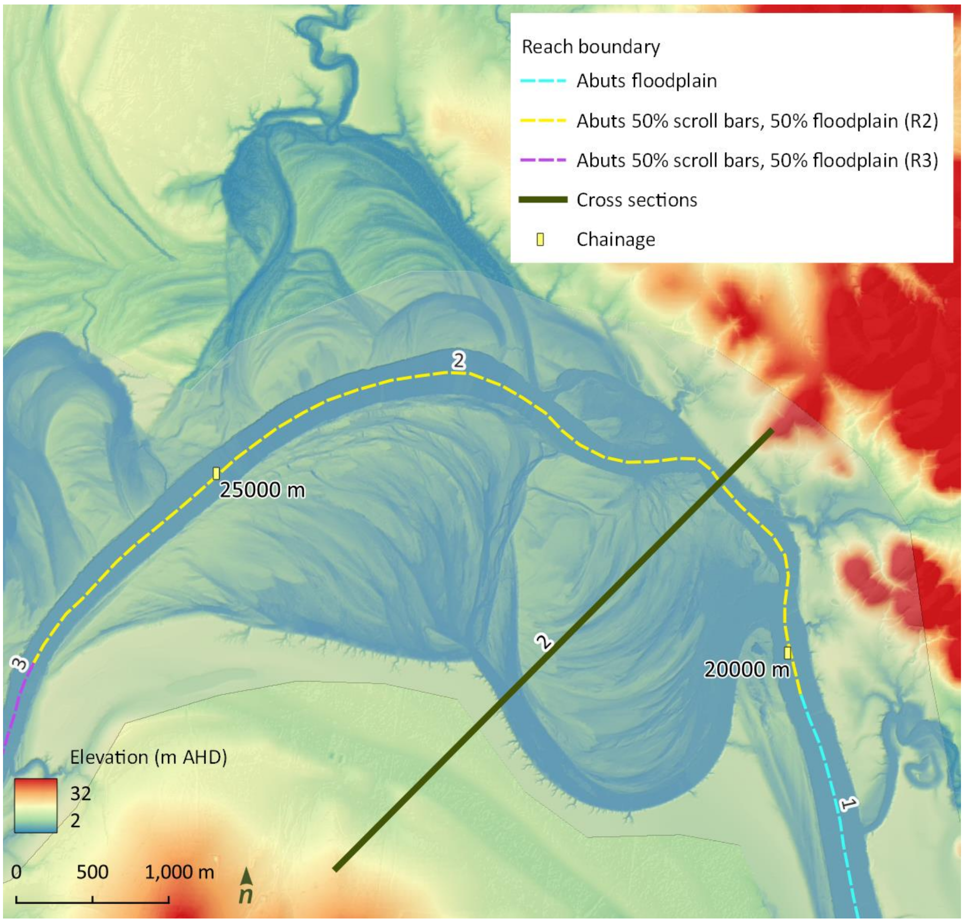


Figure 66. *Reach 2 within the Fitzroy River study area.*

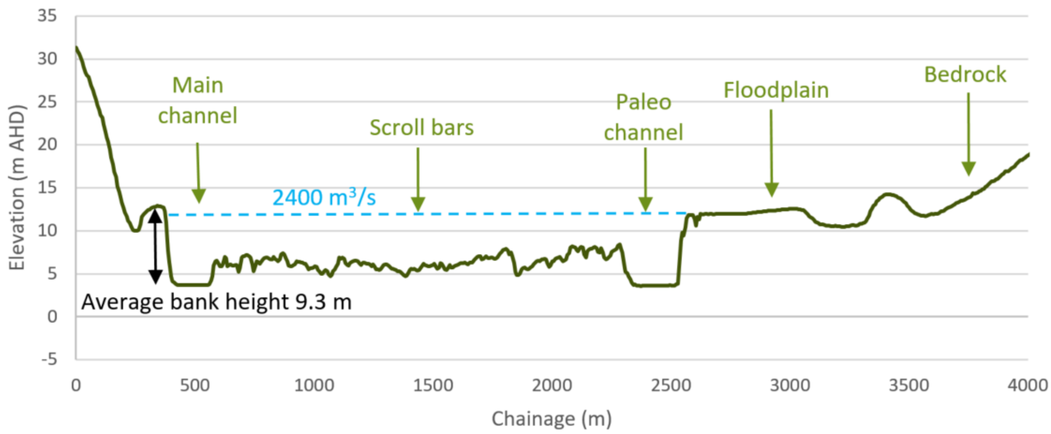


Figure 67. *Representative cross-section within the Fitzroy River reach 2 (cross-section location shown in Figure 66).*

Table 21. Key hydro-geomorphic parameters – Fitzroy River reach 2.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
2	2400	0.00000	7026	2299	9.3	50% scroll bars, 50% floodplain	Very high	9,803

Fitzroy River Reach 3

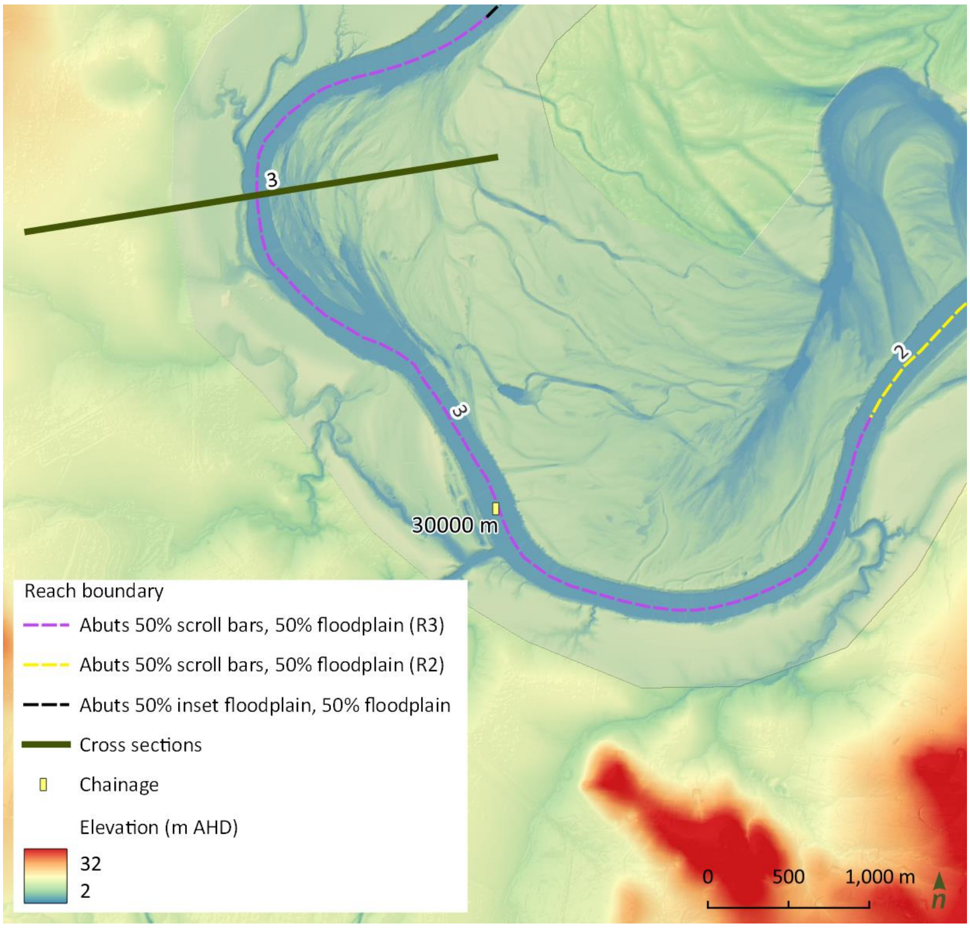


Figure 68. *Reach 3 within the Fitzroy River study area.*

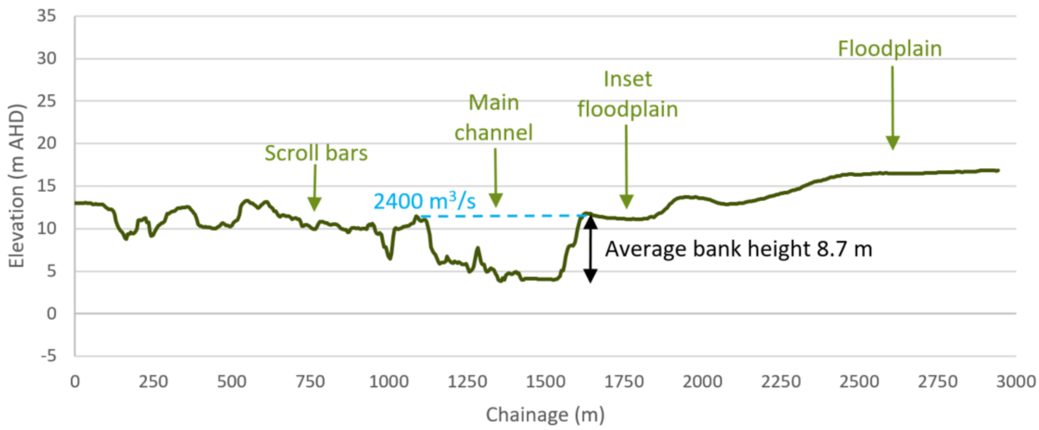


Figure 69. *Representative cross-section within the Fitzroy River reach 3 (cross-section location shown in Figure 68).*

Table 22. Key hydro-geomorphic parameters – Fitzroy River reach 3.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
3	2400	0.00002	7770	515	8.7	50% scroll bars, 50% floodplain	Very high	121,172

Fitzroy River Reach 4

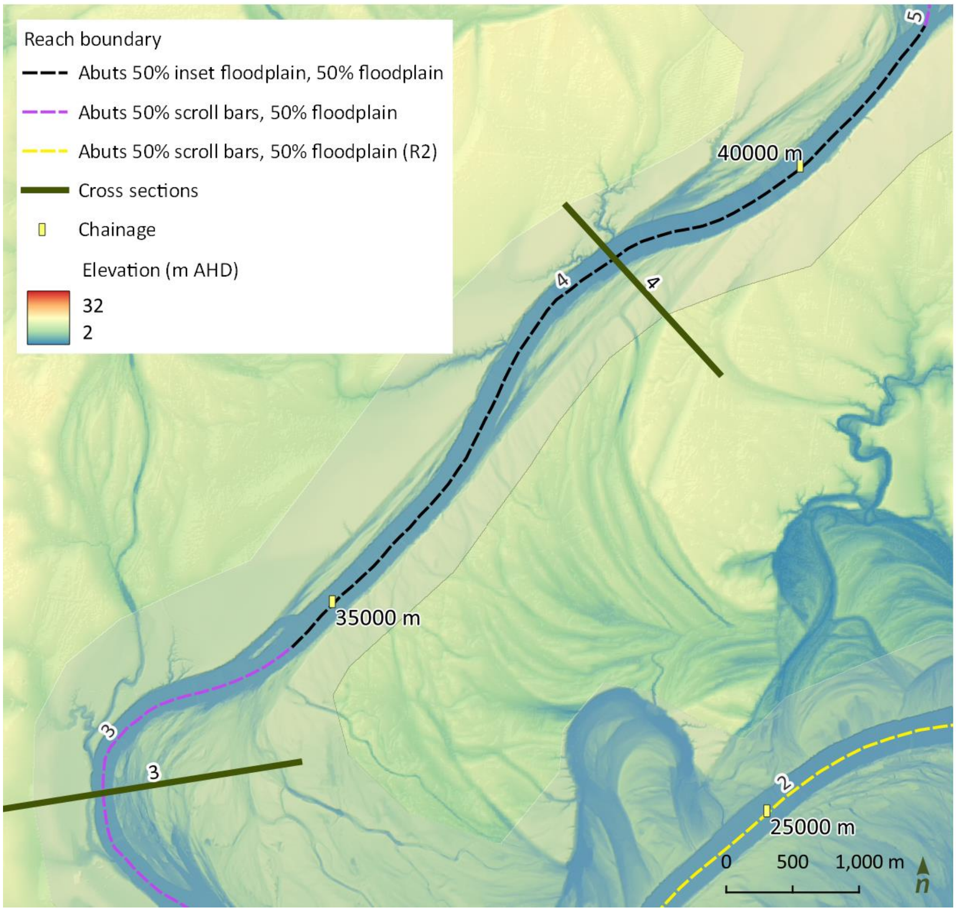


Figure 70. *Reach 4 within the Fitzroy River study area.*

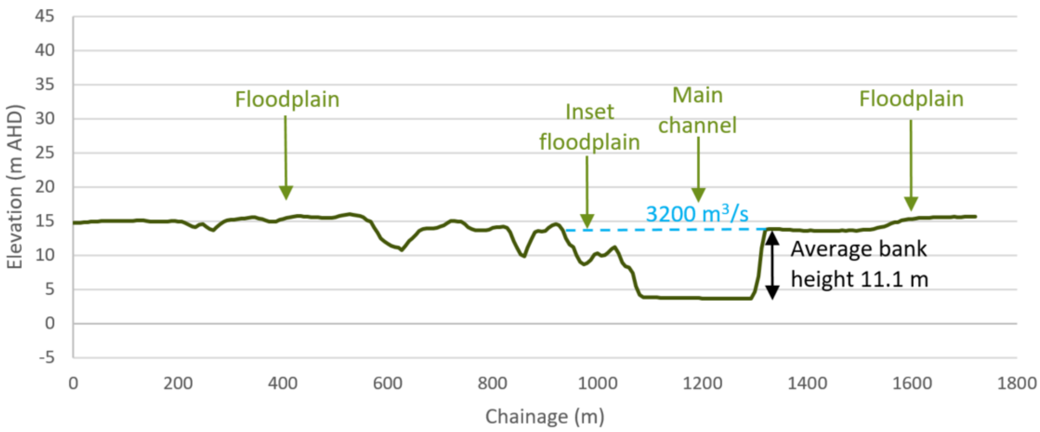


Figure 71. *Representative cross-section within the Fitzroy River reach 4 (cross-section location shown in Figure 70).*

Table 23. Key hydro-geomorphic parameters – Fitzroy River reach 4.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
4	3200	-0.00002	6855	461	11.1	50% inset floodplain, 50% floodplain	High	24,376

Fitzroy River Reach 5

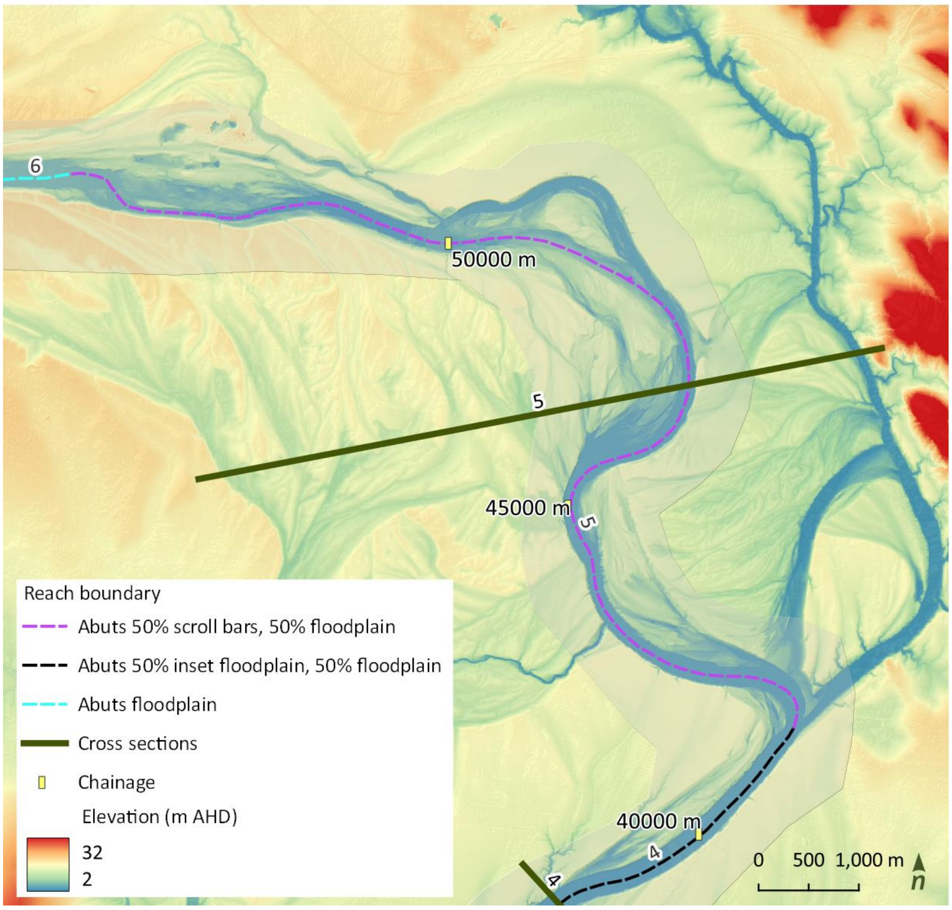


Figure 72. *Reach 5 within the Fitzroy River study area.*

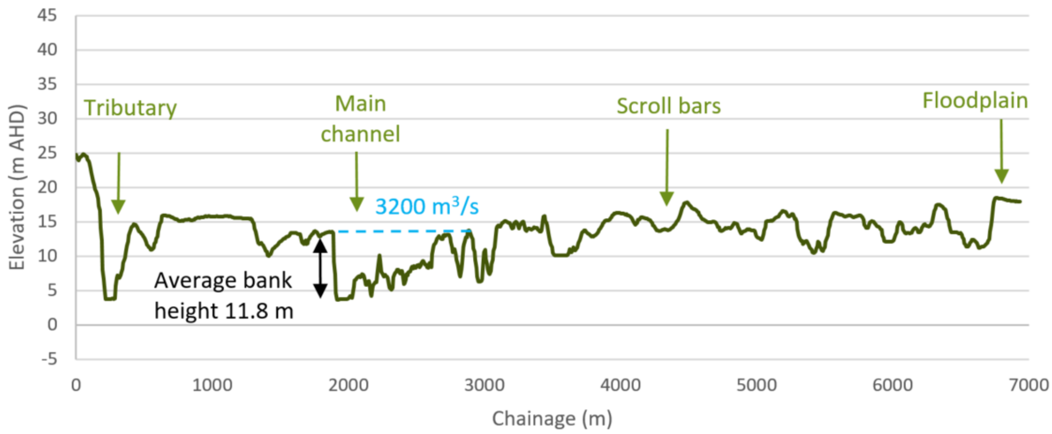


Figure 73. *Representative cross-section within the Fitzroy River reach 5 (cross-section location shown in Figure 72).*

Table 24. Key hydro-geomorphic parameters – Fitzroy River reach 5.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
5	3200	0.00000	12770	658	11.8	50% scroll bars, 50% floodplain	Very high	1,882,339

Fitzroy River Reach 6

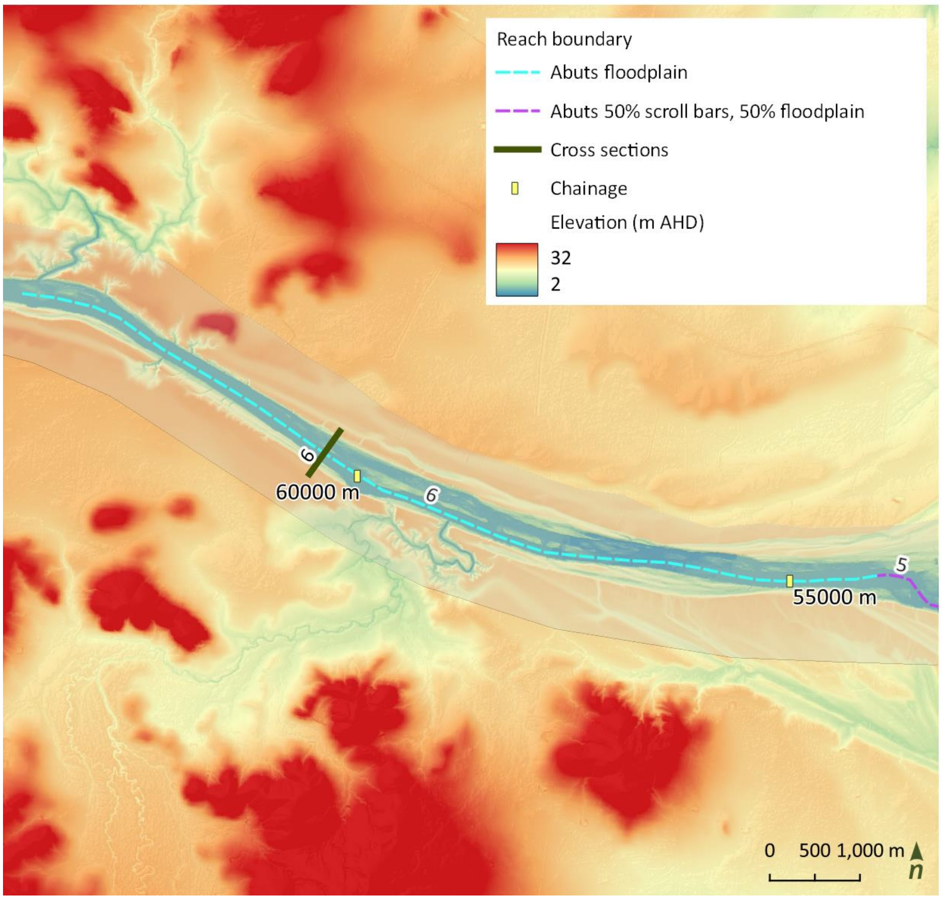


Figure 74. *Reach 6 within the Fitzroy River study area.*

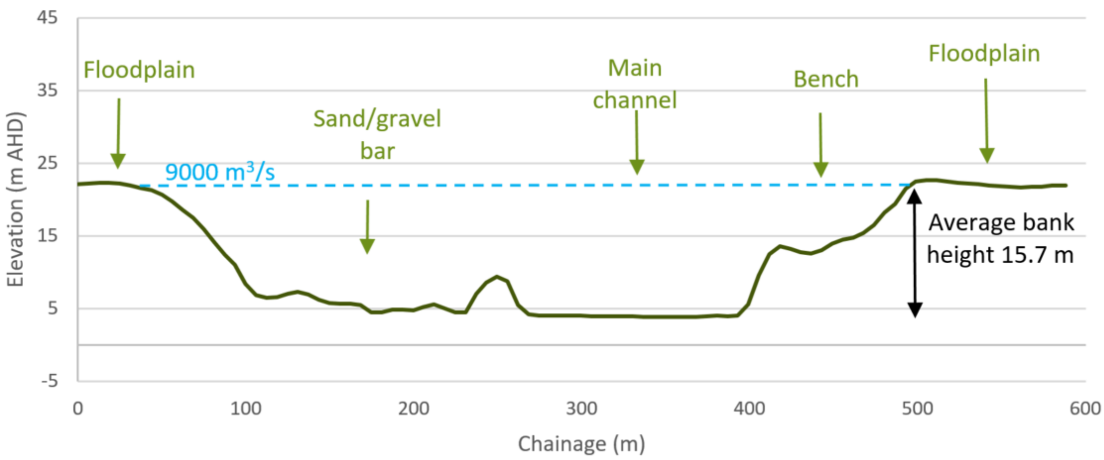


Figure 75. *Representative cross-section within the Fitzroy River reach 6 (cross-section location shown in Figure 74).*

Table 25. Key hydro-geomorphic parameters – Fitzroy River reach 6.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
6	9000	0.00024	10279	476	15.7	Floodplain	High	152,418

Table 26. Dynamic SedNet Bank Erosion key input parameters – Fitzroy River case study area.

Link (Sub-catchment)	Bank Full Flow (m^3/s)	Link Slope (m/m)	Link Length (m)	Channel Width (m)	Bank Height (m)	Riparian Vegetation Percentage (%)	Maximum Riparian Vegetation Effect. (%)	Stream bank material erodibility (%)	Bank Erosion Coeff.	SedNet sediment loss (m^3) (2009 – 2018)*
SC #97	11,560	0.0026	19,690	307	21.5	70	95	5	2.0E-06	81,919
SC #99	11,132	0.0281	5,029	165	21.5	80	95	25	2.0E-06	483,317
SC #101	11,077	0.0046	7,134	206	21.5	53	95	25	2.0E-06	265,478
SC #105	10,973	0.0018	12,687	195	21.5	76	95	38	2.0E-06	147,351
SC #106	10,451	0.0161	2,956	172	21.5	82	95	25	2.0E-06	142,277
SC #108	10,444	0.0073	18,464	214	21.4	77	95	50	2.0E-06	1,074,928
SC #110	10,435	0.0374	5,710	269	21.4	78	95	75	2.0E-06	2,223,925

*Note: in 2018 Dynamic SedNet data was only available from January to June.

Table 27. Summary of hydro-geomorphic parameters - Fitzroy River case study area.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018) LiDAR	Sediment mobilised **per km (m^3/km) (2009 – 2018)**
1	2000	0.00000	19724	881	7.6	Floodplain	High	48,868	2,478
2	2400	0.00000	7026	2299	9.3	50% scroll bars, 50% floodplain	Very high	9,803	1,395
3	2400	0.00002	7770	515	8.7	50% scroll bars, 50% floodplain	Very high	121,172	15,595
4	3200	-0.00002	6855	461	11.1	50% inset floodplain, 50% floodplain	High	24,376	3,556
5	3200	0.00000	12770	658	11.8	50% scroll bars, 50% floodplain	Very high	1,882,339	147,403
6	9000	0.00024	10279	476	15.7	Floodplain	High	152,418	14,828

5.5 Murray Creek

Overview

The Murray Creek case study extends for 23 kilometres, from the Mount Charlton to Jolimont Creek confluence, just downstream of the Bruce Highway (Figure 76). The floodplains along this reach support sugarcane cultivation and grazing. The upper slopes support grazing and rural residential development.

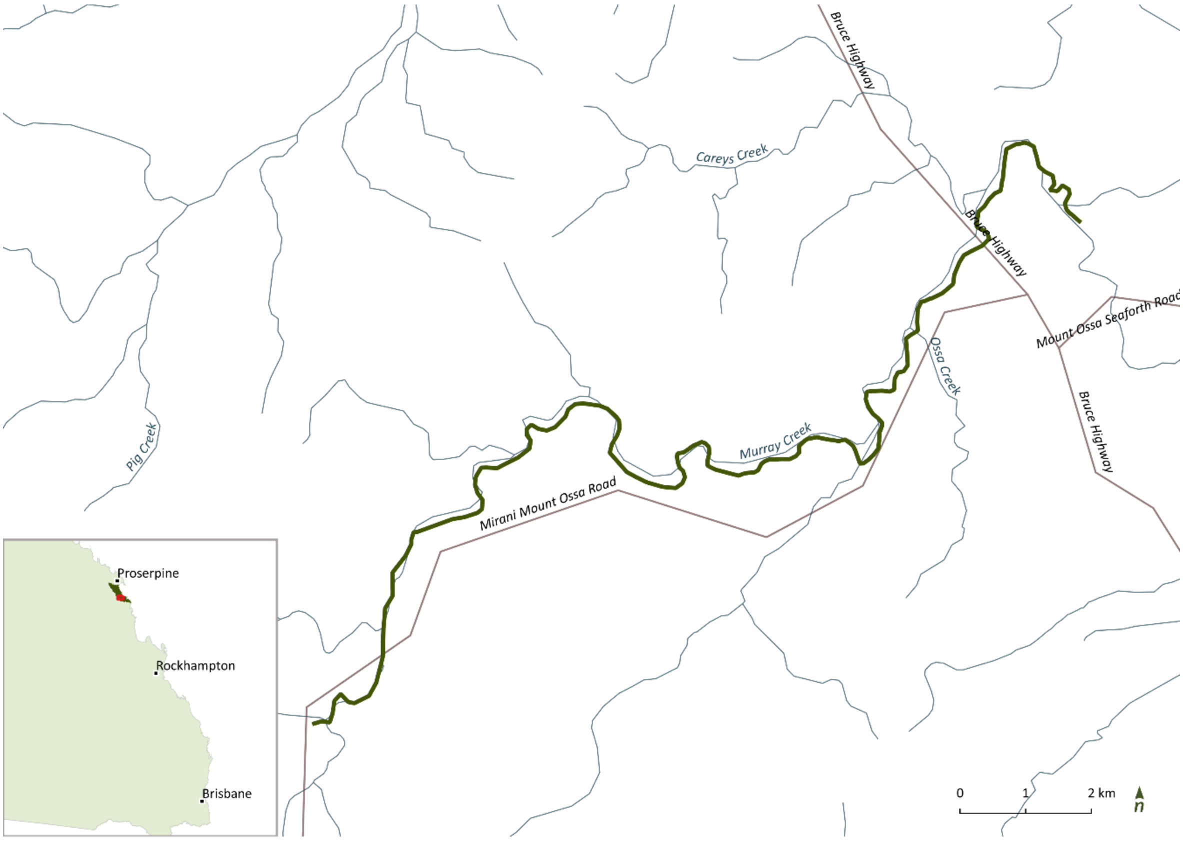


Figure 76. *The Murray Creek case study area.*

The case study area is shown in Figure 77, Figure 78 and Figure 79. Through this area Murray Creek flows through varying degrees of bedrock confinement. Within the upper portion of the case study area (upstream of chainage 10,000 m) there are expansive areas of terraces which sit 10-15 m above the channel bed. Within the terraces there are discontinuous floodplains between 50 -250 m in width (see cross-section 3 in Figure 80).

Through the mid zone the valley confinement increases (between chainage 6,000 m and 9,000m), and the channel is significantly confined by bedrock. Downstream of the confined section there are more expansive zones of inset floodplains between 300 -800 m wide (see cross-sections 1 and 2 in Figure 80). The downstream section of the case study area flows through estuarine plains (Figure 81).

Murray Creek is a gravel bed stream with abundant instream gravel deposits including bars and islands in the upper reaches of the case study area (see cross-section 3 in Figure 80). These gravel deposits form pool - riffles sequences within the stream (Figure 82 and Figure 84). In-channel bedrock exposures occur where the channel approaches the valley margins (Figure 83 and Figure 85). Within the lower estuarine portion there are sandy instream deposits.

Riparian longitudinal connectivity is generally poor and diminishes in a downstream direction. Remnant pockets of vegetation exist throughout the system but are particularly prevalent near the forested hillslope and within small inset floodplain units (where clearing was never undertaken). For the majority of the case study area riparian vegetation condition is poor. In many locations the bank condition is severely degraded, with steep, exposed and unstable bank slopes, particularly on outside bends which abut inset floodplain units (see Figure 82).

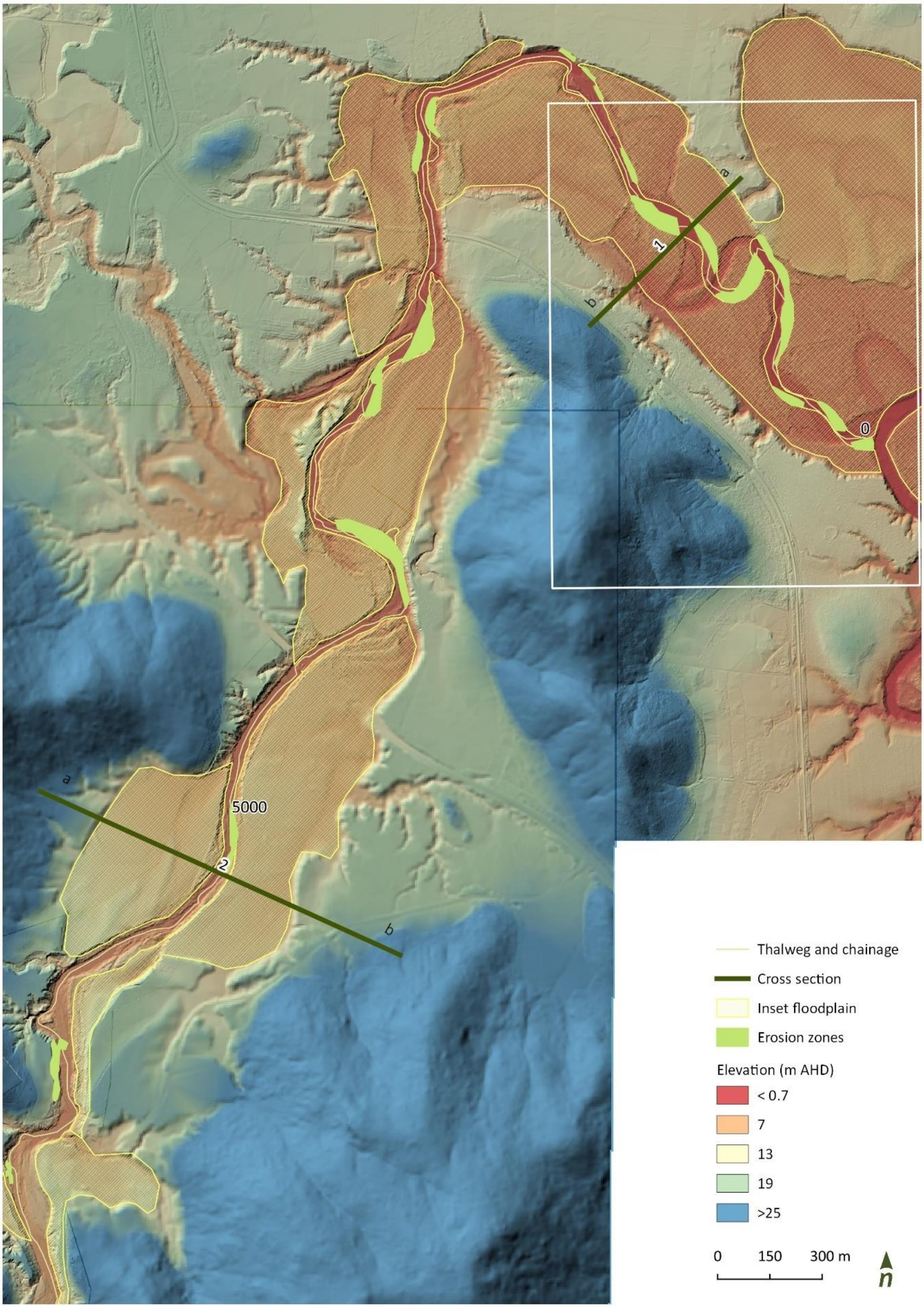


Figure 77. *The downstream portion of the Murray Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

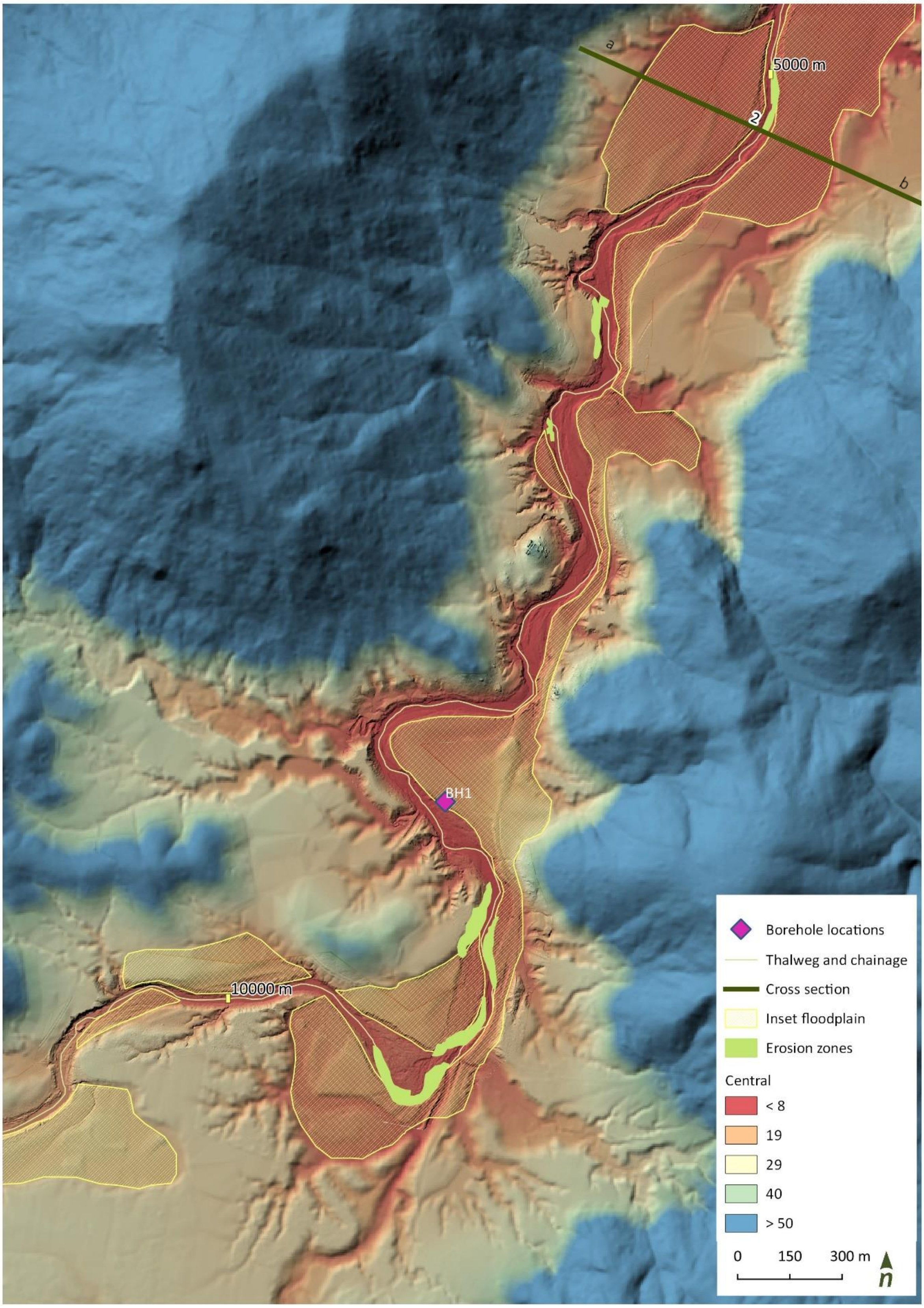


Figure 78. *The middle portion of the Murray Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

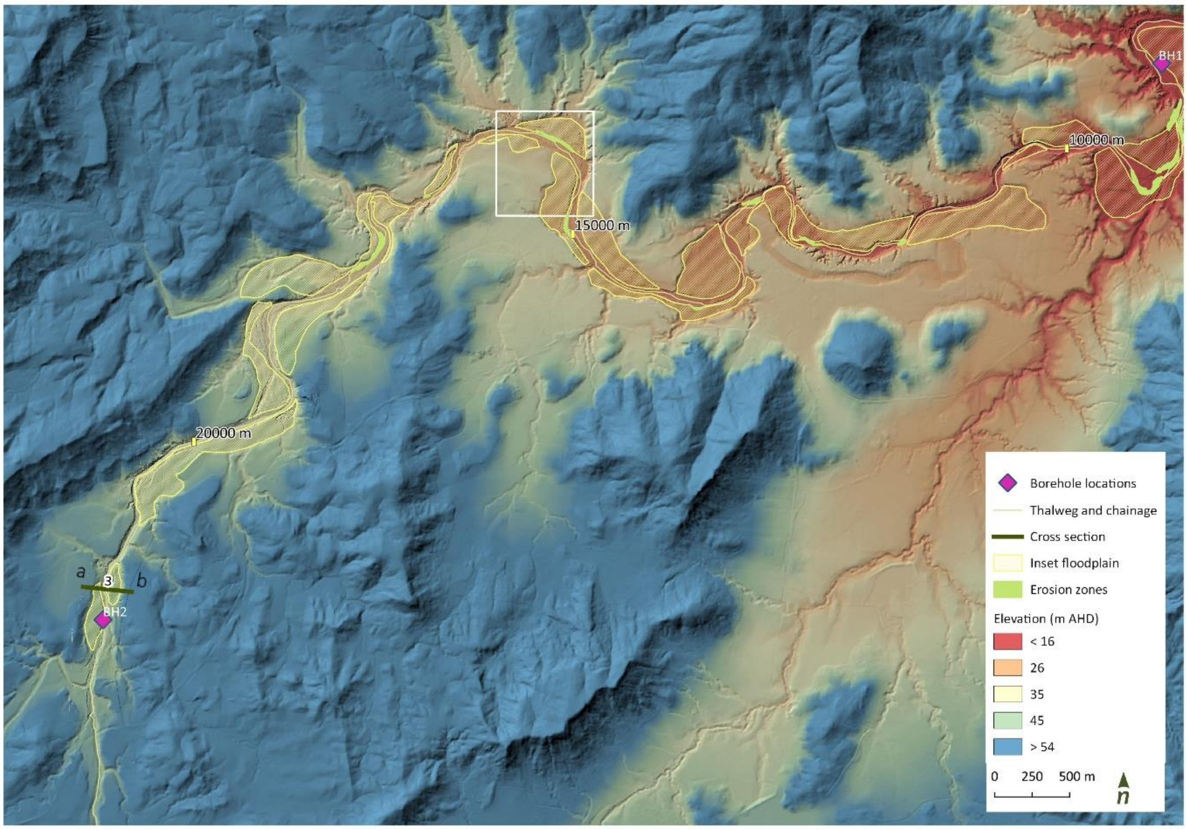


Figure 79. *The upper portion of the Murray Creek case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

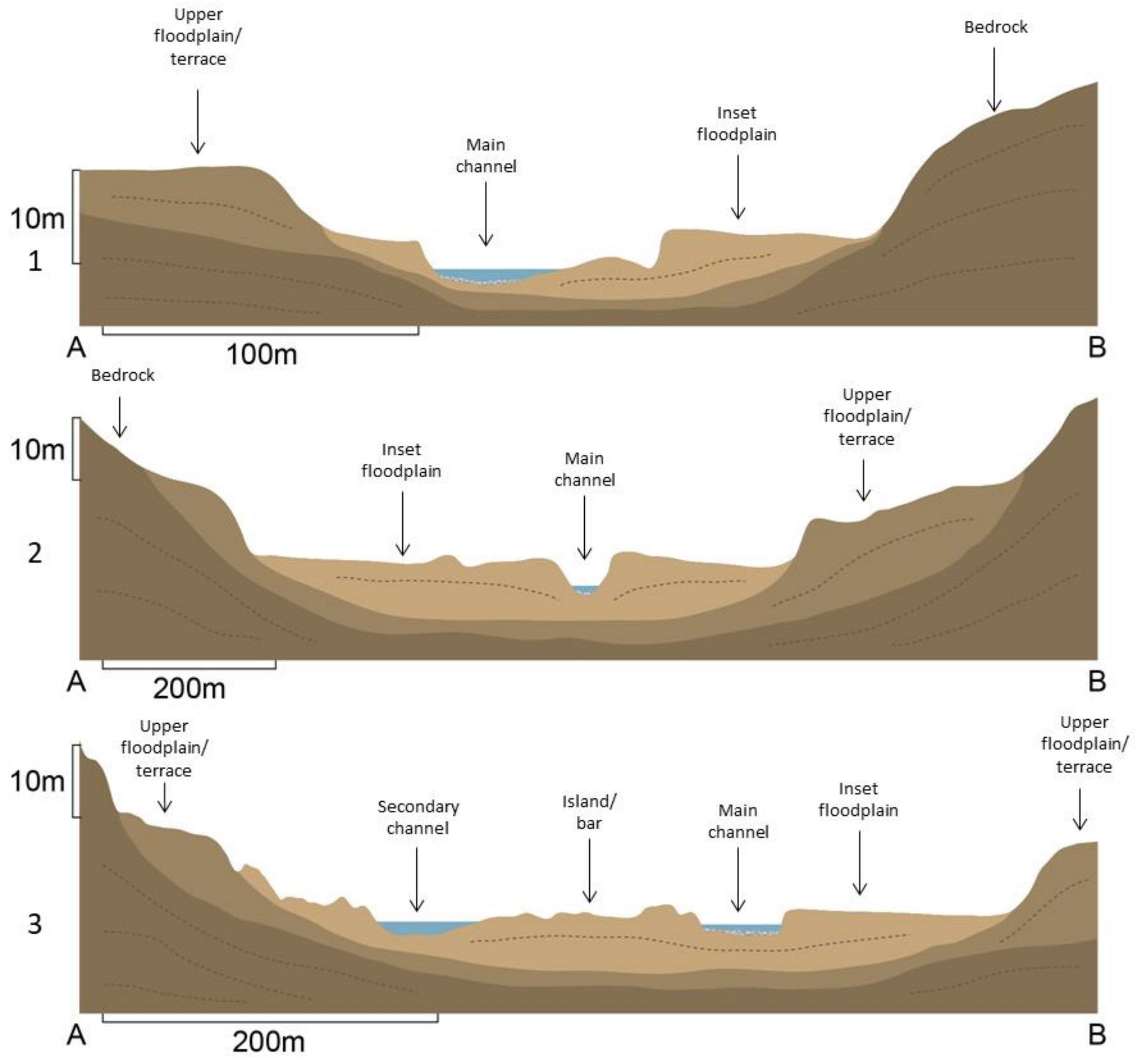


Figure 80. *The three typical sections within the Murray Creek case study area (shown in Figure 77, Figure 78 and Figure 79) with the key geomorphic units. Note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

Figure 81. *The downstream section of Murray Creek case study area within the estuary where the banks consist of estuarine muds and there are sandy instream deposits.*

Figure 82. *Section of Murray Creek downstream of the Bruce Highway*.

Figure 83. *Murray Creek through the bedrock-controlled section upstream of the Bruce Highway.*

Figure 84. *Bank attached gravel bar and associated riffles within Murray Creek.*

Figure 85. *Bedrock control within Murray Creek adjacent to the forested hillslopes*.

Geomorphic reaches

The Murray Creek study area consists of one Dynamic SedNet modelled link. There is significant variability in the geomorphic form of this case study area which includes a gently sloping tidal reach and steep bedrock controlled gorge. To improve Dynamic SedNet parametrisation the Murray Creek study reach has been split into ten reaches, primarily based on degree of confinement (Figure 86).

A summary of key hydro-geomorphic parameters for each of the ten reaches, is provided below. The reach extent and a representative cross-section with each reach is shown in Figure 87 to Figure 106. Key hydro-geomorphic parameters for each reach (based on LiDAR analysis and hydraulic modelling) are provided in Table 28 to Table 37

Key input parameters used in the Dynamic SedNet model for each link within the Murray Creek case study area are shown in Table 38. A summary of key hydro-geomorphic parameters for each of the ten reaches within the Murray Creek study area is provided in Table 39.

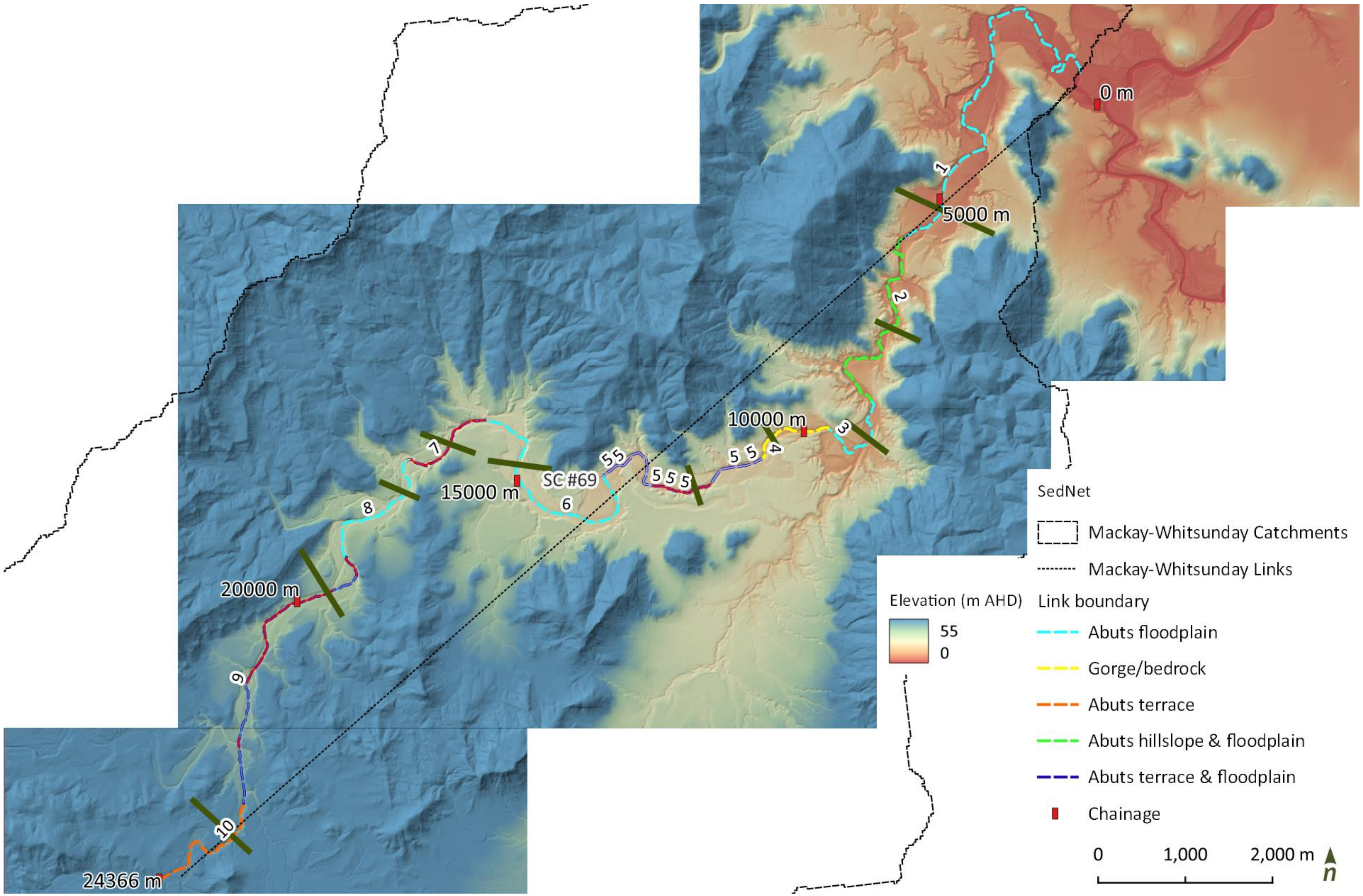


Figure 86. *Murray Creek case study area. Showing ten reaches. Dynamic SedNet sub-catchments are shown in black.*

Murry Creek Reach 1

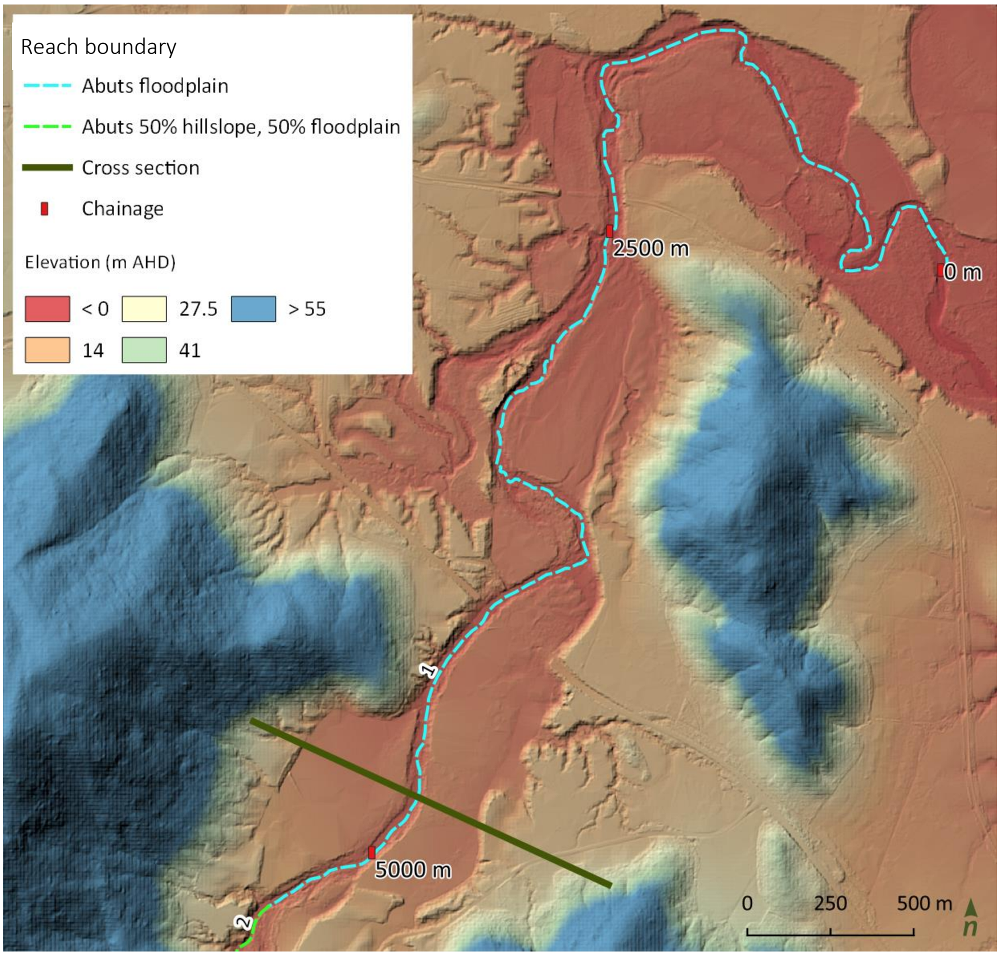


Figure 87. *Reach 1 within the Murray Creek study area.*

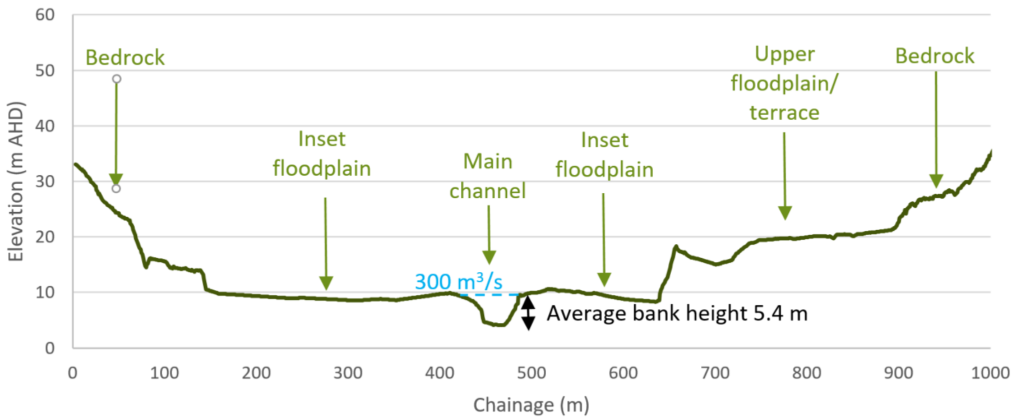


Figure 88. *Representative cross-section within the Murray Creek reach 1 (cross-section location shown in Figure 87).*

Table 28. Key hydro-geomorphic parameters – Murray Creek reach 1.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
1	300	0.0010	5366	65	5.4	Floodplain	High	135,520

Murry Creek Reach 2

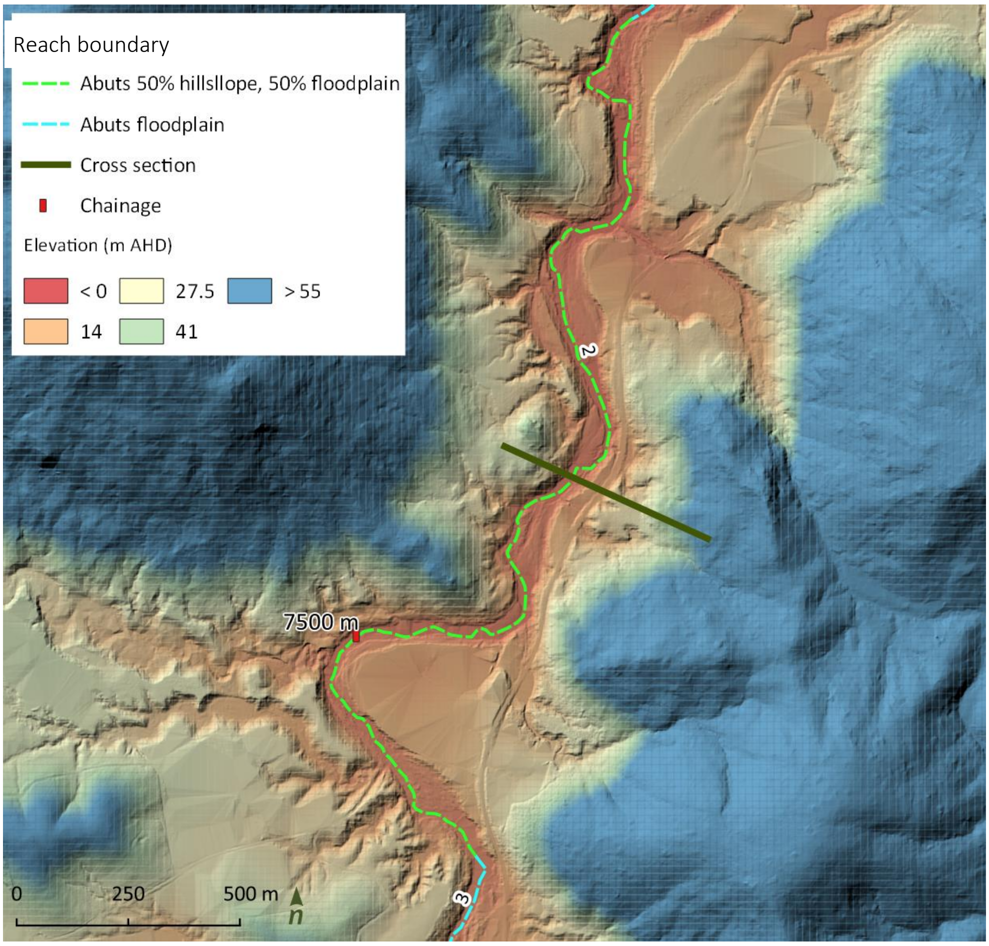


Figure 89. *Reach 2 within the Murray Creek study area.*

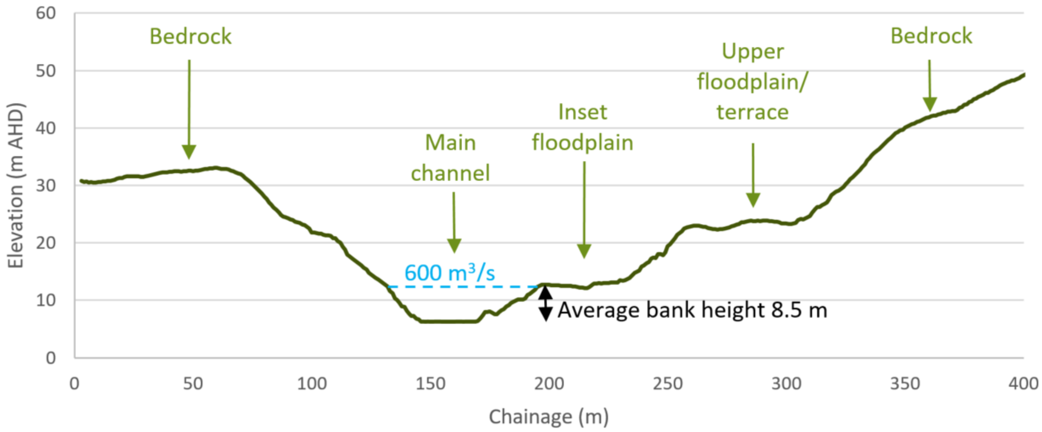


Figure 90. *Representative cross-section within the Murray Creek reach 2 (cross-section location shown in Figure 89).*

Table 29. Key hydro-geomorphic parameters – Murray Creek reach 2.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
2	600	0.0011	2805	47	8.5	50% hillslope, 50% floodplain	50% very low, 50% high	14,912

Murry Creek Reach 3

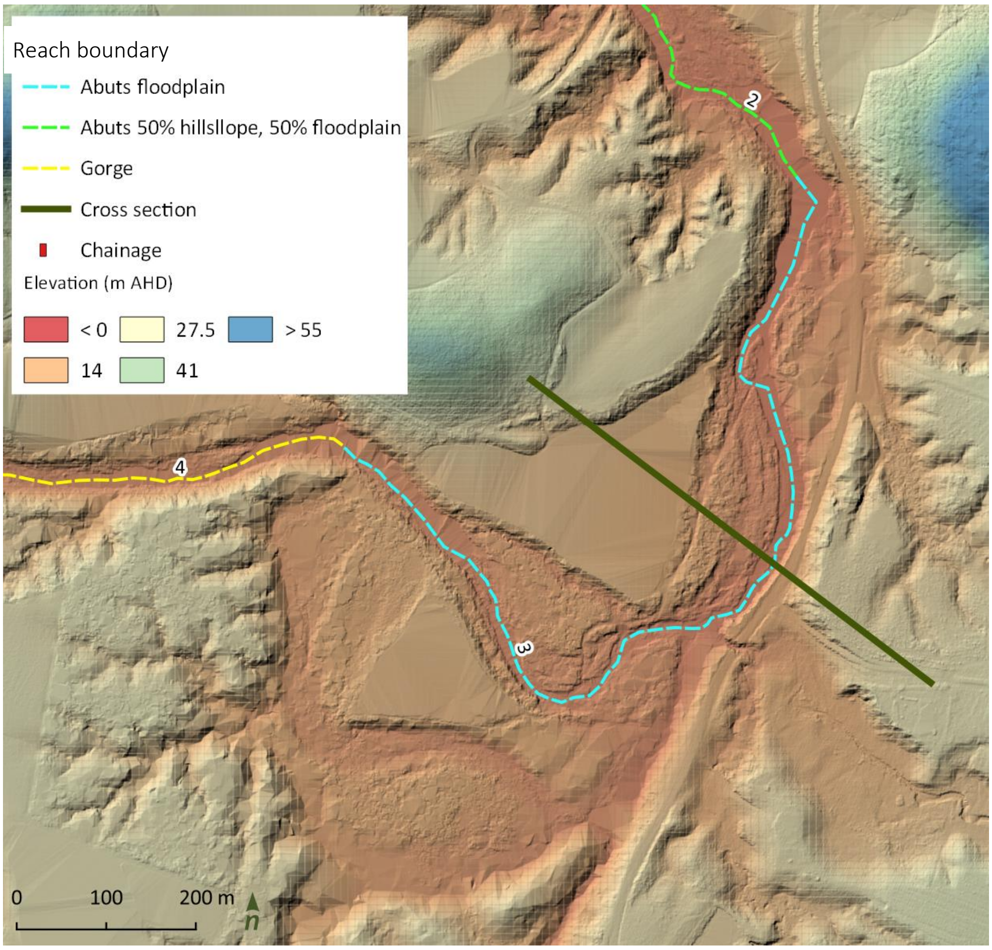


Figure 91. *Reach 3 within the Murray Creek study area.*

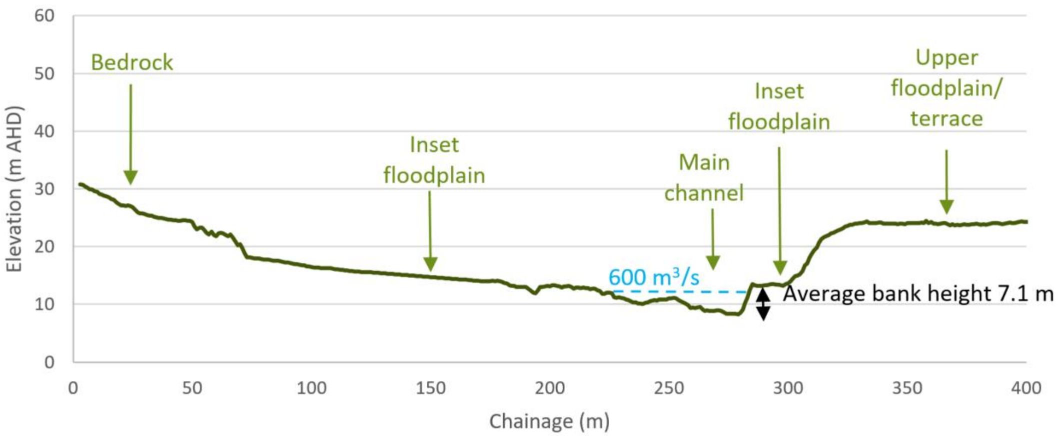


Figure 92. *Representative cross-section within the Murray Creek reach 3 (cross-section location shown in Figure 91).*

Table 30. Key hydro-geomorphic parameters – Murray Creek reach 3

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
3	600	0.0014	1197	59	7.1	Floodplain	High	44,942

Murry Creek Reach 4

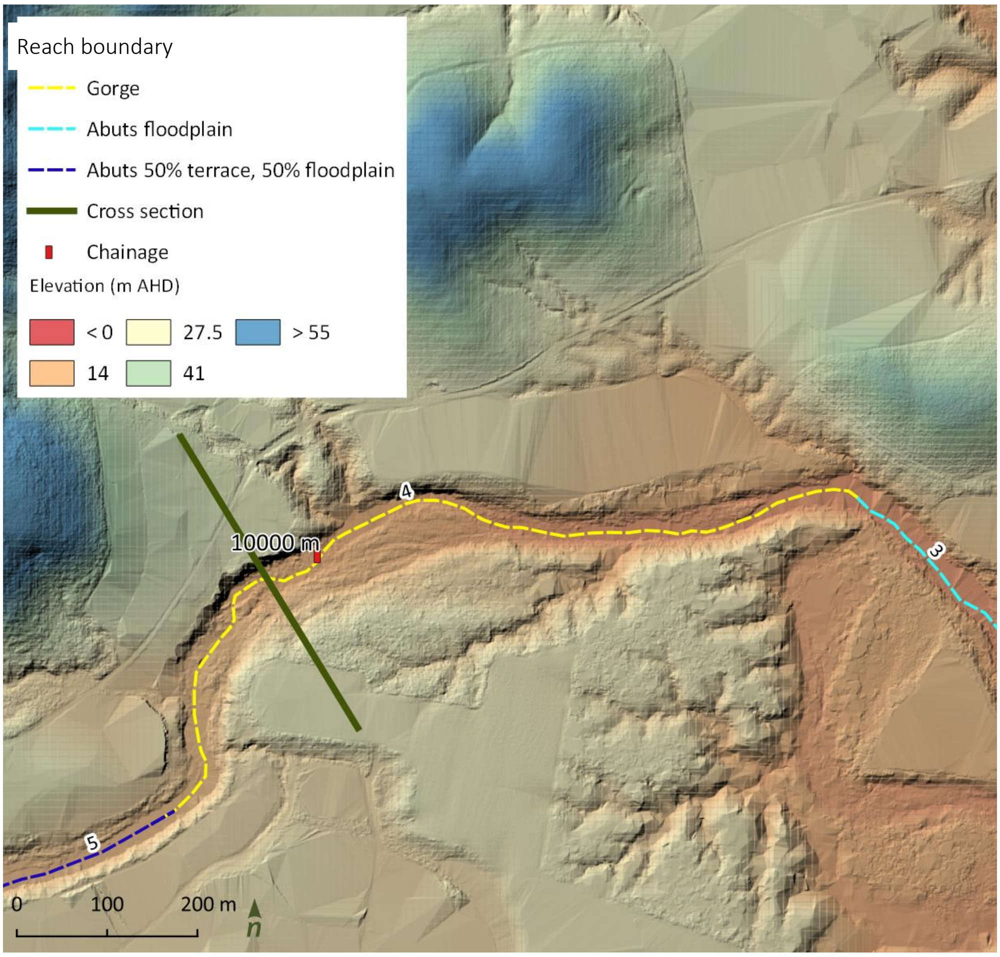


Figure 93. *Reach 4 within the Murray Creek study area.*

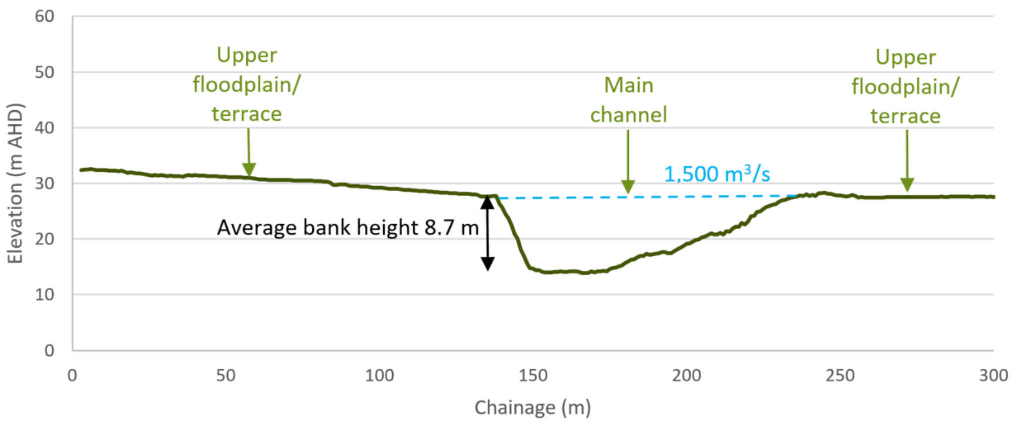


Figure 94. *Representative cross-section within the Murray Creek reach 4 (cross-section location shown in Figure 93).*

Table 31. Key hydro-geomorphic parameters – Murray Creek reach 4.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
4	1500	0.0058	1038	82	8.7	Gorge/bedrock	Very low	0

Murry Creek Reach 5

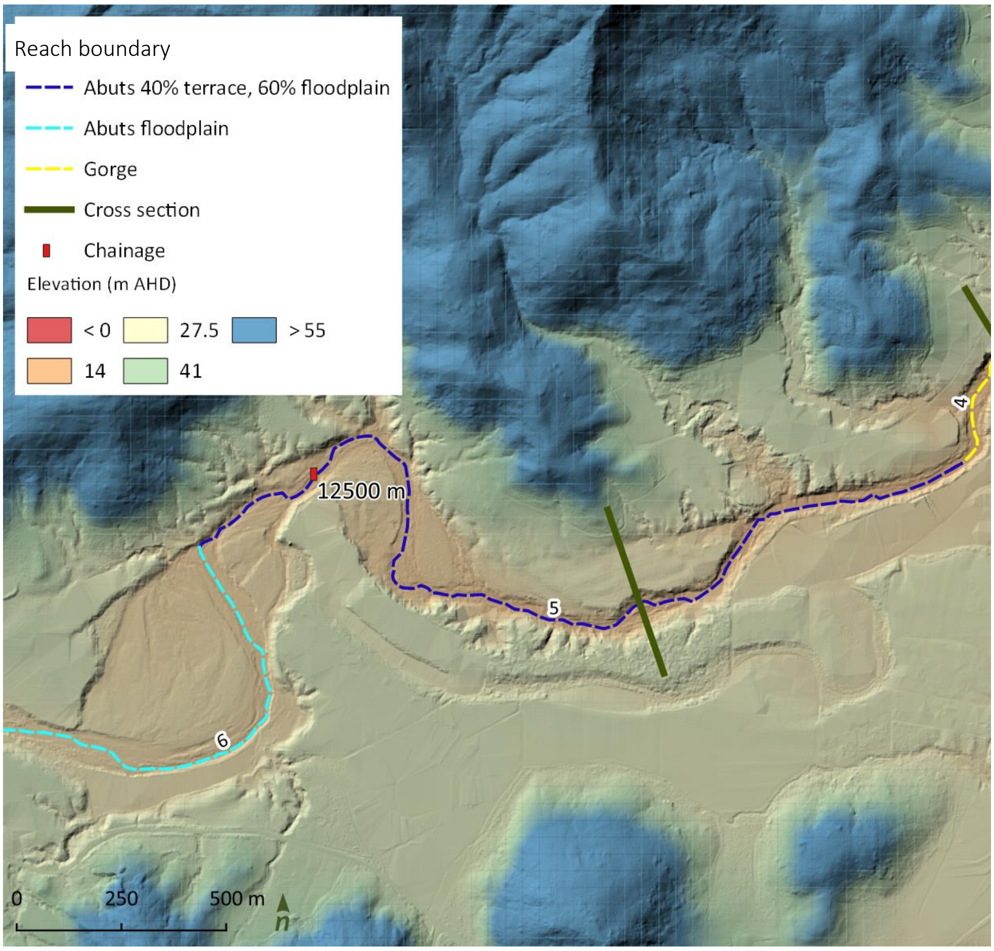


Figure 95. *Reach 5 within the Murray Creek study area.*

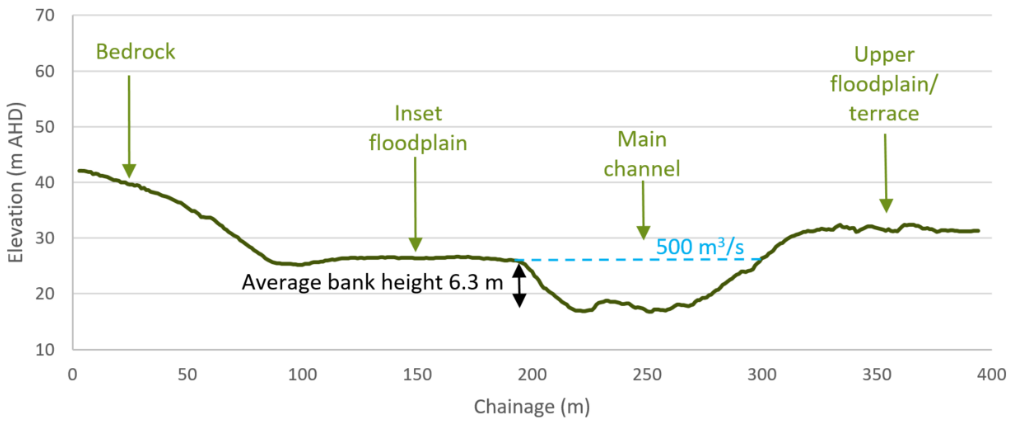


Figure 96. *Representative cross-section within the Murray Creek reach 5 (cross-section location shown in Figure 95).*

Table 32. Key hydro-geomorphic parameters – Murray Creek reach 5.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
5	500	0.0015	2511	57	6.3	40% terrace, 60% floodplain	40% low, 60% high	10,669

Murry Creek Reach 6

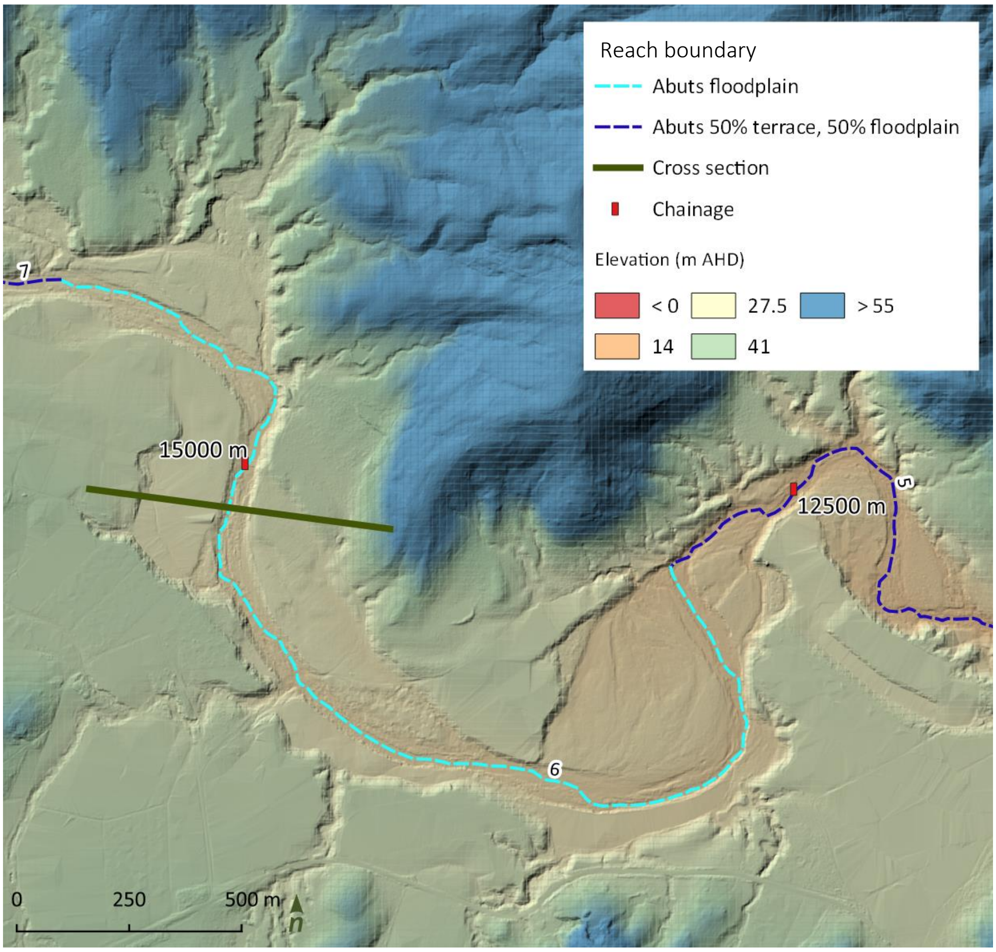


Figure 97. *Reach 6 within the Murray Creek study area.*

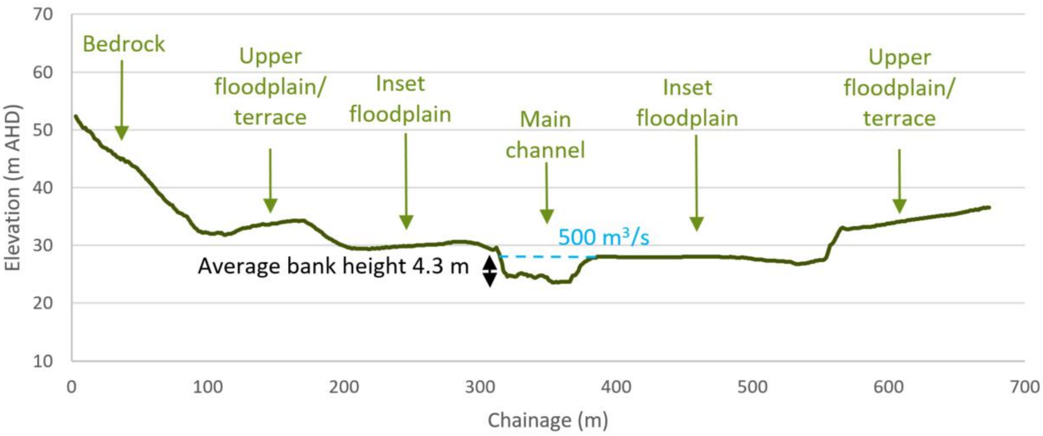


Figure 98. *Representative cross-section within the Murray Creek reach 6 (cross-section location shown in Figure 97).*

Table 33. Key hydro-geomorphic parameters – Murray Creek reach 6.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
6	500	0.0019	2886	61	4.3	Floodplain	High	22,990

Murry Creek Reach 7

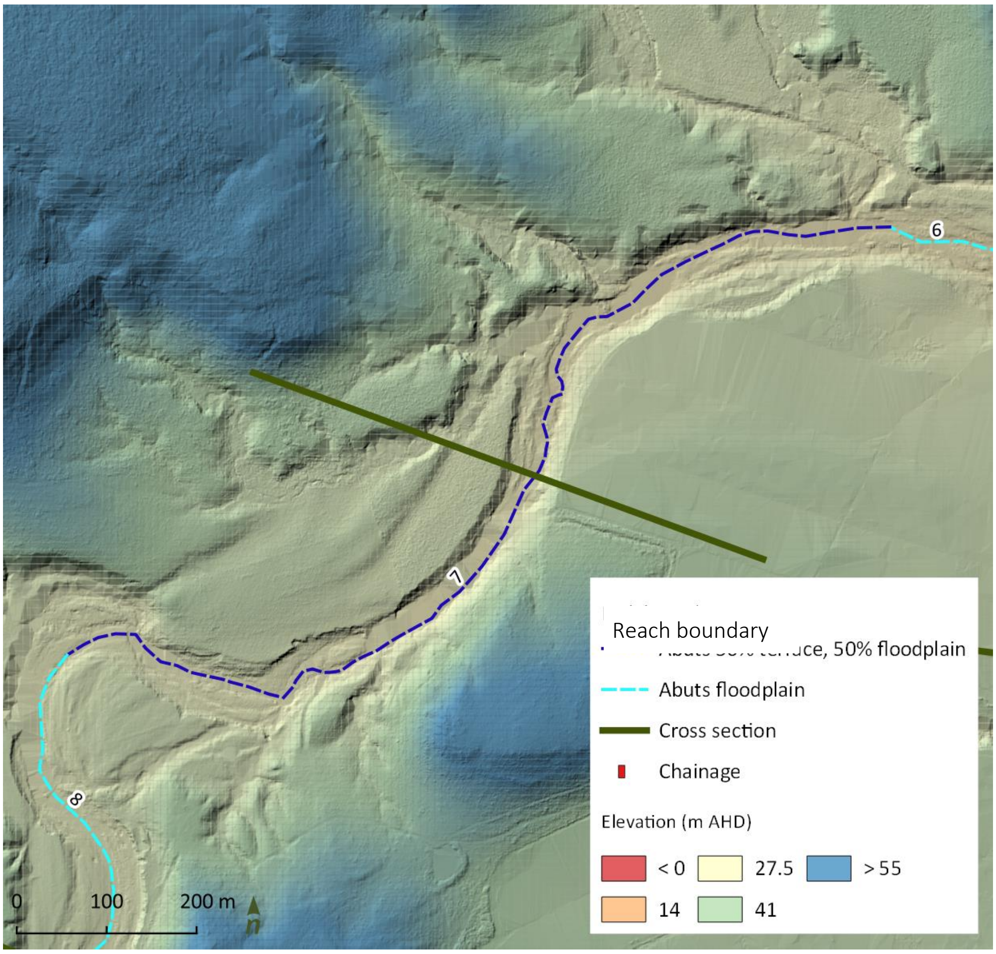


Figure 99. *Reach 7 within the Murray Creek study area.*

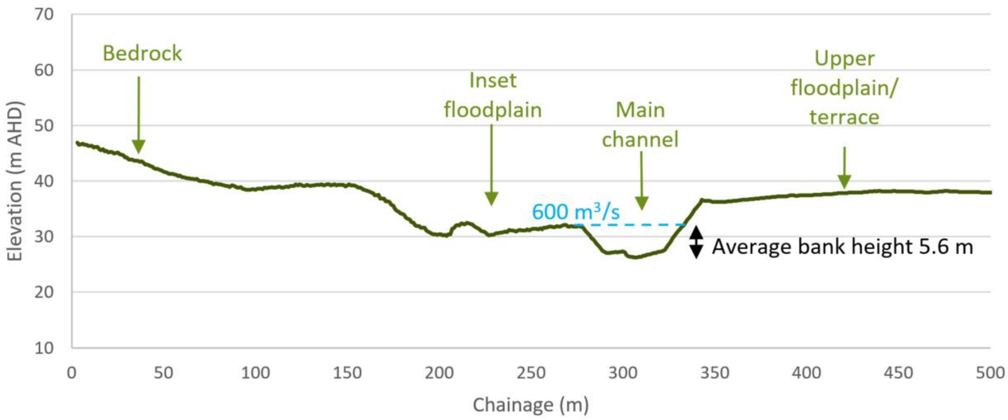


Figure 100. *Representative cross-section within the Murray Creek reach 7 (cross-section location shown in Figure 99).*

Table 34. Key hydro-geomorphic parameters – Murray Creek reach 7.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
7	600	0.0028	1226	69	5.6	50% terrace, 50% floodplain	50% low, 50% high	1,682

Murry Creek Reach 8

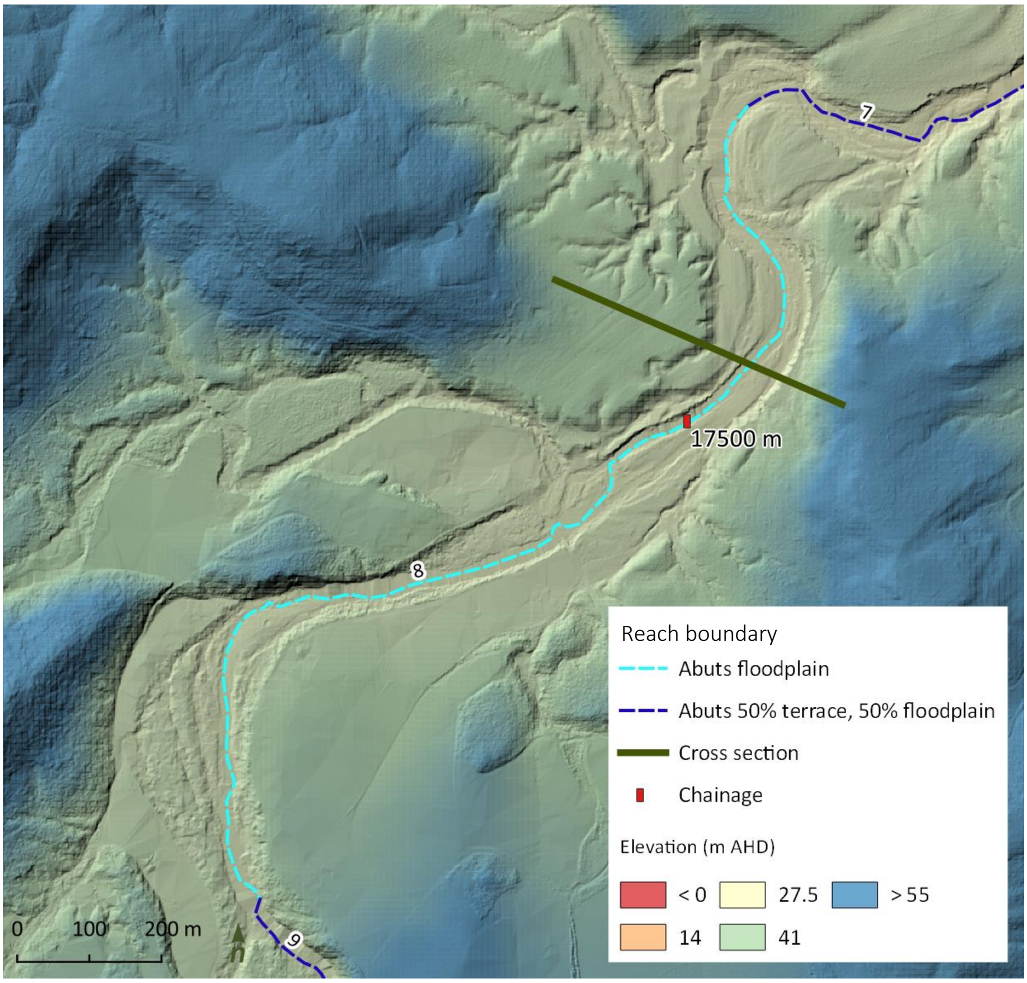


Figure 101. *Reach 8 within the Murray Creek study area.*

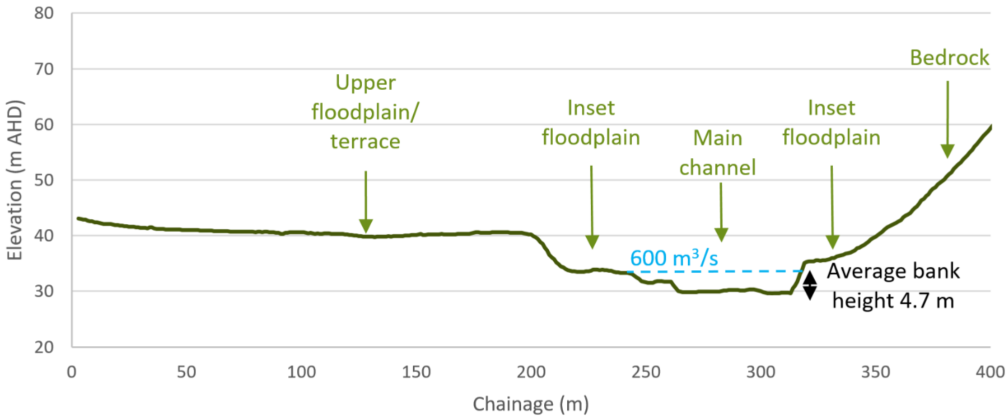


Figure 102. *Representative cross-section within the Murray Creek reach 8 (cross-section location shown in Figure 101).*

Table 35. Key hydro-geomorphic parameters – Murray Creek reach 8.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
8	600	0.0025	2309	69	4.7	Floodplain	High	11,250

Murry Creek Reach 9

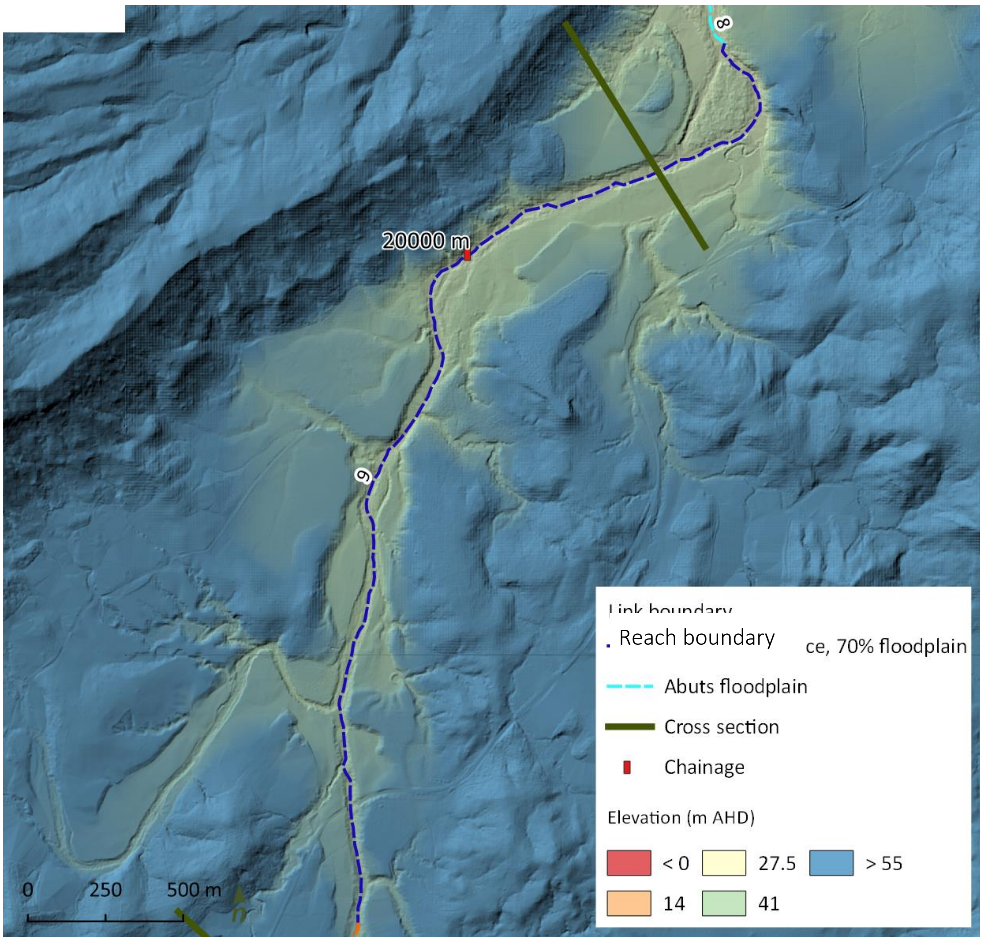


Figure 103. *Reach 9 within the Murray Creek study area.*

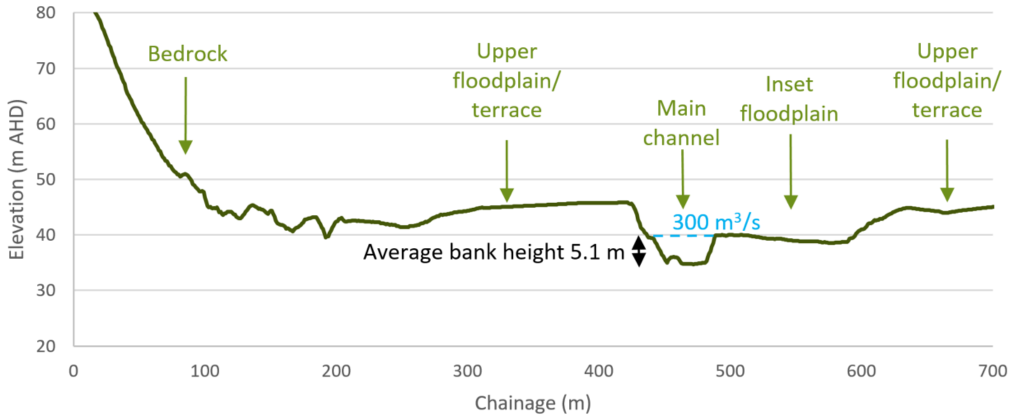


Figure 104. *Representative cross-section within the Murray Creek reach 9 (cross-section location shown in Figure 103).*

Table 36. Key hydro-geomorphic parameters – Murray Creek reach 9.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
9	300	0.0032	3102	97	5.1	30% terrace, 70% floodplain	30% low, 70% high	0

Murry Creek Reach 10

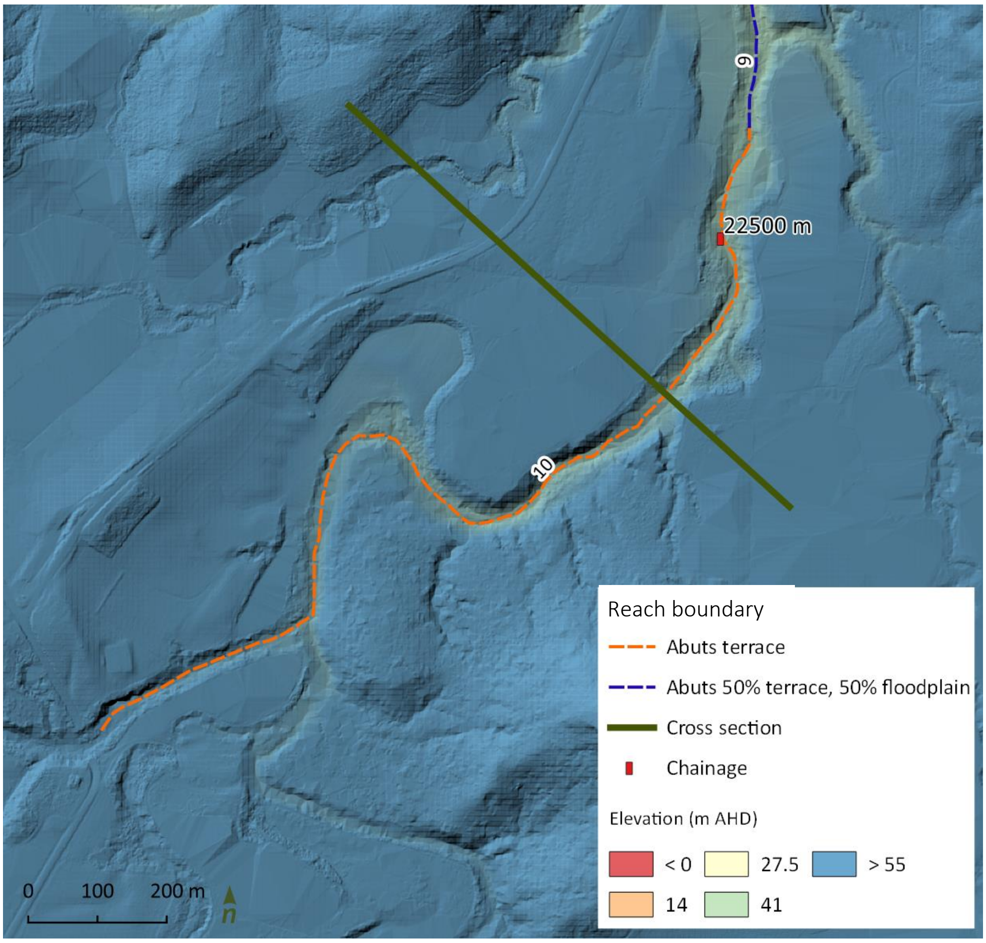


Figure 105. *Reach 10 within the Murray Creek study area.*

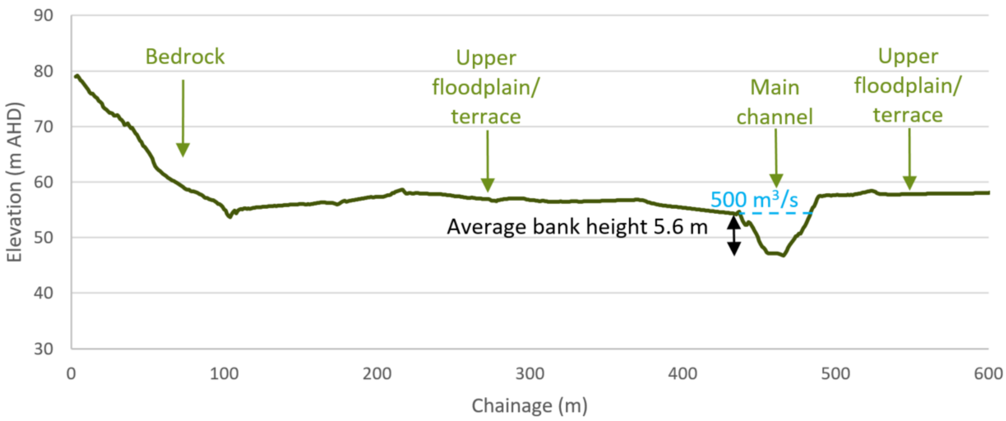


Figure 106. *Representative cross-section within the Murray Creek reach 10 (cross-section location shown in Figure 105).*

Table 37. Key hydro-geomorphic parameters – Murray Creek reach 10.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
10	500	0.0058	1642	66	5.6	Terrace	Low	- (no 2018 data)

Table 38. Dynamic SedNet Bank Erosion key input parameters – Murray Creek case study area.

Link (Sub-catchment)	Bank Full Flow (m^3/s)	Link Slope (m/m)	Link Length(m)	Channel Width (m)	Bank Height (m)	Riparian Vegetation Percentage (%)	Maximum Riparian Vegetation Effect. (%)	Stream bank material erodibility (%)	Bank Erosion Coeff.	SedNet sediment loss (m^3) (2009 – 2018)*
SC #69	400	0.00225	22894	35	5.9	63	95	93	0.000035	176,848

*Note: in 2018 Dynamic SedNet data was only available from January to June.

Table 39. Summary of hydro-geomorphic parameters - Murray Creek case study area.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018) LiDAR	Sediment mobilised **per km (m^3/km) (2009 – 2018)**
1	300	0.0010	5366	65	5.4	Floodplain	High	135,520	25,255
2	600	0.0011	2805	47	8.5	50% hillslope, 50% floodplain	50% very low, 50% high	14,912	5,316
3	600	0.0014	1197	59	7.1	Floodplain	High	44,942	37,546
4	1500	0.0058	1038	82	8.7	Gorge/bedrock	Very low	0	0
5	500	0.0015	2511	57	6.3	40% terrace, 60% floodplain	40% low, 60% high	10669	4,249
6	500	0.0019	2886	61	4.3	Floodplain	High	22,990	7,966
7	600	0.0028	1226	69	5.6	50% terrace, 50% floodplain	50% low, 50% high	1,682	1,372
8	600	0.0025	2309	69	4.7	Floodplain	High	11,250	4,872
9	300	0.0032	3102	97	5.1	30% terrace, 70% floodplain	30% low, 70% high	0	0
10	500	0.0058	1642	66	5.6	Terrace	Low	- (no 2018 data)	- (no 2018 data)

5.6 O'Connell River

Overview

The O'Connell River case study extends for 17 kilometres, from the Horse Creek confluence to the Andromache River confluence, just upstream of the Bruce Highway (Figure 107). The floodplains along this reach support sugarcane cultivation however there are also some small areas used for grazing.

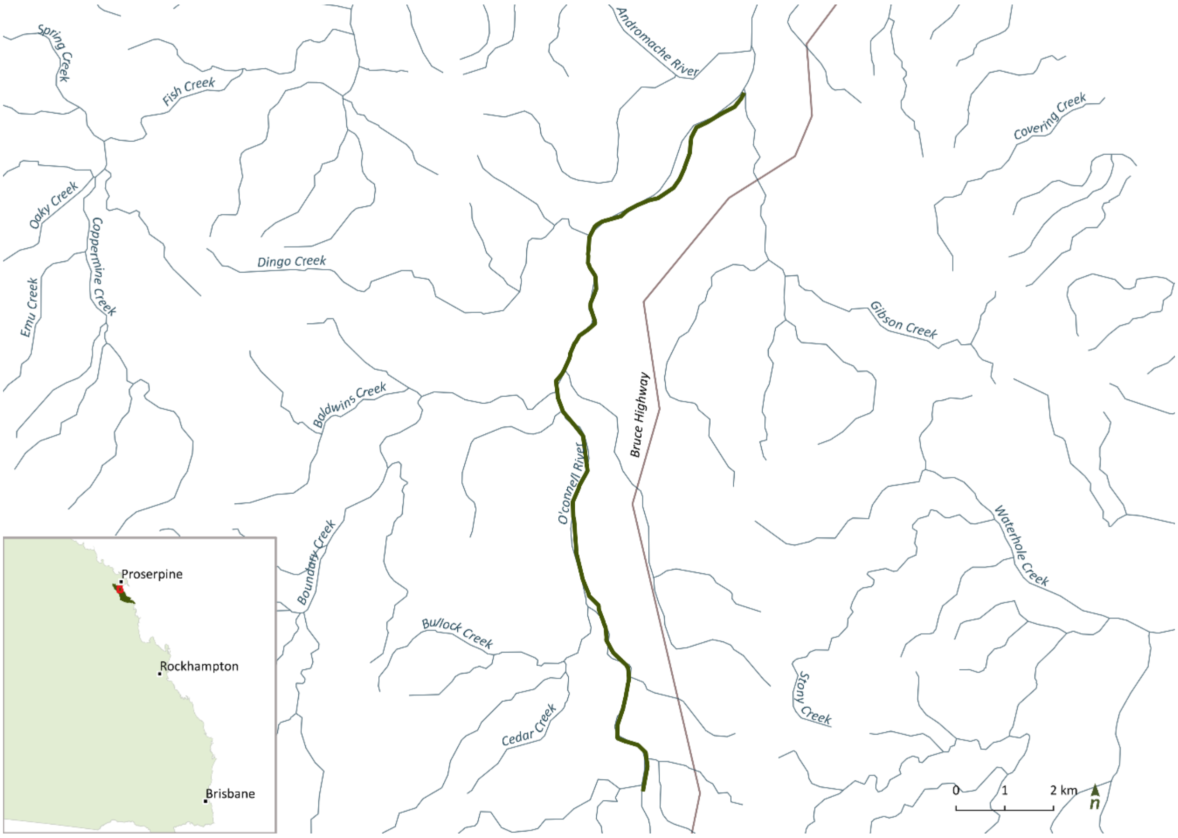


Figure 107. *The O'Connell River case study area.*

The case study area is shown in Figure 110 and Figure 111. The upper portion of the case study area (i.e. upstream of chainage 8,000 m) flows through alluvial valley approximately two kilometres in width. The alluvial development includes:

- Fill terrace units which sit 12-15 m above the channel bed, comprised of a red sandy clay (Figure 108).
- Inset floodplain and bench units which sit 3-6 m above the channel bed, comprised of silts, sands, gravels and cobbles (Figure 109).

The inset floodplain units are 200-500 m in width with terraces forming the majority of the alluvial development (see cross-section 3 in Figure 112). Within this section the low sinuosity channel can abut either bedrock, terrace or inset floodplain units.

Approximately 200 m downstream of the Boundary Creek confluence the channel is constricted by both terrace units and bedrock for approximately 3 km (i.e. between chainage 5,000 m and 8,000 m: see cross-section 2 in Figure 112). Within this zone there is very limited inset floodplain development, however there is isolated inset bench development.

Downstream of the Dingo Creek confluence the O'Connell River emerges into a broader zone of inset floodplain development (i.e. downstream of chainage 5,000 m – see cross-section 1 in Figure 112). Within this section the inset floodplains are typically 300 -500 m wide before confining significantly near the Andromache River confluence.

Throughout the case study area there is a low sinuosity gravel-to-cobble bed channel with some isolated bedrock control. Within the channel are extensive bars which form riffles through the system (Figure 113). Downstream of Dingo Creek confluence as the channel emerges from the confinement there is widespread channel aggradation. The aggradation predominately consists of gravels and cobbles. The O'Connell River transitions to predominantly sandy bed system closer to its mouth.

Figure 108. *Looking across at the left bank immediately upstream of the Boundary Creek confluence – terrace to the left of the image and inset floodplain to the right.*

Figure 109. *Looking downstream along the right bank located 1.5 km upstream of the Boundary Creek confluence. Site is subject to meander migration.*

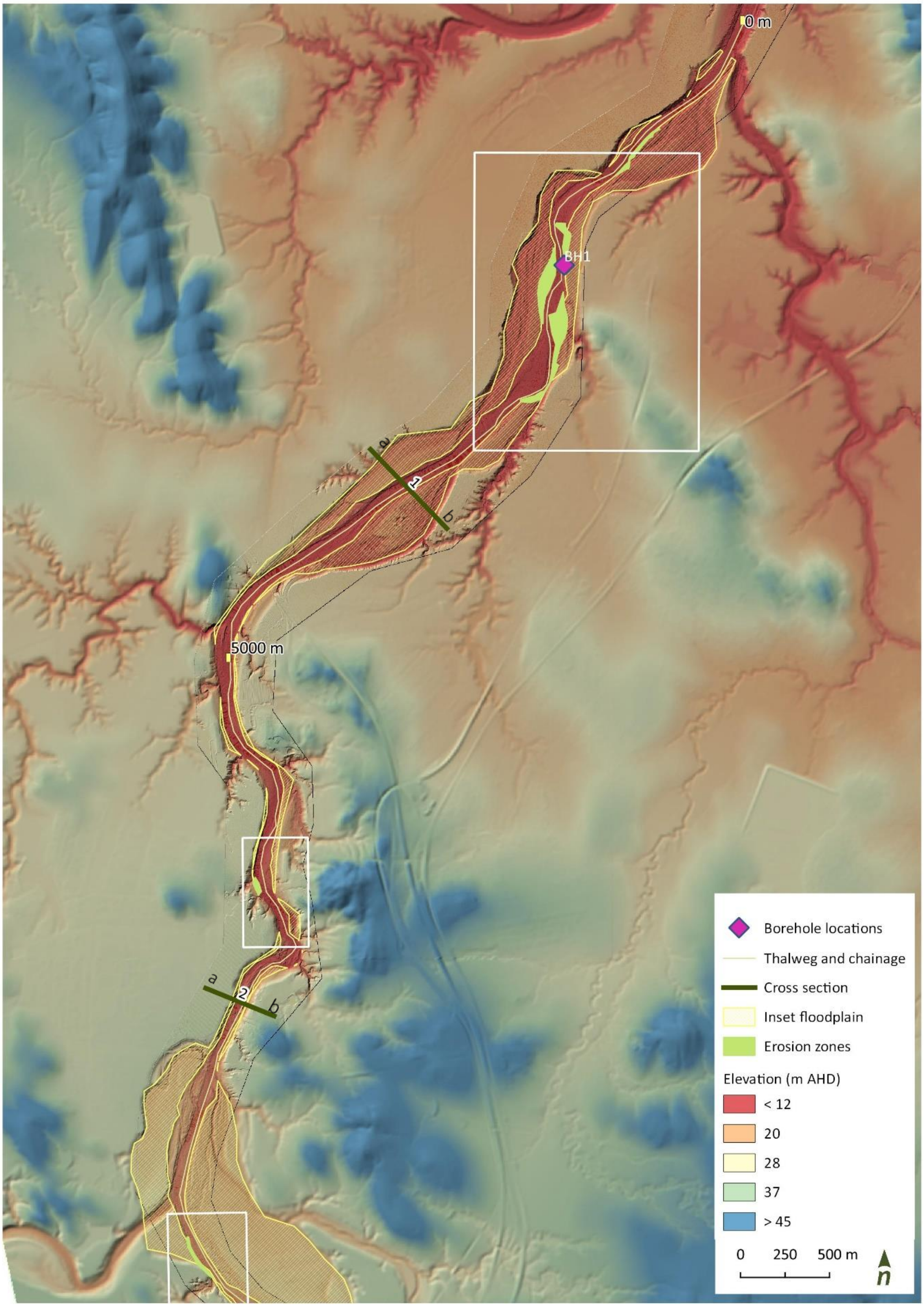


Figure 110. *The downstream portion of the O'Connell River case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

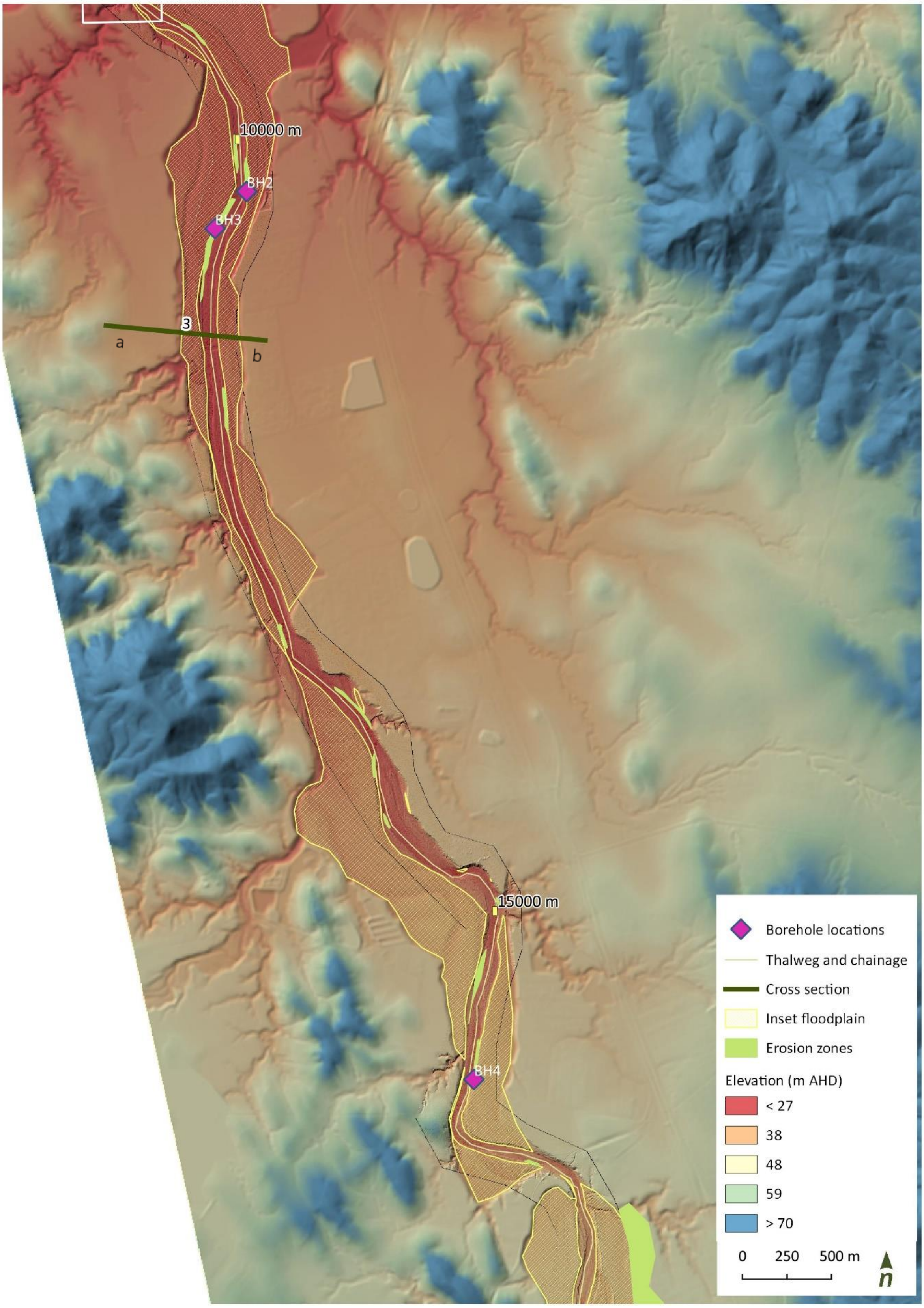


Figure 111. *The upstream portion of the O'Connell River case study showing elevation, inset floodplains, erosion areas and representative cross section locations.*

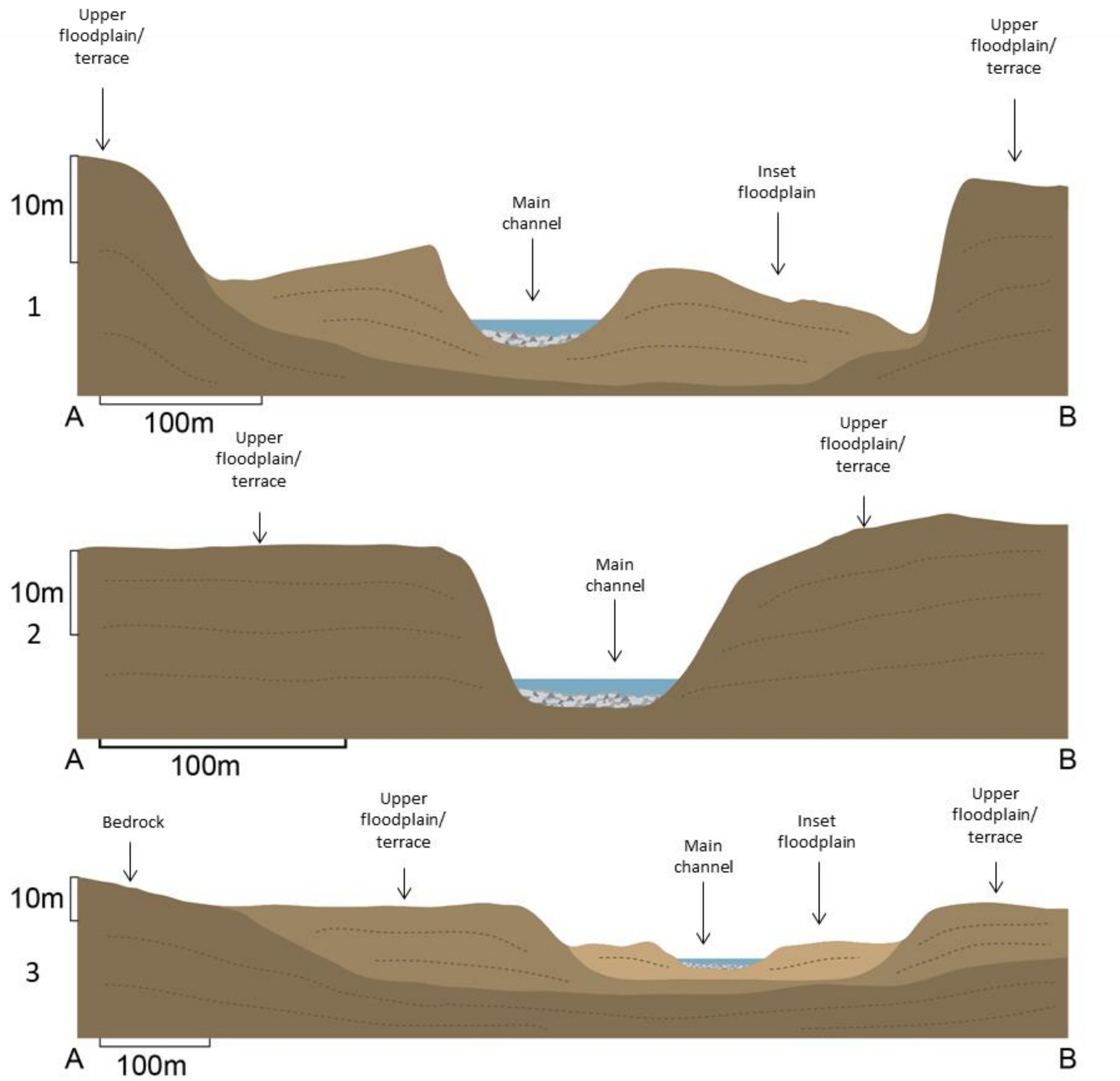


Figure 112. *The three typical sections within the O'Connell River case study area (shown in Figure 110 and Figure 111) with the key geomorphic units. Note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

Figure 113. *Looking across at the right bank upstream of the Boundary Creek confluence where there are abundant instream gravels.*

Riparian vegetation through the case study area is poor, typically ranging from narrow bands of woody vegetation along the channel margins to no woody vegetation. However, there are some more extensive pockets of remnant vegetation within small inset floodplain units and within drainage lines (where clearing was never undertaken).

Geomorphic reaches

The O'Connell River study area consists of three Dynamic SedNet modelled links. The two downstream Dynamic SedNet links align relatively well with the geomorphic features within the study reach. However, there is significant variability in the geomorphic form across the link for SC #46. To improve Dynamic SedNet parametrisation the O'Connell River study reach has been split into seven reaches, primarily based on degree of confinement (Figure 114).

A summary of key hydro-geomorphic parameters for each of the seven reaches is provided below. The reach extent and a representative cross-section with each reach is shown in Figure 115 to Figure 128. Key hydro-geomorphic parameters for each reach (based on LiDAR analysis and hydraulic modelling) are provided in Table 40 to Table 46.

Key input parameters used in the Dynamic SedNet model for each link within the O'Connell River case study area are shown in Table 47. A summary of key hydro-geomorphic parameters for each of the seven reaches within the O'Connell River study area is provide in Table 48.

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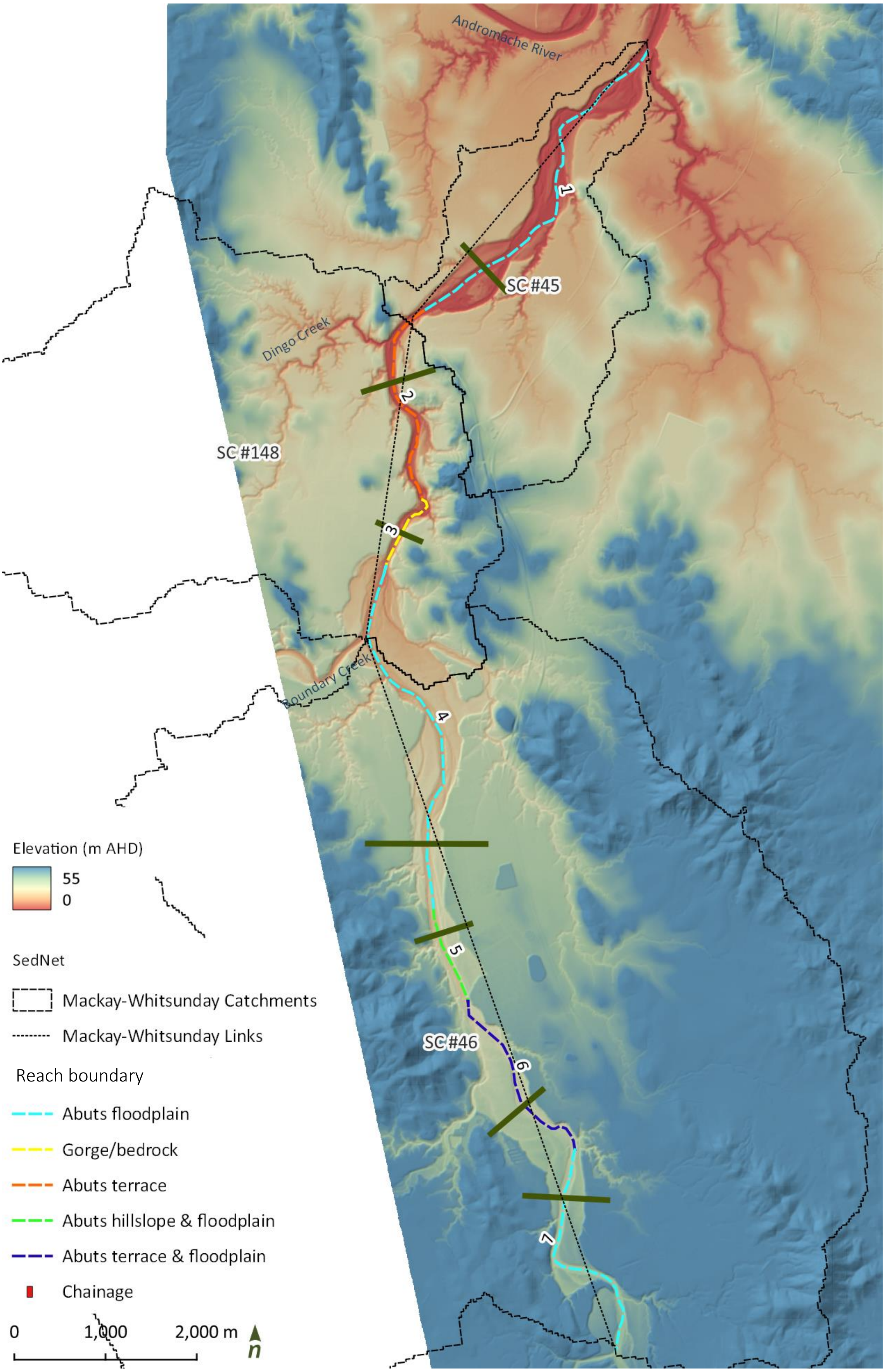

Figure 114. *O'Connell River case study area. Showing 7 reaches. Dynamic SedNet sub-catchments are shown in black.*

O'Connell River Reach 1

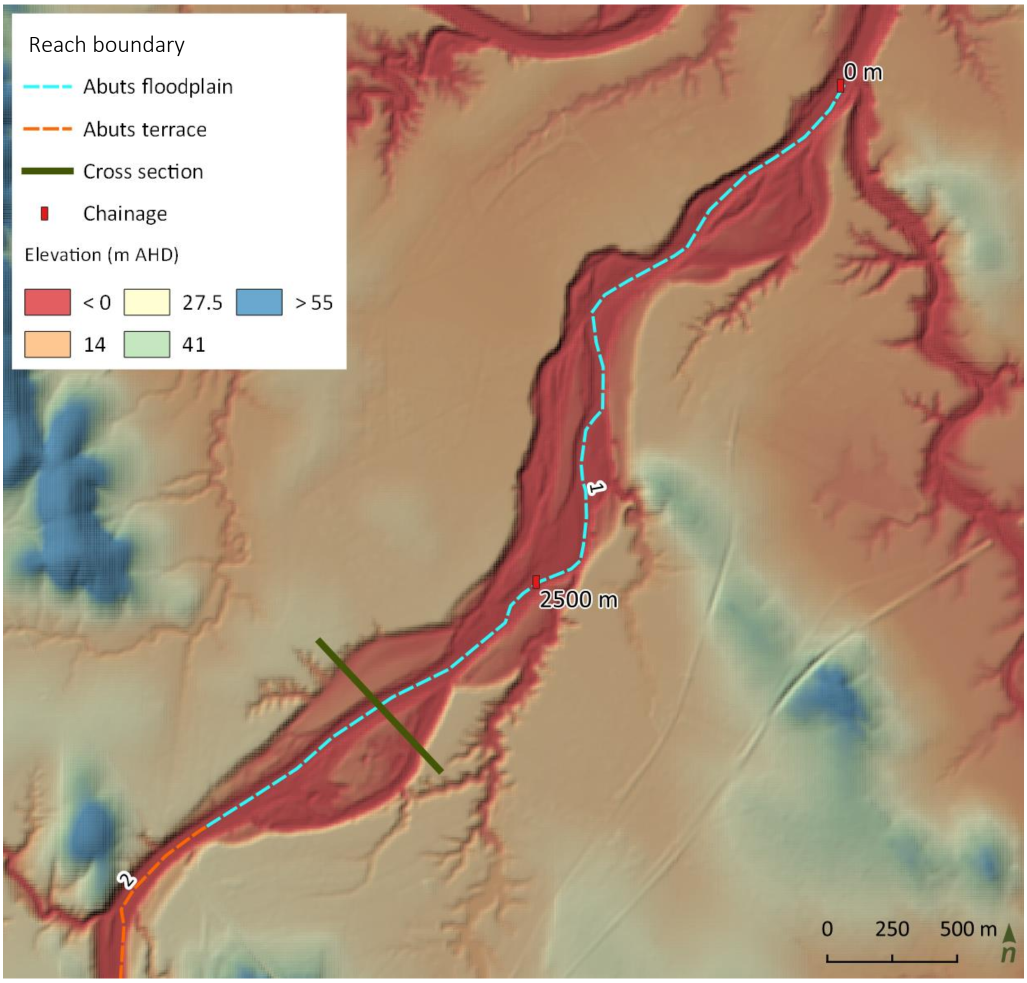

Figure 115. *Reach 1 within the O'Connell River study area.*

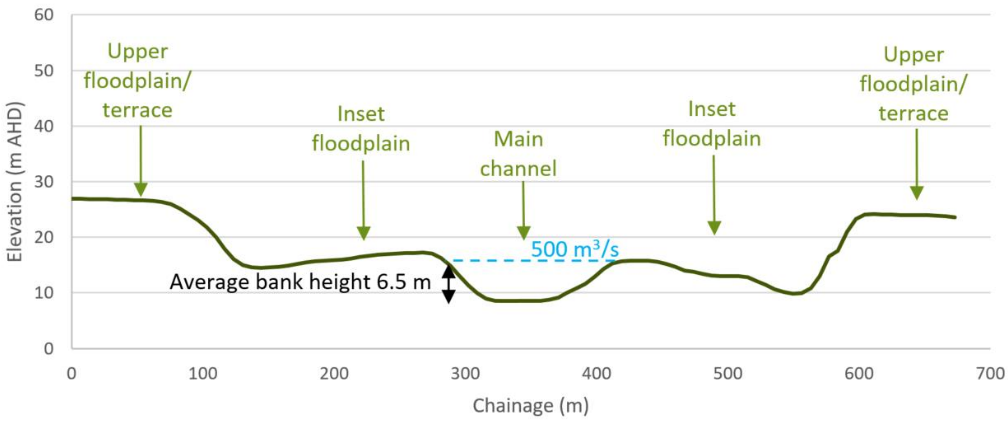

Figure 116. *Representative cross-section within the O'Connell River reach 1 (cross-section location shown in Figure 115).*

Table 40. Key input parameters – O'Connell River reach 1.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
1	500	0.0014	4119	61	6.5	Floodplain	High	175,652

O'Connell River Reach 2

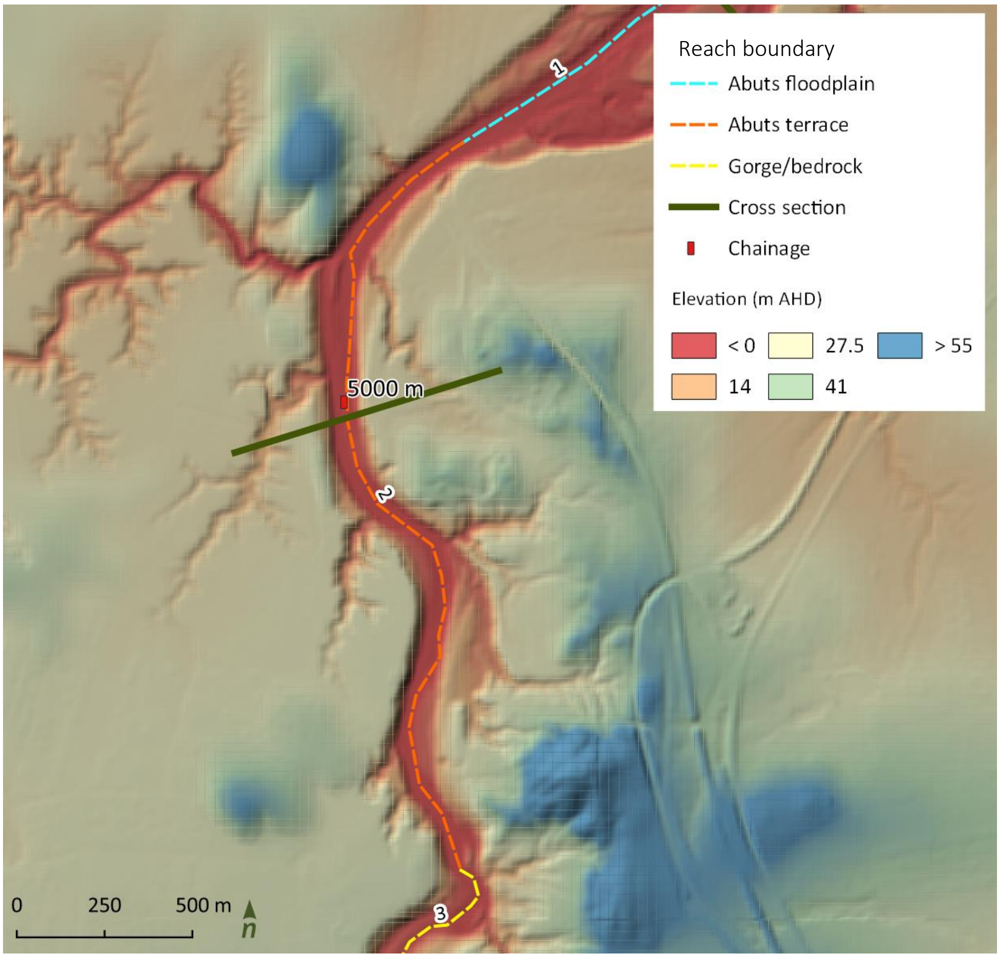

Figure 117. *Reach 2 within the O'Connell River study area.*

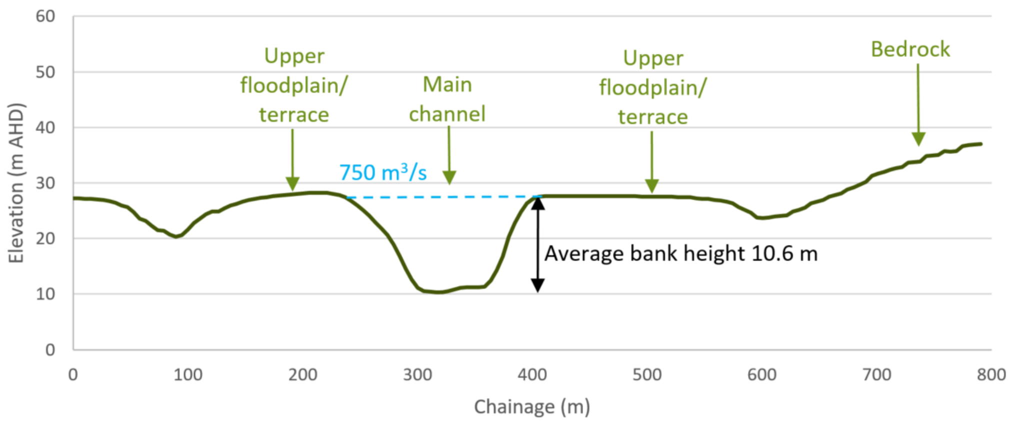

Figure 118. *Representative cross-section within the O'Connell River reach 2 (cross-section location shown in Figure 117).*

Table 41. Key input parameters – O'Connell River reach 2.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
2	750	0.0006	2371	126	10.6	Terrace	Low	19,084

O'Connell River Reach 3

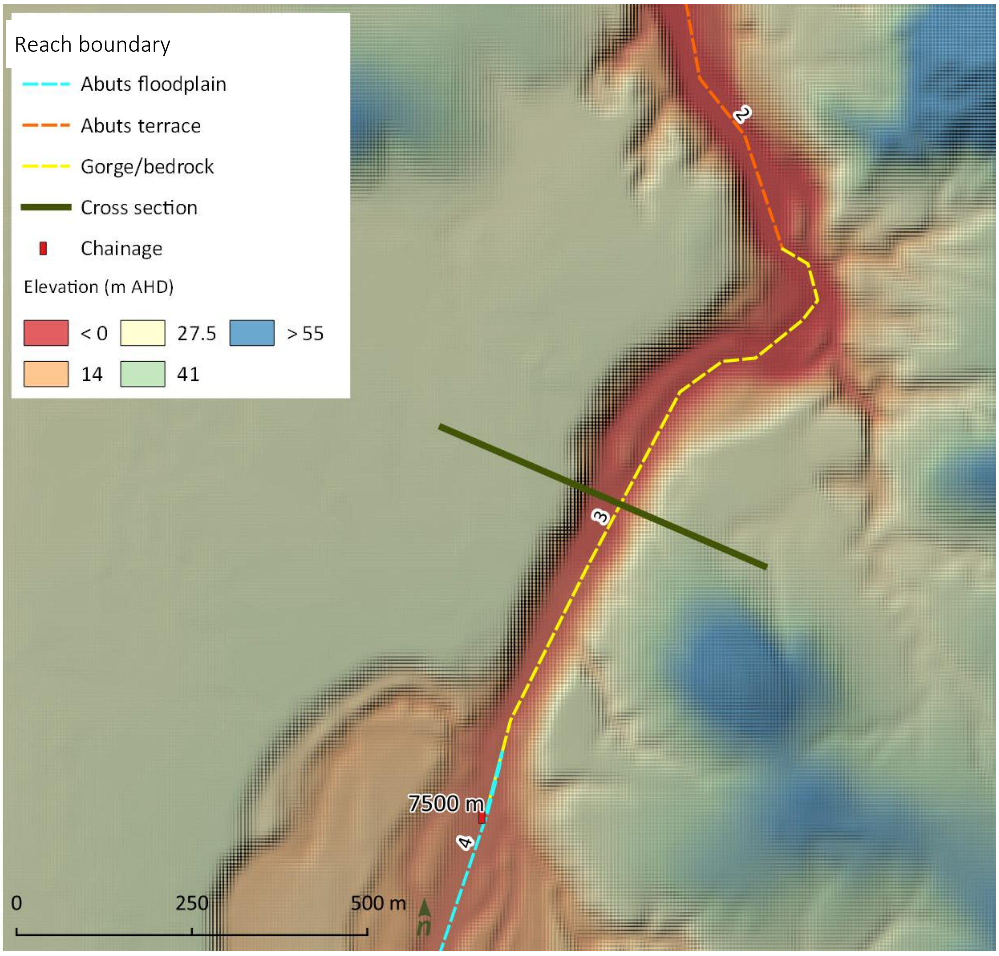

Figure 119. *Reach 3 within the O'Connell River study area.*

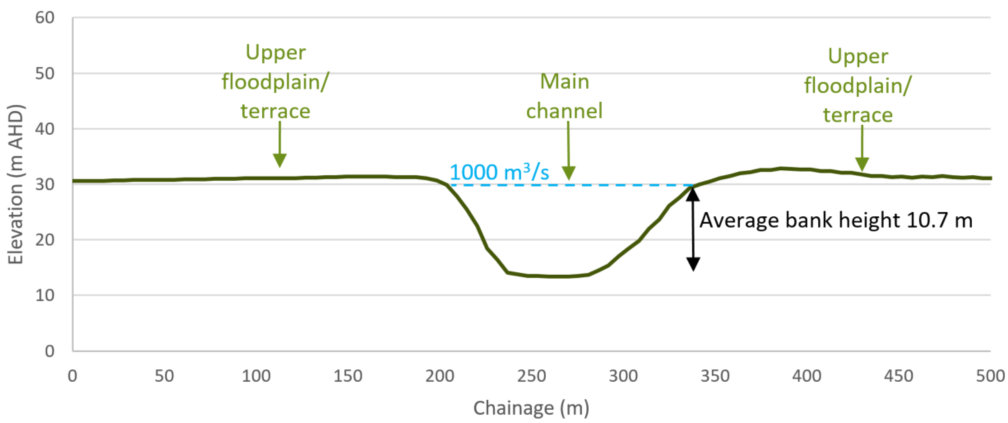

Figure 120. *Representative cross-section within the O'Connell River reach 3 (cross-section location shown in Figure 119).*

Table 42. Key input parameters – O'Connell River reach 3.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
3	1000	0.0046	1001	114	10.7	Gorge/bedrock	Very low	0

O'Connell River Reach 4

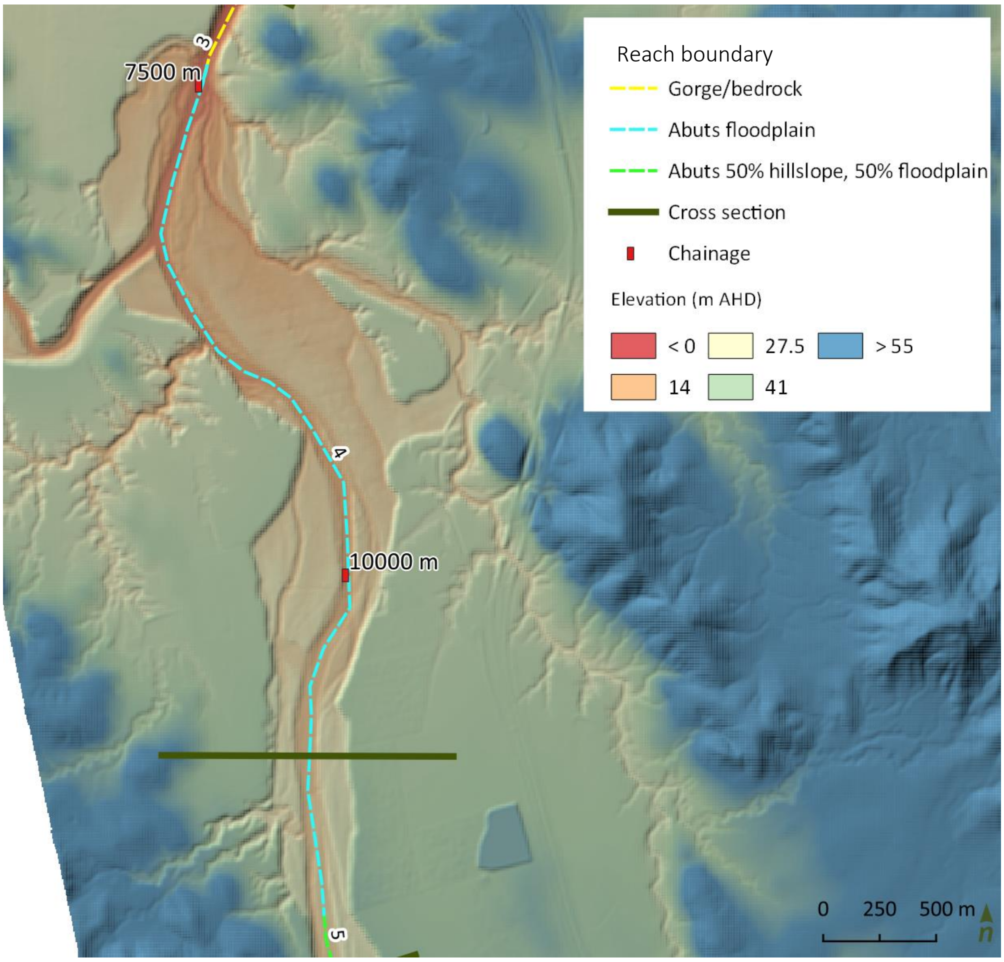

Figure 121. *Reach 4 within the O'Connell River study area.*

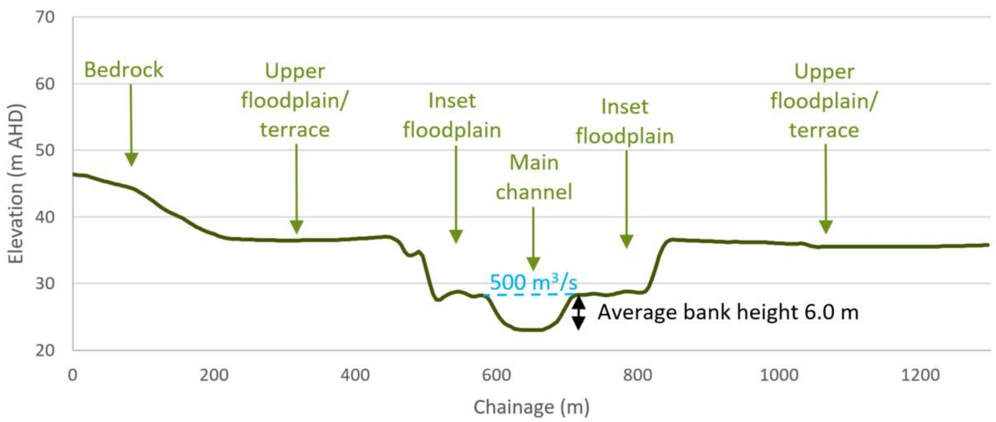

Figure 122. *Representative cross-section within the O'Connell River reach 4 (cross-section location shown in Figure 121).*

Table 43. Key input parameters – O'Connell River reach 4.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
4	500	0.0019	4241	132	6.0	Floodplain	High	50,716

O'Connell River Reach 5

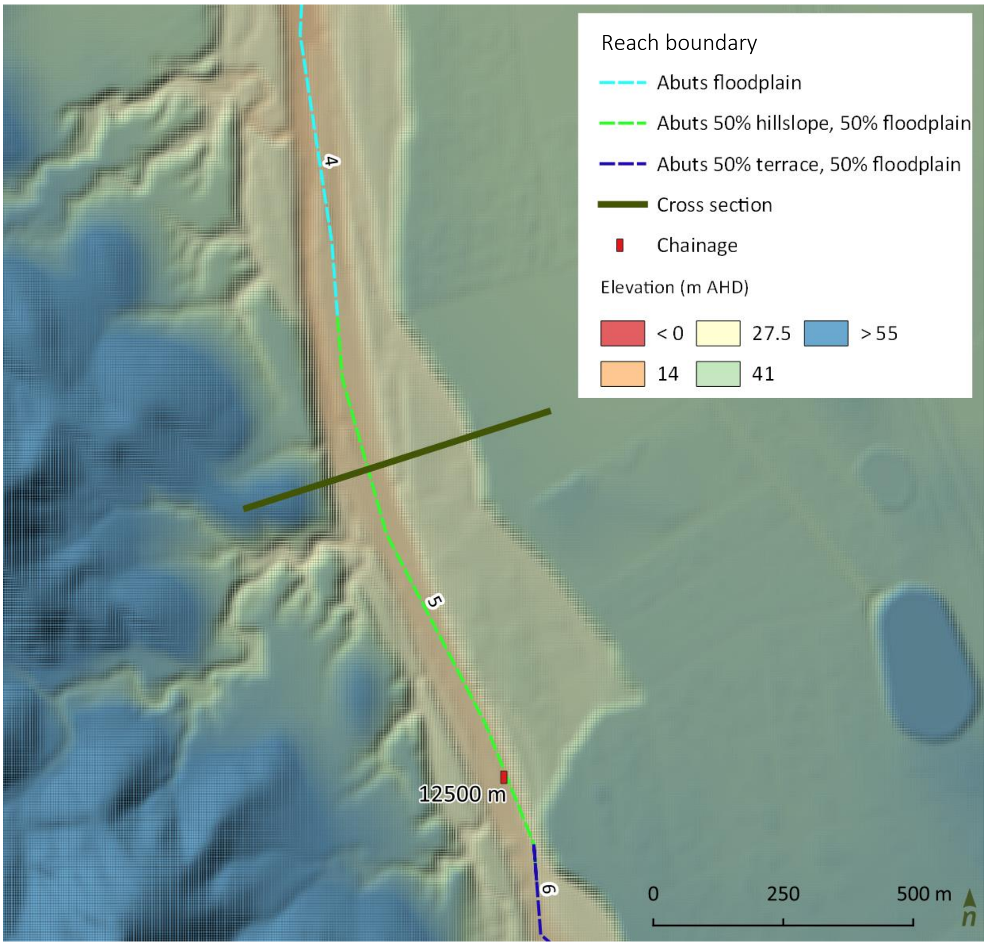

Figure 123. *Reach 5 within the O'Connell River study area.*

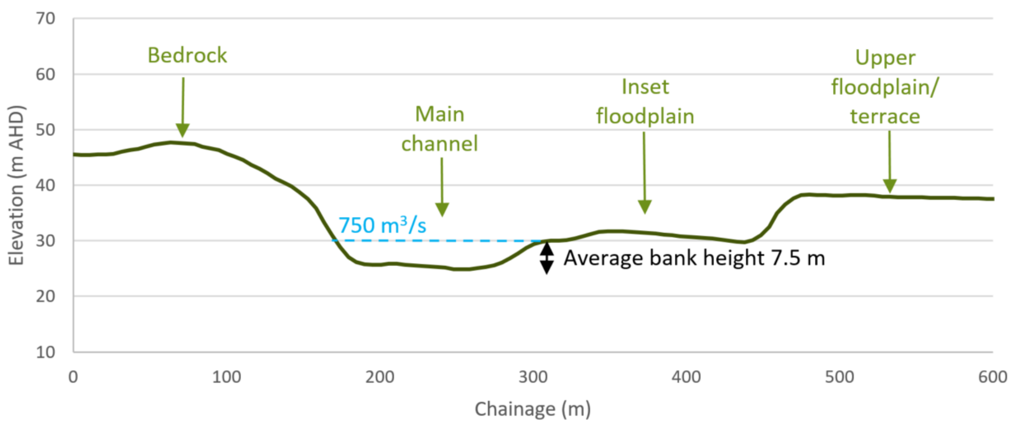

Figure 124. *Representative cross-section within the O'Connell River reach 5 (cross-section location shown in Figure 123).*

Table 44. Key input parameters – O'Connell River reach 5.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
5	750	0.0018	1154	72	7.5	50% hillslope, 50% floodplain	50% very low, 50% high	0

O'Connell River Reach 6

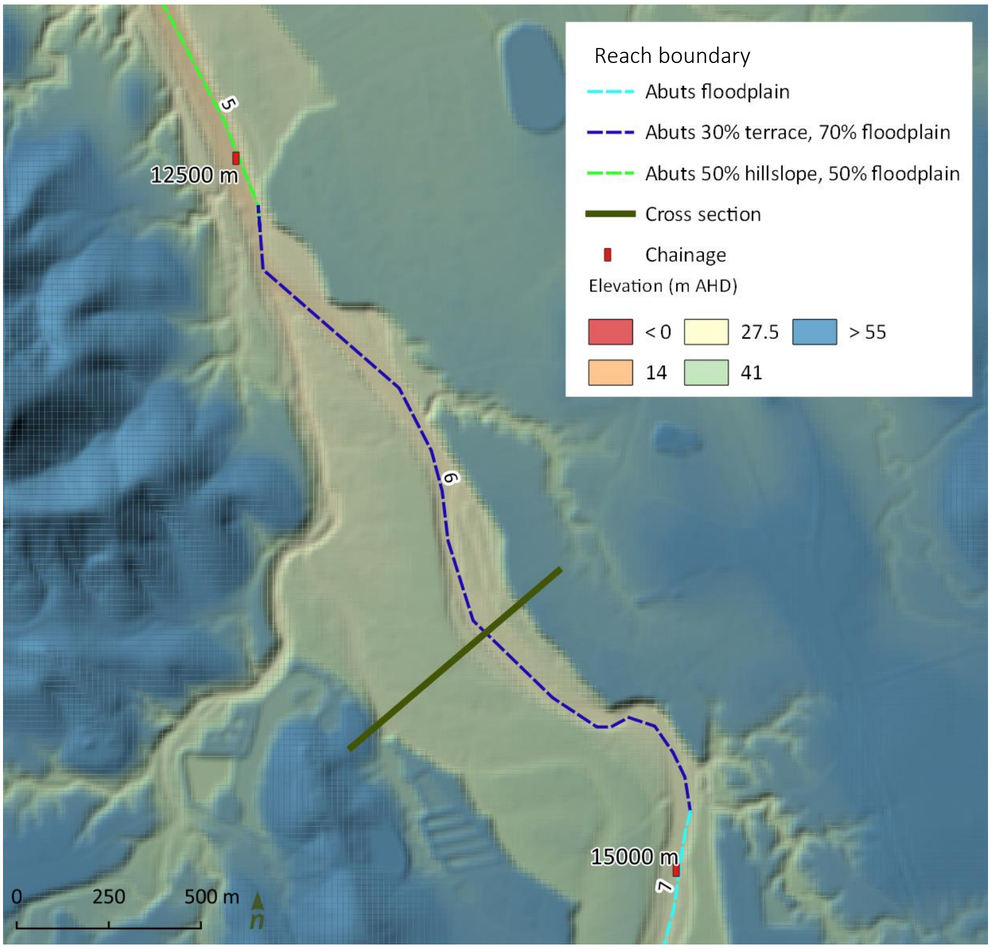

Figure 125. *Reach 6 within the O'Connell River study area.*

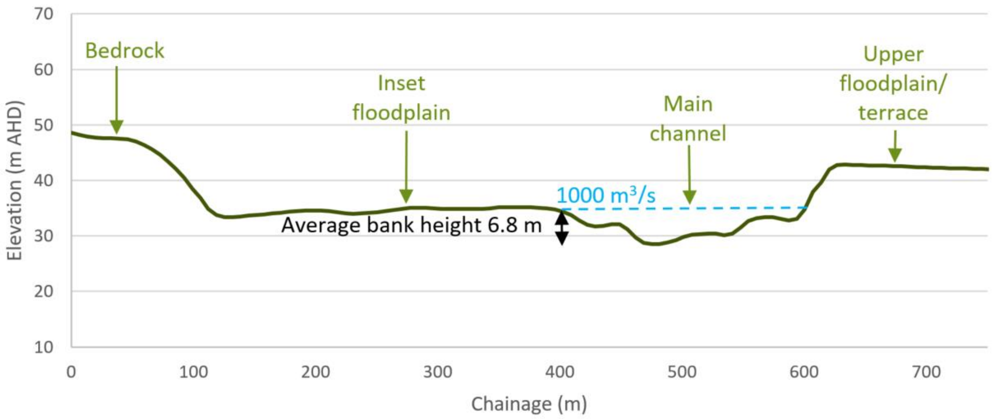

Figure 126. *Representative cross-section within the O'Connell River reach 6 (cross-section location shown in Figure 125).*

Table 45. Key input parameters – O'Connell River reach 6.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
6	1000	0.0021	2269	70	6.8	30% terrace, 70% floodplain	30% low, 70% high	7,398

O'Connell River Reach 7

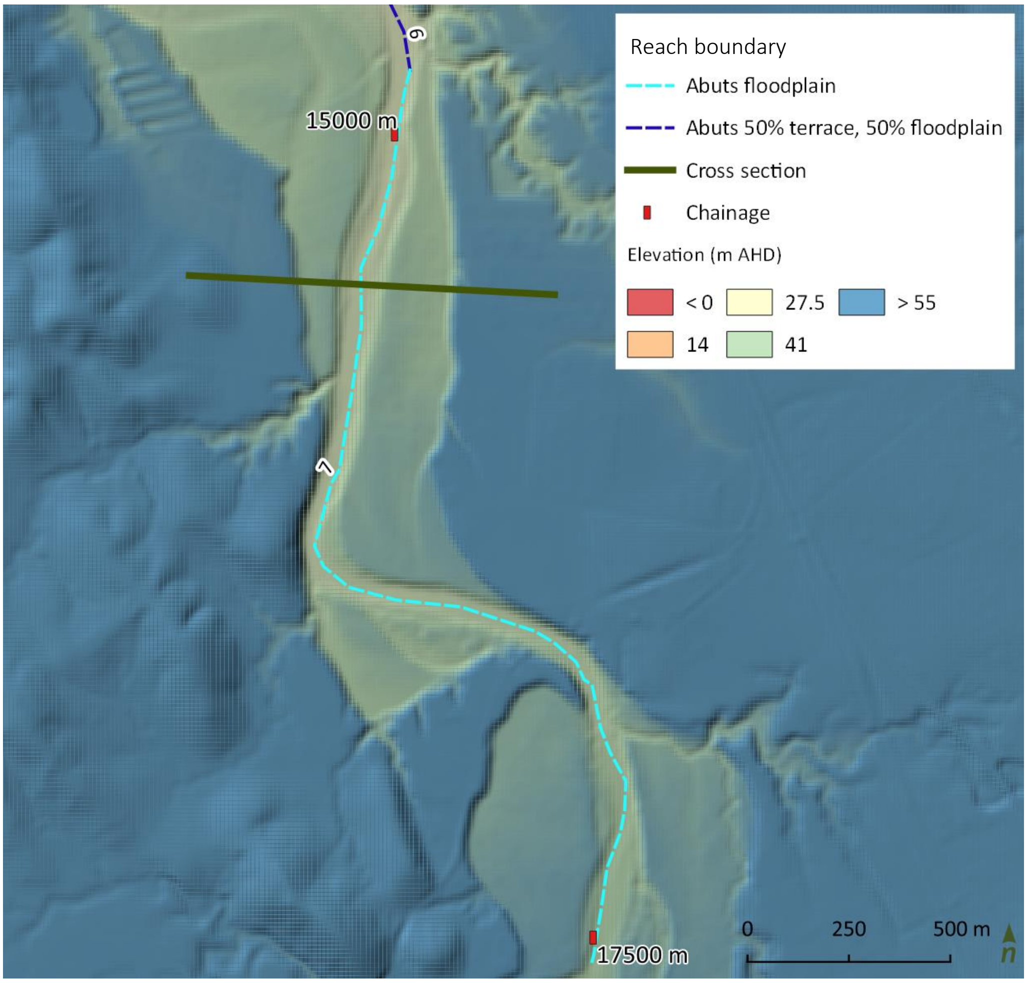

Figure 127. *Reach 7 within the O'Connell River study area.*

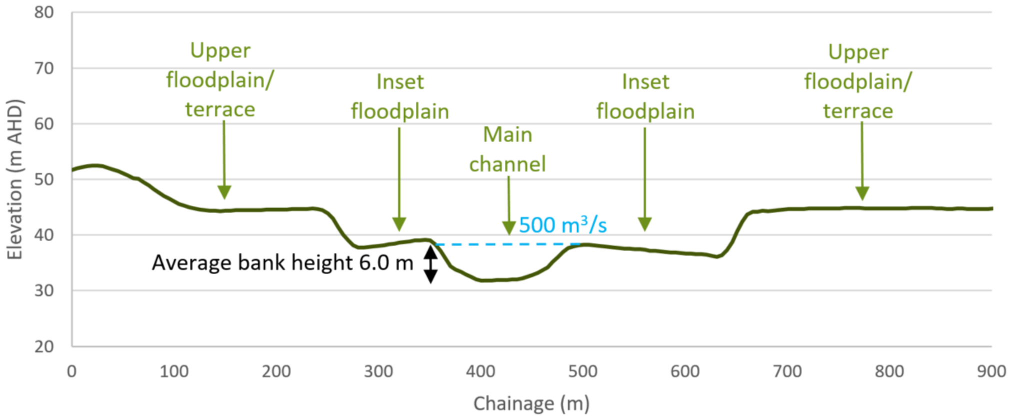

Figure 128. *Representative cross-section within the O'Connell River reach 7 (cross-section location shown in Figure 127).*

Table 46. Key input parameters – O'Connell River reach 7.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018)
7	500	0.0019	2734	76	6.0	Floodplain	High	26,352

Table 47. Dynamic SedNet Bank Erosion key input parameters – O'Connell River case study area.

Link (Sub-catchment)	Bank Full Flow (m^3/s)	Link Slope (m/m)	Link Length (m)	Channel Width (m)	Bank Height (m)	Riparian Vegetation Percentage (%)	Maximum Riparian Vegetation Effect. (%)	Stream bank material erodibility (%)	Bank Erosion Coeff.	SedNet sediment loss (m^3) (2009 – 2018)*
SC #45	594	0.0017	4230	82	8.9	56	95	100	5.0E-05	82,456
SC #148	627	0.0008	3961	74	8.8	80	95	98	5.0E-05	17,820
SC #46	405	0.0019	9351	56	7.0	56	95	99	5.0E-05	117,188

*Note: in 2018 Dynamic SedNet data was only available from January to June.

Table 48. Summary of hydro-geomorphic parameters – O'Connell River case study area.

Reach number	Bank Full Flow (m^3/s)	Reach Slope (m/m)	Reach Length (m)	Channel Width (m)	Bank Height (m)	Channel boundary	Erodibility	Sediment mobilised (m^3) (2009 – 2018) LiDAR	Sediment mobilised **per km (m^3/km) (2009 – 2018)**
1	500	0.0014	4119	61	6.5	Floodplain	High	175,652	42,644
2	750	0.0006	2371	126	10.6	Terrace	Low	19,084	8,049
3	1000	0.0046	1001	114	10.7	Gorge/bedrock	Very low	0	0
4	500	0.0019	4241	132	6.0	Floodplain	High	50,716	11,959
5	750	0.0018	1154	72	7.5	50% hillslope, 50% floodplain	50% very low, 50% high	0	0
6	1000	0.0021	2269	70	6.8	30% terrace, 70% floodplain	30% low, 70% high	7,398	3,260
7	500	0.0019	2734	76	6.0	Floodplain	High	26,352	9,639

6 References

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