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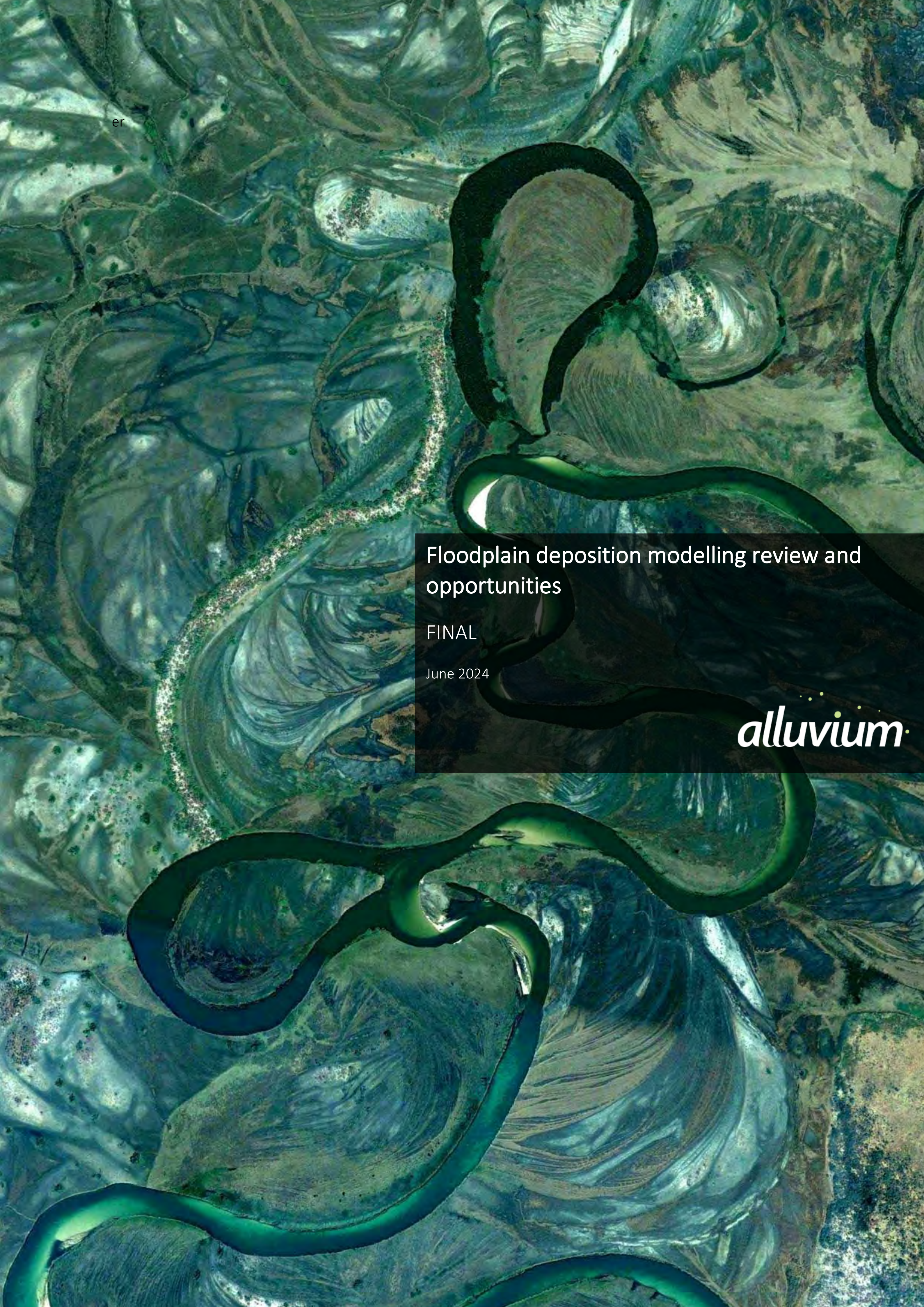

Floodplain deposition modelling review and opportunities

FINAL

June 2024

alluvium

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 Melissa Barton. This piece was commissioned by Alluvium and tells our story of caring for Country, through different forms of waterbodies, from creeklines to coastlines. The artwork depicts people linked by journey lines, sharing stories, understanding and learning to care for Country and the waterways within.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for the Department of Environment and Science under the contract titled 'DES1221100 - 2023 Research, Development and Innovation Priorities for the Queensland Water Modelling Network.

Authors: Marnina Tozer, Misko Ivezich, Isabelle Flook, Sheyanne Frisby
Review: Ian Rutherfurd
Approved: Misko Ivezich

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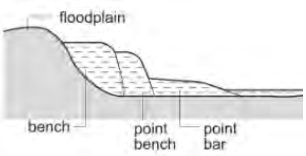
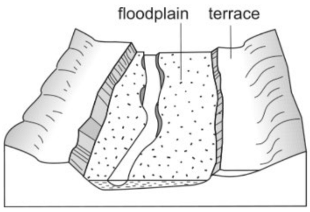
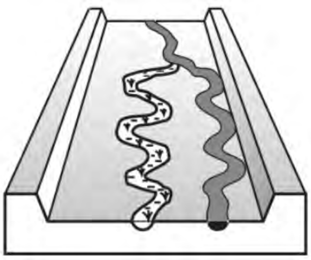
Key terms

Term	Conceptual diagram	Description
Floodplain		A relatively flat alluvial landform that border river channels and is periodically inundated by floodwater and its associated sediment. Formed from lateral accretion (within channel) and vertical accretion (overbank) deposits.
Bench		A distinctly stepped, elongate, straight to gently curved feature that attached 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 at an elevation above the channel bed but below a higher floodplain/terrace.
Genetic floodplain		Genetic floodplains are connected and constructed by the current flow regime.
Hydraulic floodplain		Hydraulic floodplains have longer sediment residence times than genetic floodplains and do not have to formed from the current flow regime. They can be hydrologically and sedimentologically disconnected for longer periods than genetic floodplains
Terrace		Terraces are typically, a relatively flat (planar), valley marginal feature that is perched above the contemporary channel and/or floodplain. They are often old floodplain surfaces. Terraces are inundated so infrequently that they are no longer strongly influenced by contemporary alluvial processes
Palaeochannel (prior channel, abandoned or ancestral channel)		Palaeochannels are abandoned channel preserved within floodplain deposits. They can form due to avulsion processes (a sudden shift in main channel position). A palaeochannel may be partially or entirely filled with sediments delivered during overbank flooding.

Summary

Overview

Alluvium Consulting Australia Pty Ltd (Alluvium) have been engaged by the Department of Environment and Science (DES) to investigate and assess opportunities to improve the modelling of floodplain deposition which has large impacts on sediment export rates from the Great Barrier Reef (GBR) catchments to the reef lagoon.

This project builds on Alluvium's previous Queensland Water Modelling Network (QWMN) projects which assessed issues associated with stream bank modelling in GBR catchments and provided a framework to help support water modellers make better decisions. This project addresses the C*onsolidation and Extension Challenge Statement* as outlined in the 2023 Challenge Statements document which builds on the following QWMN investments:

- Improving how gully erosion and river sediment transport processes are represented in Queensland catchment models (Prosser, 2018)
- Review of existing bank erosion prediction models, opportunities and research gaps (Alluvium, 2020)
- Improvements to stream bank modelling (Alluvium, 2022)

Paddock to Reef sediment models estimate the volume of eroded sediment lost to floodplain deposition. The amount of modelled deposition can have a large impact on sub-catchment fine sediment export rates (i.e. the portion of eroded sediment which reaches the GBR). The sediment export rates, derived from the modelling, guide hundreds of millions of dollars of investment in landscape restoration.

Prosser (2018) identified several limitations and future research needs relating to floodplain deposition modelling. These included:

- improved parameterisation of bankfull flow and floodplain area in the models
- using large-scale hydrodynamic modelling to explore floodplain deposition processes, and
- investigating floodplain re-connection as a tool for management.

This project explored these three issues to provide greater confidence in floodplain deposition estimates and export rates. Specifically, this project has the following objectives:

1. **Objective 1** - Review floodplain deposition processes in Queensland river valleys and assess the applicability of the Dynamic SedNet floodplain deposition model in modelling these processes
2. **Objective 2** - Explore the opportunities for floodplain reconnection as a tool in GBR water quality management which could help reduce sediment loads, improve soil condition and provide flood mitigation in a changing climate.

Key study findings

A literature review undertaken for this project identified that bankfull flow recurrence interval, floodplain flow volumes, floodplain vegetation, valley confinement and constrictions, floodplain area and morphology, and sediment supply are important drivers of floodplain deposition.

This study explored the variability of some of these variables across the GBR because the SedNet model makes some assumptions about the hydrology and geomorphology of floodplains in the GBR catchments. Specifically, the model assumes that:

a) Water moves onto the floodplain (and hence begins deposition of sediment) when the bankfull flow is exceeded
b) All flow volumes above bankfull engage with the floodplain and move sediment onto the floodplain.

We assessed these assumptions. In general, the results demonstrate that channel dimensions (and bankfull flows) as well as floodplain widths (confinement) and elevations are extremely variable and the SedNet assumptions need to be reconsidered

To test the first assumption, the study reviewed 17 case study areas which consisted of 60 Dynamic SedNet modelled links. As part of this review both bankfull flow and floodplain area was assessed and compared to the SedNet parametrisation. This assessment identified large variations in the bankfull flow and floodplain areas used in Dynamic SedNet compared to values identified in hydraulic modelling and LiDAR analysis. The majority of links assessed (i.e. 63%) underestimated bankfull flow. The bankfull flow estimates from the Dynamic SedNet model links assessed in this study are typically in the 1-10 year ARI range. However, the bankfull flows within the 17 case studies assessed for the study are often in the 5-50 year range. The implication of this finding is that flood flows move onto floodplains less frequently than the Dynamic SedNet model parameterisation predicts, meaning that the model is usually overestimating the amount of sediment being trapped on the floodplain.

To test the second assumption we developed more detailed two-dimensional hydrodynamic modelling for three case study areas. The findings highlighted that valley and terrace constrictions, which are widespread in GBR catchments, exert substantial control on floodplain hydraulics. A large portion of the flow (≈ 30-70%) above the bankfull flow is still conveyed within the channel margin (i.e. above the channel margins) and not across the floodplain.

As part of Objective 2 above, the study modelled different channel and floodplain roughness scenarios (i.e. to simulate riparian and floodplain revegetation). The results indicate that increasing the channel and/or floodplain roughness can result in substantial changes to the key metrics that impact floodplain deposition i.e. floodplain flow volumes and floodplain velocities. However, the impacts are highly dependent on the floodplain characteristics.

Summary and recommendations

This study has identified that the majority of SedNet links underestimated bankfull flow and that often the majority of flow greater than bankfull flow is conveyed within the channel margins and not on the floodplain. As a result, the proportion of flow that is actually passing over the floodplains within the GBR catchments will be significantly less than the current modelling predicts. ***Based on these findings it is likely that the floodplain deposition volumes for the majority of links are substantially overestimated.*** The other implication of this work is that relatively small changes to the SedNet model can result in substantial improvements in the accuracy of its floodplain deposition estimates.

The following recommendations are based on the outcomes of this study and will substantially improve the modelled floodplain deposition results of the SedNet model:

1. It is recommended all bankfull flow estimates within the Dynamic SedNet model are updated by using the Manning's equation approach outlined in Section 4.20. This method relies on the characteristics of the channel, rather than flood hydrology, to identify when flow moves onto the floodplain. The effectiveness of this approach relies on the accuracy of the other channel geometry parameters (i.e. slope, channel width and bank height). However, if these parameters are correct then the Manning's equation approach, which accounts for the geomorphic variability of the channels, should significantly improve bankfull flow estimates compared to the current hydrological approach (i.e. 1-2 year ARI).
2. The percentage of floodplain flow (i.e. flow above the bankfull flow) modelled in the Dynamic SedNet model should be reduced from 100% to 50% ***as a temporary interim measure*** to more accurately reflect the real proportion of flow that is engaging with the floodplain. The 50% interim measure is based on the findings in this study that a significant portion of the flow (≈ 30-70%) above the bankfull flow is still conveyed within the channel margin and not across the floodplain. Eventually the proportion of flow moving onto the floodplain can be estimated more accurately for each link based on a floodplain classification approach (see below recommendation).
3. A floodplain classification approach should be developed, and more detailed two-dimensional hydraulic modelling should be undertaken to understand the channel-floodplain connectivity processes for each main floodplain type. This will help refine the floodplain deposition model in Dynamic SedNet for different floodplain types.

4. Improve modelled estimates of floodplain deposition by measuring the deposition rates on a representative range of GBR floodplain types to test some of the assumptions in the SedNet model, and test the conclusions from this study. A variety of methods exist to measure past deposition rates, as well as monitoring active deposition from floods. These results will improve model calibration.
5. Reach scale stream management programs should also consider floodplain deposition as a key design criteria, in addition to stream stability.

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) have been engaged by the Department of Environment and Science (DES) to investigate and assess opportunities to improve the modelling of floodplain deposition which has large impacts on sediment export rates within the Great Barrier Reef (GBR) catchments.

The QWMN's Research, Development and Innovation Strategy 2021-2024 (RDI Strategy) outlines four RDI priorities to guide effort and investment for the 2021-2024 period. This project addresses the following key priorities:

- landscape restoration and resilience – *water modelling can improve the design and impact of investment in landscape rehabilitation and building resilience in Queensland*
- building trust and confidence – *building understanding of, and trust in water models is needed to avoid misconceptions and a lack of confidence in water model outputs and end uses.*
- model improvement and integration – *there are opportunities to improve integration across model suites, domains and scales to improve system knowledge and design of management interventions*

This project builds on Alluvium's previous Queensland Water Modelling Network (QWMN) projects which assessed issues associated with stream bank modelling in GBR catchments and provided a framework to help support water modellers make better decisions. This project addresses the Consolidation and extension challenge statement as outlined in the 2023 Challenge Statements document which builds on the following QWMN investments:

- Improving how gully erosion and river sediment transport processes are represented in Queensland catchment models (Prosser, 2018)
- Review of existing bank erosion prediction models, opportunities and research gaps (Alluvium, 2020)
- Improvements to stream bank modelling (Alluvium, 2022)

1.1 Background

Paddock to Reef sediment models estimate the volume of eroded sediment lost to floodplain deposition. The amount of modelled deposition can have a very big impact on sub-catchment fine sediment export rates (i.e. the portion of eroded sediment which reaches the GBR). The sediment export rates, derived from the modelling, guide hundreds of millions of dollars of investment in landscape restoration. In many upper catchment areas (i.e. The Dawson River, Isaac River etc) where there are widespread erosion issues it is very hard to identify cost-effective projects due to the very low sediment export rates; due largely to high modelled floodplain deposition. For example, the Dynamic SedNet sediment budget for the Fitzroy catchment is shown in Figure 1. In the Fitzroy catchment the model estimates that approximately 47% of the total catchment sediment supply is deposited on floodplains.

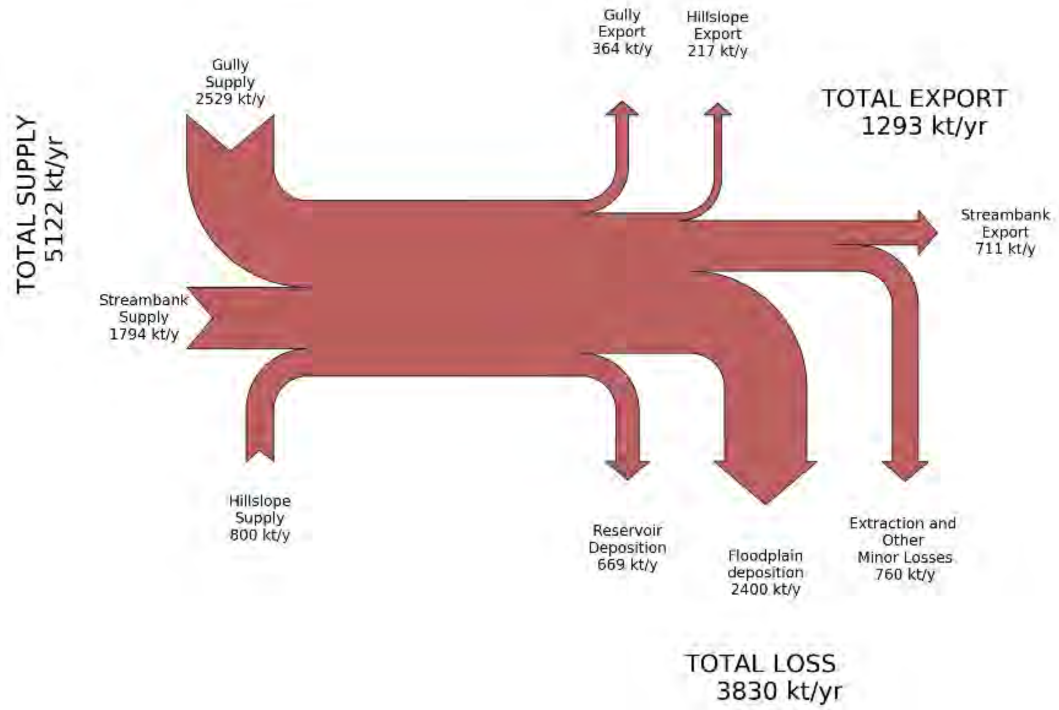


Figure 1. *Dynamic SedNet sediment budget for the Fitzroy catchment. Showing a high modelled volume of floodplain deposition.*

Sub-catchments with significant erosion problems are often dismissed because of a putative lack of contribution to sediment exports predicted by the Dynamic SedNET modelling. However, the modelled floodplain deposition that stops sediment being delivered downstream is highly sensitive to several poorly known parameters and the precise values are quite uncertain. It is possible that the actual sediment delivery is much higher than modelled from inland sub-catchments. As a result, large areas of degraded landscapes which are currently disregarded for landscape restoration may be significant sediment sources to the GBR.

This project aims to build more confidence floodplain deposition modelling and identify future modelling and management opportunities associated with floodplain deposition.

1.2 Study objectives

Prosser (2018) identified several limitations and future research needs relating to floodplain deposition modelling. This includes:

- improved parameterisation of bankfull flow and floodplain area
- using large-scale hydrodynamic modelling to explore floodplain deposition processes, and
- investigating floodplain re-connection as a tool for management.

This project will investigate many of these issues to provide greater confidence in floodplain deposition estimates and export rates. Specifically, this project has the following objectives:

3. **Objective 1** - Review floodplain deposition processes in Queensland rivers and assess the applicability of the Dynamic SedNet floodplain deposition model in modelling these processes
4. **Objective 2** - Explore the opportunities for floodplain reconnection as a tool in GBR water quality management which can help reduce sediment loads, improve soil condition and provide flood mitigation in a changing climate.

Overall, this project aims to improve our understanding of floodplain deposition processes and modelling and map out a pathway to improve estimates of floodplain deposition.

1.3 Report structure

This report has the following structure:

- Section 2 reviews floodplain deposition processes in Queensland
- Section 3 provides an overview of the Dynamic SedNet floodplain deposition model
- Section 4 presents a review of the parameterisation of the Dynamic SedNet floodplain deposition model in 17 case study areas
- Section 5 presents case study assessments which use two-dimensional hydrodynamic modelling to assess floodplain deposition processes
- Section 6 provides a summary of the study and outlines recommendations

2 Understanding floodplain deposition processes in Queensland catchments

2.1 What is a floodplain?

Floodplains are formed by the physical interaction of fluvial processes. The form and evolution of a floodplain is driven by the adjacent waterway's ability to entrain and transport sediment and the erosional resistance of the floodplain which forms the channel boundary (Nanson and Croke, 1992). Defining a "floodplain" is not a simple and unambiguous task (Nanson and Croke, 1992; Moody et al., 1999). Floodplains often comprise various distinct surfaces, with varying elevations, and varying inundation frequencies (Grams and Schmidt, 2002; Heitmuller et al., 2015).

Historically, in a traditional engineering context, floodplains were defined based on bank full recurrence interval (i.e. 1 – 2 yrs) (Wolman and Leopold, 1957; Leopold et al.,1964; Dury, 1973) (Figure 2a). Williams' (1978) also defined floodplains with reference to bankfull flow delineating 'active' and 'inactive' floodplains (Figure 2b). Where an inactive floodplain, commonly referred to as a terrace, was defined as surface inundated so infrequently that it is no longer strongly influenced by contemporary alluvial processes (Leopold et al., 1964).

Nanson and Croke (1992) also defined floodplains in a time dependent context; differentiating between 'hydraulic' and 'genetic' floodplains based on the timescale of formation (Figure 2c). The genetic floodplain was defined as a "largely horizontally-bedded alluvial landform adjacent to a channel, separated from the channel by banks, and built of sediment transported by the present flow-regime" (Nanson and Croke, 1992). Where the present flow-regime was defined as being within the last 100 years. Genetic floodplain development processes vary in different river types. In laterally migrating river topographically distinct genetic floodplain develop over successive flow events. In contrast, in laterally stable rivers genetic floodplain units can be stacked vertically over successive flow events (Croke et al., 2016).

The hydraulic floodplain, in comparison, had similar morphological characteristics but was largely formed by a prior flow regime, although it is inundated in high magnitude and low frequency flow events under the contemporary flow regime.

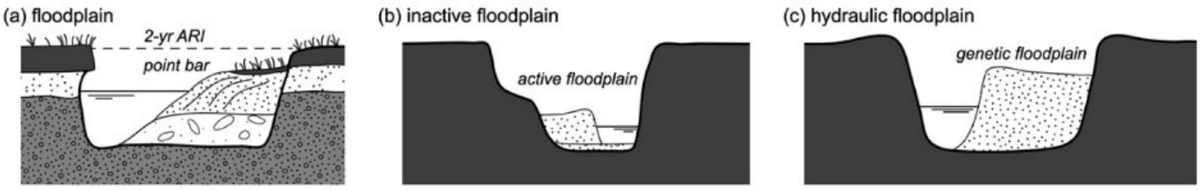


Figure 2. *(a) Traditional definition of a floodplain based on a bankfull recurrence interval < 2 years (Wolman and Leopold, 1957), (b) Williams (1978) delineation of an 'active' and 'inactive' floodplain. (c) Nanson and Croke (1992) differentiation of a genetic and hydraulic floodplain based on the timescale of floodplain formation processes (from Croke et.al., 2016).*

An alluvial channel varies its form and constructs and erodes its surrounding floodplain to create a conduit for water and sediment transport. Over a timescale of decades or centuries only a fraction of the total alluvial sediment in a river valley is transported within the channel, the majority is stored in contemporary or ancient floodplains (Nanson and Croke, 1992). While terraces are often described as floodplains formed under prior flow regimes it is important to recognise the limitation of time-dependent classifications. Floodplains often form and reform over considerable time periods and often reflect time transgressive processes. For example, along a slowly migrating channel the distal (landward) units of the floodplain may be remnants of prior flow regimes, while the upper or riverward units likely comprise sediment deposited under the present flow regime. This reflects the "polycyclic" (Cohen and Nanson, 2008; Kermode et al., 2012) nature of deposition within riverine environments.

In the context of this study floodplains are as defined as:

Relatively flat surfaces adjacent to a river formed from river processes

2.2 What are the different types of floodplains?

Classification and characterisation of river and floodplain hydrology and morphology can support waterway management programs. Numerous river and floodplain classifications have been developed (e.g. Nanson and Croke, 1992 and Croke et al., 2016). Two key classifications schemes developed by Nanson and Croke (1992), Nanson and Knighton (1996) and Croke et al. (2016), relevant to this study, are summarised below and in 2.3.

Nanson and Croke (1992) developed a genetic classification of floodplains which recognises the genetic association (interdependence) between rivers and their floodplains. This is an energy-based classification which acknowledges the important balance between energy exerted by the flow and the resistance of the floodplain to erosion. The classification is based primarily on specific stream power (which is governed by controls including flow regime, valley slope, and valley confinement), and floodplain sediment (i.e resistance to erosion determined by cohesiveness of sediment). The classification system recognises three main classes of floodplain described below:

- high-energy non-cohesive floodplains,
- medium energy non-cohesive floodplains,
- and low-energy cohesive floodplains.

The approach also recognises nine geomorphic factors / floodplain forming processes which provide additional levels of floodplain differentiation. These include valley confinement, channel cutting and filling, braid-channel accretion, lateral point bar accretion, overbank vertical accretion, anabranching, scroll bar formation, counter point accretion, and organic accumulation. Nanson and Croke's (1992) genetic classification of floodplains is summarised in Table 1.

Nanson and Knighton (1996) further developed the classification of anabranching (multi-channel) systems. Six types of anabranching rivers were identified based on stream energy, sediment size, and morphological characteristics; these were classified from low energy organic or fined textured systems, to relatively high-energy gravel- or boulder-transporting systems.

Table 1. Genetic classification of floodplains (adapted from Nanson and Croke, 1992).

Order/ suborder	Type	Specific stream power, ω (W/m²)	Sediment	Erosional and depositional processes	Landforms	Channel planform	Environmental	References
Class A: High-Energy Non-Cohesive Floodplains								
ω = > 300 W/m², Disequilibrium floodplains which erode in response to extreme events, typically located in steep headwater areas where channel migration is prevented by valley confinement.								
A1	Confined coarse textured floodplains	>1000	Poorly sorted boulders and gravel; buried soils	Catastrophic floodplain erosion and overbank vertical accretion; abandoned channel accretion, minor lateral accretion	Boulder levees; sand and gravel splays; back channels, abandoned channel, and scour holes.	Single-threaded straight/ irregular	Steep upland headwater valleys	Stewart and Lamarche (1967)* Baker (1977)*
A2	Confined vertical accretion floodplains	300-1000	Basal gravels and abundant sand with silty overburden	Catastrophic floodplain erosion and overbank vertical accretion	Large levees and deep back channels and scour holes	Single-thread straight/irregular	Upland headwater valleys	Nanson (1986); Croke (1991)
A3	Unconfined vertical accretion sandy floodplains	300-600	Sandy-strata inter-bedded muds	Catastrophic channel widening; overbank vertical accretion; island deposition and abandoned-channel accretion. Minor lateral accretion	Flat floodplain surface	Single-thread wandering	Semi-arid open valleys	Schumm and Lichty (1963); Burkham (1972)
A4	Cut and fill floodplains	~ 300	Sands, silts, and organics	Catastrophic gullying, overbank vertical accretion; abandoned-channel accretion	Flat floodplain surface; channel fills; swampy meadows	Straight/irregular	Upland dells and semi-arid alluvial-filled valleys	Graf (1983a, 1983b); Young (1986); Prosser (1988)
Class B: Medium-Energy Non-Cohesive Floodplains								
ω = 10-300 W/m², Equilibrium floodplains formed by regular flow-events in relatively unconfined valleys								
B1	Braided-river floodplains	50-300	Gravels, sand and occasional silt	Braid-channel accretion and incision; overbank vertical accretion; minor lateral and abandoned-channel accretion	Undulating floodplain of abandoned channels and bars; backswamps	Braided	Abundant sediment load; alternating sedimentation zones in tectonically and/or glacially active areas	Doeglas (1962); Fanstock (1963); Williams and Rust (1969); Ferguson (1981); Carson (1984); Brierley and Hickin (1991)
B2	Wandering gravel-bed river floodplains	30-200(?)	Gravels, sands, silts, and organics	As for braided and meandering rivers	Abandoned channels; sloughs; braided bars; islands; back channels	Braided, meandering and anastomosing	Abundant sediment load; alternating sedimentation zones in tectonically active areas	Church (1983); Doeglas and Church (1987)*; Brierley and Hickin (1991)

Order/ suborder	Type	Specific stream power, ω (W/m²)	Sediment	Erosional and depositional processes	Landforms	Channel planform	Environmental	References
B3	Meandering river, lateral-migration floodplains	10-60	Gravels, sands, and silts	Cut-bank erosion; Lateral point-bar accretion; overbank vertical and abandoned-channel accretion. Counterpoint accretion; minor oblique accretion	Flat to undulating floodplain surface; oxbows; backswamps	Meandering	Usually middle to lower valley reaches	Sundborg (1956); Wolman and Leopold (1957); Jackson (1976); Nanson (1980); Ferguson (1981); Hickin and Nanson (1984)
B3a	Lateral migration, non-scrolled floodplains	ditto	ditto	ditto	ditto	ditto	ditto	ditto
B3b	Lateral migration, scrolled floodplains	ditto	Sands and minor gravels	As for B3 with scroll-bar formation	Distinctly scrolled floodplains	ditto	ditto	Jackson (1976); Nanson (1980)
B3c	Lateral migration/backswamp floodplains	ditto	Sands, silts, and organics	As for B3	Central scrolled floodplain with flanking backswamps	ditto	ditto	Fisk (1947); Speight (1965); Blake and Ollier (1971); Woodroffe et al. (1989)
B3d	Lateral migration, counterpoint floodplains	ditto	Sands with abundant silts and organics	As B3 with pronounced counterpoint accretion	Concave benches with scrolled floodplains	Confined meandering	ditto	Hickin (1979); Lewin (1983); Nanson and Page (1983)
Class C: Low-Energy Cohesive Floodplains								
ω = < W/m², Floodplains formed by regular flow-events along laterally stable single-thread or anastomosing low-gradient channels								
C1	Laterally stable, single-channel floodplains	<10	Abundant silts and clays with organics	Overbank vertical accretion	Flat floodplains with low levees; backswamps	Single-thread straight/meandering	Abundant fine sediment load middle-lower reaches	Beckinsale and Richardson (1964); Nanson and Young (1981); Brown (1983); Croke (1991)
C2	Anastomosing-river floodplains	ditto	Gravel and sands with abundant silts and clays	Overbank vertical accretion; island deposition	Flat floodplains with extensive levees, islands and floodbasins crevasse-channels and splays	Anastomosing	Very low gradient with wide floodplains	Smith and Smith (1980); Rust (1981); Smith (1983); Nanson et al. (1986); Smith, pers com. (1990)*

Order/ suborder	Type	Specific stream power, ω (W/m²)	Sediment	Erosional and depositional processes	Landforms	Channel planform	Environmental	References
C2a	Anastomosing-river, organic rich floodplains	ditto	As for C2 with abundant organics and lacustrine deposits	As for C2 with peat formation, and lacustrine sedimentation	As for C2 with lakes and peat swamps	ditto	As for C2 in humid environments	Smith and Smith (1980); Smith (1983)
C2b	Anastomosing-river, inorganic floodplains	ditto	As for C2 but with little or no organics	As for C2	As for C2	Anastomosing channels and co-existing floodplain-surface braid channels	As for C2 in semi-arid environments	Nanson et al. (1986); Rust and Nanson (1986)

*Specific stream-power estimated from data in these papers.

Study implications

Objective 1 - Review floodplain deposition processes in Queensland rivers and assess the applicability of the SedNet floodplain deposition model in modelling these processes

Different types of floodplains will have varying morphological characteristics, including slope, which will impact flood hydraulics and erosion and deposition processes.

Objective 2 – Explore the opportunities for floodplain reconnection as a tool in GBR water quality management

Different floodplain types will have different levels of connection. Many higher energy floodplains may have less fine sediment deposition in a single event due to higher floodplain velocities, however these floodplains may be flooded more frequently. The cumulative effect could be that a higher energy floodplain may have similar rates of floodplain deposition to a less well-connected lower energy floodplain.

2.3 River and floodplain types in Queensland

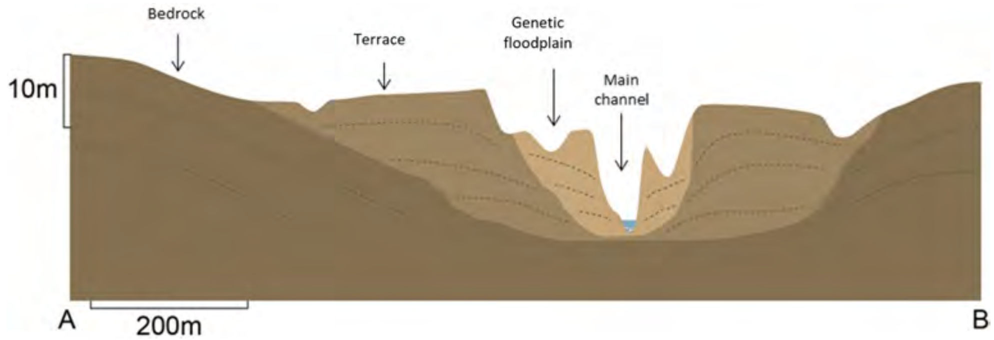
There is a diversity of channel and floodplain forms in Queensland. Kemp et al. (2016) identified four main channel types in southeast Queensland, including (1) simple channel with low-energy floodplains, (2) simple channels with high-energy floodplains, (3) compound channels with low-energy floodplains, and (4) compound channels with high-energy floodplains. Compound channels in particular are widespread in southeast Queensland. The prevalence of compound, high-energy, channels in the region suggests a distinctive floodplain geomorphology in Queensland, reflective of the highly variable flow regime.

The floodplains of rivers in the GBR catchments tend to be more complicated than the floodplains described by Nanson and Croke (1992). Many of these rivers have an entrenched compound channel (or "macrochannel") morphology bounded by resistant old floodplain/terrace deposits (Croke et al., 2013; Brooks et al., 2014; Fryirs et al., 2016; Daley et al., 2018) (Figure 3a and Figure 3b). 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 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.

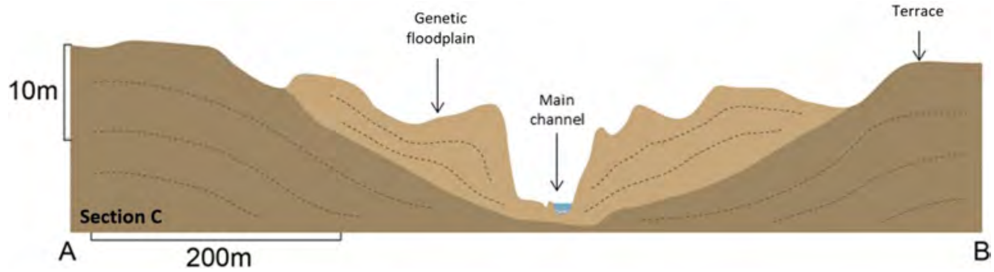
Compound channel morphology develops in flood-dominated systems where long periods of low flow conditions are punctuated by episodic large flood events. In these systems, with highly variable hydraulic regimes, extreme flood events form entrenched macro channels with large channel capacity relative to mean flows (Baker, 1977; Hickin, 1983; Brakenridge, 1988). In contrast, the genetic floodplains reflect more contemporary flow regimes (e.g. 1 – 2 yr flows)(Nanson and Croke, 1992; Croke et al.,2016).

The identification of bankfull stage in Australian rivers can be challenging as it depends on the identification of an active floodplain that may be characterised by an irregular surface (Kemp et al., 2016). The hydrological definition of bankfull discharge is also complicated by the range of bankfull discharge which has been documented; with some rivers conforming to the average bankfull recurrence period (i.e. 2 yrs)(Page et al., 2005; Kemp, 2010), and other with significantly higher recurrence intervals (i.e. a recurrence interval of 30 yrs at one location on the Brisbane River)(Kemp et al, 2015). In Queensland, compound channels with both high and lows banks (Croke et al., 1981) further complicate the definition of channel banks and "bankfull" discharge.

River type



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



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

Figure 3. *Two typical cross sections in the Mary River showing* examples *of different river and floodplain types within Great Barrier Reef catchments (Alluvium, 2020)*.

Coastal Queensland rivers have particular floodplains that are reviewed below. Croke et al (2016) defined various inundation/floodplain surfaces in the Lockyer Creek (Queensland). These surfaces are typical of inundation areas within and adjacent to macrochannels in hydrologically-variable settings (such as many GBR catchments). The study identified four major inundation surfaces described below:

- within-channel bench [Q ~ 2.33 yr average recurrence interval (ARI)]
- genetic floodplain (Q = 20 yr ARI)
- hydraulic floodplain (20 yr < Q ≤200 yr ARI), and
- terrace (Q > 1000 yr ARI).

Within-channel benches are narrow longitudinally disconnected units formed by bedload transport processes rather than overbank process; they are ephemeral landforms which can be fluvially-reworks or destroyed by flood events (Croke et al., 2016). Within-channel benches are a dominate source of sediment during flood events (Croke et al., 2013; Fryirs et al., 2016), they also important for channel stabilisation and recovery following large flood events.

Genetic floodplains correspond to recurrence intervals of up to 20 yr ARI and have formed within approximately the last 1000 years (Croke et al., 2016). Genetic floodplains are primary sediment sinks, disrupting sediment transport to downstream reaches for extended time periods (Croke et al., 2013; Thompson et al., 2016b).

Hydraulic floodplains correspond to inundation frequencies of up to 200 yr ARI and subsequently to much longer sediment residence times (several 1000 years)(Croke et al., 2016) Hydraulic floodplains can be hydrologically and sedimentologically disconnected for longer periods; limiting potential for contemporary sediment storage.

Terraces are associated with inundation frequencies greater than 1000 years, and represent deposition over 10,000 years or more. Croke et al. (2016) define terraces as surfaces that are no longer inundated, with sedimentology comprising well-developed stable soil horizons.

Croke's classification scheme of floodplain surfaces is summarised in Table 2, and the spatial distribution of floodplain surfaces in the Lockyer is illustrated in Figure 4.

Many of the coastal rivers of Queensland have some characteristics which are similar to Lockyer Creek including:

- Laterally inactive due to the resistant floodplain substrate
- Widespread within channel benches which are the dominant erosion/deposition zones
- Very high channel capacity which can contain very large flood prior to floodplain engagement.

Table 2. General characteristics of different inundation surfaces along Lockyer Creek (from Croke et al., 2016).

Name of inundation surface	Position relative to channel bed in the Lockyer	Hydrological characteristics in the Lockyer	Sedimentological characteristics in the Lockyer	Age structure in the Lockyer
Within-channel bench	1–3 m above, lowest inundation surfaces, contained within the macrochannel.	Inundated with the 2.33 year recurrence interval flow	Horizontally-bedded, coarse (sand and gravel) sediments deposited by within-macrochannel bedload transport	Less than 300 years
Genetic floodplain	Around 10 m above channel bed, occur outside the macrochanel and extend from the banktop.	Inundated with up to the 10 year recurrence interval flow.Contain Spill-out Zones (SOZs) which are the high energy portions of genetic floodplain. Occur where upstream channel capacity is significantly (~2×) larger than immediately downstream. They have deepest overland flooding on genetic floodplains. Tend to occur where hydraulic floodplains and genetic floodplains merge.	Alternating horizontally-bedded units of fine-grained silts and clays and thinner	<1000 years to present
Hydraulic floodplain	Around 10–20 m above channel bed, occur outside the macrochanel and extend from the banktop. Tend to occur along flow expansion reaches.	Inundated with up to the 20–200 year recurrence interval flow.	Coarser sandy units deposited by overbank vertical accretion.	2000–270 years
Terrace	Greater than 10 m above channel bed, occur outside the macrochanel and along valley margins. Tend to occur along flow contraction reaches.	Probable maximum flood (PMF).	Pedogenically-altered, horizontally-beddedfine-grained silty-clay units deposited by overbank vertical accretion.	Late-Pleistocene to early-Holocene

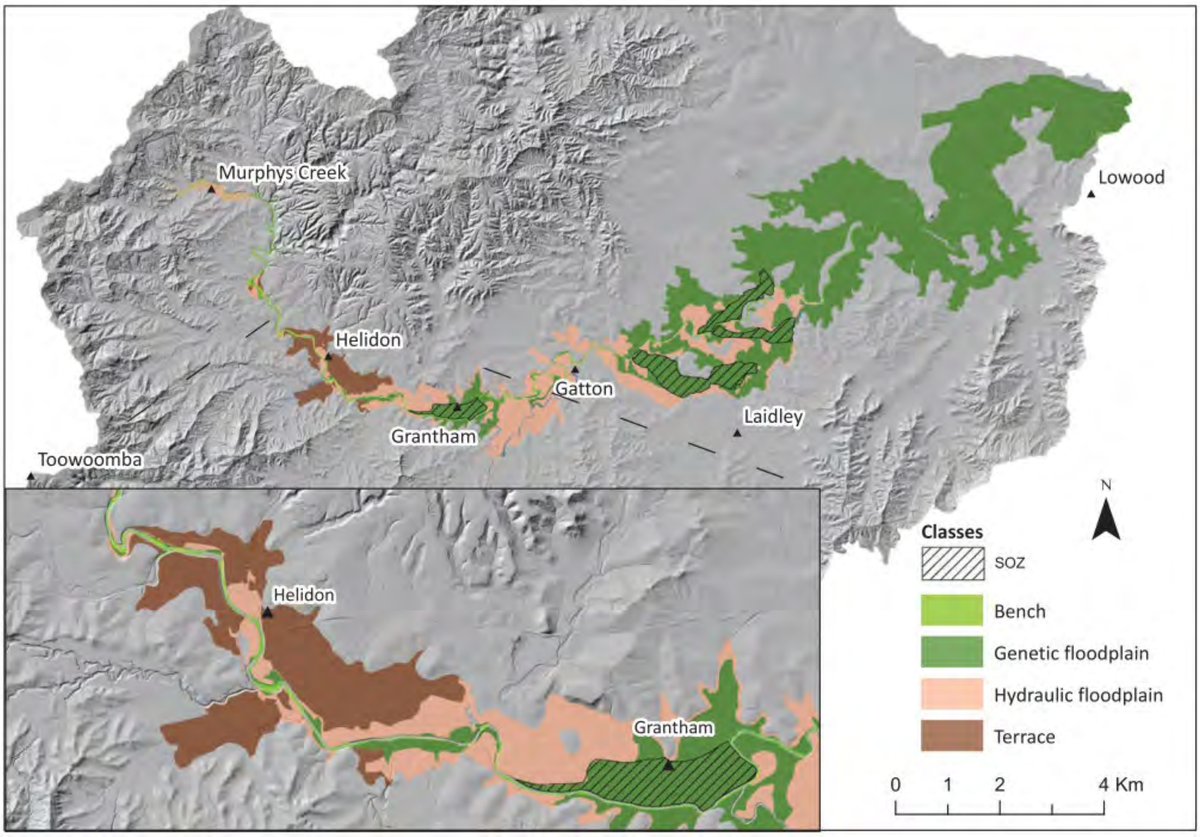


Figure 4. *Flood inundation classification of the four major surfaces identified in Lockyer Creek; within-channel benches exist within the boundary of the channel; genetic floodplains are present at the township of Grantham and in the lower Lockyer downstream of Gatton. An inset is shown of the valley around Helidon which displays evidence of all four surfaces (from Croke et al., 2016).*

Study implications

Objective 1 - Review floodplain deposition processes in Queensland rivers and assess the applicability of the SedNet floodplain deposition model in modelling these processes

There are often multiple floodplain surfaces, each with varying inundation frequencies and deposition processes. The SedNet model only allows for one floodplain surface to be modelled.

Objective 2 - Explore the opportunities for floodplain reconnection as a tool in GBR water quality management

The inundation frequency of different inundation surfaces has important implications for management. Targeting lower, more frequently inundated surfaces for riparian/floodplain management may result in a greater benefit compared to management on higher, less frequently inundated surfaces.

2.4 Forms and processes of disturbed floodplains

Evidence suggests that the Brisbane River was characterised by a compound channel morphology prior to commencement of European agriculture and grazing within the catchment (Kemp et al., 2015). Many Queensland coastal streams have a similar compound morphology which was formed prior to European settlement (Hughes & Croke, 2017).

However compound channel morphology in some other Queensland rivers likely resulted from incision processes following land use changes; where the active floodplain was confined to cut and fills occurrences within an over deepened channel (Thompson et al., 2016a).

Major disturbances which have occurred within Queensland catchments, and the corresponding influence river-floodplain connection and floodplain sediment deposition is summarised in Table 3.

Table 3. Floodplain and channel disturbances and the impacts on river-floodplain connection

Disturbance	Impact on river-floodplain connection and floodplain deposition
Agricultural land use which is often characterised by a reduced floodplain roughness (compared to pre-disturbed conditions)	When overbank flows occur, flow velocity is higher compared to pre-disturbed conditions due to reduced roughness, resulting in higher potential for sediment transport, avulsion risk and lower rates of deposition of suspended sediment.
Artificial leeves	Artificial leeves disconnect floodplains from channel i.e. reduced fluxes of water and sediment. They can also drive channel incision.
Incision (channel deepening) following land use changes (i.e. channel mining, catchment clearing, urbanisation etc.).	Larger channel capacity and therefore higher flow recurrence interval required to overtop banks. As the bankfull flow recurrence interval increases the frequency of floodplain inundation (via overbank flows) decreases. This results in decreased rates of suspended sediment deposition across floodplains.

2.5 Channel-floodplain connectivity

The structure of floodplains (as described in the last sections) determines the space for deposition in various floods. It also influences the way that water and sediment move onto floodplains. To understand floodplain sedimentation we need to understand how water and sediment move onto floodplains. Many hydraulic and geomorphic models represent floodplains as relatively flat surfaces adjacent to a waterway that may or may not comprise levees and point bars. However, high resolution topographic date (i.e. LiDAR) shows that many floodplains, particularly meandering floodplains, have complex morphology and often contain channel networks that enhance channel-floodplain connectivity (David et al., 2017; Trigg et al., 2012). Simple models often intrinsically link channel-floodplain connectivity with bankfull flow (Leopold et al., 1964; Williams, 1978), suggesting that floodplain engagement only occurs after a threshold stage of bankfull flow is reached. This notion reduces the waterway corridor to a state of being either channelised (below bankfull discharge) or flooded (above bankfull discharge). In reality, topographic data suggests there is more likely a continuum of connectivity between waterways and their floodplains in many systems (Czuba et al., 2019).

The continuum of connectivity is often dependent on the presence of floodplain channels which convey water between the channel and floodplain across a range of flows before the banks (or leeves) are overtopped (Czuba et al, 2019). These low points in the river bank represent remnants of paleochannels, bar ridges and swales, and channel cutoffs. Such floodplain channels are not explicitly accounted for in simple floodplain models (e.g. Nanson and Croke, 1992). Laboratory studies suggest that formation of scroll-barridges and swales, channel cutoffs, and point bar accretion result in the development of complex floodplain morphology and likely influence connectivity between floodplain channels and waterways (van Dijk et al., 2012; van Dijk et al., 2013).

Czuba et al (2019) developed a conceptual model of river-channel connectivity dynamics on a low-gradient meandering river. The model describes meandering rivers as transitioning between three discharge dependent phases: single thread, multithread, and fully inundated. In the single thread phase water is transported within the main channel, in the multithread phase water is transported within the main channel and multiple floodplain channels, and in the fully inundated phase water extends across most of the floodplain. The model acknowledges that boundaries between each phase are blurred (i.e. there are intermediary phases). Example image of streams in the multi-thread and fully inundated phase is provided in Figure 6 and Figure 7.

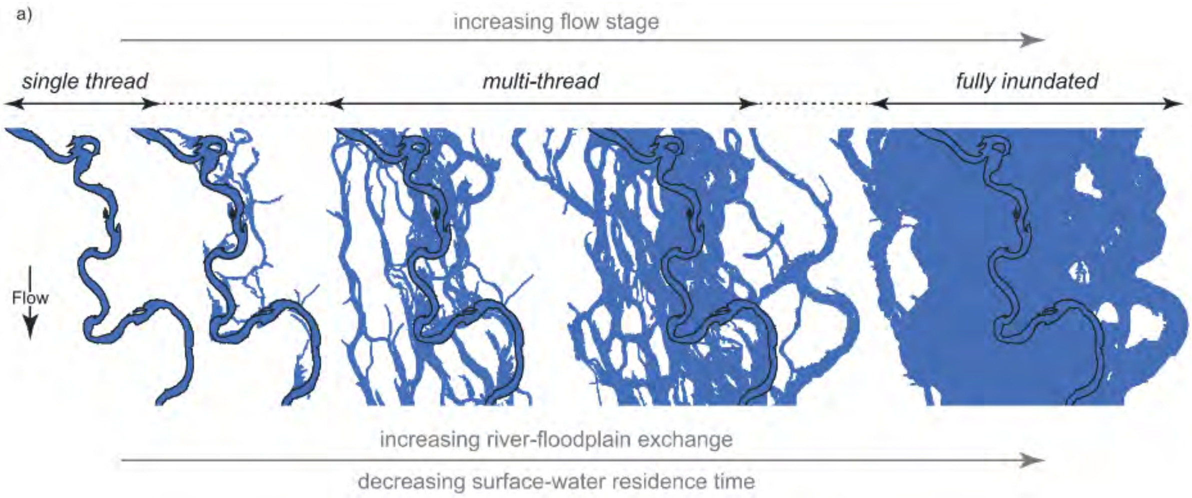


Figure 5. *Conceptual model of lateral surface-water river-floodplain connectivity where low-gradient, meandering river-floodplain systems are classified as having three, flow-dependent regimes: single thread, multithread, and fully inundated (from Czuba et al., 2019). Sediment generally stays in suspension in floodplain channels, in contrast once a choke point (i.e. due to valley constriction or tributary junctions) is engaged backwatering occurs inducing deposition of sediment.*

Figure 6. *Aerial imagery of the Stanley River in the multithread phase.*

Figure 7. *Aerial imagery of the Mary River (Kenilworth) in the fully inundated phase.*

Park et al. (2020) investigated channel-floodplain connectivity in a floodplain reach in the middle of the Amazon valley. The study aimed to decouple two key channel-floodplain connectivity processes: floodplain channel flows and overbank flows. The study found that floodplain channels control water residence time on floodplains and are associated with sediment deposition leading to positive topographic features such as ridges. In contrast overbank flows control the majority of water storage (90%) and sediment budget (80%) of the floodplain. Comparison of major connectivity processes are provided in Table 3.

Table 4. Comparison of major channel-river connectivity processes (adapted from Park, 2020).

Processes	Floodplain channelised flows	Overbank flows
Controls	Water residence time, and water surface area	Majority of water and sediment budgets
Controlled by	Floodplain geomorphology	Bank height
Associated floodplain geomorphic processes	Positive topographic development	Alleviation and smoothing of positive topography features through vertical accretion; filling depressions (i.e. negative topography)
Spatial scale of processes	Localised where floodplain channels are engaged	Localised in wider area where bank height is relatively low
Inundation duration	Longer (initial connection to disconnection)	Shorter (only during close to the flood peak)

Above we have described how deposition varies across a floodplain depending on the pattern of connection to the river. But the amount and type of deposition also varies along the river valley (longitudinally) because of changes in the width of the floodplain. Many authors have described how floodplain ‘confinement’ varies along rivers leading to sediment ‘compartments’.

As a general model, sediment transport from a particular sediment source, through a river network, declines with distance downstream of source due to deposition process (Prosser, 2018). However, Croke et al. (2013) identified that channel-floodplain sediment connectivity in Lockyer Creek (Queensland) varied longitudinally depending on valley and channel morphology. Lockyer Creek has a macro-channel morphology characteristic of the variable flow regime in the region. Throughout the waterway the macro-channel dimensions, and the bankfull recurrence interval, vary systemically with degree of confinement. Within this system there are confined reaches with little deposition, and floodplain reaches with significant floodplain deposition; this pattern of sediment distribution was reflected in the 2011 flood event. Therefore, in systems varying channel and floodplain morphology sediment delivery cannot be represented by a uniform distance variable.

Croke et al. (2013) used the spatial extent of flood inundation (from 2D hydraulic modelling of the 2011 flood) along Lockyer Creek to delineate nine reaches that display variations in channel-floodplain connectivity. Contraction reaches are defined as those sections of the valley where little or no floodplain inundation occurs. Whereas expansion reaches defined areas where extensive floodplain inundated occurred. The study found a clear link between expansion and contraction reaches, macrochannel capacity, and recurrence intervals. Bankfull recurrence intervals varied from 10s of years to 3300 yrs. Contraction reaches were associated with an increase in both bankfull discharge and ARI; with the highest bankfull ARIs occurring at the downstream extent of the contraction reaches. For example, macrochannels near Helidon township require an ARI >3000 yrs to fill to bankfull. Therefore, floodplain inundation via overbank flows is rare. However dynamic sequences of channel-floodplain connectivity, at various temporal stages, are known to occur in the Lockyer Valley. For example, floodplain inundation in some expansion reaches reflect overbank flow, while others reflect backwater inundation due to valley constriction or tributary junctions (which typically result in reduced flow velocity). Floodplain inundation also occurred in reaches with ‘perched channels’ due to upstream bank breaching or bank low points.

Hydrological connectivity controls patterns of sedimentological connectivity. Croke et al. (2013) showed that floodplains in contraction reaches in the Lockyer Valley are hydrologically disconnected for extended time periods and therefore, effective floodplain sediment storage is limited. However, due to high stream power the Contraction reaches do erode in large floods, so that they are the dominant source of sediment to downstream reaches (see example in Figure 8). In contrast, expansion reaches had low erosion rates but the highest floodplain storage.

Figure 8. *A contraction reach of Lockyer Creek near Gatton. The floodplains are rarely inundated, and flows are largely contained within the channel leading to high rates of channel erosion and limited floodplain deposition*

Study implications

Objective 1 - Review floodplain deposition processes in Queensland rivers and assess the applicability of the SedNet floodplain deposition model in modelling these processes

SedNet reduces the waterway corridor to a state of being either channelised (below bankfull discharge) or flooded (above bankfull discharge). There is more likely a continuum of connectivity between waterways and their floodplains in many systems. Furthermore, the floodplain connection processes can vary significantly longitudinally along the river even over short distance.

Objective 2 - Explore the opportunities for floodplain reconnection as a tool in GBR water quality management

Understanding floodplain connections is critical for targeting zones for riparian/floodplain management. For example, increasing roughness within expansion reaches or floodplain channels may result in significantly more deposition compared to other floodplain areas.

2.6 Fine sediment deposition processes on Queensland floodplains

Overview

Floodplain morphology is linked to the form and processes of the river channels which shape them. Deposition, reworking, and erosion are key processes associated with the formation and development of floodplains. Floodplains form as sediment accumulates on floodplain surfaces. Nanson and Croke (1992) defined the three main accretion processes as

i. lateral accretion,
ii. vertical accretion
iii. braid bar accretion

Lateral point-bar accretion occurs in meandering rivers which progressively erode outside meanders and accrete point bars on the inside of bends; creating a new floodplain of accumulated point bar deposits (Ritter et al., 1973; Nanson, 1980). This accretion process can result in various floodplain morphologies, some with little surface relief others with a series of concentric ridges (i.e. meander scroll bars). Floodplain features associated with medium-energy non-cohesive meandering floodplains are shown in Figure 9a.

Overbank vertical accretion occurs when flow exceeds the capacity of a river channel, flows spills onto the floodplain, and fine material settles out of suspension and is deposited on the floodplain. On the floodplain increased wetted surface area, in combination with increase roughness, causes a reduction in flow velocity enabling sediment to settle on the floodplain. Vertical accretion is generally the dominate accretion process in low-gradient single-thread channel (Ritter et al., 1973, Nanson and Young, 1981) and anastomosing channels where steam power is not high enough to cause meander migration (Smith, 1980). Vertical floodplain accretion is self limiting as increases in floodplain elevation correspond with a decrease in the frequency of inundation and sedimentation (Wolman and Leopold, 1957)). Floodplain features associated with laterally stable single thread channel, and associated low-energy cohesive floodplains, are shown in Figure 9b.

Braid-channel accretion occurs when bars are abandoned and are gradually incorporated into floodplain deposits. Braid-channel accretion can occur due to several process including when the main channel shifts to another part of the valley abandoning bars, and when large floods result in extensive bar deposits.

Erosional processes are also associated with floodplain evolution. The two key erosional processes are floodplain stripping and avulsions. **Floodplain stripping** occurs when significant areas of the floodplain surfaces are removed and transported by high-magnitude flow events. Floodplain stripping is more prevalent in confined systems where floodplain flows are confined by valley margins. Overbank flows can also result in the erosion and formation of flood channels. Channel **avulsion** occurs when a river rapidly changes its course, abandoning the original channel (termed the parent channel) and scouring a new channel/s across the floodplain/s (the daughter channel); switching flow from one channel to another.

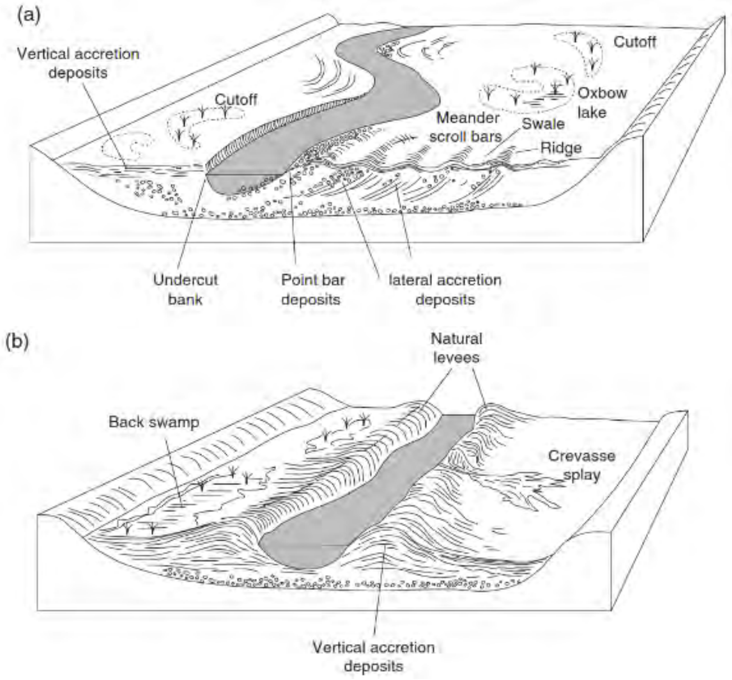


Figure 9. *Floodplain features associated with (a) medium-energy non-cohesive meandering floodplains, (b) low energy cohesive floodplains. In Charlton (2007) adapted from Nanson and Croke (1992).*

Mechanics of overbank sedimentation

There are two major hydraulic processes involved in transferring sediment suspension onto floodplains: turbulent diffusion and advection. Lateral turbulent diffusion occurs due to the mixing of low velocity floodplain flow and high velocity channel flow. As the channel has higher sediment transport capacity, and therefore higher suspended sediment concentration compared to the floodplain, turbulent diffusion results in a net sediment transfer towards the floodplain (Rhoads, 2020). Advection is the transport of sediment within the flow field and occurs when flow spills onto the floodplain during unsteady flows (Nicholas & Walling, 1998). Lateral turbulent diffusion is the dominate mechanism of sediment transfer in straight channels where floodplain flow travels parallel to the channel. Whereas, advection is the dominant mechanism of sediment transfer in meandering rivers where floodplain flow deviates from the channel direction (Rhoads, 2020).

Overbank sedimentation plays an important role in the development of levees. Levees are elongate raised ridges which form at the interface between the channel and floodplain during overbank flows. As flow moves out of the channel onto the floodplain there is a sudden loss of momentum due to lateral turbulent diffusion. This results in deposition of the coarse fraction of the suspended sediment along the channel edge.

The thickness of sediment deposited on a floodplain and the particle size of the sediment decreases with distance from the channel (Rhoads, 2020). Deposition of suspended sediment occurs when settling velocity dominates over turbulent diffusion. The settling velocity is primarily a function of the density, shape and size of the particulate matter (Charlton, 2007). A large particle (i.e. sand) will settle faster than a clay or silt particle and as a result will not travel as far in suspension. Sediment will be transported in suspension as long as the upward component of the turbulence is large enough to overcome the weight of the particle. If not large enough, it will fall at a rate governed by the settling velocity and may be deposited.

Floodplain deposition rates

Floodplains are important sources and sinks for sediments and associated pollutants. Several studies have assessed floodplain suspended sediment trapping efficiencies at various spatial and temporal scales (Swanson et al., 2008; Day et al., 2008; Benedetti, 2003). These studies found that the sediment trapping efficiency of a floodplain is dependent on hydrology (peak discharge and flood duration), floodplain morphology (presence of levees or distributary channels, and floodplain development), and suspended sediment supply.

Benedetti (2003) found that suspended sediment concentration and the incoming suspended sediment load timing drove floodplain deposition rates on the Mississippi River. Swanson et al. (2008) and Day et al. (2008) investigated the influence of suspended sediment yield and floodplain development on suspended sediment trapping efficiency on the Fly and Strickland River in Papua New Guinea. On the Strickland River high sediment yield resulted in higher floodplain levees and deposits, and a corresponding lower trapping efficiency. In comparison, the Fly River has higher floodplain connectivity via the channel and flood runners, and therefore higher floodplain exchange rates.

Garber (2021) demonstrated that, for 19 catchments in the Brisbane River system, overbank flows transported about half of the total suspended sediment transported by the river. The other half was carried during normal non-flood flows. However, for different catchments the rate varied between 5% and 98%. This percentage provides a basic control on the total amount of floodplain deposition.

Studies suggest that floodplains can trap up to 44% of catchment suspended sediment yields in small (2 sq.km) catchments (Pizzuto et al., 2014, 2017), but they typically trap in the range of 0.1-1% of total sediment yield per km in larger (103 sq.km) catchments (Pizzuto et al., 2017). However, sediment budget data show that trapping efficiencies vary by up to two orders of magnitude per kilometre of river corridor (Pizzuto et al., 2017). Garber's (2021) analysis suggests that the floodplain trapping efficiency, or percentage of the total overbank proportion of the annual suspended sediment yields, is at most 4% of the suspended sediment yield per km of river in the Brisbane River catchment.

Pietsch et al. (2015) investigated the significance of in-channel depositional surfaces in the Normanby River. Where in-channel units are benches or inner floodplains (i.e. genetic floodplains), within the macro-channel, which sit below the more expansive hydraulic floodplain. The study used LiDAR based mapping in combination with optical dating of in-channel deposits to compare aggradation rates of various depositional zones in the catchment (i.e. inset features, hydraulic floodplains and coastal plain). The benches were found to be significant stores of contemporary (i.e. recent decades/last century) fine sediment, annually accounting for greater than 50% of the volume of hillslope and subsoil derived sources. The study also found that accelerated aggradation on inset features has occurred in response to accelerated rates of erosion since European settlement.

Hughes et al. (2010) analysed changes in rates of floodplain accretion in Theresa Creek, a sub catchment of the Fitzroy River, in response to landscape disturbance. Using optical dating and ^{137}Cs depth profiles, the study estimated floodplain deposition rates pre and post European settlement. Floodplain accretion rates (mm yr^{-1}) were found to have increased by three to four times since European settlement. Agricultural areas with cleared floodplain, in particular, had high accretion rates. Hughes et al. (2010) also found in-channel benches (deposited since European settlement) to be significant stores of sediment.

Amos et al. (2009) assessed floodplain deposition rates in four geographically dispersed sites in the Fitzroy River catchment using ^{137}Cs inventory and depth profile techniques. There was considerable variability in the four floodplain depth profiles measured; results ranged from erosion to greater that 60 cm of deposition in the last 40 – 50 years. Average annual deposition rates (vertical accretion) ranged from 0 to 15 mm. Comparable annual deposition rates of 0-10 mm have been observed in temperate and tropical environments (Rumsby, 2000 and Terry et al., 2006).

Other than these studies outlined above there are minimal empirical studies of floodplain deposition rates in Queensland. Within GBR catchment floodplain deposition is primarily estimated by a catchment scale sediment budget model (Dynamic SedNet). Often there is limited data to calibrate floodplain deposition rates in GBR catchments but Bainbridge et. al. (2023) highlighted the benefits of using multiple lines of evidence of sediment sources and sinks.

The role of vegetation in floodplain deposition

Riparian vegetation affects and responds to fluvial processes. Its above-ground biomass modifies the flow field (inducing floodplain deposition) and retains sediments. While the below-ground biomass influences the hydraulic and mechanical properties of the sediment and subsequently the erosion potential of the floodplain (Gurnell, 2014).

Riparian vegetation plays an important role in trapping and stabilising sediments, and modifying sedimentary and morphological environments by accelerating the development floodplains (Gurnell et al., 2012). The distribution, flexibility, life stage and density of woody floodplain vegetation strongly influences sediment deposition in deep (>1 m) overbank flows (Griffin et al., 2014). Woody vegetation modifies the flow field through form drag which reduces the flow velocity and shear stress on the substrate surface (the skin friction shear stress). During flow events drag on woody vegetation can result in orders of magnitude reductions in shear stress on the floodplain surface and consequentially sediment deposition on that surface (Kean and Smith, 2004). If in-channel boundary shear stress is sufficiently high, it will carry sediment (e.g. sands) in suspension onto the floodplain. As shear stress reduces on the floodplain (due to woody vegetation) sediment will settle out of suspension.

The crucial role of riparian vegetation as physical ecosystem engineers in riverine systems has been confirmed by field observations, flume studies, and numerical modelling in terms of the flow resistance provided by vegetation (McKenney et al., 1995; Bennett et al., 2008), and the role of vegetation in reducing shear stress and trapping sediment (Gurnell et al., 2000, 2007). Griffin et al. (2014) used one-dimensional models of flow and suspended sediment transport to assess the effects of woody vegetation on overbank sand transport. The results showed that drag on woody vegetation reduced skin friction shear stress by two orders of magnitude, however velocities were still high enough to transport sand 50 m across vegetated floodplains.

Trees typically only encourage deposition around them early in their life. Garber (2021) demonstrated that both *Melaleuca bracteata* and *Casuarina cunninghamiana* can absorb enough shear stress to induce the deposition of suspended sediment (coarse silt and finer). However, they typically only exhibit the densities needed to do so at the beginning of their life cycle (5-12 years old) until within-patch competition and stand thinning ceases.

Study implications

Objective 1 - Review floodplain deposition processes in Queensland rivers and assess the applicability of the Dynamic SedNet floodplain deposition model in modelling these processes

This Dynamic SedNet model assumes laminar flow on the floodplain, so there is no resuspension of sediment, and the roughness of the floodplain and complexity of floodplain flow dynamics are simplified. The Dynamic SedNet formulation also assumes that all the discharge above the bankfull discharge flows across the floodplain. The suspended sediment concentration is assumed to be completely mixed across the channel and floodplain.

Objective 2 - Explore the opportunities for floodplain reconnection as a tool in GBR water quality management

In certain areas vegetation on floodplains can result in significant reductions in surface velocity and shear stress across floodplains, and as a result increase rates of floodplain sediment capture.

2.7 Floodplain deposition summary

Bankfull flow recurrence interval, floodplain flow volumes, floodplain vegetation, floodplain area and morphology, and sediment supply are important drivers of floodplain deposition. These key factors which influence floodplain deposition in GBR catchments are summarised in Table 5. Each of these factors should be considered when quantifying floodplain deposition rates.

Table 5. Key factors which influence floodplain deposition in GBR catchments.

Factor	Impact on floodplain deposition
Proportion of channelised and overbank flows	Water and sediment move onto floodplains via many low points in the banks, up to the point at which the entire floodplain is inundated.
Bankfull flow recurrence interval	As the bankfull flow recurrence interval increases the frequency of floodplain inundation (via overbank flows) decreases. This results in decreased rates of suspended sediment deposition across floodplains.
Proportion of sediment carried in flood flows	The proportion of sediment load carried during floods is on average 50%, but for specific floodplains this can vary from 2% to 98%.
Floodplain flow volumes	Higher floodplain flow rates during flood events can increase the volume of suspended sediment transported, and ultimately deposited, onto floodplains.
Floodplain flow velocity	Vegetation increases floodplain boundary resistance. When overbank flows occur, flow velocity is reduced by the increases roughness of the floodplain surface due to vegetation, resulting in deposition of suspended sediment (Charlton, 2007). Understory vegetation is more important here than are trees.
Cross-sectional area	There is a significant increase in cross-sectional area when overbank flows occurs. An increase in cross-sectional area results in more contact between the flow and the boundary material (floodplain surface) and therefore an increase in flow resistance and decrease in flow velocity. This results in increased rates of suspended sediment deposition across floodplains.
Channel and floodplain morphology	The floodplains in contraction reaches are hydraulically disconnected for extended time periods, whereas floodplains in expansion reaches are hydraulically connected and have higher rates of deposition. Backwater inundation, due to downstream valley constriction, increases inundation and deposition rates. The presence of low bank points also increases floodplain inundation prior to the flood peak.

Sediment concentration	Higher suspended sediment concentration results in higher floodplain deposition rates. Agricultural areas, for example, are a significant source of sediment and therefore floodplains immediately downstream tend to have higher accretion rates.

3 Understanding the efficacy of the Dynamic SedNet model in estimating floodplain deposition volumes

3.1 Dynamic SedNet

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 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 responses based on land use. Dynamic SedNet uses a daily rainfall-runoff model to predict runoff for each FU in each sub-catchment, and subsequently to predict daily flow and bankfull flow for 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 etc.).

The floodplain deposition component of Dynamic SedNet models the mass of fine sediment deposited on the floodplain of each stream link represented in the node-link network. The floodplain deposition model is a component of the Dynamic SedNet Stream Fine Sediment composite model, which comprises the Stream Bank Erosion model with the option of including floodplain deposition and/or channel deposition/remobilisation modelling. The Dynamic SedNet estimated sediment budget for the Fitzroy catchment is shown in Figure 10. The accuracy of these estimates is explored below.

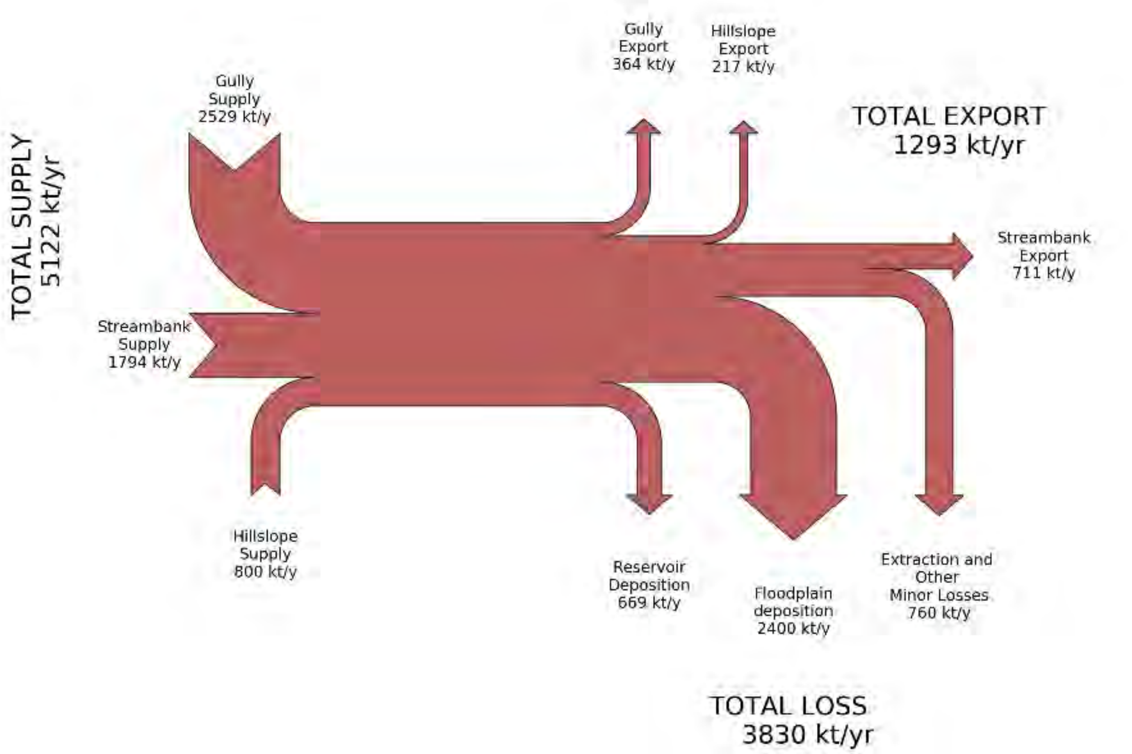


Figure 10. *Fitzroy River catchment Dynamic SedNet Total Suspended Sediment budget.*

3.2 Modelling floodplain deposition

Overbank flow occur when flows are greater than the capacity of the channel, and flow overtops the river bank breaking out onto the floodplain. Flow velocity across floodplains is considerably less than flow velocity in the channel; hence deposition of fine sediment occurs on the floodplain during overbank flows (Waters et al., 2014).

The floodplain deposition component models the fine sediment deposited on the floodplain of each link on a daily basis. The daily floodplain deposition in the Dynamic SedNet model is represented as a function of three key controls (Prosser et al., 2001); the fine sediment supplied to a link, the proportion of the fine sediment load delivered to the floodplain via overbank flows, and the proportion of sediment deposited on the floodplain. The proportion of sediment delivered to the floodplain is represented by the proportion of daily discharge delivered to the floodplain via overbank flows. The proportion of sediment deposited on the floodplain increases exponentially with residence time (Prosser et al., 2001). The Dynamic SedNet floodplain fine sediment deposition equation is illustrated in Figure 11.

$$\textit{Floodplain deposition (t/day)} = \textit{Fine sediment supply (t/day)} \times \textit{Proportion of daily discharge that goes overbank} \times 1 - e^{-\left(\frac{\textit{mean settling velocity}\left(\frac{m}{s}\right) \times \textit{floodplain area}(m^2)}{\textit{floodplain discharge}\ (m^3/s)}\right)}$$

Figure 11. *Floodplain fine sediment deposition equation.*

Floodplain deposition (F_i) is calculated as (Prosser et al., 2001; Wilkinson et al., 2010, 2014; Ellis and Searle**,** 2014):

$$\boldsymbol{F_i = I_i\left({}^{Q_f}\!/_{Q_L}\right)\left(1 - e^{-(VA_f/Q_f)}\right)}$$

Where:

I_i = daily fine sediment supply (tonnes/day)
Q_L = daily discharge (m^3/s)
Q_{bf} = bankfull discharge (m^3/s)
Q_f = daily floodplain discharge (m^3/s), (daily discharge minus bankfull discharge)
A_f = floodplain area (m^2)
V = mean settling velocity (m/s), default is 0.0007

Where the proportion of daily discharge that goes over bank is calculated as:

$${}^{Q_f}\!/_{Q_L} = \frac{Q_L - Q_{bf}}{Q_L} \quad \text{if } Q_L > Q_{bf}$$

$${}^{Q_f}\!/_{Q_L} = 0 \quad \text{if } Q_L < Q_{bf}$$

The key input parameters required for the Dynamic SedNet floodplain deposition component are outlined in Figure 12.

Figure 12. Dynamic SedNet floodplain deposition key input parameters and potential data sources.

Parameter	Units	Description	Data source / Basis	Limitations
I_i (daily fine sediment supply)	tonnes /day	Total suspended (fine) sediment supply to the link	Lateral Load + Inflow Load + Residual Load	
Qi(daily discharge)	m^3/s	Time varying parameter		
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	Bankfull discharge used in the SedNet model typically

				underestimate the actual bankfull flows
Q_f (daily floodplain discharge))	m^3/s	Daily discharge minus bankfull discharge	-	Underestimation of bankfull flow results in overprediction of floodplain flow in the SedNet model.
A_f (floodplain area)	m^2	Spatially variable	Calculated from an input grid of values 0, and 1 for floodplains. Floodplain area estimated using 1:100,000 scale landscape mapping, with some checking through aerial photograph interpretation (Prosser, 2018).	Floodplain areas used in the SedNet model typically underestimate the actual floodplain area
V (mean settling velocity for floodplain deposition)	m/s	Default is 0.0007	Stokes Law (Gerhart and Gross, 1985), assuming 30 µm mean particle size based on suspended sediment analysis	Ideally set to the lower end of expected suspended sediment sizes, so larger particles can be expected to settle within the floodplain residence time (Wilkinson et al, 2009)

3.3 Limitations of modelling floodplain deposition

Bankfull flow recurrence interval, floodplain flow volumes, floodplain vegetation, floodplain area and morphology, and sediment supply are important drivers of floodplain deposition. This section considers how well the Dynamic SedNet model represents these key factors which influence floodplain deposition.

Bankfull discharge is an important control on catchment erosion and deposition processes. When higher flows are confined within a channel (i.e. within an entrenched channel) there is greater potential for flow to erode the channel bed or banks, and to transport sediment downstream without depositing sediment on floodplains (Prosser, 2018). SedNet applies a bankfull discharge based on a default 1.58 year recurrence interval (derived from a global study on rivers with active floodplains). However, higher discharges are confined within channel in many Queensland rivers (e.g. Croke et al., 2013, Alluvium, 2020). Underestimation of bankfull flow would result in overprediction of the proportion of the fine sediment load delivered to the floodplain. Considering the influence of bankfull discharge on floodplain deposition, improved parameterisation of bankfull flow is required.

The Dynamic SedNet Model models floodplain deposition as a function of **floodplain area**. Therefore, to some extent, the model represents deposition patterns observed in Queensland waterway such as the Lockyer Creek where higher deposition rates occur in expansion (floodplain) reaches (Croke et al., 2013). However, Dynamic SedNet does not account for other characteristics of contraction and expansion reaches such as variation in bankfull flow recurrence intervals (Prosser, 2018). The floodplain area input is based on the mapping of flat valley bottoms from DEMs (Gallant and Dowling, 2003) and defines the maximum flood water inundation extent. However, hydraulically disconnected terrace units (which are not inundated) may be captured as flat valley surfaces. Prosser (2018) identified that floodplain area estimates could be improved by using flood extents derived from flood maps or estimated from 2D hydraulic models.

The Dynamic SedNet model does not account for influence of **floodplain morphology** on deposition rates. Narrow floodplains would be characterised by higher flow velocities and therefore lower rates of deposition compared to broad floodplains.

The Dynamic SedNet model does not account for influence of **floodplain roughness** on deposition rates. Rougher (i.e. densely vegetated) floodplains would be characterised by lower flow velocities and therefore higher rates of deposition compared to denuded floodplains.

4 Case study assessment of Dynamic SedNet modelled links

A case study assessment was used to assess the parameterisation of the floodplain deposition model in Dynamic SedNet. 17 case study reaches were identified for which high resolution LiDAR data was available. The LiDAR was used to assess floodplain area and bankfull flow (based on a one-dimensional hydraulic model). The findings were compared to the Dynamic SedNet parameterisation.

4.1 Methodology

For each case study area high resolution LiDAR data was used to estimate floodplain area and bankfull flow. The Dynamic SedNet and LiDAR methodology is described below:

Floodplain classification

Dynamic SedNet

In Queensland the input Dynamic SedNet floodplain area is estimated using 1:100,000 scale landscape mapping, with some checking through aerial photograph interpretation (Prosser, 2018).

LiDAR analysis

High resolution LiDAR data was used to estimate the floodplain area in the case study area. Two floodplain inundation surfaces were delineated in each case study area. The inundation surfaces were classified based on elevation above river bed using a Relative Elevation Model, cross-sectional geometry, and morphology of the inundation surface.

Bankfull flow assessment

Dynamic SedNet

The SedNet input bankfull flow is based on derived ARI discharge determined from long run of hydrology in the Source model. The default bankfull ARI is 1.58 years.

LiDAR

One-dimensional HEC-RAS models were developed for the study areas. Flood frequency analysis from gauge data (when available) was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to estimate the flow where the flow height matched the floodplain surface throughout the case study area. This was used as an estimate of bankfull flow.

Input parameters used within the Dynamic SedNet model (i.e. Manning's roughness coefficient, slope, channel width and bank height) were also used to estimate of bankfull flow using Manning's equation, as detailed below:

$$Q = \frac{1\, A\, R^{2/3} S^{1/2}}{n}$$

Where:

Q = bankfull flow (m^3/s)

A = bankfull cross-sectional area (channel width × bank height) (m^2)

R = hydraulic radius (A/wetted perimeter) (m)

S = hydraulic gradient (assume equal to channel slope) (m/m)

n = Manning's roughness coefficient

4.2 Overview

The seventeen case study areas are located within the Cape York region, Burdekin Basin, Fitzroy Basin and Burnett Mary region. The case studies are shown in Figure 13 and described in Table 6. Each of the seventeen case study areas are discussed below.

Figure 13. *The location of the seventeen case study areas.*

Table 6. Description of the case study areas.

Region	Stream	Description
Cape York	Laura River	A 70 km section (including 7 SedNet model links) of the Laura River extending from the Honey Dam outflow at Lakeland, to just upstream of the Mosman River confluence at Laura.
	Normanby River	A 20 km section (including 2 SedNet model links) of the Normanby River extending downstream of the junction of the East and West Normanby River branches, approximately 20 km north east of Lakeland.
Burdekin	Basalt River	The Basalt River case study area includes 4 Sednet model links and extends for approximately 70 kilometres upstream of its confluence with the Burdekin River, north of Charters Towers.
	Haughton River	The Haughton River case study area extends for approximately 60 kilometres downstream from its confluence with the Reid River to its confluence with Cromarty Creek, downstream of Giru. The reach includes 2 SedNet model links.
	Rosella Creek	The Rosella Creek case study area extends for approximately 54 kilometres upstream of its confluence with the Bowen River in the Burdekin River catchment. The reach includes 5 Sednet model links.
	Murray Creek	A 23 km section of Murray Creek upstream of the Bruce Highway.

Region	Stream	Description
Mackay Whitsundays	O'Connell River	A 17 km section of O'Connell River upstream of the Bruce Highway.
Fitzroy	Fitzroy River	A 65 km section of the Fitzroy River upstream of the tidal barrage in Rockhampton.
	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.
	Woleebee Creek	The Woleebee Creek case study area extends for approximately 60 kilometres upstream of its confluence with the Juandah Creek, northwest of Wondoan, to just upstream of its confluence with Hellhole Creek. The reach includes 5 SedNet model links.
	Raby Creek	The Raby Creek case study extends for approximately 22 kilometres, from the Mimosa Creek confluence, upstream of Wooroona, to the foothills of the Dawson Range State Forest. The reach includes 1 SedNet model link.
	Panorama Creek	The Panorama Creek case study extends for approximately 32 kilometres, the upstream portion includes approximately 22 km of Panorama Creek from the Consuelo Creek confluence, the lower portion then meets and becomes the Comet River near the Rolleston township. The reach includes 2 SedNet model links.
	Dawson/Mackenzie River	The case study area includes a 16 km reach of the Mackenzie River (including 1 SedNet model link), and a 25 km reach (including 4 SedNet model links) of the Dawson River extending upstream from their confluence that forms the Fitzroy River near Duaringa.
Burnett Mary	Mary River	A 40 km section of Mary River which extends from the Yabba Creek confluence to Six Mile Creek, just upstream of Gympie.
	Three Moon Creek	A 48 km section of Three Moon Creek (including 3 SedNet links) extending from the Spring Creek confluence, upstream of Moonford, to Mulgildie.
	Barambah Creek	The Barambah Creek case study extends for approximately 55 kilometres, from the Barker Creek confluence immediately downstream of Lake Barambah, to the Sunday Creek confluence, southwest of Mondure. The reach includes 4 SedNet model links.
	Obi Obi Creek	An 18 km section of Obi Obi Creek extending upstream from its confluence with the Mary River at Kenilworth. The reach includes 1 SedNet model link.

4.3 Cape York - Laura River

Overview

The Laura River case study area extends for approximately 70 kilometres, from the Honey Dam outflow at Lakeland, to just upstream of the Mosman River confluence at Laura (Figure 14). The river drains the greater Normanby catchment and outflows into Charlotte Bar and the GBRF Lagoon in the Cape York Region. The floodplains along this reach are largely used for grazing, while the upper catchment to the north supports irrigated cropping and horticulture through the Lakeland irrigation scheme. While there are no active weirs within the study reach there is significant water resource development in the upper catchment which has included damming of creeks and sub-artesian springs and drilling of bores. The catchment geology includes the

Hodgkison Formation – characterised by metamorphic greywacke, siltstones and mudstones, and the McClean Basalt – Basalt lava flows.

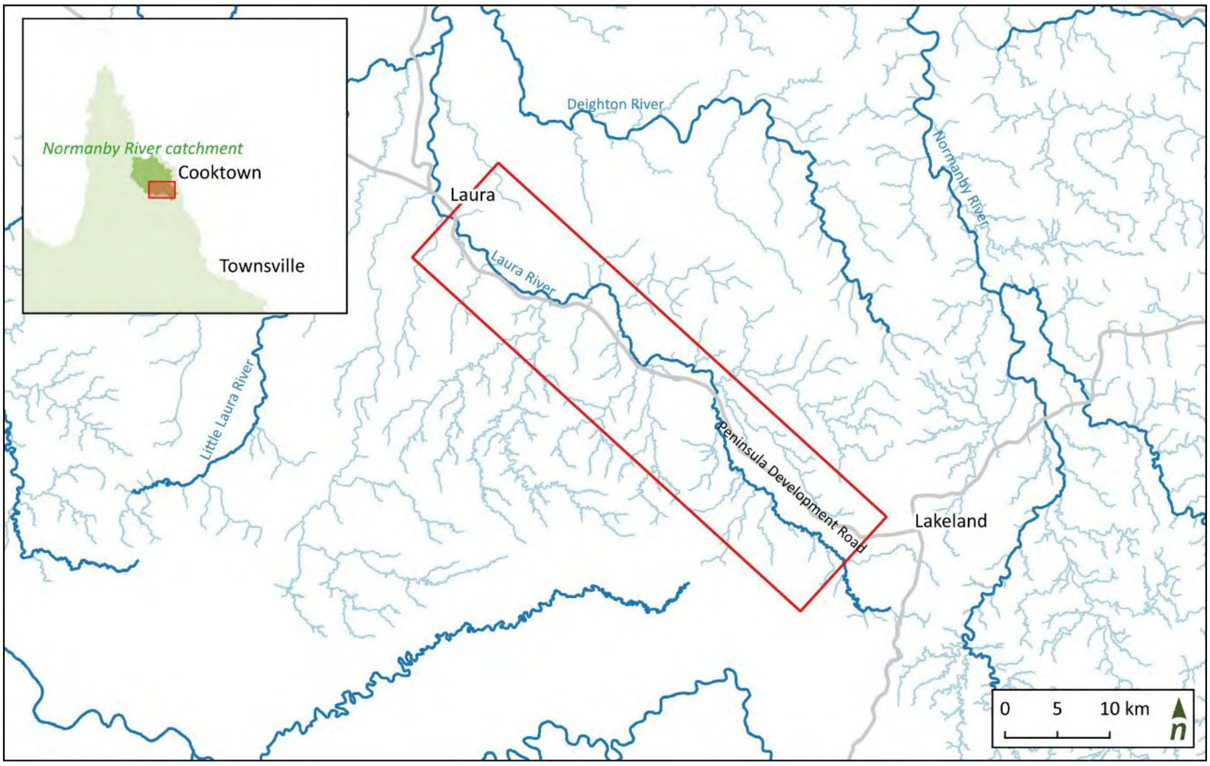


Figure 14. *The Laura River case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Laura River study area (Figure 15), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the case study area.

The Laura River flows through varying degrees of bedrock and terrace confinement. Within the study area the channel is typically entrenched and bound by upper floodplains/terraces which sit 10 – 20 m above the channel bed. The terrace is bordered by basaltic plateaus, associated with the Mclean Basalt formation, on the northern/eastern side, and volcanic/metamorphic hillslopes associated with the Hodgkinson formation on the southern/western side. The upper floodplain/terrace width is typically narrower (<500m) through the upper reaches (upstream of chainage 55,000m) and the lower reaches (downstream of chainage 25,000m), and up to 2,500 m through the mid reaches.

The dominant floodplain surface (by area) in the Laura River study area is terraces, there are isolated areas with genetic floodplains (Figure 15). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 16.

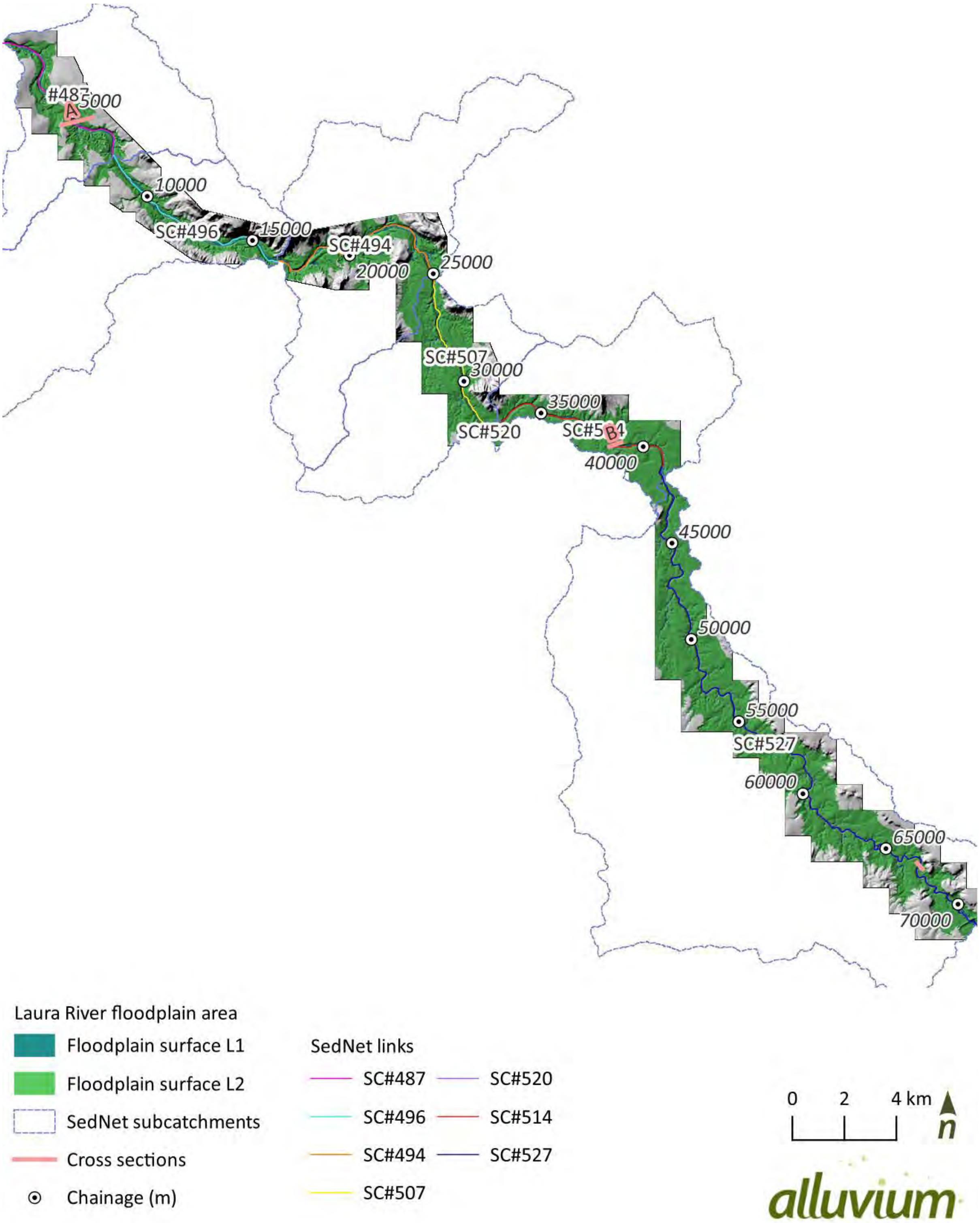


Figure 15. *The Laura River case study area the two major inundation surfaces in the area; the genetic floodplain and terrace. The representative cross section locations are also shown.*

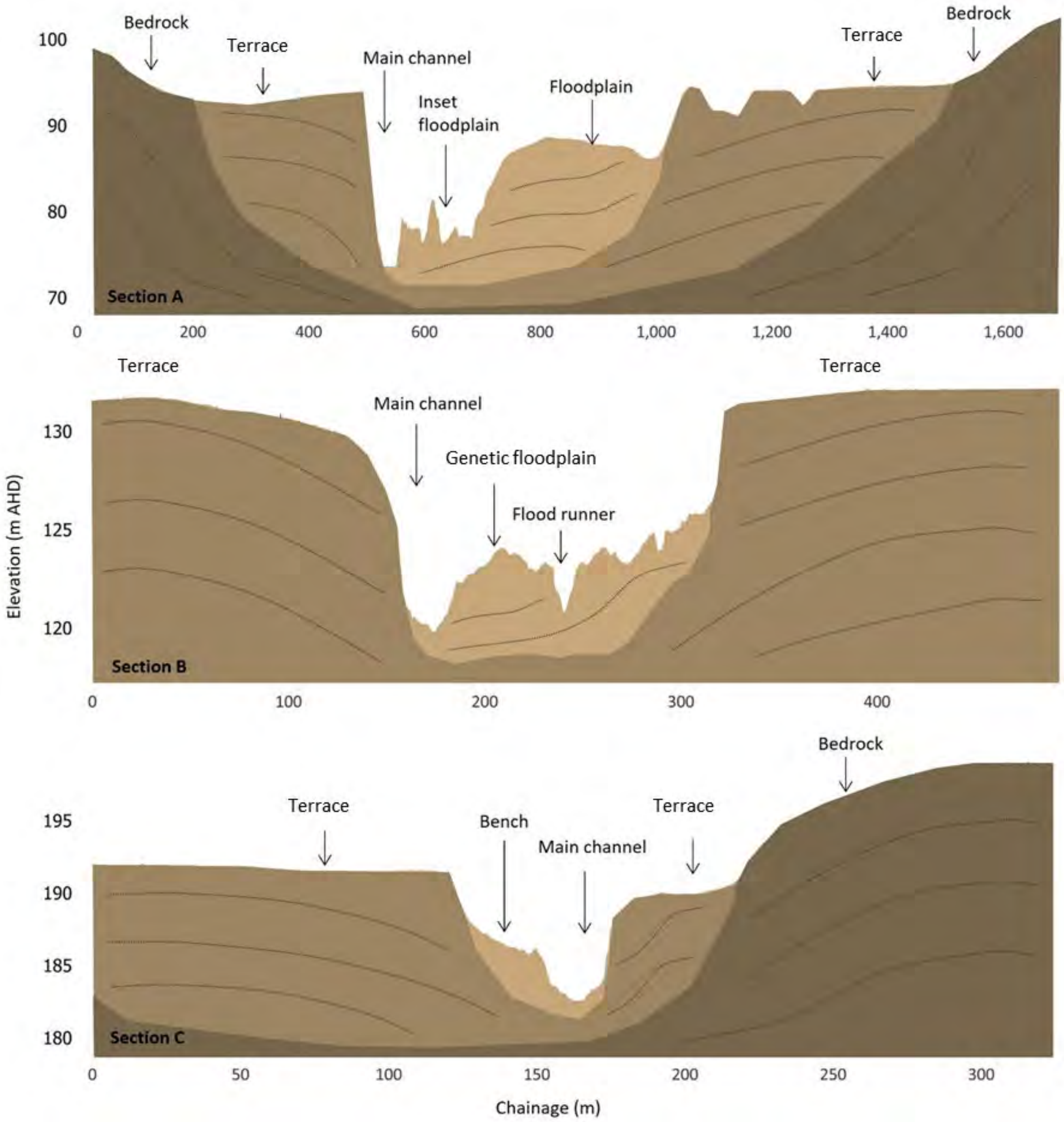


Figure 16. *The three typical sections in the Laura River case study area (shown in Figure 15) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Laura River case study area are provided in Table 7. The SedNet floodplain area generally ranges from 143% to 1200% of the LiDAR derived genetic floodplain area. There is one link in an upper reach (SC #514) where the SedNet floodplain area is 42% of the LiDAR derived genetic floodplain area. In general, the input Dynamic SedNet floodplain areas are overpredicted.

Table 7. Comparison between Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Laura River case study area.

Link (Sub-catchment)	SedNet Floodplain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR genetic floodplain area
		Genetic floodplain (km²)	Terrace (km²)	
SC #487	10.2	0.8	13.8	1200%
SC #496	10.9	1.5	13.7	750%
SC #494	2.1	1.5	19.5	143%
SC #507	3.2	1.2	17.8	266%
SC #520	0.0	1.0	7.6	-
SC #514	0.7	1.7	52.3	42%
SC #527	13.5	2.5	44.9	535%

Bankfull flow assessment

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Laura River case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated to flow heights, a consistent Mannings roughness of 0.04 for the channel and 0.07 for the overbanks was used across all case studies. A stream gauge with 55 years of data is present at the downstream extent of the study reach (Figure 17). Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for two flow events, 1,200 m^3/s and 2,800 m^3/s are shown in Figure 17. The channel capacity varies throughout the case study area. Bankfull flow is typically 1,200 m^3/s in the upper reaches (upstream of chainage 44,000 m) which has an estimated return period of 3 years. Bankfull flow is 2,800 m^3/s in the lower reaches, which has an estimated return period of 50 years. In the lower reaches a flow of 1,200 m^3/s is close to aligning with the elevations of the genetic floodplain.

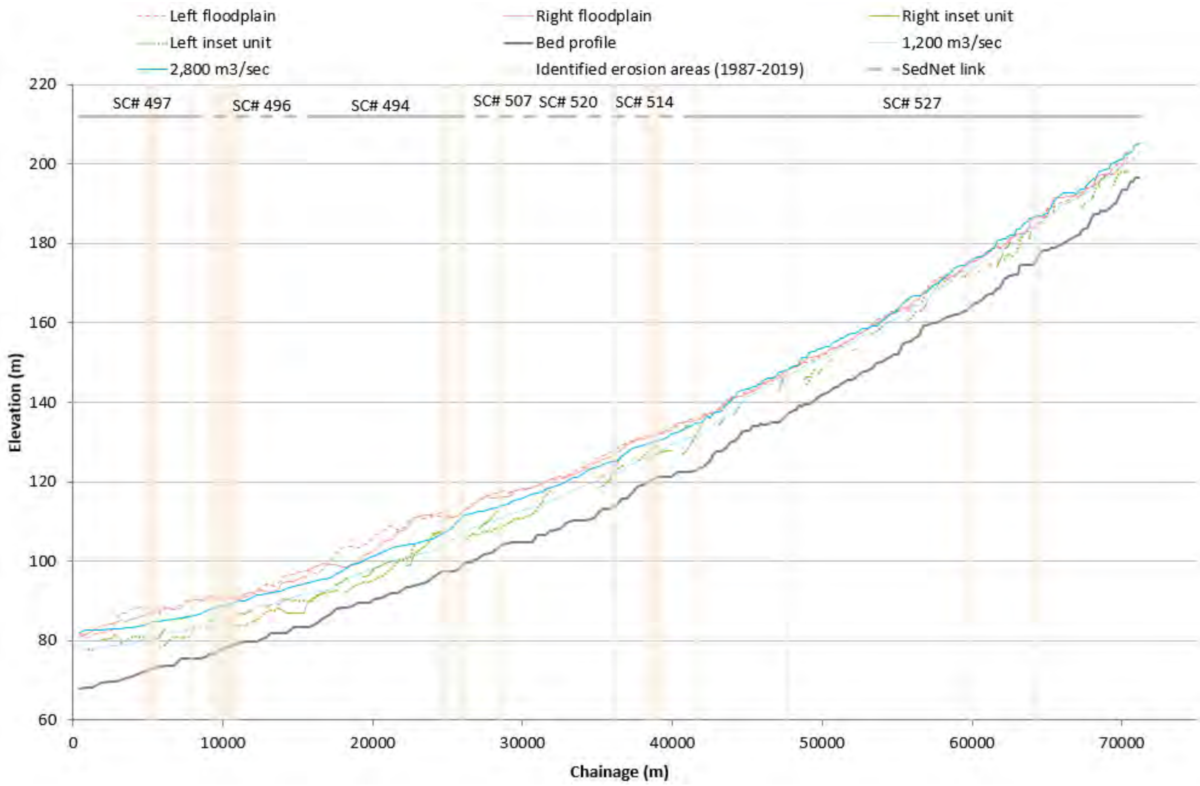


Figure 17. *The water surface elevation for a range of flow events near the bankfull elevation within the Laura River case study area.*

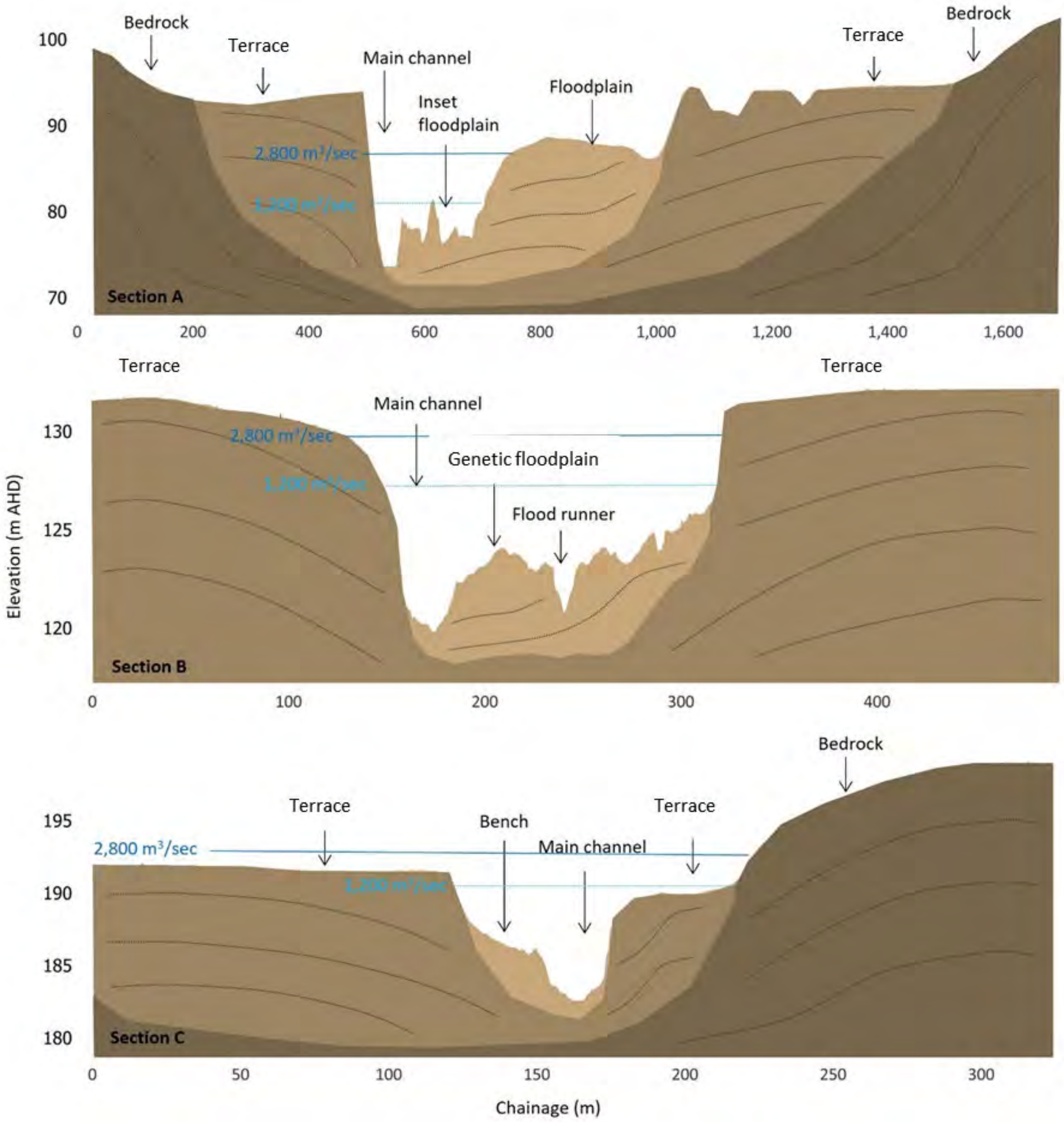


Figure 18. *The three typical sections in the Laura River case study area (shown in Figure 15) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Laura River case study area range between 60 m^3/s in the upper reaches and 159 m^3/s in the lower reaches, which has a return period of approximately 1 year (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is approximately 1,200 m^3/s in upper reaches (SC#527) and approximately 2,800 m^3/s in downstream reaches (SC#514, SC#520, SC#507, SC#494, SC#496 and SC#487), which have return periods of 3 years and 50 years respectively (Table 8).

The SedNet bankfull flow is approximately 5% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 8). This estimate is closer to the modelled bank full flow (compared to the SedNet input bankfull flow). ***Note we have not checked the other parameters in the SedNet model used for the Manning's equation in this study (i.e. bank height and channel width).***

Table 8. Comparison between Dynamic SedNet modelled and hydraulic model derived bankfull flow in the Laura River case study area.

Link (Sub-catchment)	SedNet Bankfull Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bankfull flow
SC #487	139	2800	1388	5%
SC #496	159	2800	1293	6%
SC #494	143	2800	1812	5%
SC #507	133	2800	982	5%
SC #520	125	2800	2031	4%
SC #514	119	2800	1206	4%
SC #527	60	1200	528	5%

4.4 Cape York - Normanby River

Overview

The Normanby River case study area extends for approximately 20 kilometres downstream of the junction of the East and West Normanby River branches, approximately 20 km north east of Lakeland (Figure 19). The floodplains along this reach largely support low density grazing of native vegetation, no largescale clearing of floodplains for agriculture is evident.

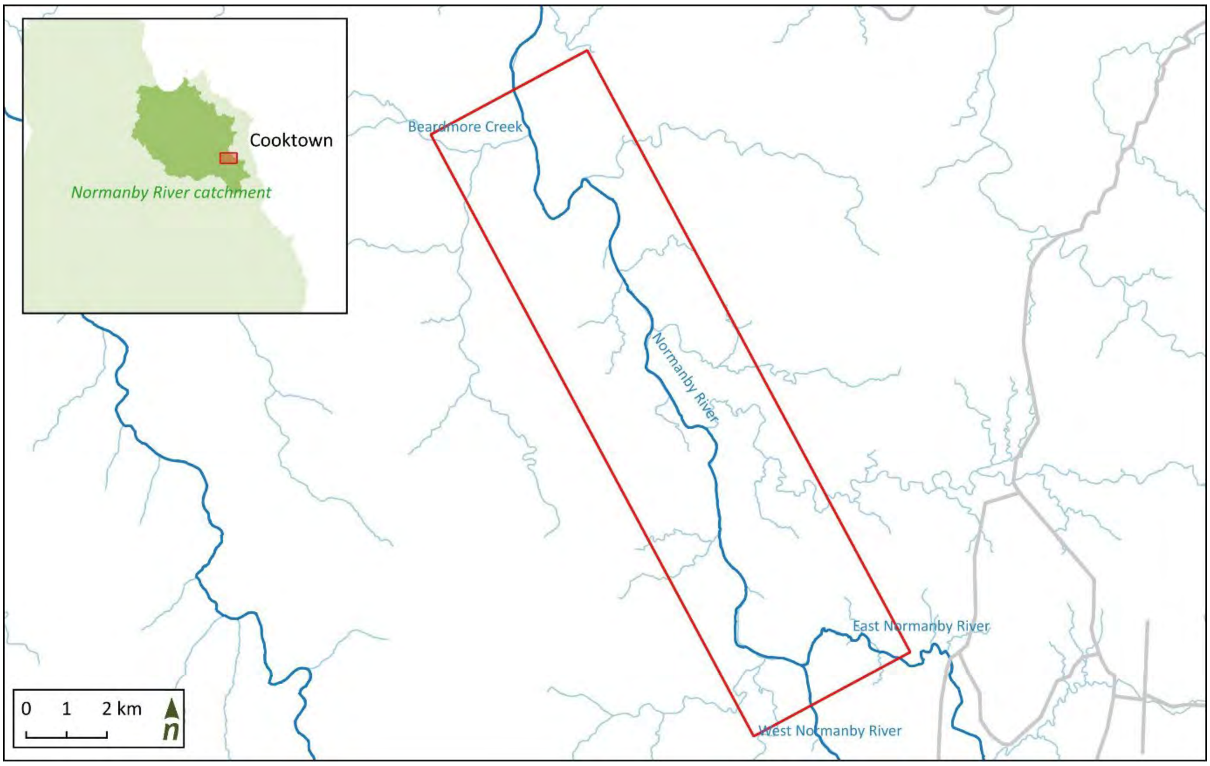


Figure 19. *The Normanby River case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Normanby River study area (Figure 20), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Normanby River case study area.

The Normanby River flows through varying degrees of bedrock and terrace confinement. Within the study area the main channel is bound by genetic floodplains (up to 300 m in width) and the top of bank sits between 3 – 6 m above the channel. There is an upper floodplain/terrace throughout much of the reach which sits approximately 15-20 m above the channel. The main channel intermittently abuts both terrace and hillslope boundaries.

The dominant inundation surfaces in the Normanby River study area are genetic floodplains and terraces (Figure 20). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 21.

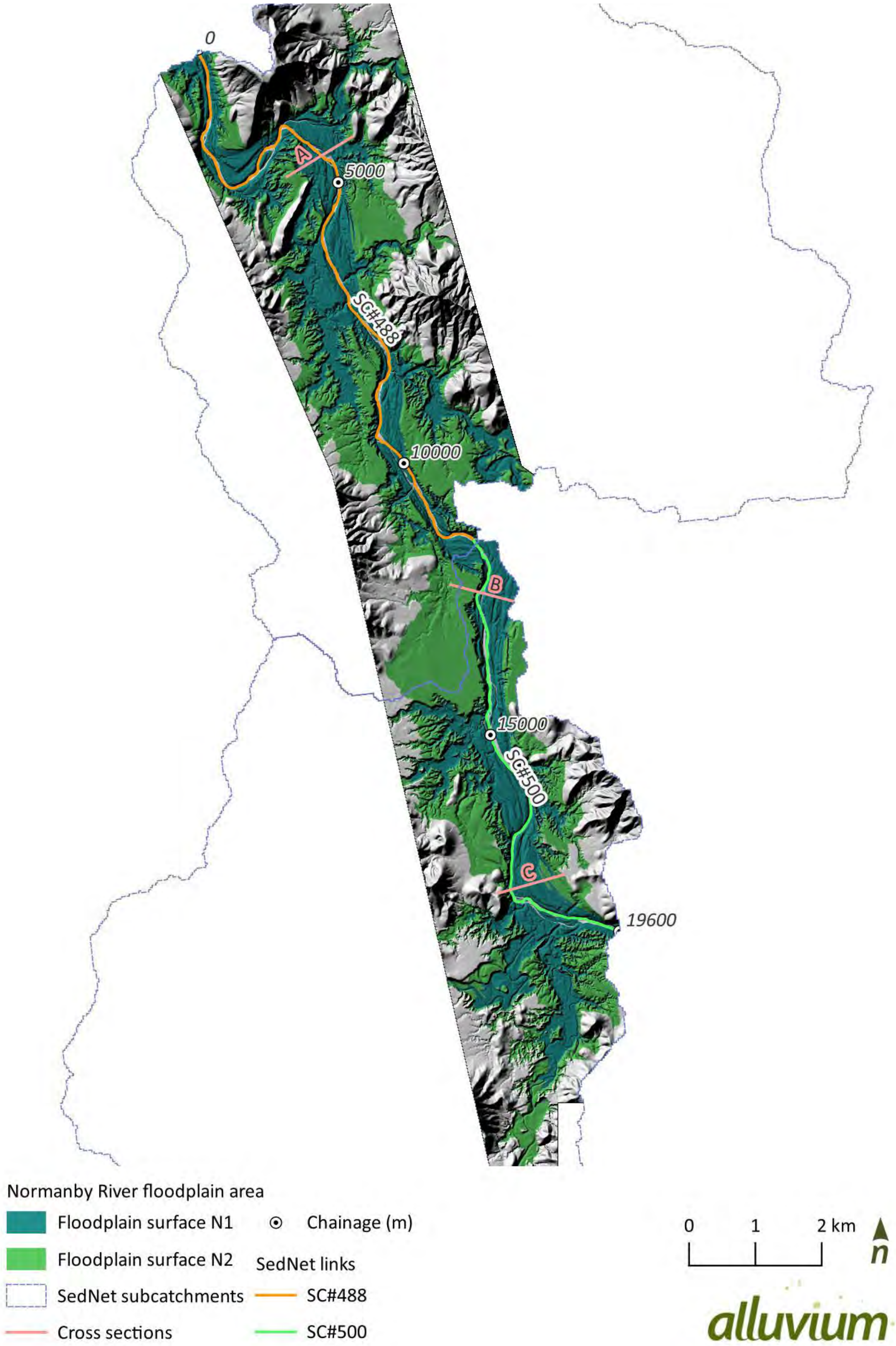


Figure 20. *The Normanby River case study area showing two major inundation surfaces; the genetic floodplain and terrace. The representative cross section locations are also shown.*

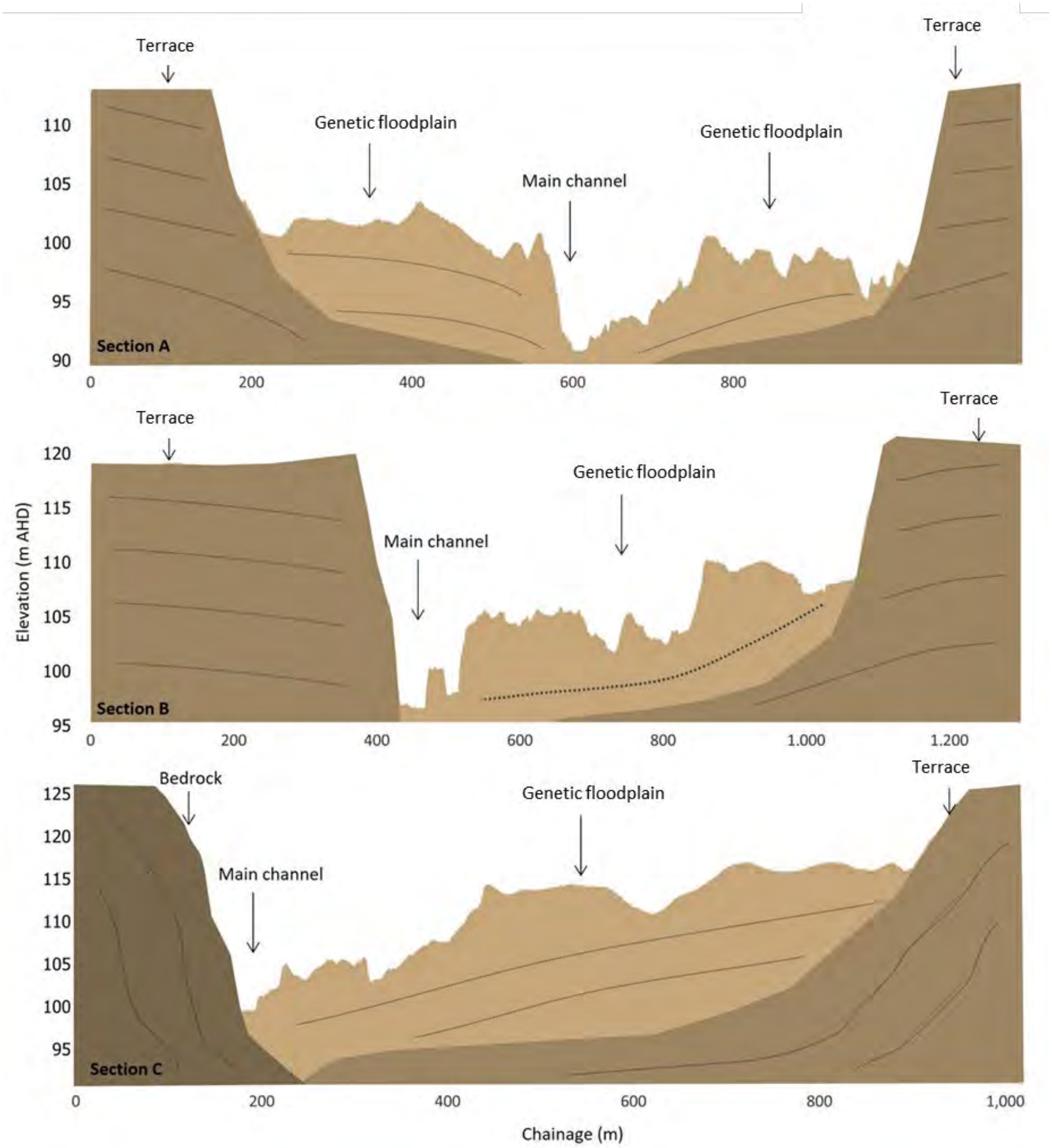


Figure 21. *The three typical sections in the Normanby River case study area (shown in Figure 20) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain areas in the Normanby River case study area are provided in Table 9.   The SedNet floodplain area is marginally larger than the LiDAR derived genetic floodplain area. The input Dynamic SedNet floodplain areas align well with the LiDAR derived floodplain areas in this case study area.

Table 9. Comparison between Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Normanby River case study area.

Link (Sub-catchment)	SedNet Floodplain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR genetic floodplain area
		Genetic floodplain (km²)	Terrace (km²)	
SC #488	18.8	17.0	17.0	110%
SC #500	19.0	17.5	15.3	108%

Bankfull flow assessment

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Normanby River case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 56 years of data is present approximately 30 km downstream of the study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 400 m³/s, 750 m³/s and 900 m³/s are shown in Figure 22. Representative bankfull flows in three typical cross-sections are shown in Figure 23. The channel capacity varies throughout the case study area, however is typically 400 m³/s in the steeper upper reaches (upstream of chainage 17,000), and between 750 m³/s – 900 m³/s in the mid and lower reaches (below chainage 17,000). The return period for these events is estimated between 1.5 – 3 year ARI (BOM, 2023).

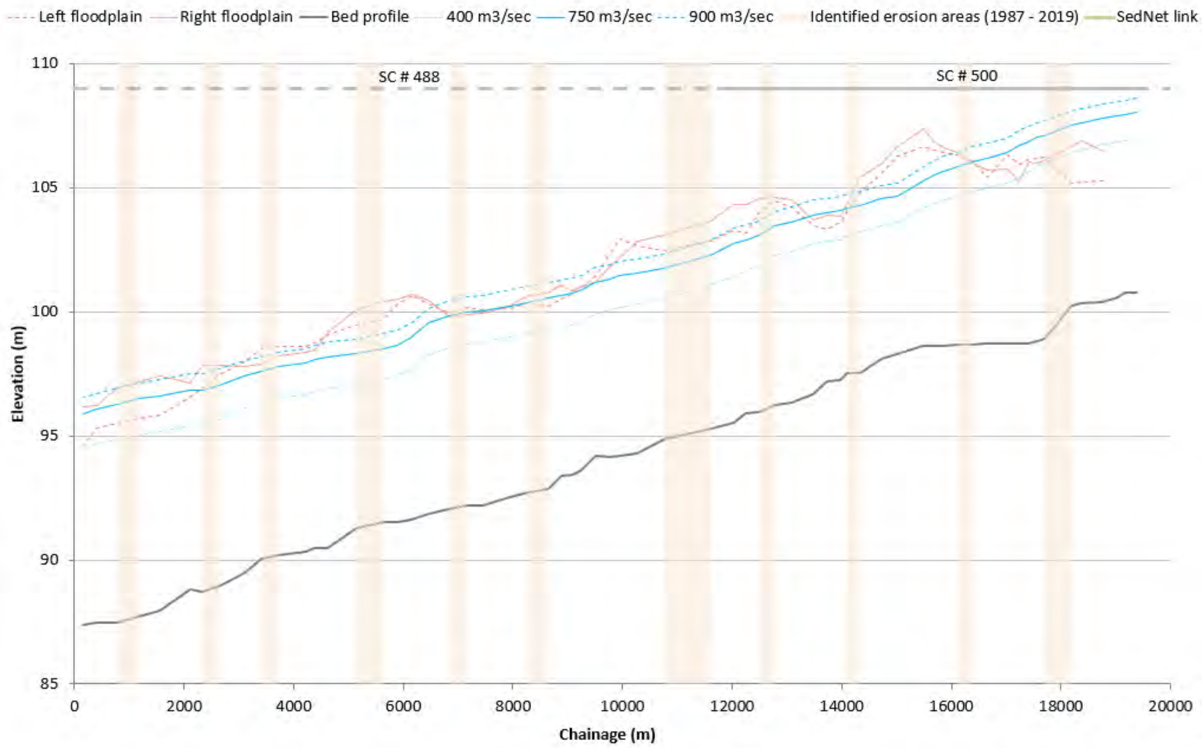


Figure 22. *The water surface elevation for a range of flow events near the bankfull elevation within the Normanby River case study area.*

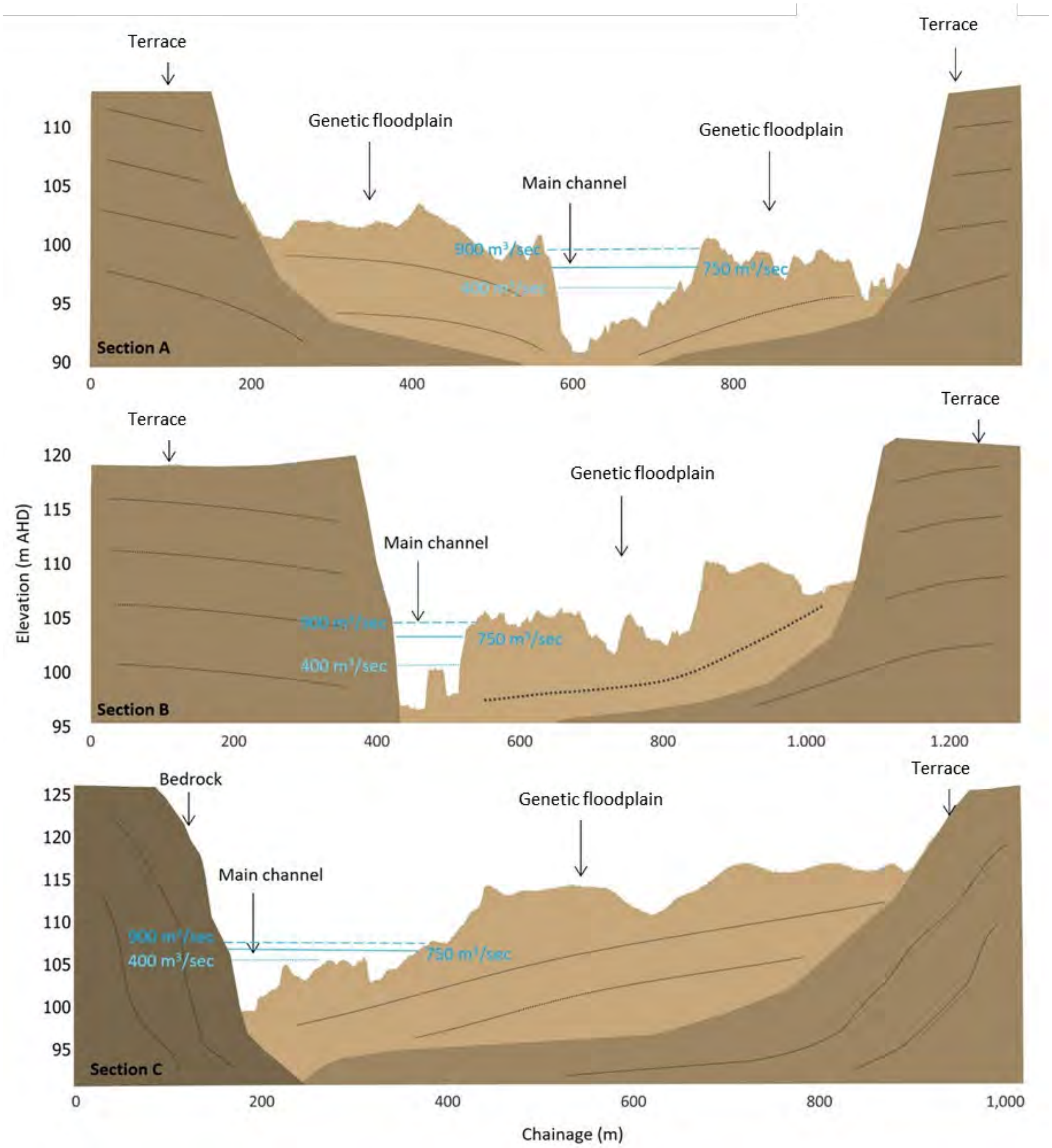


Figure 23. *The three typical sections in the Normanby River case study area (shown in Figure 20) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the case study area is approximately 290 m^3/s, which has a return period of less than 1 year (Table 10) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flows range between is approximately 450 m^3/s and 900 m^3/s, which have return periods of 1.5 -3 years.

The SedNet bankfull flow is approximately 38% of the actual modelled bank full flow in all reaches (Table 10). As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 10). This estimate is higher than both the modelled bank full flow and SedNet input bankfull flow.

Table 10. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Normanby River case study area.

Link (Sub-catchment)	SedNet Bankfull Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #488	295	750	764	39%
SC #500	288	750	1412	38%

4.5 Burdekin - Basalt River

Overview

The Basalt River case study area extends for approximately 70 kilometres upstream of its confluence with the Burdekin River, north of Charters Towers (Figure 24). The floodplains along this reach largely support grazing of native vegetation. The landscape formations surrounding the study reach are dominated by the basaltic plateaus, associated with the Nulla Basalt geological formation.

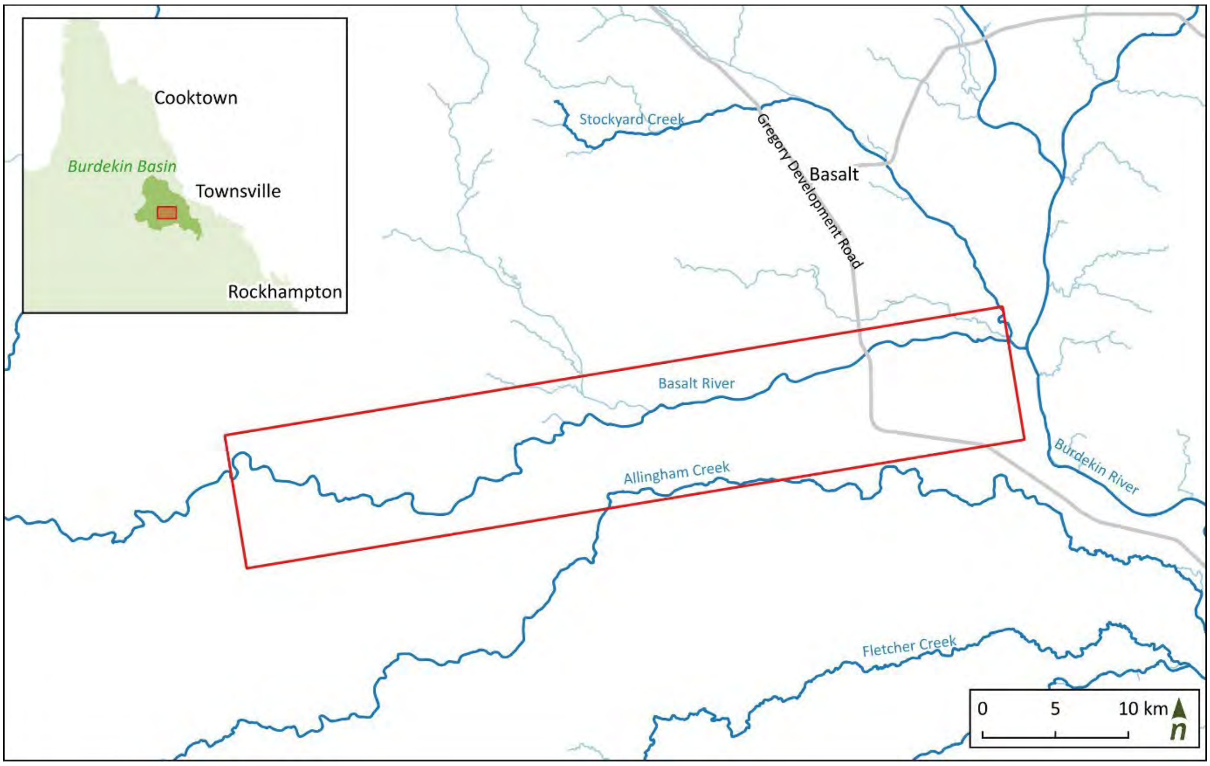


Figure 24. *The Basalt River case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Basalt River study area (Figure 25), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Basalt River case study area.

The Basalt River flows through a basalt plateau which controls the planform alignment considerably, particularly through the mid and upper reaches. The extent of alluvial development varies in accordance with valley confinement. In the upper reaches, the channel sits within a deeply entrenched gorge, approximately 60 m below the basalt plains, the low flow channel is shallow and broad and intermittently abuts the valley margins with discontinuous genetic floodplain up to 200 m in width.

The upper hydraulic floodplain broadens through the mid reaches to up to 2 km in sections. There are discontinuous genetic floodplains of varying widths but typically less than 200 m.

The lower reaches emerge onto a broader floodplain setting with upper hydraulic floodplain widths several kilometres wide. The main channel is deeply entrenched with the floodplain sitting 10 – 15 m above a shallow low flow channel.

The dominant inundation surfaces in the Basalt River study area are hydraulic floodplains (Figure 25). Variations in the degree of channel entrenchment and geomorphic units can be seen in the three typical sections shown in Figure 26.

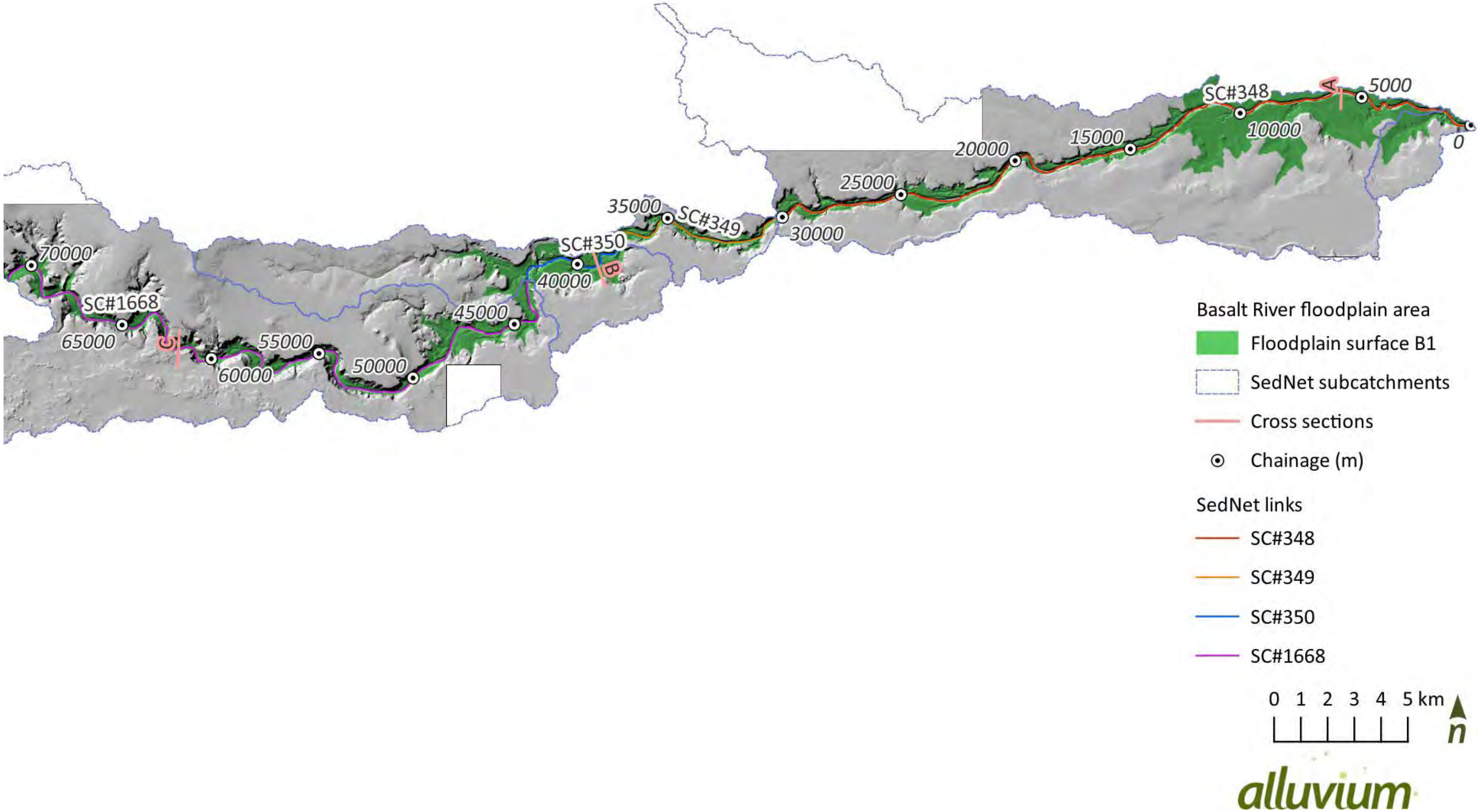


Figure 25. *The Basalt River case study area showing one major inundation surfaces; the hydraulic floodplain. The representative cross section locations are also shown.*

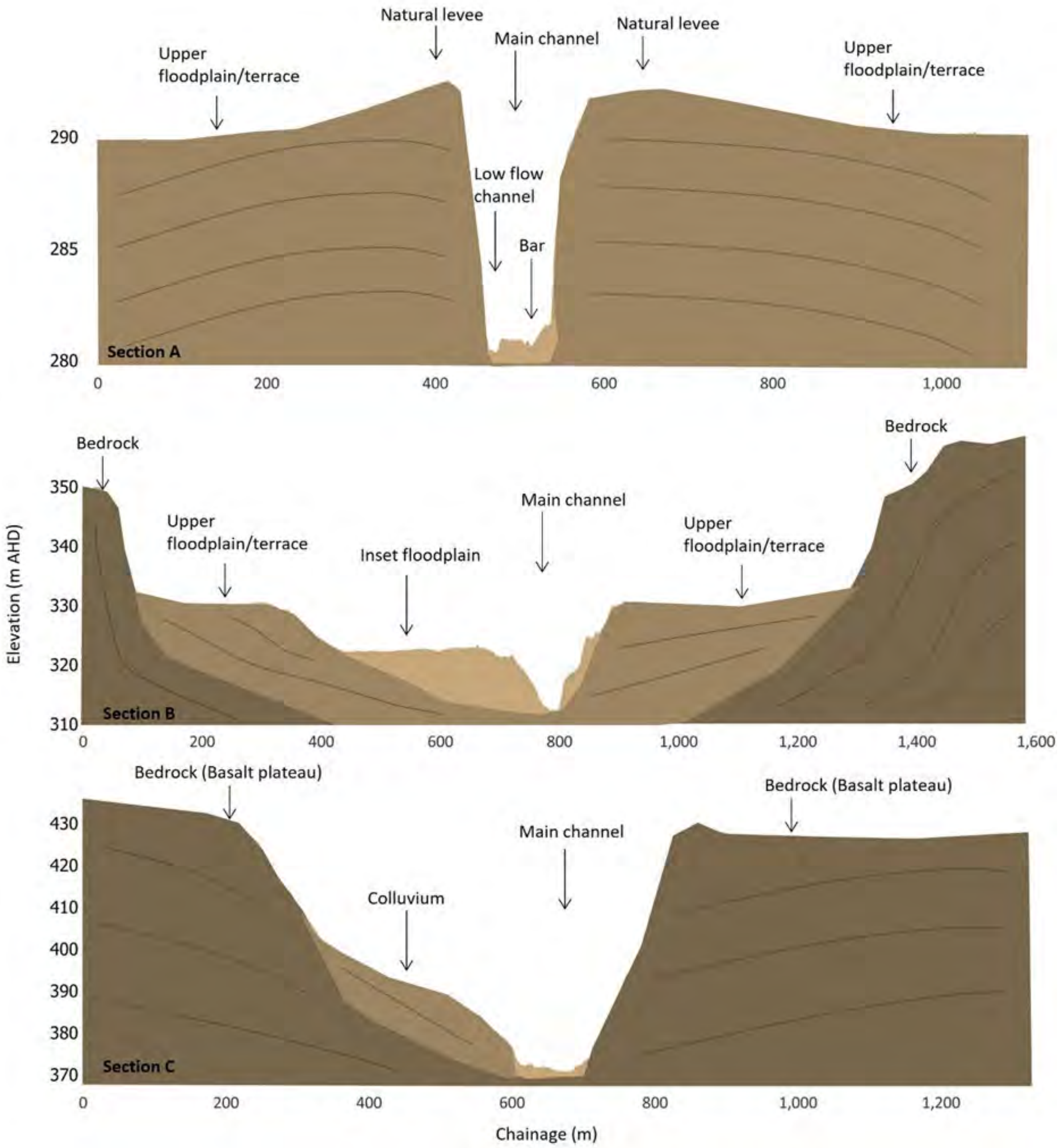


Figure 26. *The three typical sections in the Basalt River case study area (shown in Figure 25) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Basalt River case study area are provided in Table 11. The SedNet floodplain area ranges from 4% to 25% of the LiDAR derived floodplain area. Therefore, the input Dynamic SedNet floodplain areas are underestimated.

Table 11. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Basalt River case study area.

Link (Sub-catchment)	SedNet Floodplain area (km²)	LiDAR hydraulic floodplain (km²)	SedNet floodplain area as a % of LiDAR area
SC #348	15.3	60.1	25%
SC #349	2.2	50.0	4%
SC #350	4.3	54.4	8%
SC #1668	7.8	54.4	14%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bankfull flow in the Basalt River case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events ranging from 600 m^3/s to 3,000 m^3/s are shown in Figure 27. Representative bankfull flows in three typical cross-sections are shown in Figure 28. The channel capacity varies throughout the case study area, however is typically 600 m^3/s in the steep upper reaches (upstream of chainage 40,000 m), 900 m^3/s in the lower-mid reaches (between chainage 40,000 m – 12,000 m) and up to 3,000 m^3/s at the downstream extent (below chainage 12,000 m). The return period for these events is estimated at 4, 8 and 80 years (BOM, 2023).

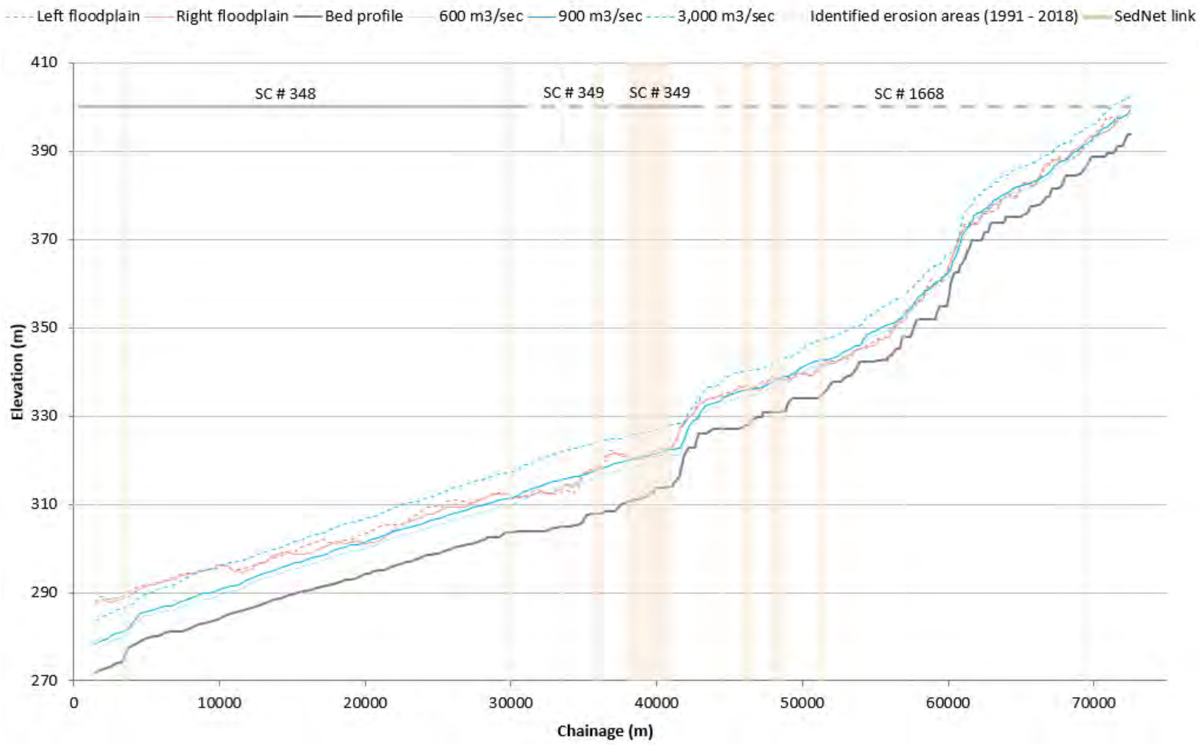


Figure 27. *The water surface elevation for a range of flow events near the bankfull elevation within the Basalt River case study area.*

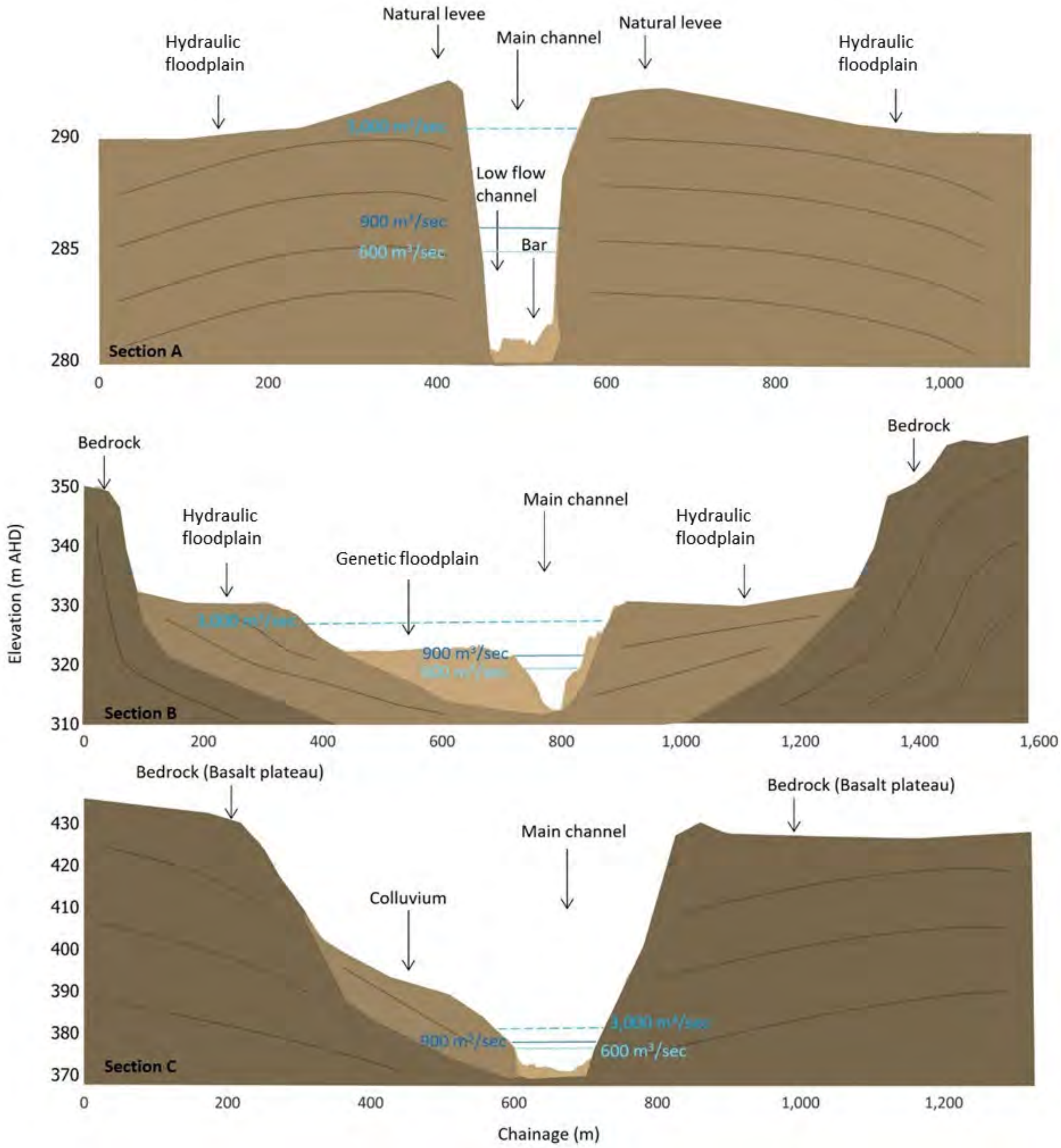


Figure 28. *The three typical sections in the Basalt River case study area (shown in Figure 25) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Basalt River case study area range between 128 m^3/s and 150 m^3/s across the four links, which has a return period of approximately 1 year (Table 12) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is approximately 600 m^3/s in upper reaches (SC#1668) and approximately 900 m^3/s in downstream reaches (SC#348, SC#349 and SC#350), which have return periods of 4 years and 8 years respectively.

The SedNet bankfull flow is 14% to 24% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 12). This estimate is higher than both the the modelled bank full flow and SedNet input bankfull flow.

Table 12. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Basalt River case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #348	128	900	1635	14%
SC #349	146	900	1249	16%
SC #350	150	900	2271	17%
SC #1668	145	600	2106	24%

4.6 Burdekin - Haughton River

Overview

The Haughton River case study area extends for approximately 60 kilometres downstream from its confluence with the Reid River to its confluence with Cromarty Creek, downstream of Giru (Figure 29). The Haughton River discharges into the nationally and internationally significant Ramsar-listed, Bowling Green Bay coastal wetland. The floodplains of the upper reaches are predominately used for grazing while the mid and lower reaches support irrigated cropping (largely sugar cane) as well as horticultural enterprises. Sand mining along the Haughton River is also ongoing.

There are two weirs located in the lower reaches, just upstream of the Giru township. The Giru weir was constructed in 1977 and the Val Bird weir constructed in 1983, both were constructed to support irrigation water supply in the region.

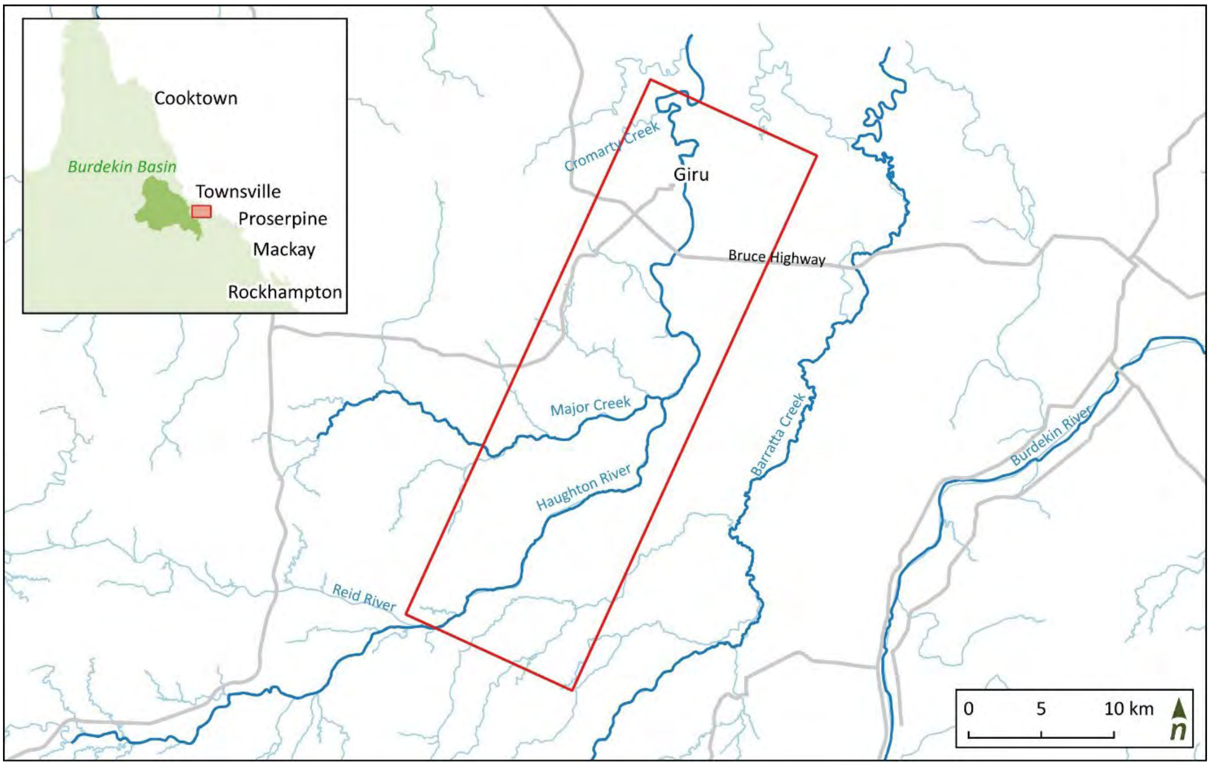


Figure 29. *The Haughton River case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Haughton River study area (Figure 30), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Haughton River case study area.

The river has a low sinuosity planform and flows through an unconfined setting. Through the upper reaches (upstream of the Major Creek confluence) the low flow channel meanders across a wide sandy bed. The hydraulic floodplain sits approximately 8 – 10m above the bed and has a channel width of 150 – 250m. Through the mid reaches the bank heights reduce to between 3 – 5 m. There are two weirs through this section and several levees constructed along the banks. Downstream of the Giru weir the channel is highly sinuous meandering across the tidal plains with bank heights of less than 3m. The Giru weir acts as a tidal barrier limiting the estuarine reach to this point. There are significant paleo-channel features within the downstream floodplain indicating avulsion are common in the recent Holocene period.

The dominant inundation surfaces in the Haughton River study area are genetic floodplains and terraces (Figure 30). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 31.

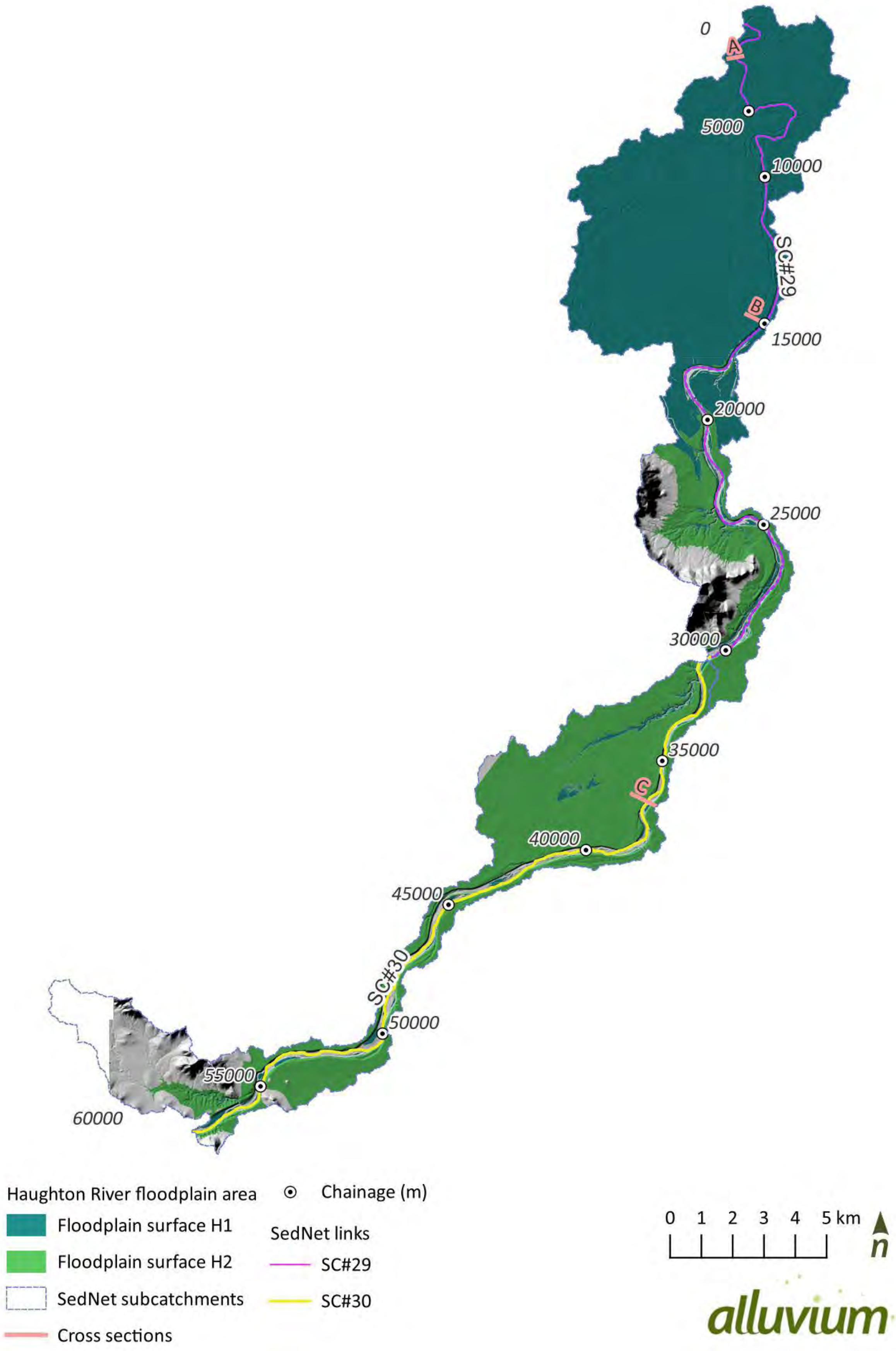


Figure 30. *The Haughton River case study area showing two major inundation surfaces; the genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

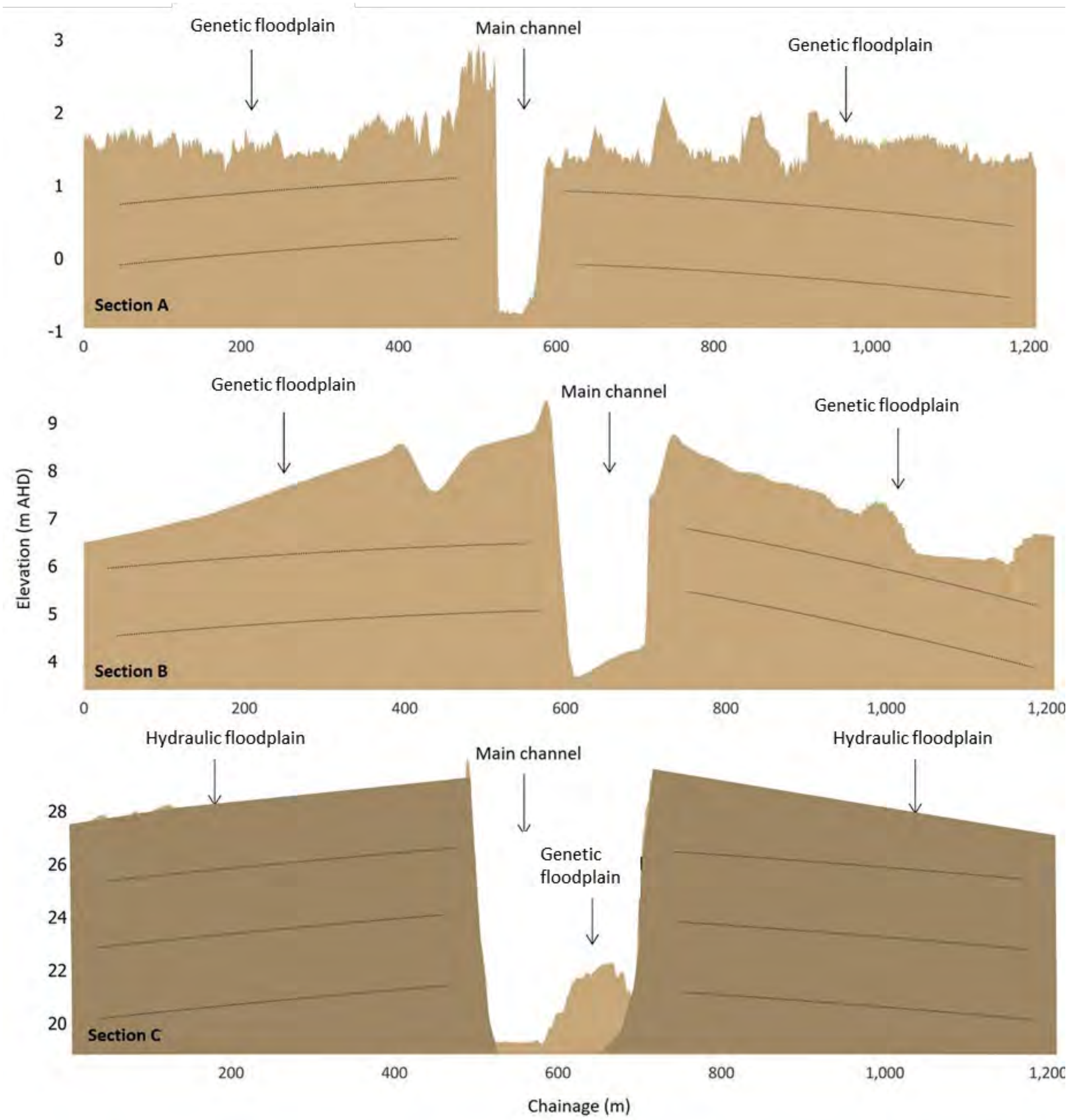


Figure 31. *The three typical sections in the Haughton River case study area (shown in Figure 30) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Haughton River case study area are provided in Table 13. The SedNet floodplain area is 220% and 21% of the LiDAR derived floodplain area in the lower and upper reaches respectively. Therefore, the input Dynamic SedNet floodplain areas are both overestimated and underestimate in this study area.

Table 13. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Haughton River case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR floodplain area
		Genetic floodplain (km²)	Hydraulic floodplain (km²)	
SC #29	80.4	17.3	19.3	220%
SC #30	54.0	112.5	149.0	21%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Haughton River case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 250 m³/s, 1,200 m³/s and 5,000 m³/s are shown in Figure 32. Representative bankfull flows in three typical cross-sections are shown in Figure 33. The channel capacity varies throughout the case study area, however is significantly higher in the upper reaches. Upstream of the Val Bird weir pool (chainage 25,000 m) the upper floodplain is unlikely to be engaged due to the steep slope and significant channel capacity – the representative bankfull flow through here is 5,000 m^3/s which has an approximate ARI of 50 yrs. Between the two weirs (chainage 10,000 – 18,000 m) the estimated bankfull flow is 1,200 m^3/s (approximately 3 year ARI). Downstream of the Giru weir the representative bankfull flow is 250 m^3/s (1 yr ARI).

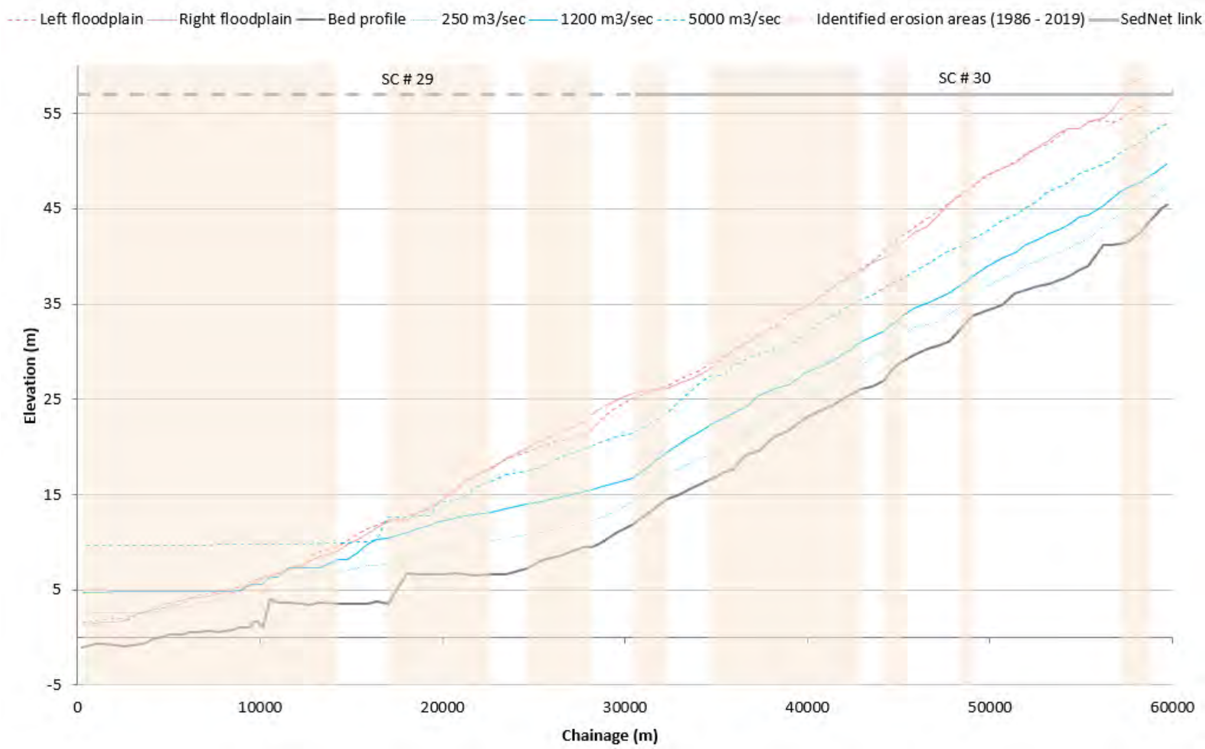


Figure 32. *The water surface elevation for a range of flow events near the bankfull elevation within the Haughton River case study area*

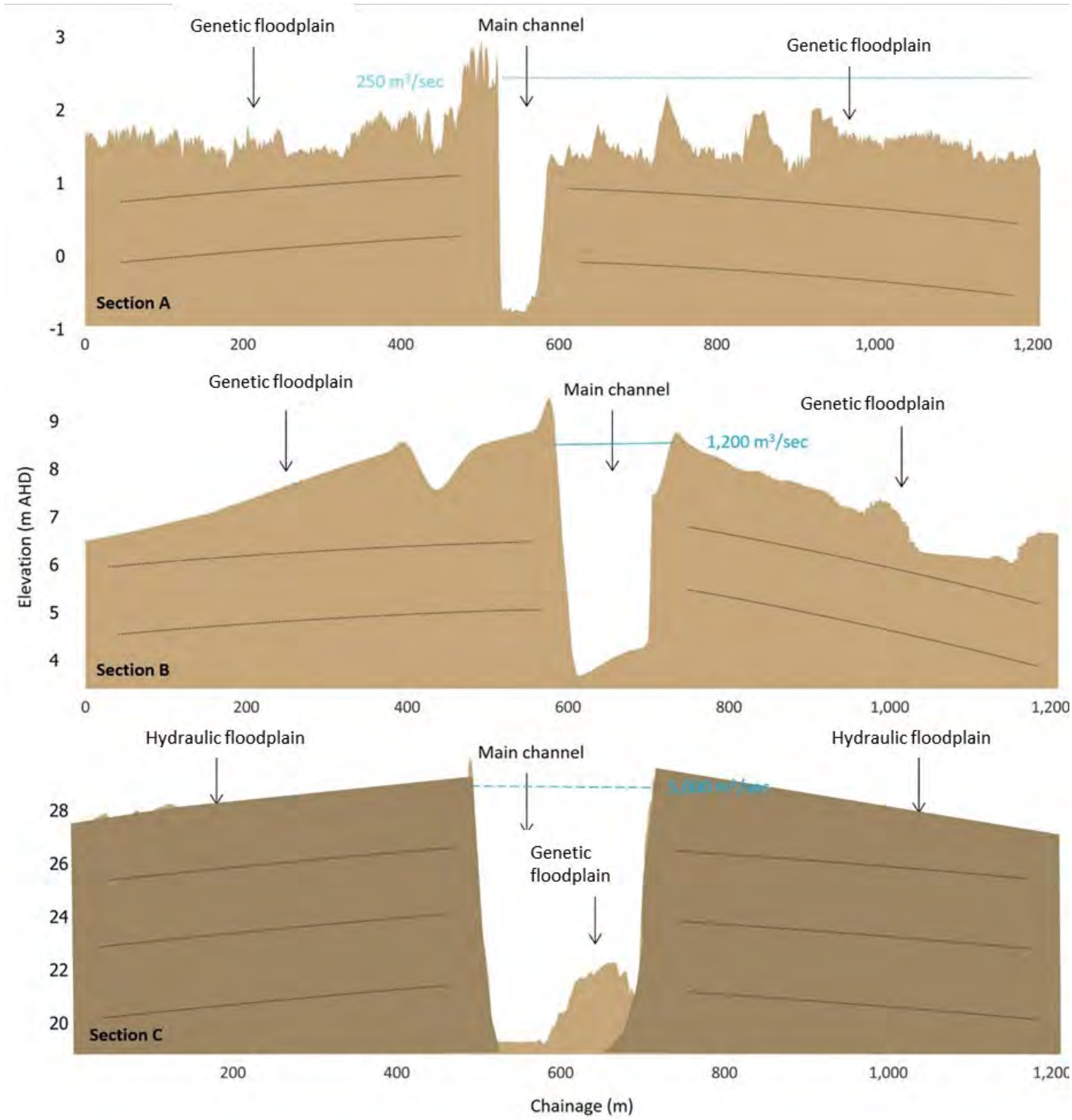


Figure 33. *The three typical sections in the Haughton River case study area (shown in Figure 30) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the case study area is 765 m^3/s in the downstream reach (SC # 29), which has a return period of between 1 – 2 years (Table 14) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flows range between is approximately 250 m^3/s downstream of Giru weir (chainage 10,000), 1,200 m^3/s between the two weirs and 5,000 m^3/s upstream of the Val Bird weir which have return periods of 1 -50 years (Figure 32).

The SedNet bankfull flow is approximately 5% of the actual modelled bank full flow in the upper reach. In the downstream reach the modelled bank full flow is variable due to the weirs.

Bankfull flow was also estimated using Manning's equation (Table 14). This estimate is closer to the modelled bankfull flow (compared to the SedNet input bankfull flow) in the upper reach.

Table 14. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Haughton River case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #29	765	250 - 5000	900	15%-306%
SC #30	254	5000	2425	5%

4.7 Burdekin - Rosella Creek

Overview

The Rosella Creek case study area extends for approximately 54 kilometres upstream of its confluence with the Bowen River in the Burdekin River catchment (Figure 34). Rosella Creek (named Kangaroo Creek in the upstream reaches above chainage 40,000 m and throughout Link #197) flows through gently undulating grazing country comprised of fine-grained sedimentary rocks.

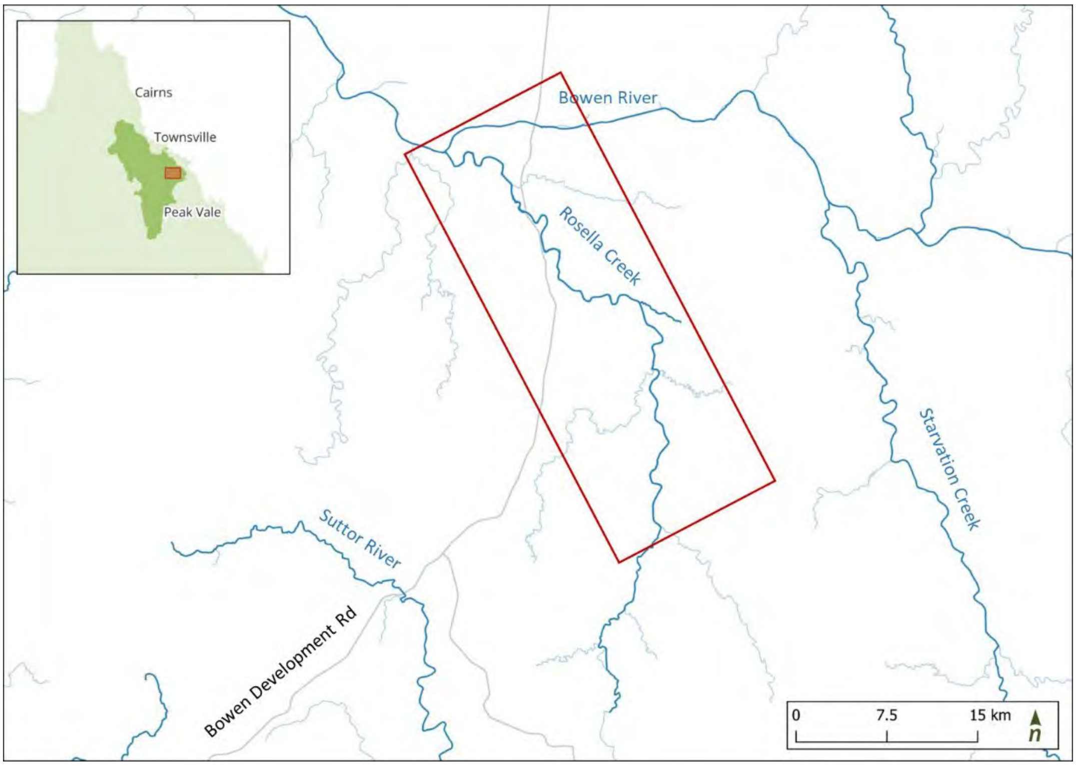


Figure 34. *The Rosella Creek case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Rosella Creek study area (Figure 35), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Rosella Creek case study area.

The channel is predominantly partly confined and planform-controlled, apart from at the uppermost extent of the reach where the channel abuts some protruding volcanic plugs. High terraces are evident at the downstream end of the study area, associated with the Bowen River.

The dominant inundation surfaces in the Rosella Creek study area are genetic floodplains and terrace (Figure 34). Variations in the degree of channel entrenchment and geomorphic units can be seen in the three typical sections shown in Figure 35.

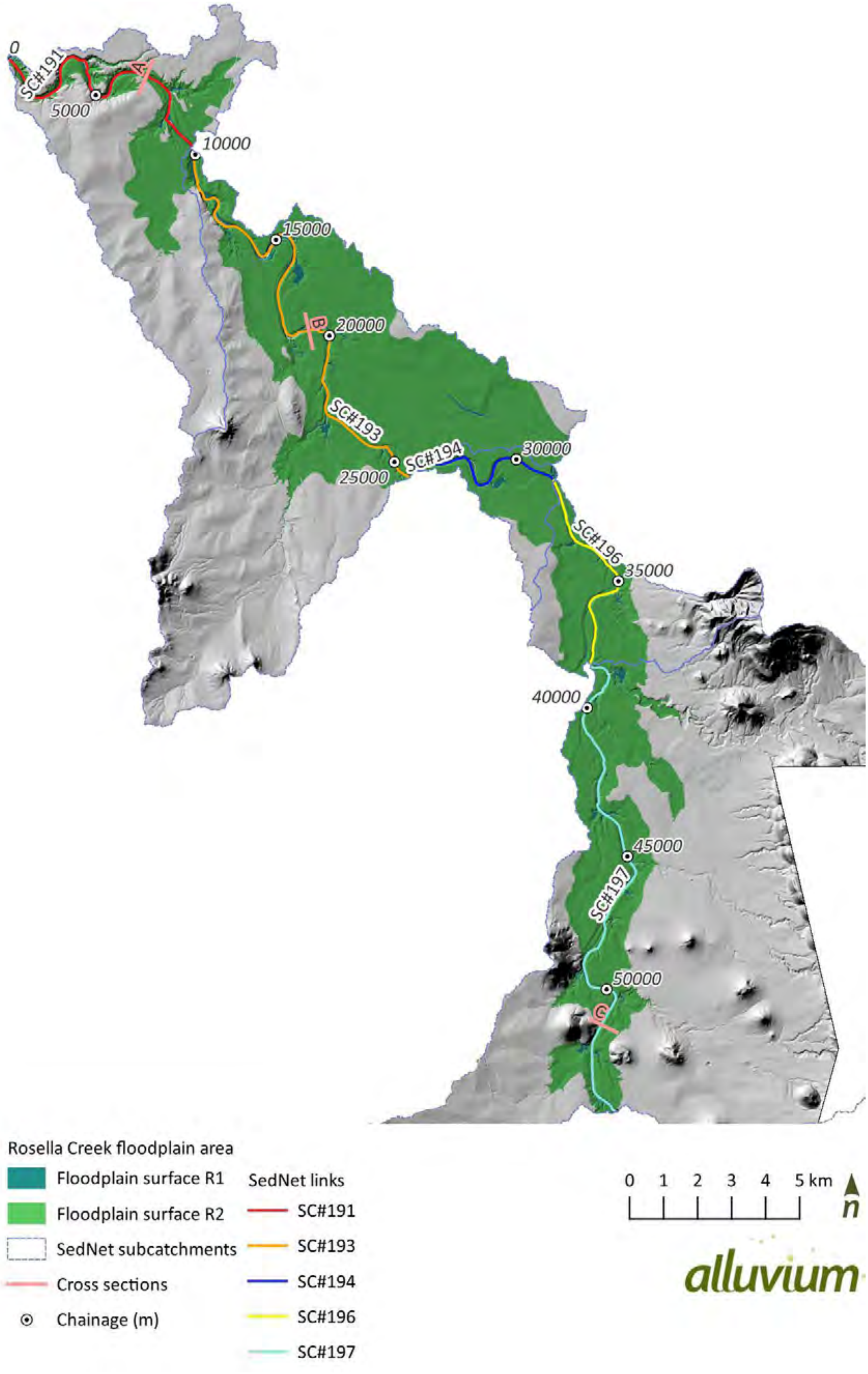


Figure 35. *The Rosella Creek case study area showing two major inundation surfaces; genetic floodplain and terrace. The representative cross section locations are also shown.*

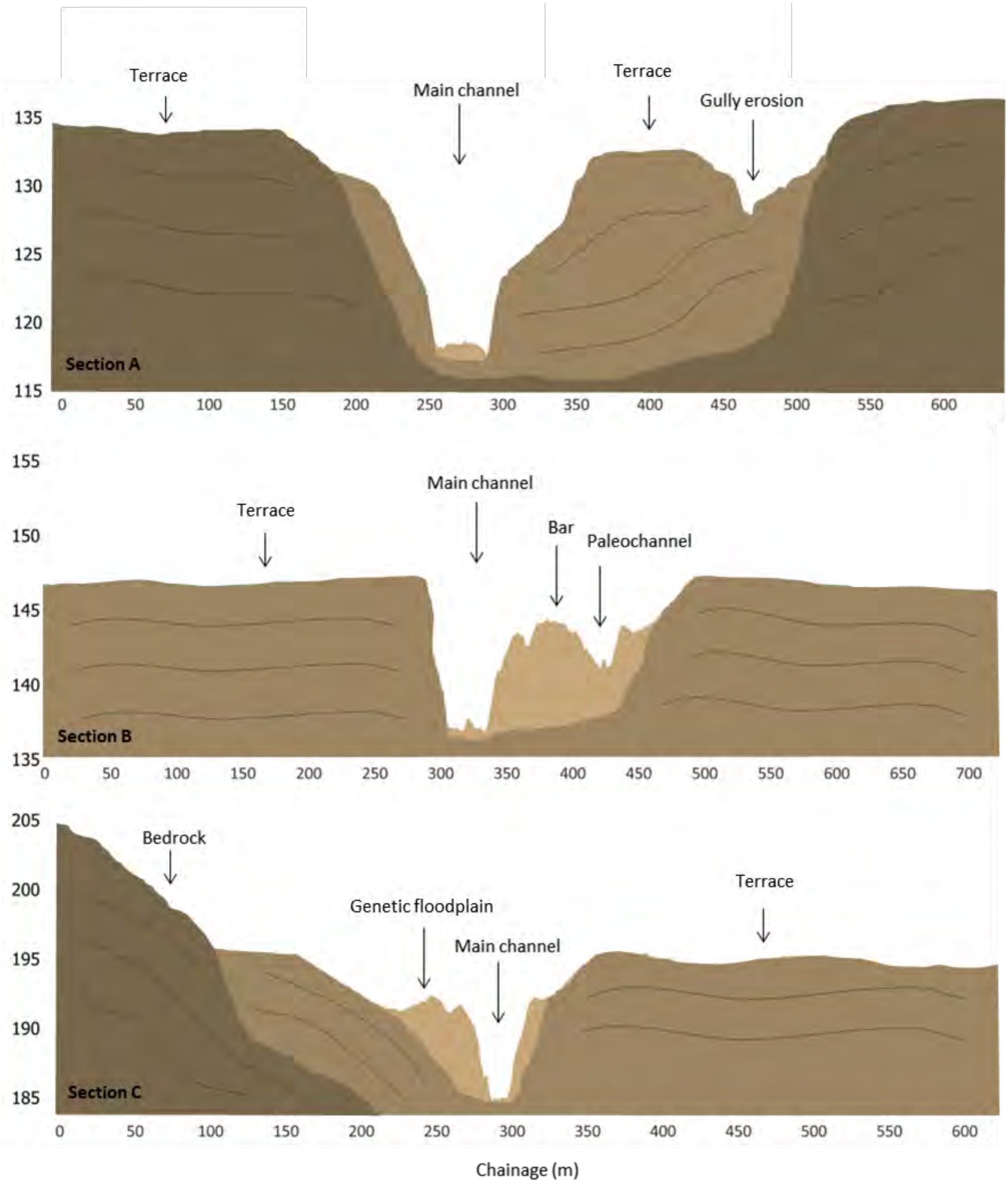


Figure 36. *The three typical sections in the Rosella Creek case study area (shown in Figure 35) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain areas in the Rosella Creek case study area are provided in Table 15. The SedNet floodplain area generally ranges from 125% to 752% of the LiDAR derived genetic floodplain area. There is one link in a lower reach (SC #194) where the SedNet floodplain area is 85% of the LiDAR derived genetic floodplain area. In general, the input Dynamic SedNet floodplain areas are overpredicted.

Table 15. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Rosella Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km²)	Terrace (km²)	
SC #191	15	12.4	187.4	125%
SC #193	22	2.9	187.4	752%
SC #194	2	2.5	187.4	85%
SC #196	5	2.1	187.4	226%
SC #197	11	2.5	187.5	460%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Rosella River case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 600 m³/s, 900 m³/s and 2,000 m³/s, are shown in Figure 37. Representative bankfull flows in three typical cross-sections are shown in Figure 38. The channel capacity of the lower floodplain is typically between 600 to 900 m³/s and the upper floodplain is typically 2,000 m³/s. There are no stream gauges available to assess the likely return period of modelled events. The return period for these events has been estimated using the Regional Flood Frequency Estimation Model (Results | Regional Flood Frequency Estimation Model (arr-software.org)), and is estimated between 2 yr ARI for 600 m^3/s, 5 yr ARI for 900 m^3/s, and 100 yr ARI for 2000 m^3/s.

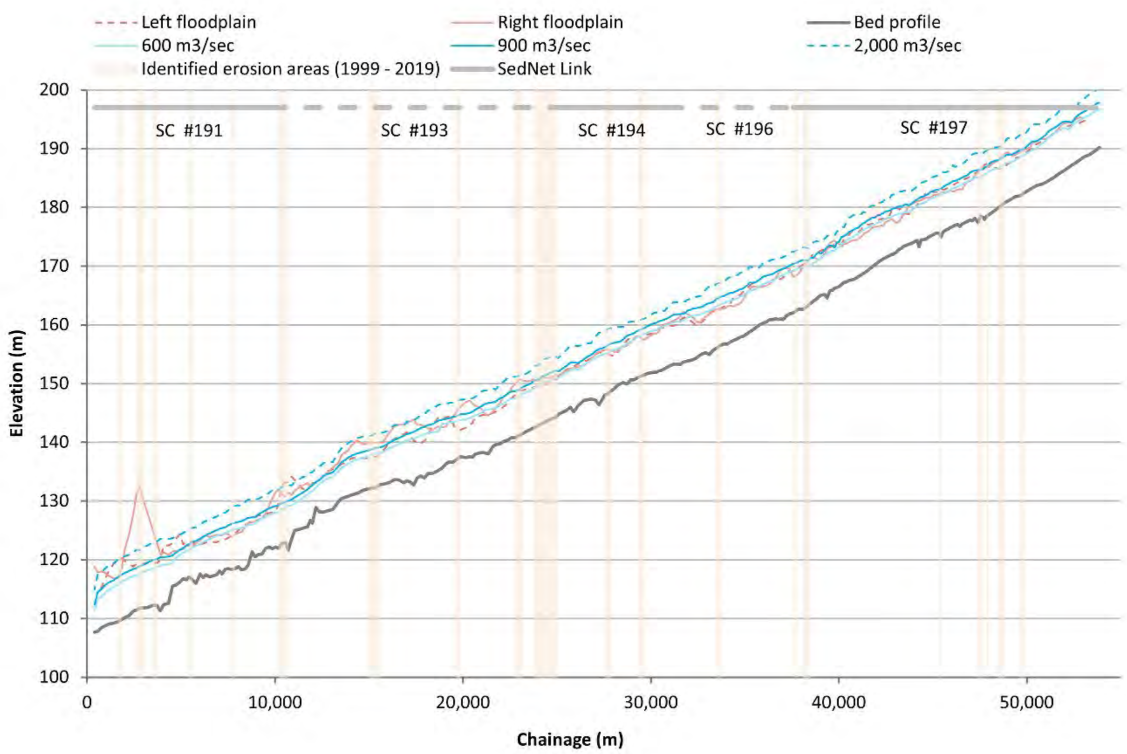


Figure 37. *The water surface elevation for a range of flow events near the bankfull elevation within the Rosella Creek case study area.*

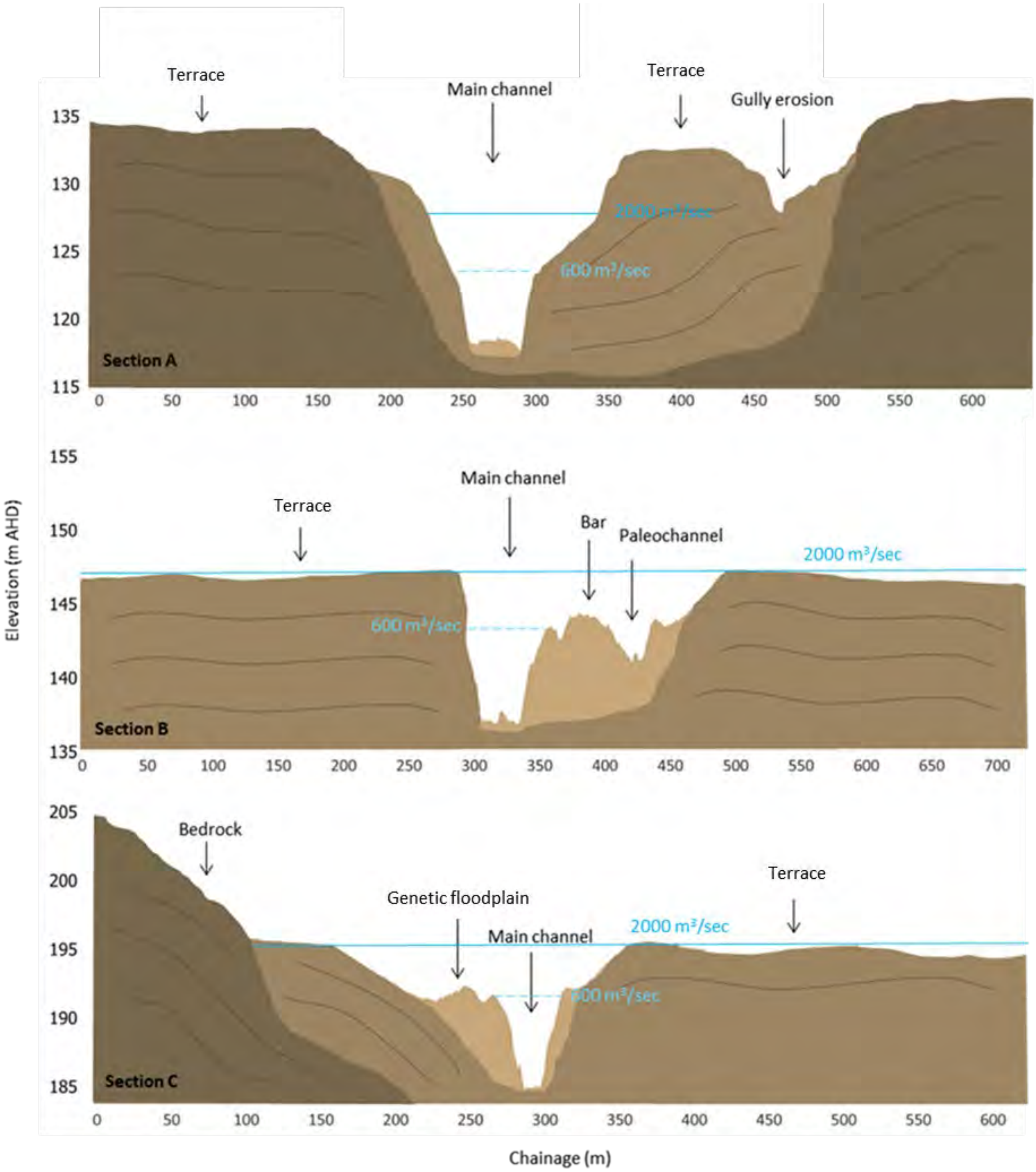


Figure 38. *The three typical sections in the Rosella Creek case study area (shown in Figure 35) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled link in the Rosella Creek case study area range between 39.21 m^3/s in the upper reaches and 57.16 m^3/s in the downstream reaches, which is estimated to be less than a 1 yr ARI event (Table 16). Comparatively, the HEC-RAS modelled bankfull flow of inset floodplain units is approximately 600 to 900 m^3/s (estimated between 2-5 yr ARI) and the upper floodplain/terrace is typically 2000 m^3/s (Table 16).

The SedNet bankfull flow is approximately 6% to 10% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 16). This estimate is closer to the modelled bank full flow (compared to the SedNet input bankfull flow).

Table 16. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Rosella Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #191	57.2	600	1716	10%
SC #193	56.9	600	1461	9%
SC #194	50.1	600	1133	8%
SC #196	35.9	600	610	6%
SC #197	39.2	600	387	7%

4.8 Mackay Whitsundays - Murray Creek

Overview

The Murray Creek case study extends for 23 kilometres, from Calen Mount Charlton Rd to Jolimont Creek confluence, just downstream of the Bruce Highway (Figure 39). The floodplains along this reach support sugarcane cultivation and grazing. The upper slopes support grazing and rural residential development.

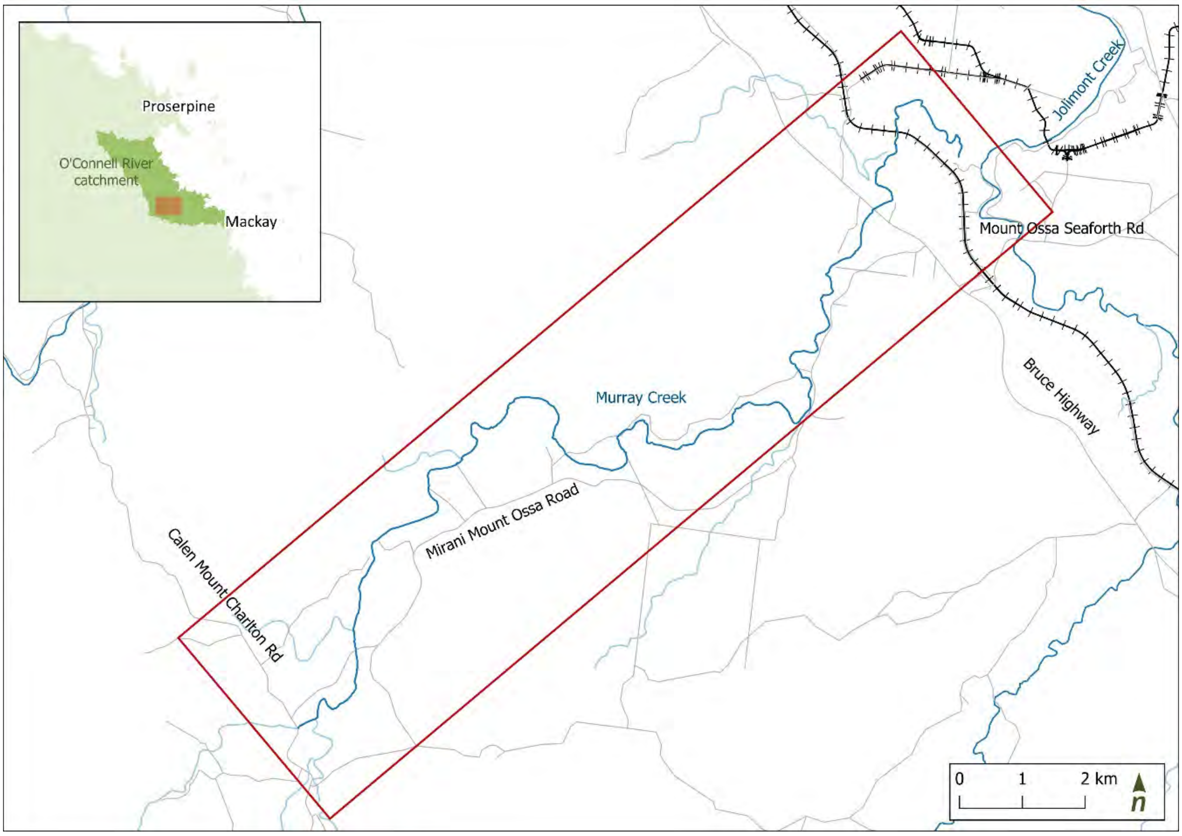


Figure 39. *The Murray Creek case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Murray Creek study area (Figure 40), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Murray Creek case study area.

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 C in Figure 41).

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 A and B in Figure 41). The downstream section of the case study area flows through estuarine plains.

The dominant inundation surfaces in the Murray Creek study area are genetic floodplains and hydraulic floodplains (Figure 40). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 41

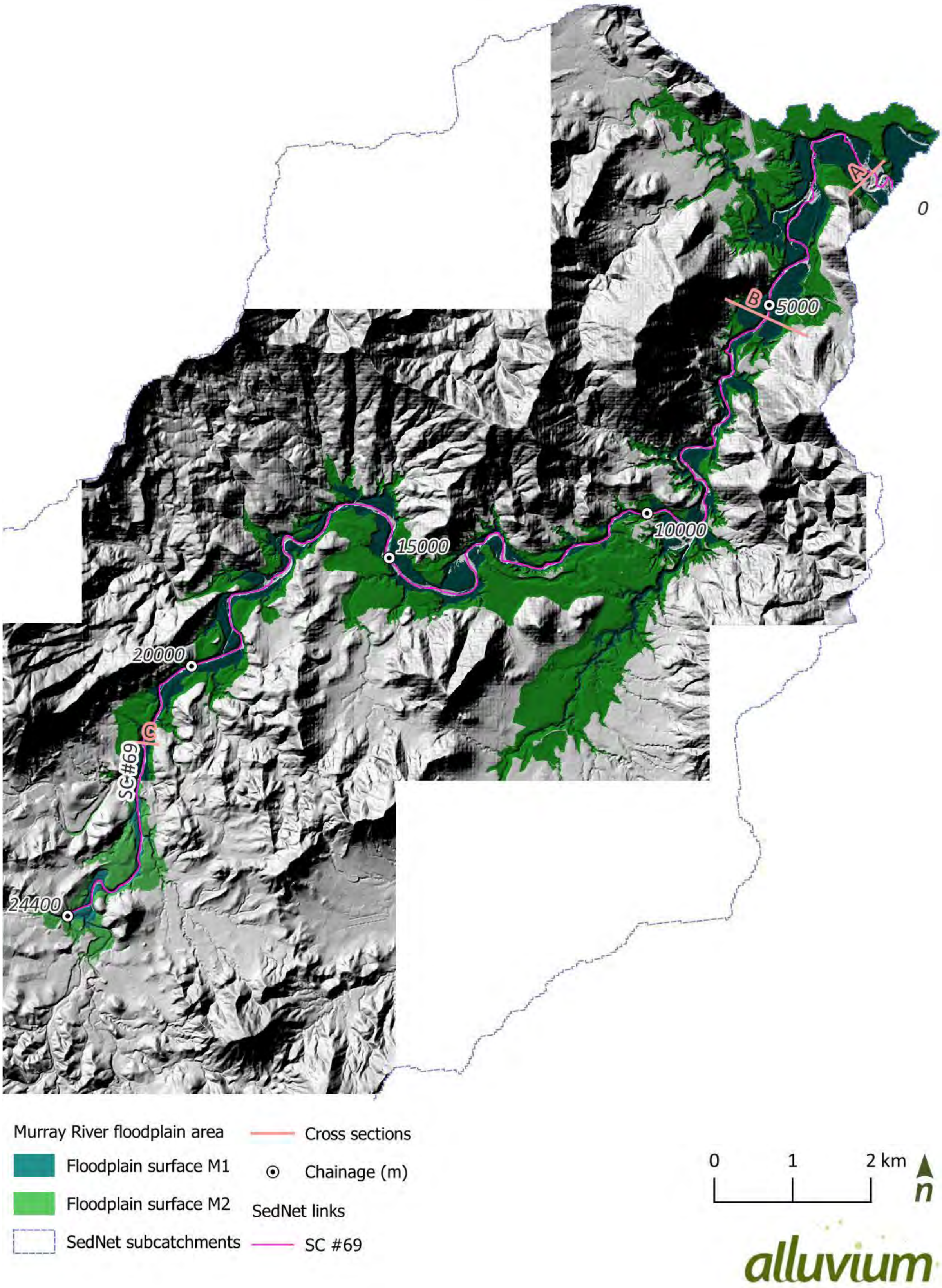


Figure 40. *The Murray Creek case study area showing two major inundation surfaces; genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

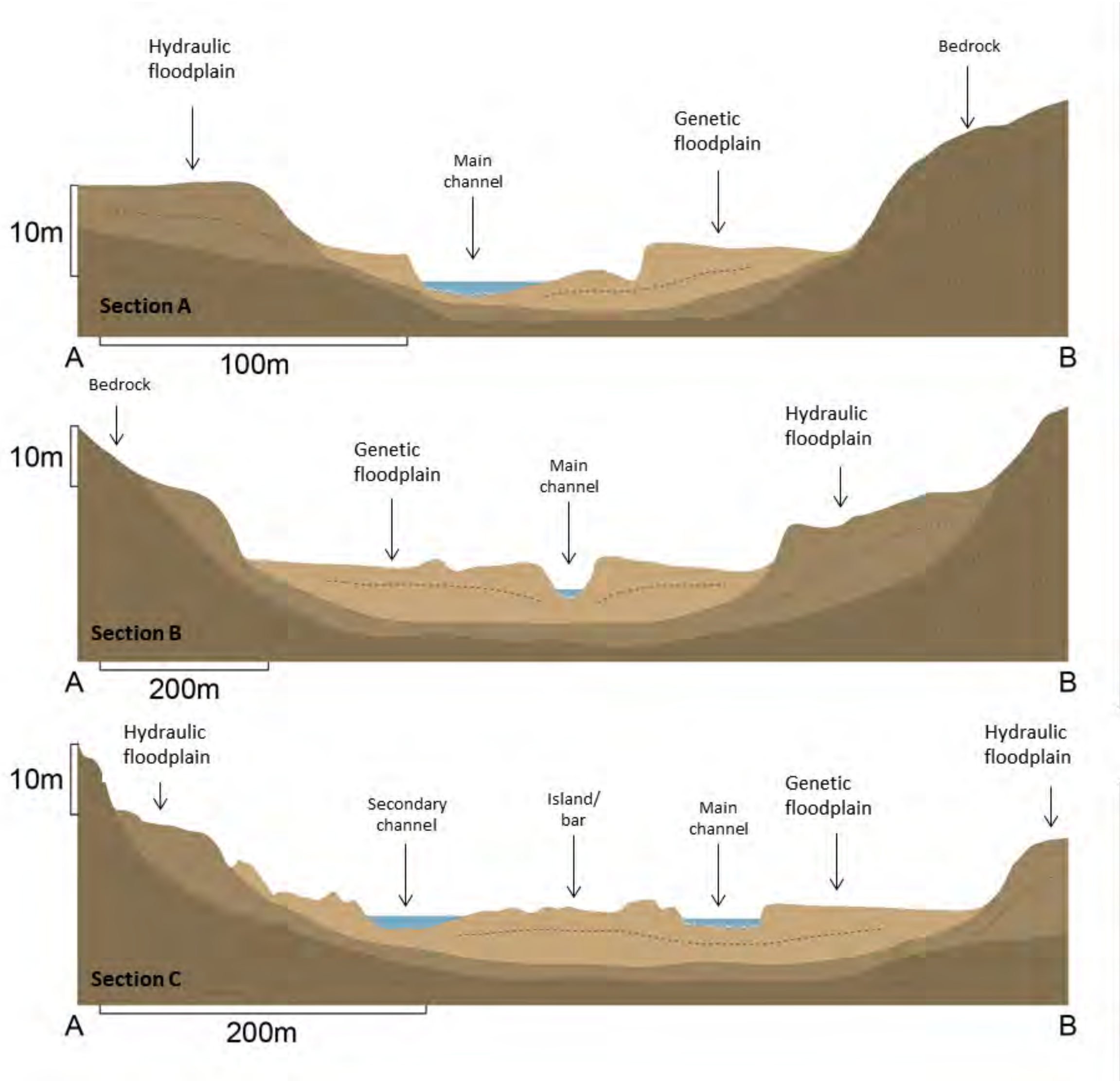


Figure 41. *The three typical sections within the Murray Creek case study area (shown in Figure 40) with the key geomorphic units. Note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Murray Creek case study area are provided in Table 17. The SedNet floodplain area generally is 133% of the LiDAR derived floodplain area. The input Dynamic SedNet floodplain area is slightly overpredicted in this case study area.

Table 17. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Murray Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km²)	Hydraulic floodplain (km²)	
SC #69	32	10	14	133%

Bankfull flow discharge

Modelled floodplain deposition volumes are highly sensitive to bankflow flow. Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Murray Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area. The model is uncalibrated, however the hydraulic roughness has been adjusted based on the channel characteristics and sinuosity. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 300 m^3/s, 600 m^3/s and 1,000 m^3/s, is shown in Figure 42. Representative bankfull flows in three typical cross-section are shown in Figure 43.

The channel capacity in the upper reaches is approximately 600 m^3/s, however this increases substantially in the mid reaches to over 1,000 m^3/s. In the lower reaches channel capacity is closer to 300 m^3/s, however this would also vary based on the tidal conditions.

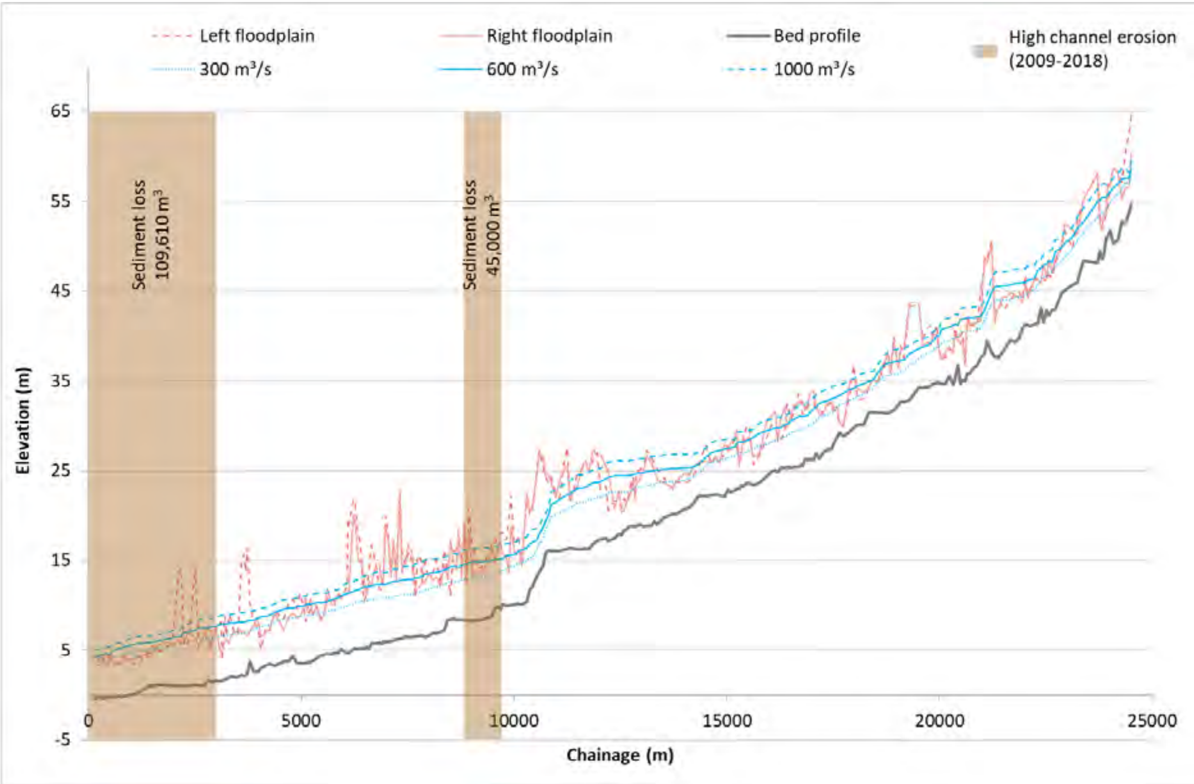


Figure 42. *The water surface elevation for three flow events near the bankfull elevation within the Murray Creek case study area.*

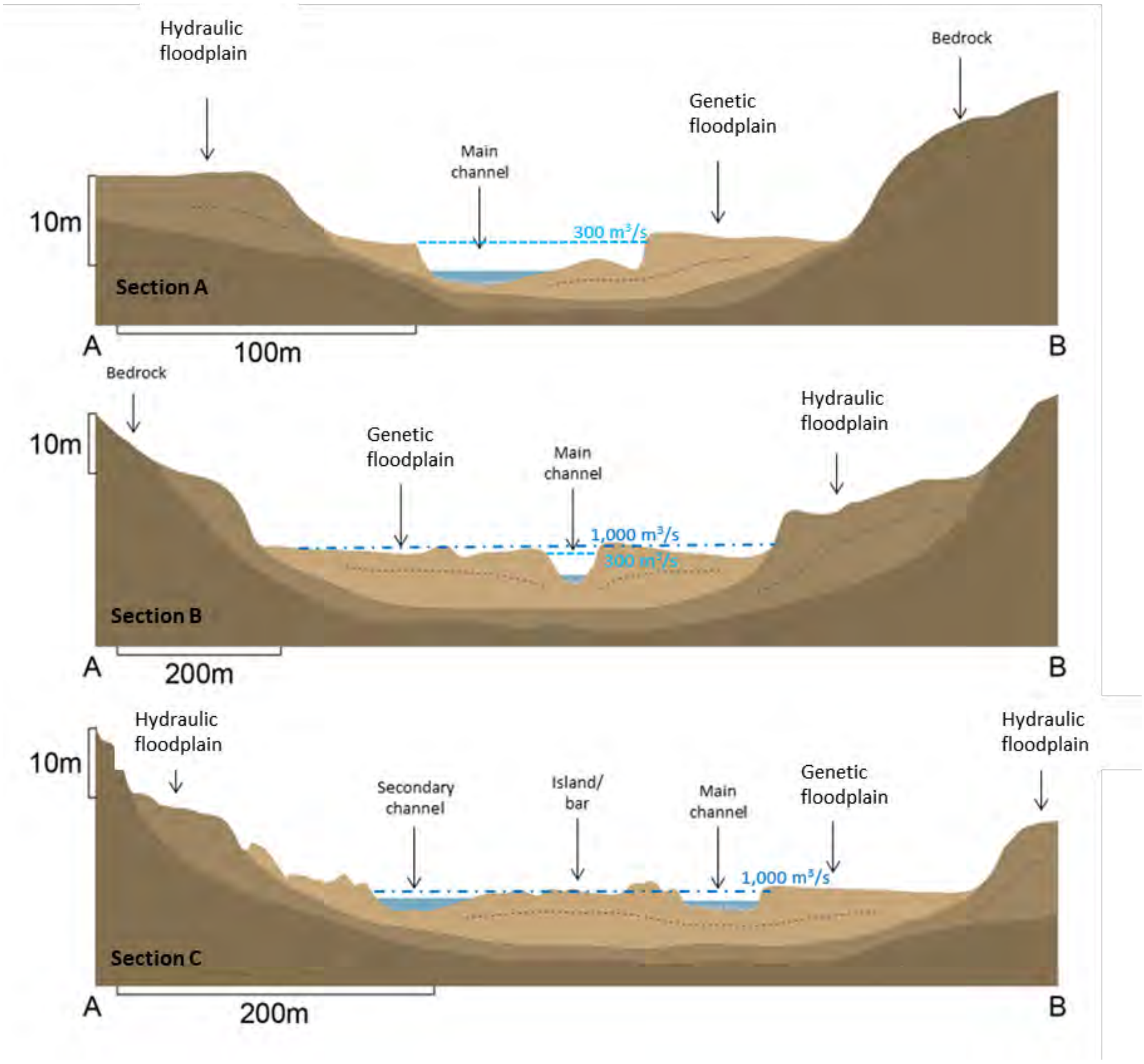


Figure 43. *The three typical sections within the Murray Creek case study area (shown in Figure 40) showing the key geomorphic units and representative bankfull flows.*

Bank full flow used in the Dynamic SedNet modelled link in the Murray Creek case study area is 400 m^3/s. The HEC-RAS modelling identified the channel capacity in the upper reaches is approximately 600 m^3/s however this increases substantially in the mid reaches to over 1,000 m^3/s. In the lower reaches channel capacity is closer to 300 m^3/s however this would also vary based on the tidal conditions.

The SedNet bankfull flow is generally lower than actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 18). This estimate is approximately double the SedNet input bankfull flow).

Table 18. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Murray Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #69	400	300-1000	659	40%-133%

4.9 Mackay Whitsundays - 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 44). The floodplains along this reach support sugarcane cultivation however there are also some small areas used for grazing.

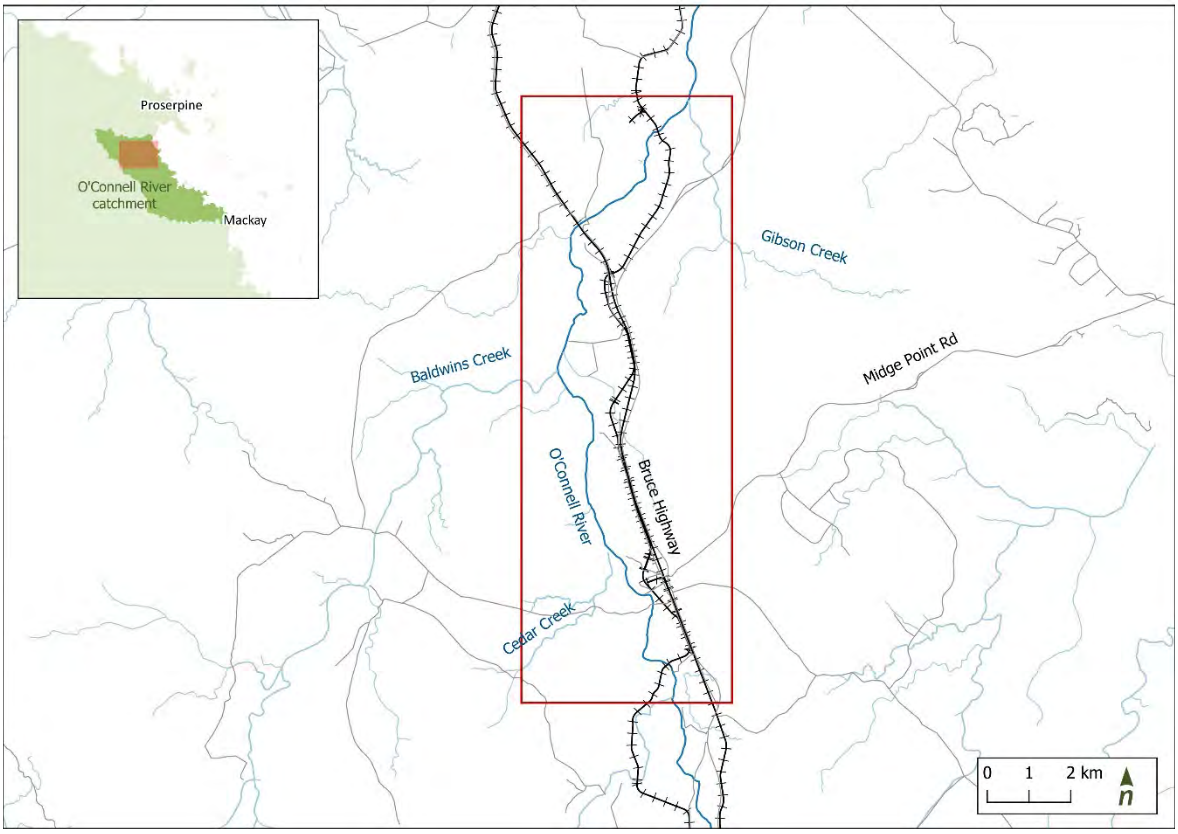


Figure 44. *The O'Connell River case study area.*

Floodplain classification

Modelled floodplain deposition volumes are highly sensitive to floodplain area. High resolution LiDAR data was used to assess the floodplain area in the O'Connell River study area (Figure 45), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the O'Connell Creek case study area.

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 include fill terrace units which sit 12-15 m above the channel bed, and genetic floodplains which sit 3-6 m above the channel bed. The genetic floodplain units are 200-500 m in width with terraces forming the majority of the alluvial development (see cross-section C in Figure 46). Within this section the low sinuosity channel can abut either bedrock, terrace or genetic 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 B in Figure 46). Within this zone there is very limited genetic 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 genetic floodplain development (i.e. downstream of chainage 5,000 m – see cross-section A in Figure 46). Within this section the inset floodplains are typically 300 -500 m wide before confining significantly near the Andromache River confluence.

The dominant inundation surfaces in the O'Connell River study area are genetic floodplains and terraces (Figure 45). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 46.

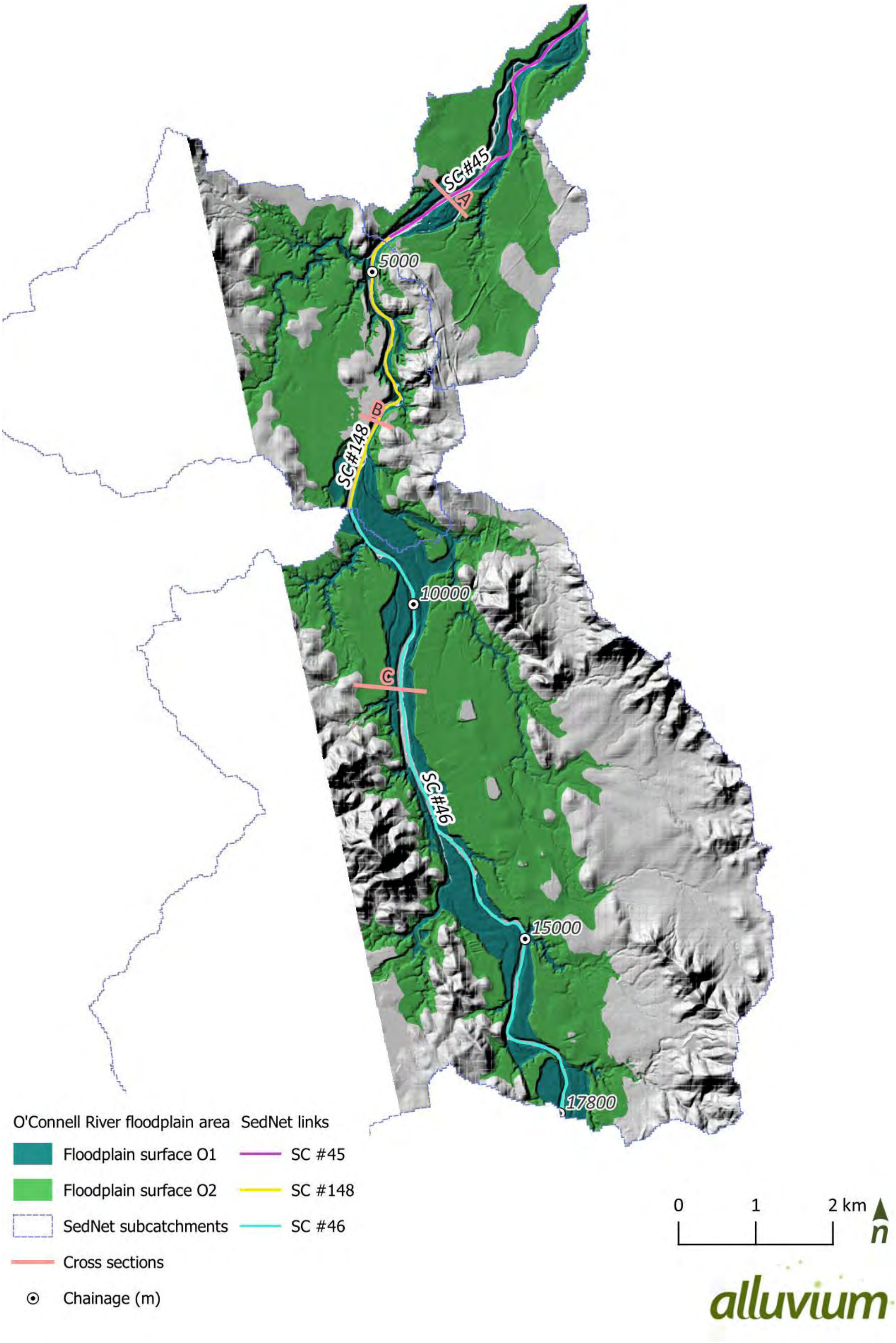


Figure 45. *The O'Connell River case study area showing two major inundation surfaces; genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

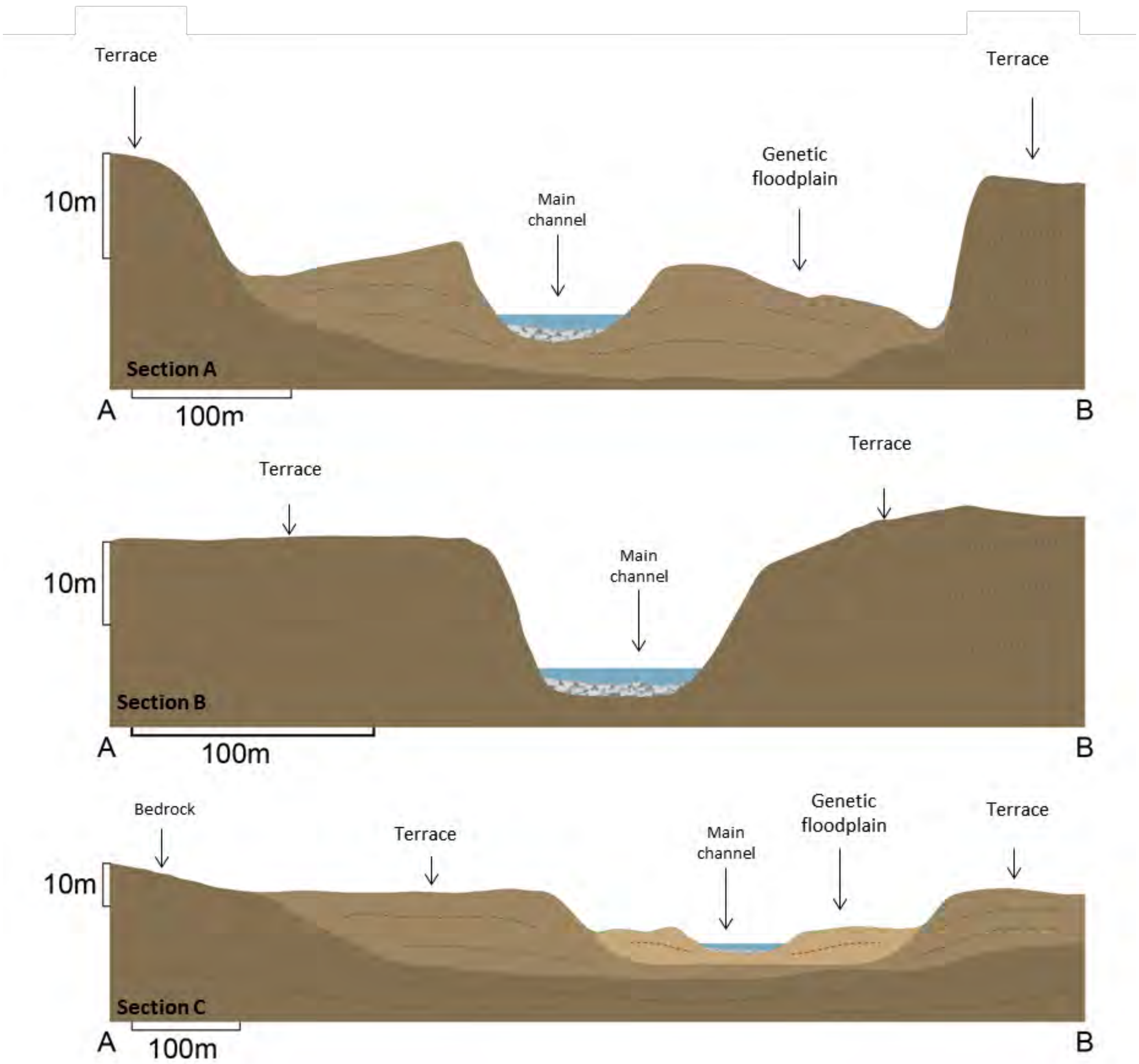


Figure 46. *The three typical sections within the O'Connell River case study area (shown in* Figure 45*) with the key geomorphic units. Note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the O'Connell River case study area are provided in Table 19. The SedNet floodplain area ranges from 135% to 300% of the LiDAR derived genetic floodplain area in the two upper reaches. In the lower lower reach (SC #45) the SedNet floodplain area is 59% of the LiDAR derived genetic floodplain area. Therefore, the input Dynamic SedNet floodplain areas are both overestimated and underestimated in this study area.

Table 19. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the O'Connell River case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR genetic area
		Genetic floodplain (km²)	Terrace (km²)	
SC #45	5.8	9.9	40.2	59%
SC #148	13.3	9.9	40.4	135%
SC #46	29.7	9.9	29.8	300%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the O'Connell River case study area.

A one-dimensional HEC-RAS model was developed for the study area. The model is uncalibrated however the hydraulic roughness has been adjusted based on the channel characteristics and sinuosity. A range of flow events were modelled to determine the channel capacity. The water surface for four flow events, 750 m^3/s, 1000 m^3/s, 1500 m^3/s and 3,000 m^3/s, is shown in Figure 47. Representative bankfull flows in three typical cross-sections are shown in Figure 48.

Upstream of the Boundary Creek confluence (i.e. chainage 8,000 m) the channel capacity is approximately 750 m^3/s (return period of less than 2 years). Within the confined section between chainage 5,000 m and 8,000 m the channel capacity exceeds 3,000 m^3/s (return period of greater than 50 years). The water surface for the 3,000 m^3/s event is 5 m below the confining terrace surface through this section. Downstream of chainage 5,000 m the channel capacity is approximately 1,500 m^3/s (return period between 2- 5 years).

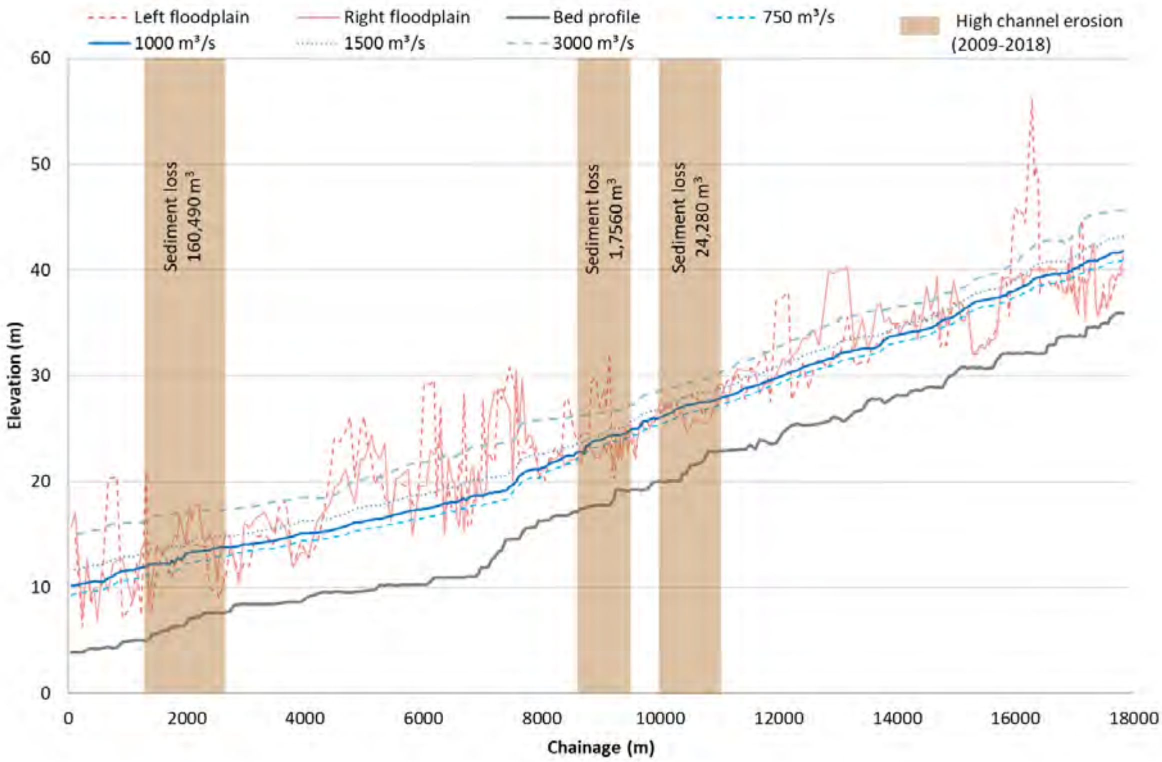


Figure 47. *The water surface elevation for a range of flow events near the bankfull elevation within the O'Connell River case study area.*

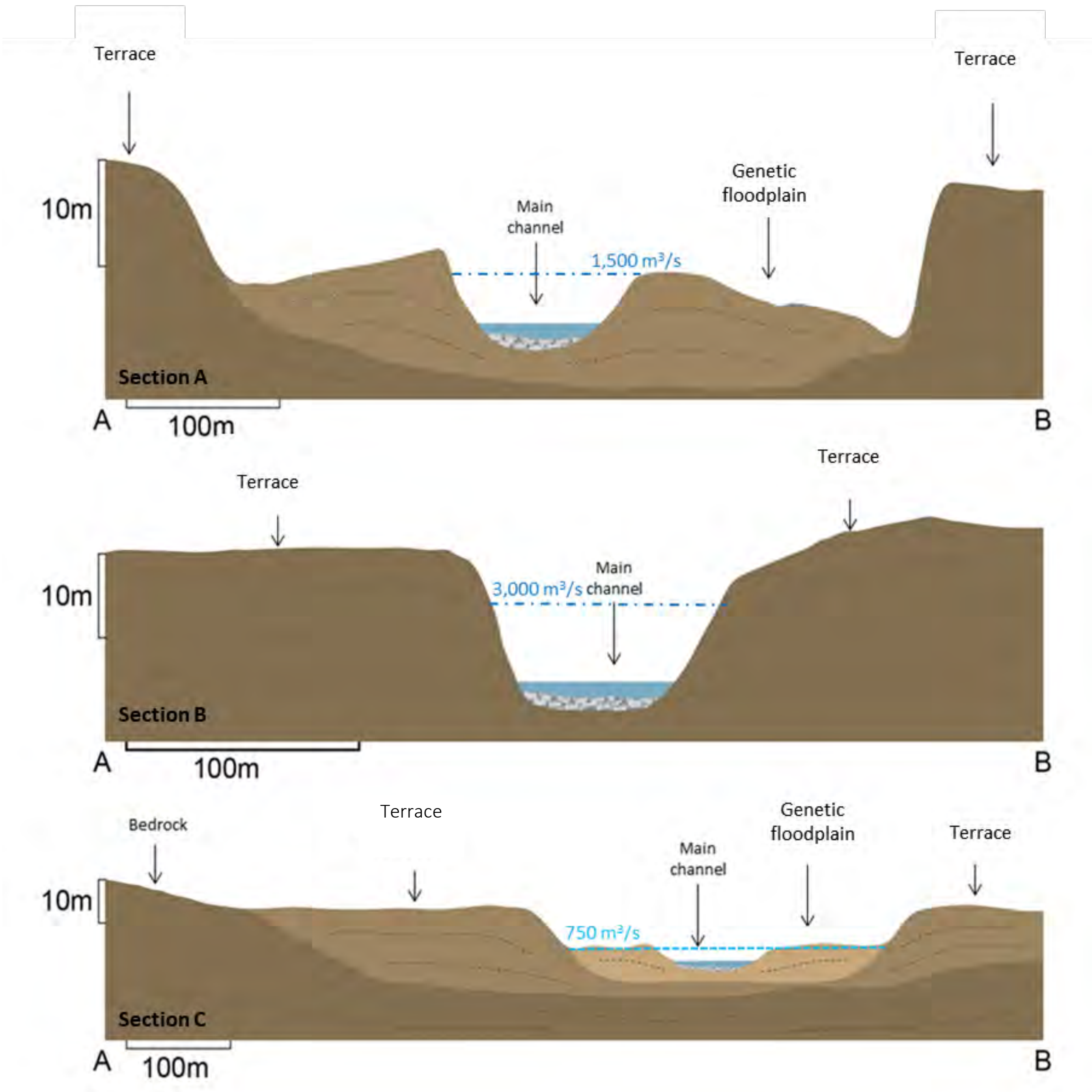


Figure 48. *The three typical sections within the O'Connell River case study area (shown in Figure 45) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled link in the O'Connell River case study area ranges between approximately 400 and 630 m^3/s. The HEC-RAS modelling identified the channel capacity upstream of the Boundary Creek confluence (i.e. chainage 8,000 m)(SC #46) to be approximately 750 m^3/s (return period of less than 2 years). Within the confined section between chainage 5,000 m and 8,000 m (SC #148) the channel capacity exceeds 3,000 m^3/s (return period of greater than 30 years). Downstream of chainage 5,000 m (SC #45) the channel capacity is approximately 1,500 m^3/s (return period of 5 years).

The SedNet bankfull is 21% to 54% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 20). This estimate is generally slightly closer to the modelled bank full flow, compared to the SedNet input bankfull flow.

Table 20. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the O'Connell River case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #45	594	1500	2834	40%
SC #148	627	3000	1702	21%
SC #46	405	750	1347	54%

4.10 Fitzroy - Fitzroy River

Overview

The Fitzroy River case study reach extends for 65 km upstream of the tidal barrage in Rockhampton (Figure 49). 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.

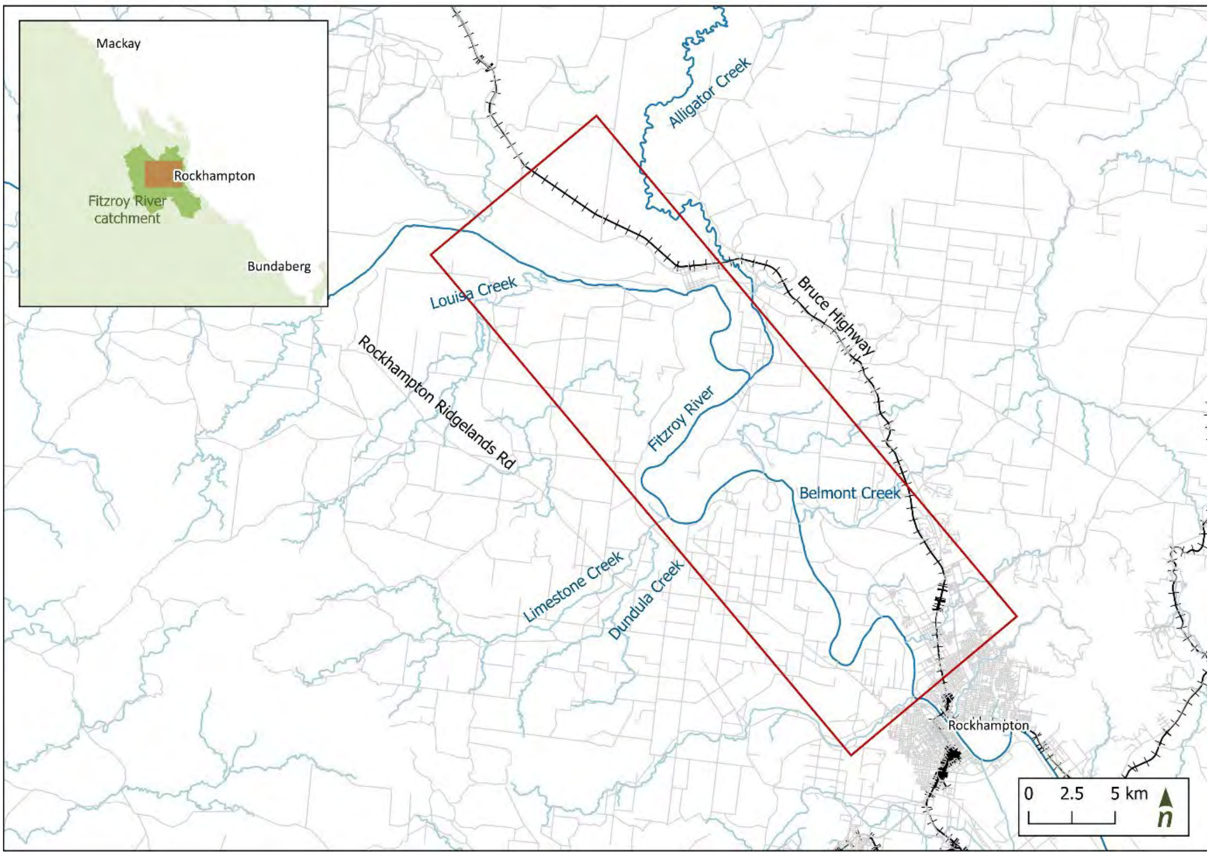


Figure 49. *The Fitzroy River case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Fitzroy River study area (Figure 50), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Fitzroy River case study area.

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 A and B in Figure 51). Both the tidal barrage and the Eden Bann Weir have impacted river hydraulics, sediment transport and bank saturation processes within this area.

The dominant inundation surfaces in the Fitzroy River study area are genetic floodplains and hydraulic floodplains (Figure 50). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 51.

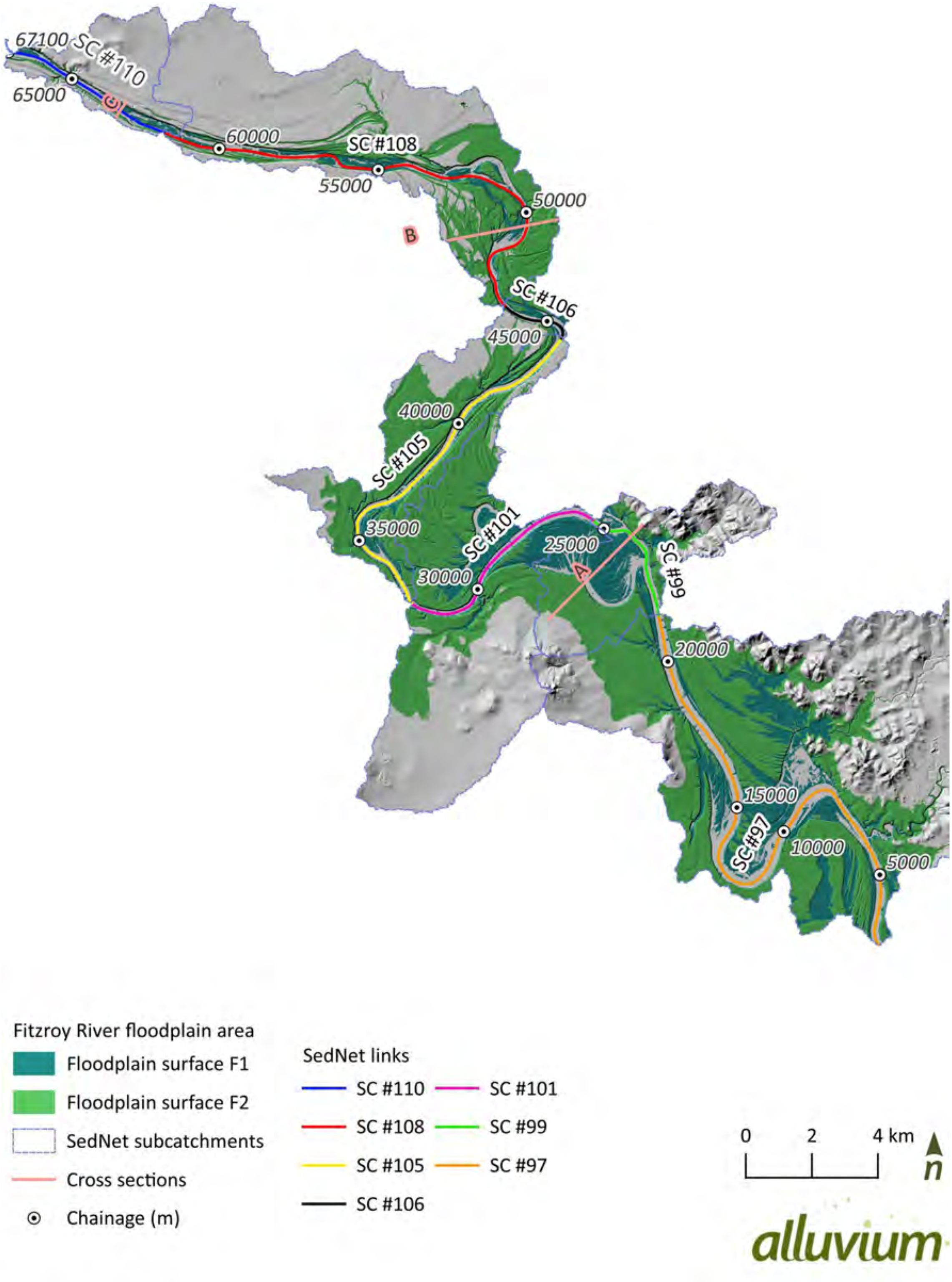


Figure 50. *The Fitzroy River case study area showing two major inundation surfaces; genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

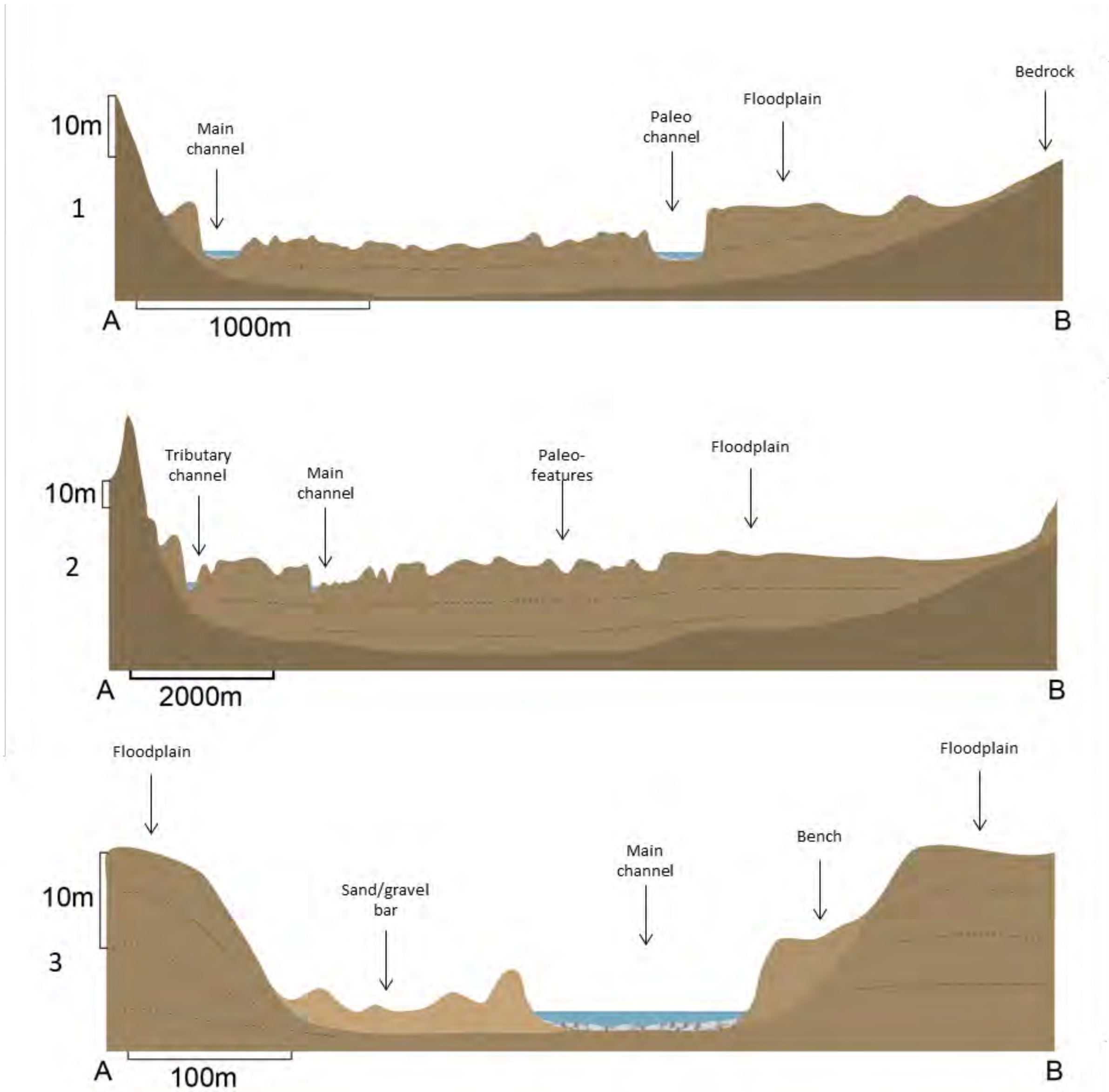


Figure 51. *The three typical sections within the Fitzroy River case study area (shown in* Figure 50*) with the key geomorphic units - note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Fitzroy River case study area are provided in Table 21. The SedNet floodplain area generally ranges from 13% to 93% of the LiDAR derived floodplain area in the lower five reaches. There is one link in an upper reach (SC #108) where the SedNet floodplain area is 261% of the LiDAR derived genetic floodplain area. In general, the input Dynamic SedNet floodplain areas are underpredicted in this case study area.

Table 21. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Fitzroy River case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR floodplain area
		Genetic floodplain (km²)	Hydraulic floodplain (km²)	
SC #97	54.4	19.4	39.3	93%
SC #99	12.1	9.7	26.1	34%
SC #101	27.1	12.9	36.6	55%
SC #105	21.5	4.4	21.5	83%
SC #106	2.3	1.1	16.5	13%
SC #108	44.7	3.8	13.3	261%
SC #110	9.8	0.7	8.8	103%

Bankfull flow discharge

Modelled floodplain deposition volumes are highly sensitive to bankflow flow. Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Fitzroy River case study area.

A one-dimensional HEC-RAS model was developed for the study area. The model is uncalibrated however the hydraulic roughness has been adjusted based on the channel characteristics and sinuosity. A range of flow events were modelled to determine the channel capacity. The water surface for five flow events between 1200 m^3/s and 5,400 m^3/s are shown in Figure 52. Representative bankfull flows in three typical cross-section are shown in Figure 53.

The channel capacity in the upper reaches is approximately 5,400 m^3/s which has an approximate return period of 5 years. Downstream towards the tidal barrage, channel capacity is closer to 2,900 m^3/s which has a return period of 3 years. It is not possible to determine the actual channel capacity within the weir pool due to the lack of bathymetric data. However, the channel capacity within this reach is unlikely to be significantly different to these modelled estimates.

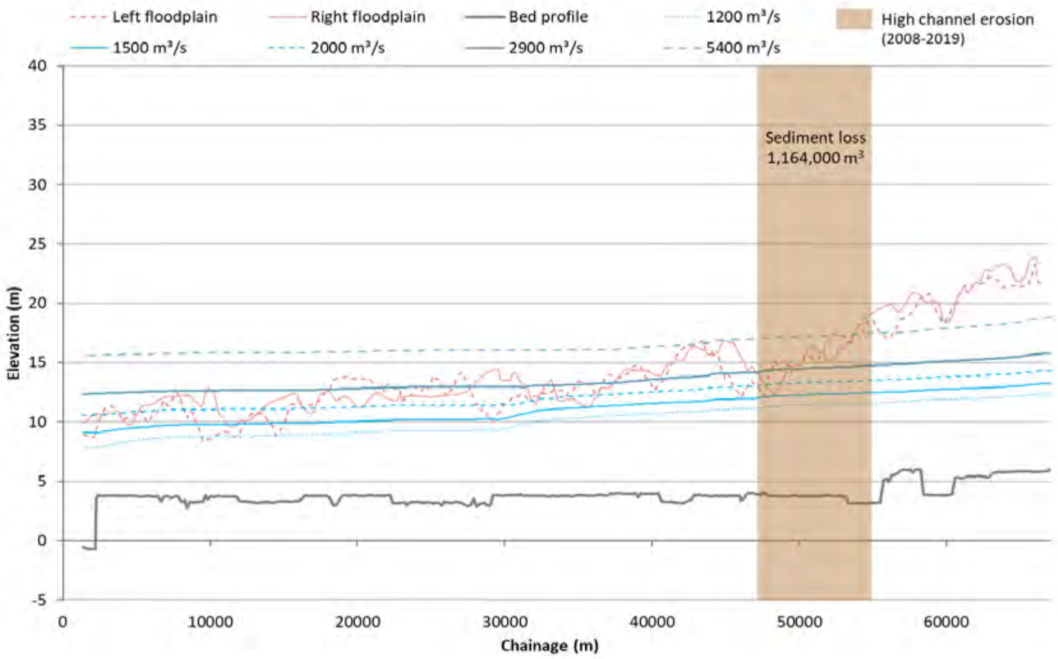


Figure 52. *The water surface elevation for a range of flow events near the bankfull elevation within the Fitzroy River case study area.*

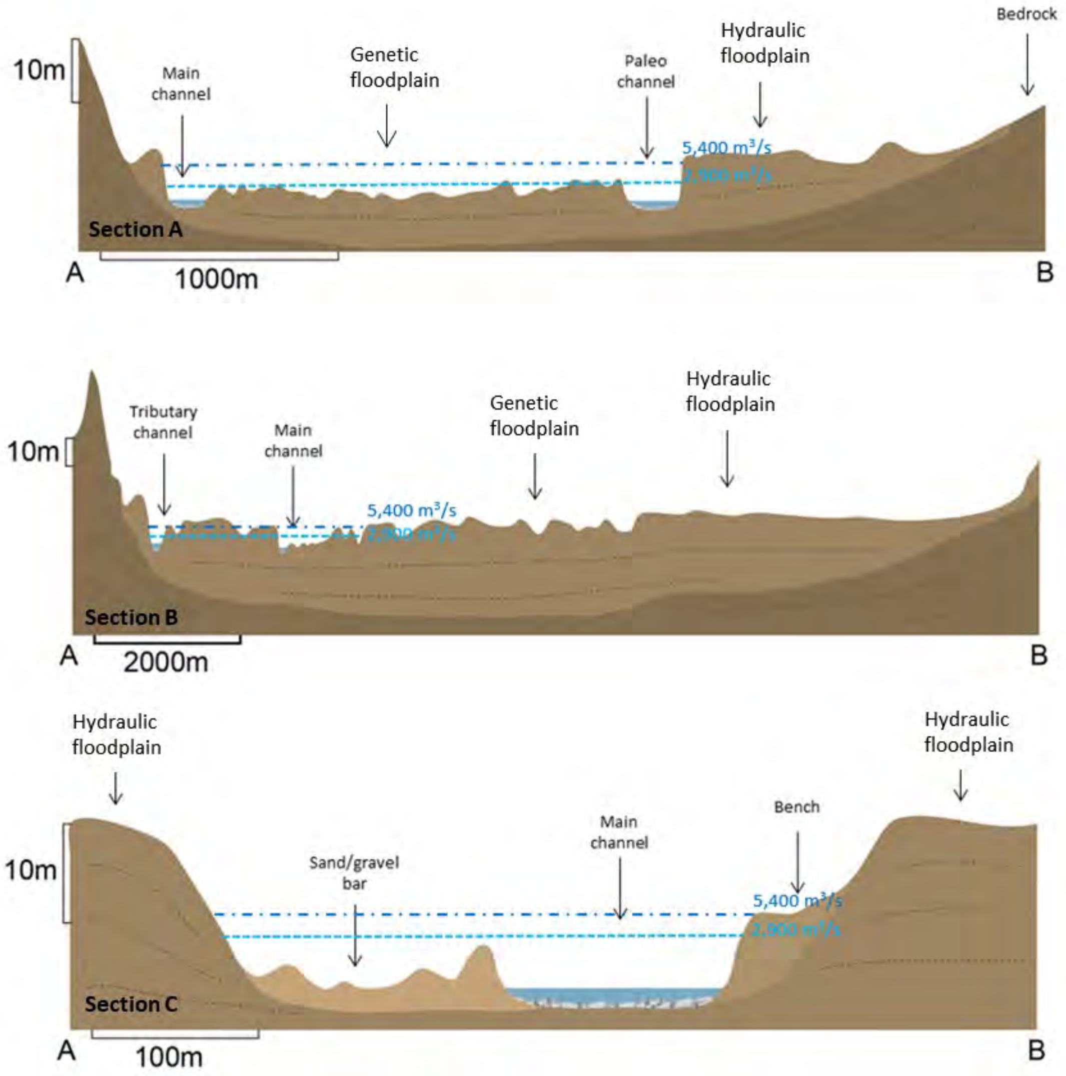


Figure 53. *The three typical sections within the Fitzroy River case study area (shown in* Figure 50*) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Fitzroy River case study area range between approximately 10,500 and 11,500 m^3/s, which have return periods of 17 and 20 years respectively (Table 22). Comparatively, the HEC-RAS modelled bankfull flow is approximately 5,400 m^3/s in upper reaches (SC#110 and upper SC# 108), and approximately 2,900 m^3/s in downstream reaches (Figure 52). Overall, the bankfull flows applied in the Dynamic SedNet model for the Fitzroy River case study reach are considerably higher than the HEC-RAS bankfull flow estimates. Even when channel roughness is reduced from 0.035 to 0.01 the Dynamic SedNet input bankfull flows exceeds the channel capacity (i.e. channel capacity is approximately 7,500 m^3/s in downstream reaches). Due to the lack of bathymetric data within the weir pool (downstream of chainage 53,000 m) it is not possible to definitively determine the actual channel capacity (and therefore bankfull flow). However, channel capacity is unlikely to be significantly different to the HEC-RAS modelled estimates.

The SedNet bankfull flow is 193% to 399% of the actual modelled bank full flow in all reaches.

Bankfull flow was also estimated using Manning's equation (Table 22). Unlike the majority of case study areas this estimate is general closer to the SedNet input bankfull flow compared to the modelled bank full flow. However, this is likely due to the the SedNet input link slopes being one and three orders of magnitude greater (i.e. steeper) than LiDAR derived bed slopes.

Table 22. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Fitzroy River case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m³/s)	Modelled Bank Full Flow (m³/s)	Manning's calculation estimated Bank Full Flow (m³/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #97	11,560	2,900	59,613	399%
SC #99	11,132	2,900	98,504	384%
SC #101	11,077	2,900	51,172	382%
SC #105	10,973	2,900	30,106	378%
SC #106	10,451	2,900	78,164	360%
SC #108	10,444	5,400	66,770	193%
SC #110	10,435	5,400	19,4417	193%

4.11 Fitzroy - 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 54). 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.

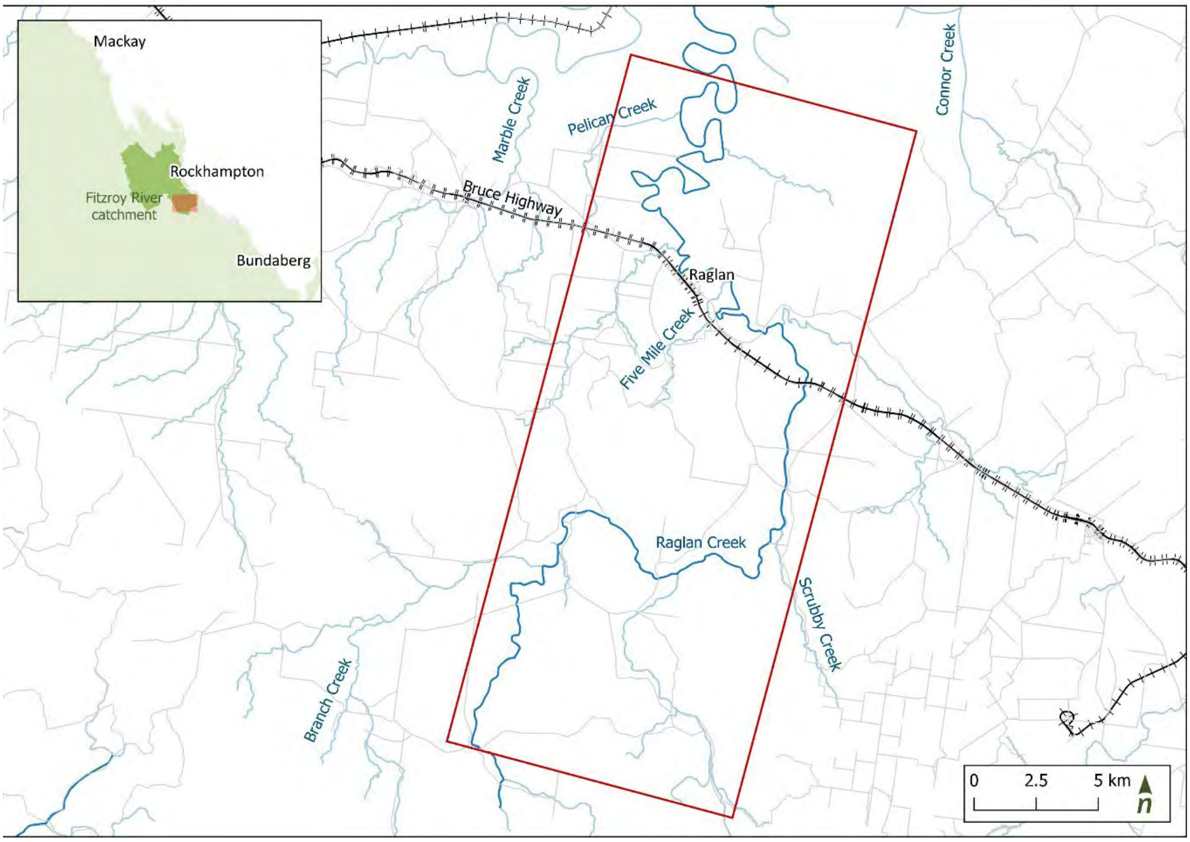


Figure 54. *The Raglan Creek case study area.*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Raglan Creek study area (Figure 55), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in 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. Through this section the channel has a wide and shallow morphology with abundant instream gravels (see cross-section C in Figure 56). 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 cross-section B in Figure 56).

The system transitions to an unconfined valley setting downstream of Raglan, where the low relief channel meanders across the tidal flats (Figure 27) within a broader compound channel (see cross-section A in Figure 56). 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.

The dominant inundation surfaces in the Raglan Creek study area are genetic floodplains and terraces (Figure 55). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 56.

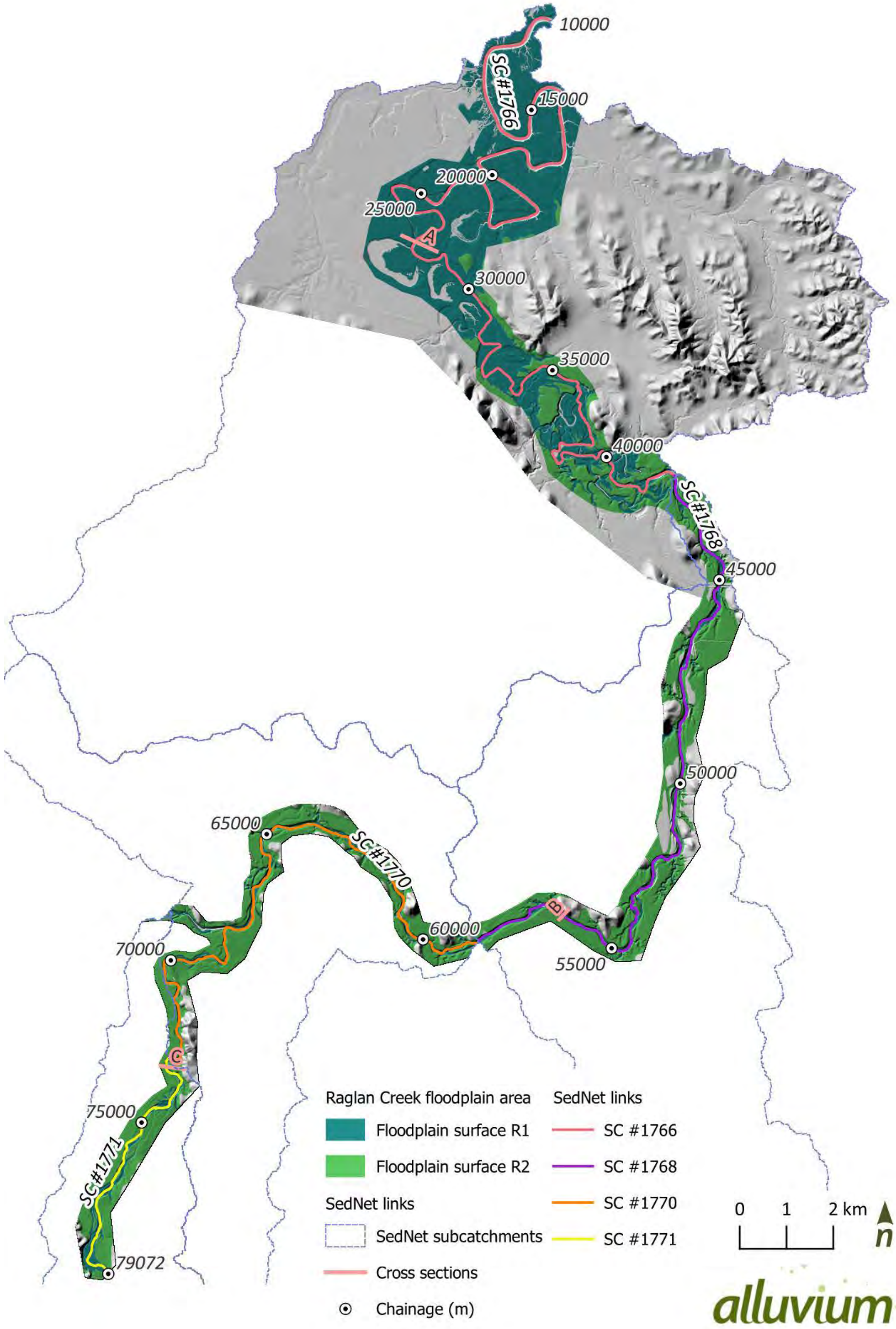


Figure 55. *The Raglan Creek case study area showing two major inundation surfaces; genetic floodplain and terrace. The representative cross section locations are also shown.*

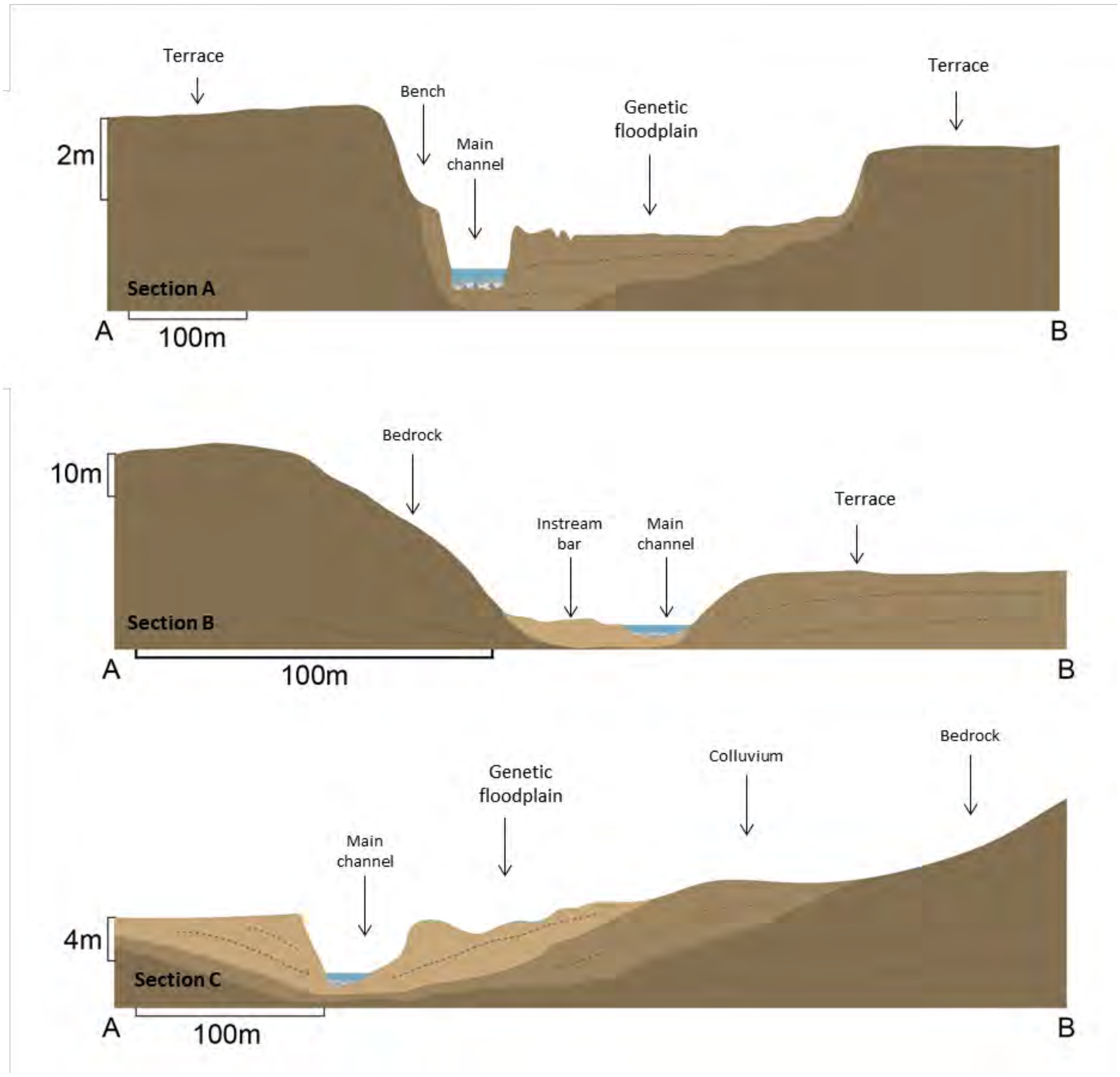


Figure 56. *The three typical sections within the Raglan Creek case study area (shown in Figure 55) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Raglan Creek case study area are provided in Table 23. The SedNet floodplain area 97% of the LiDAR derived genetic floodplain area in the lower reach. The LiDAR does not extend across the floodplain in the upper reaches therefore comparison could not be undertaken.

Table 23. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Raglan Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km²)	Terrace (km²)	
SC #1766	76.8	79.5	27.6	97%
SC #1768	24.4	-	-	-
SC #1770	12.4	-	-	-
SC #1771	13.9	-	-	-

*Note: LiDAR does not extend across the floodplain in the upper reaches.

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Normanby River case study area.

A one-dimensional HEC-RAS model was developed for the study area. The model is uncalibrated, however the hydraulic roughness has been adjusted based on the channel characteristics and sinuosity. A range of flow events were modelled to determine the channel capacity. The water surface for two flow events, 650 m^3/s and 1,250 m^3/s, are shown in Figure 57. Representative bankfull flows in three typical cross-section are shown in Figure 58.

The channel capacity in the upper reaches is approximately 650 m^3/s, however this increases substantially in the mid reaches to over 1,250 m^3/s. It is not possible to determine the capacity within the tidal reaches due to the lack of bathymetric data. However, capacity within this reach would also vary based on the tidal conditions.

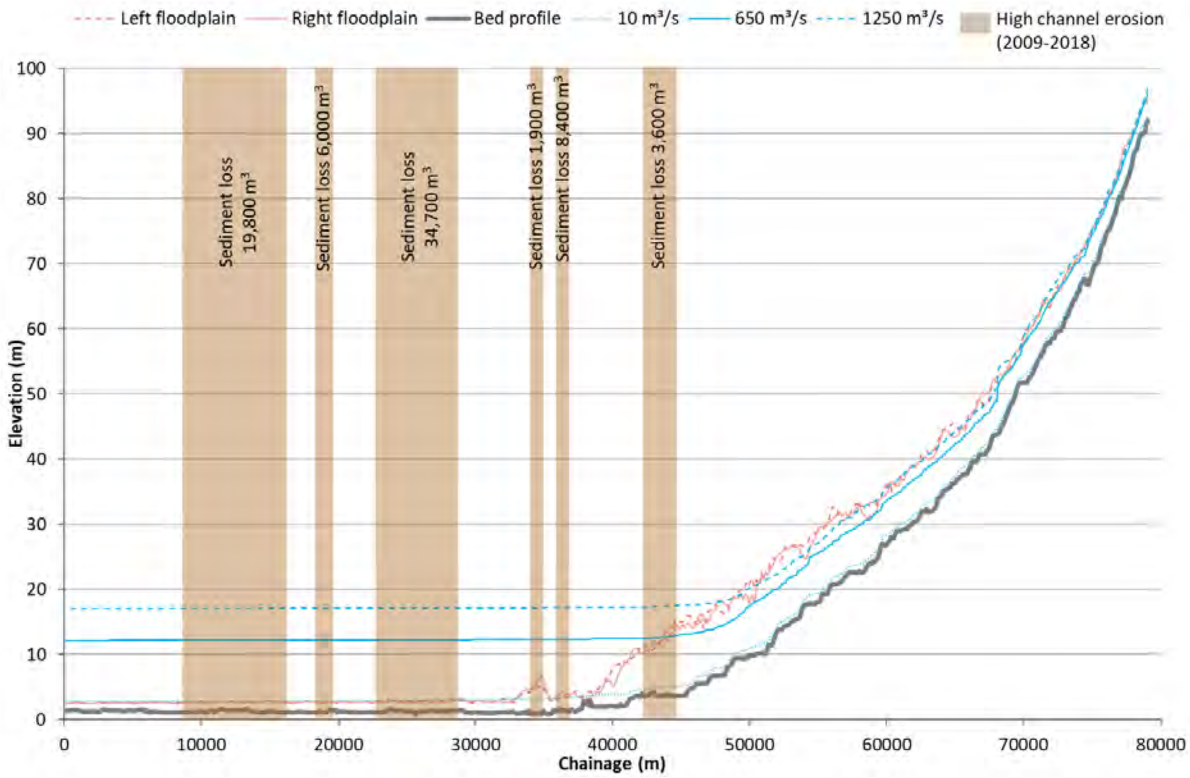


Figure 57. *The water surface elevation for two flow events near the bankfull elevation within the Raglan Creek case study area.*

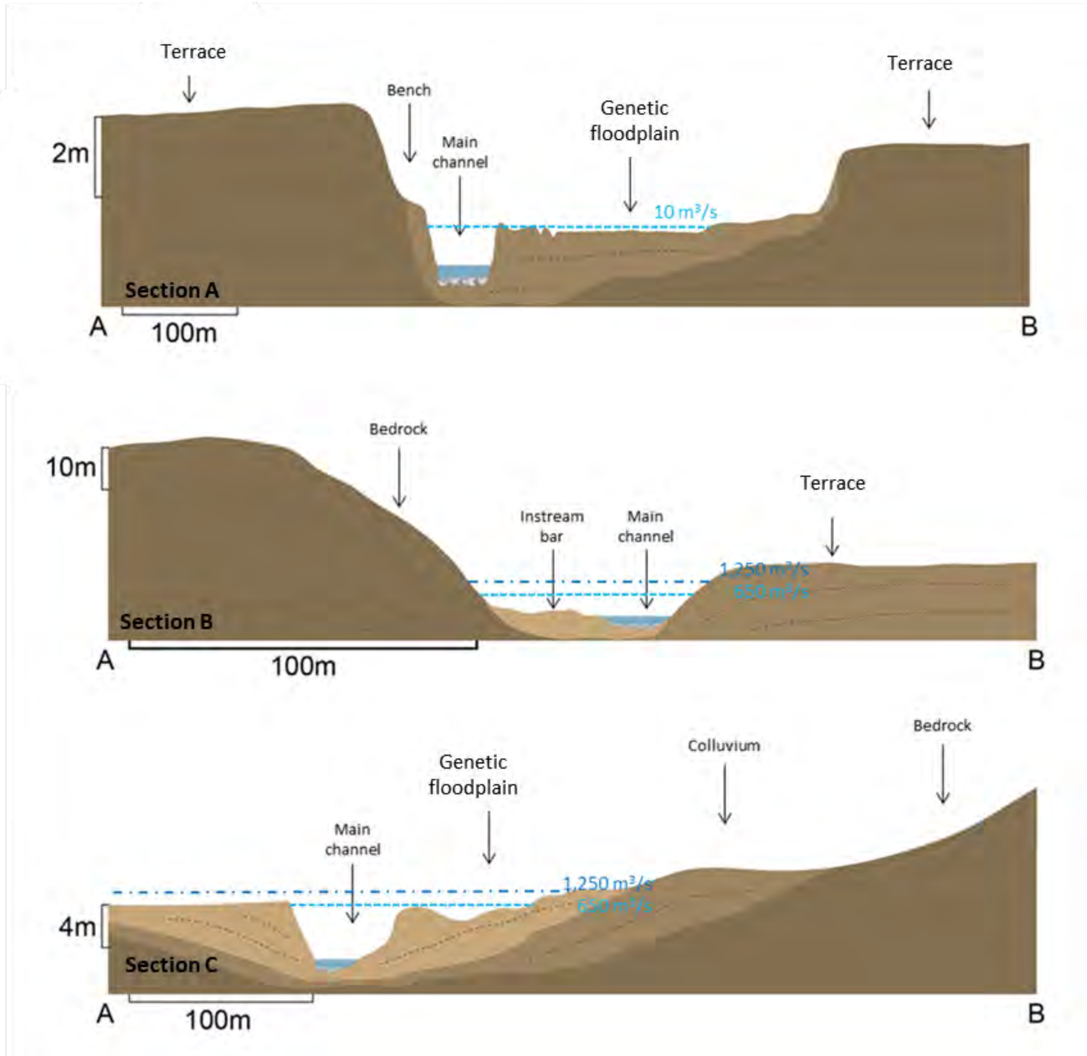


Figure 58. *The three typical sections within the Raglan Creek case study area (shown in Figure 55) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Raglan Creek case study area increases from 60 m^3/s in the upstream link to 880 m^3/s within the downstream link. This assessment was unable to determine the channel capacity within the downstream link (i.e. the tidal reach) due to the lack of bathymetric data.

The HEC-RAS modelling identified the channel capacity in the upper reaches is approximately 650 m^3/s (SC #1770 and #1771). Within the entrenched section between chainage 40,000 m and 60,000 m (i.e. SC #1768) the HEC-RAS modelling identified that the channel capacity is over 1,250 m^3/s.

The SedNet bankfull is 9% to 28% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 24). This estimate is general closer to the modelled bank full flow, compared to the SedNet input bankfull flow.

Table 24. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Raglan Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #1766	881	-	1,187	-
SC #1768	221	1,250	1530	18%
SC #1770	183	650	689	28%
SC #1771	58	650	208	9%

*It is not possible to determine the capacity within the tidal reach (SC#1766) due to the lack of bathymetric data

4.12 Fitzroy - Woleebee Creek

Overview

The Woleebee Creek case study area extends for approximately 60 kilometres upstream of its confluence with the Juandah Creek, northwest of Wondoan, to just upstream of its confluence with Hellhole Creek (Figure 59). The floodplains along this reach largely support grazing and some isolated cropping and pasture rotations.

The sub catchment geology consists of predominantly gently dipping sedimentary strata of Jurassic to Cretaceous age topped by very minor exposures of younger Tertiary sediments to the south. The Jurassic Injune Creek Group, which underlies the lower half of the catchment, consists of calcareous sandstones, silt and mud stones interlayered with minor coal seams and conglomerates. The upper extent of the catchment, where the headwaters of Wolleebee creek rise, consists of similar lithologies (Sandstones etc) of a generally coarser grain size and of slightly younger age which outcrop as a series of low tablelands at the top of the catchment.

Having experienced only minor deformation, these relatively soft and gently sloping sediments have readily weathered to form a gently undulating paleo-surface which have been shallowly dissected by more recent alluvial processes. Woleebee Creek predominately drains through dispersive black and grey sodosols which are highly vulnerable to erosion.

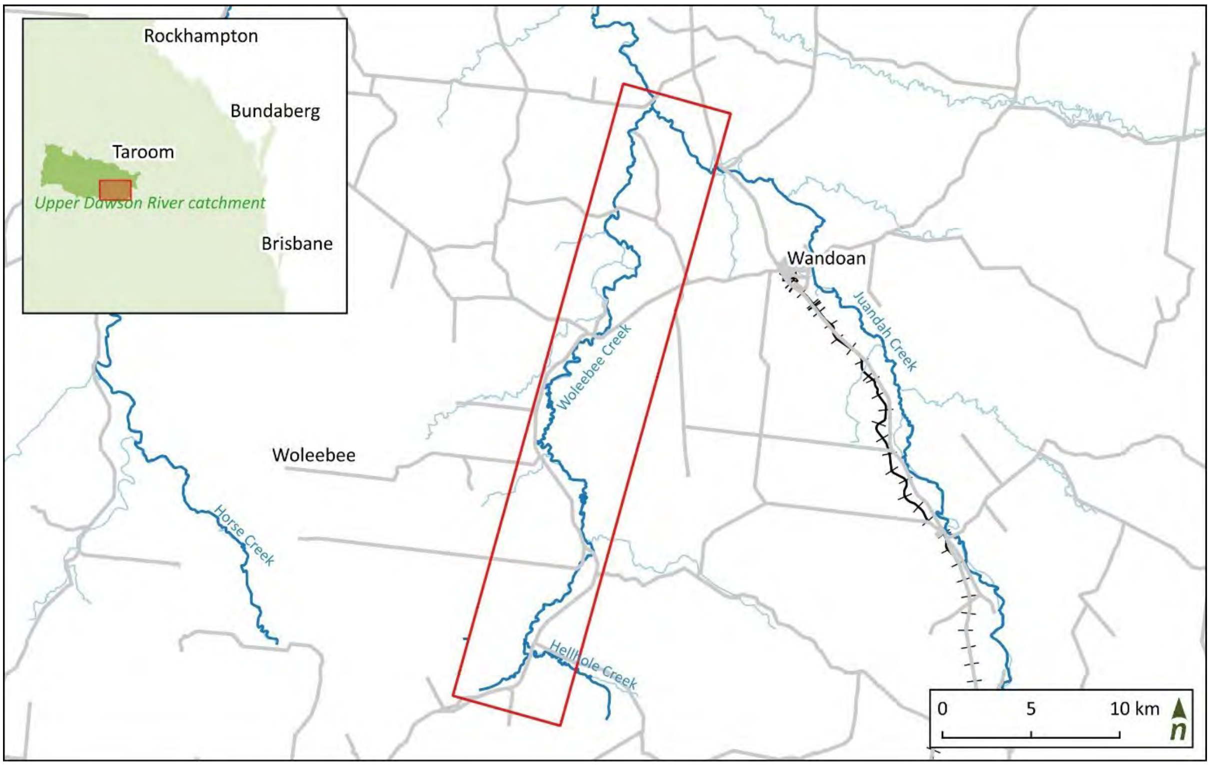


Figure 59. *The Woleebee Creek case study area*

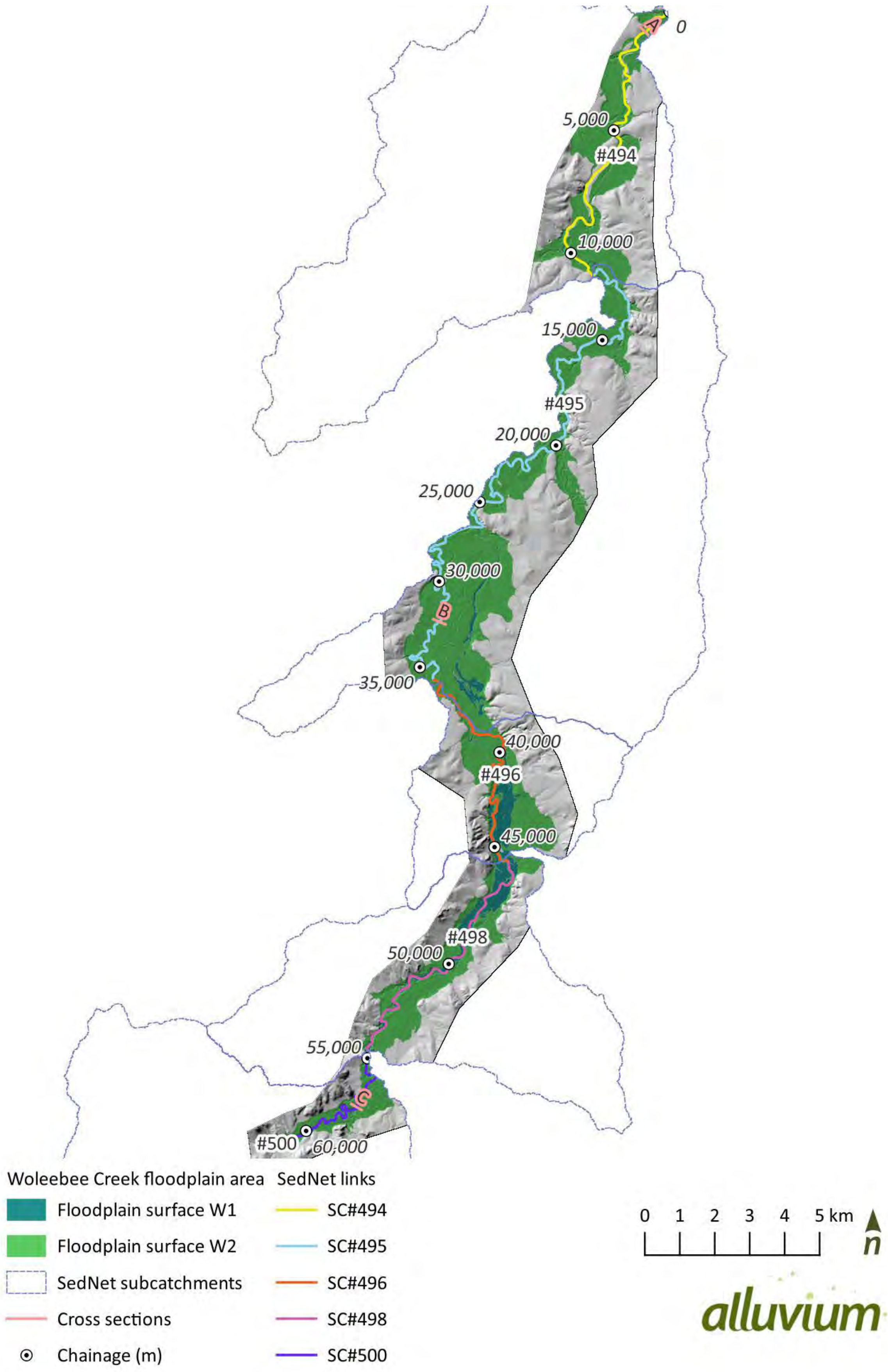
Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Woleebee Creek study area (Figure 60), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Woleebee Creek case study area.

The extent of alluvial development varies in accordance with valley confinement. In the upper reaches, the channel has a macrochannel morphology, the channel intermittently abuts the valley margins and floodplain widths are typically between 100m – 400m. The upper floodplain/terrace sitting approximately 5 – 7 m above the streambed, and the inset units typically 2 – 3 m high and up to 100 m in width.

The channel in the mid reaches meanders through a largely unconfined valley setting with sections of channel abutting the valley margins and sections with broad floodplains up to 1 km in width. The channel is typically between 4 – 6 m deep and highly sinuous in some sections. In the lower reaches the channel is entrenched, with the floodplain typically 6 – 8 m above the channel bed, and has a low sinuosity planform.

The dominant inundation surfaces in the Woleebee study area are genetic floodplains and hydraulic floodplains (Figure 60). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 52.



alluvium

Figure 60. *The Woleebee Creek case study area showing two major inundation surfaces; genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

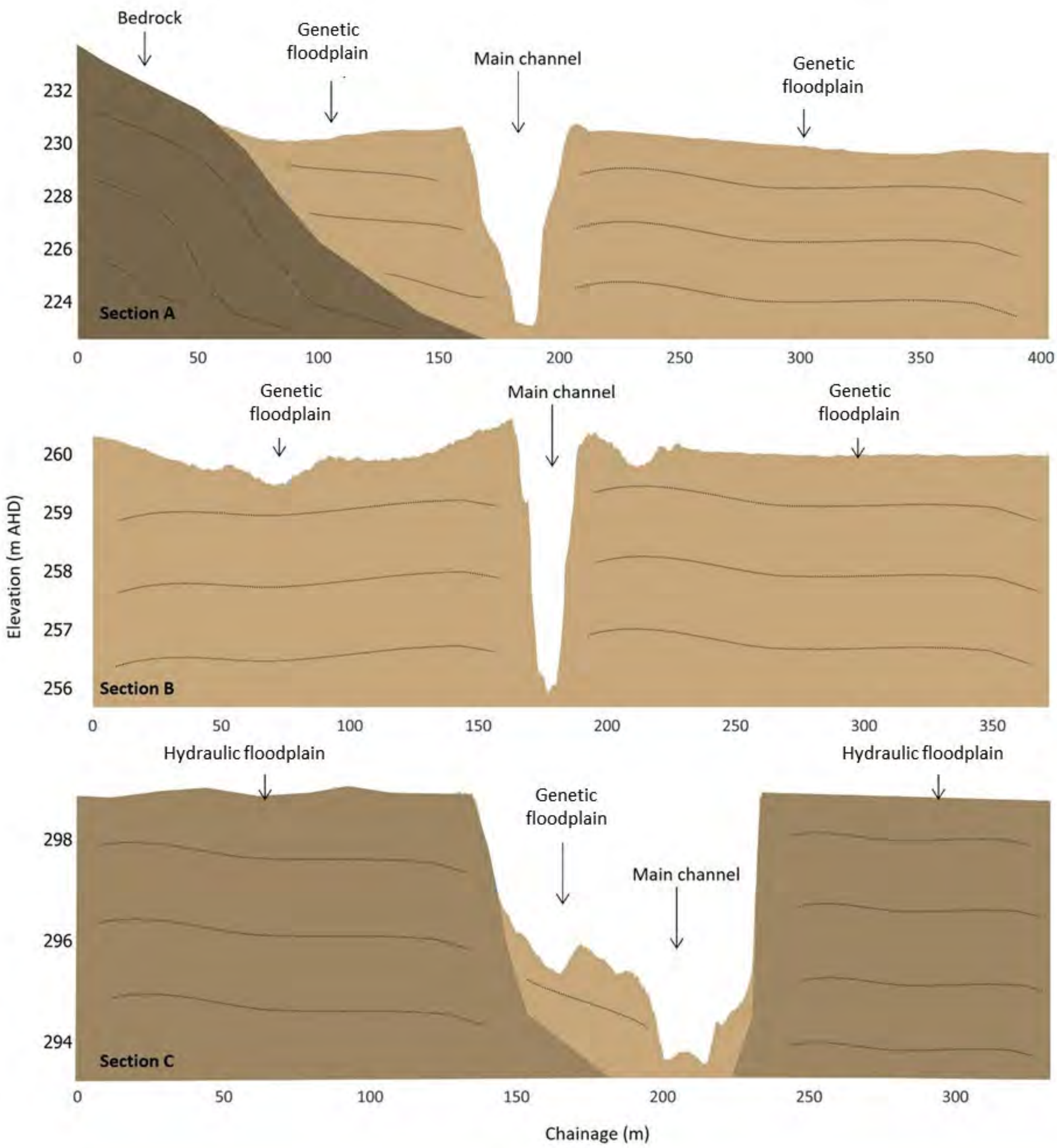


Figure 61. *The three typical sections in the Woleebee Creek case study area (shown in Figure 60) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Woleebee Creek case study area are provided in Table 25. The SedNet floodplain area ranges from 3% to 42% of the LiDAR derived floodplain area. The input Dynamic SedNet floodplain areas are underpredicted in this case study area.

Table 25. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Woleebee Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR floodplain area)
		Genetic floodplain (km²)	Hydraulic floodplain (km²)	
SC #494	14.1	0.1	33.8	42%
SC #495	20.6	1.0	50.2	40%
SC #496	6.5	2.0	42.2	15%
SC #498	5.3	2.6	42.0	12%
SC #500	0.7	0.2	25.6	3%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Wolleebee Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 49 years of data is present at the downstream extent of the study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for two flow events, 250 m³/s and 450 m³/s are shown in Figure 62. Representative bankfull flows in three typical cross-section are shown in Figure 63. The channel capacity varies throughout the case study area, however is typically 450 m³/s in the steeper upper reaches (upstream of chainage 50,000 m), and 250 m³/s in the mid and lower reaches (between chainage 0 – 50,000). The return period for these events is estimated at 3 and 8 years respectively (BOM, 2023).

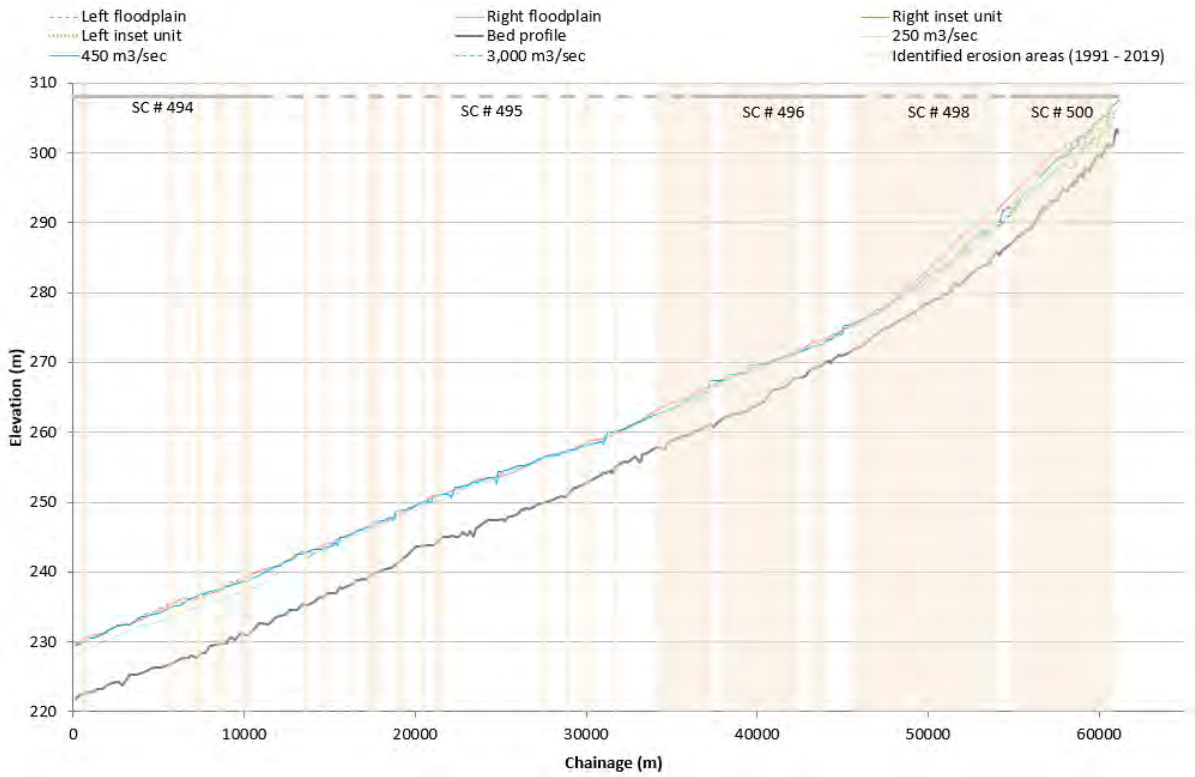


Figure 62. *The water surface elevation for a range of flow events near the bankfull elevation within the Woleebee Creek case study area*

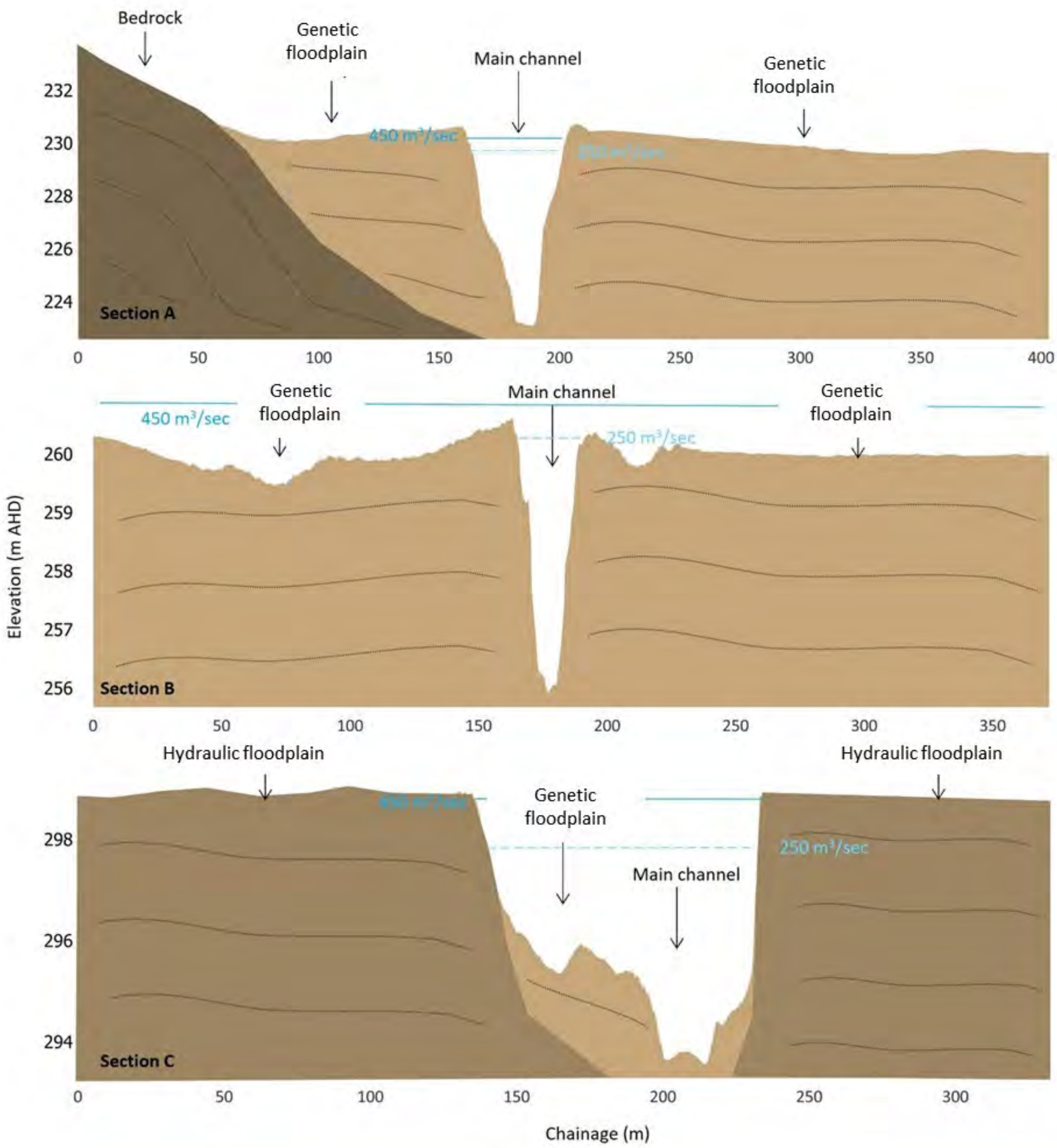


Figure 63. *The three typical sections in the Woleebee Creek case study area (shown in Figure 60) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Woleebee Creek case study area range between 19 m^3/s in the upstream most link (#500) to 122 m^3/s in the most downstream link (#494), which has a return period of approximately 1 – 2 years (Table 26) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is approximately 450 m^3/s in upper reaches (SC#498 and #500) and approximately 250 m^3/s in downstream reaches (SC#494, #495 and #496), which have return periods of 8 years and 3 years respectively (Table 26).

The SedNet bankfull is 4% to 49% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 26). This estimate aligns with the modelled bank full flow.

Table 26. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Woleebee Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #494	122	250	169	49%
SC #495	100	250	192	40%
SC #496	79	250	161	32%
SC #498	61	450	313	14%
SC #500	19	450	148	4%

4.13 Fitzroy - Raby Creek

Overview

The Raby Creek case study extends for approximately 22 kilometres, from the Mimosa Creek confluence, upstream of Wooroona, to the foothills of the Dawson Range State Forest (Figure 64). The study reach sits in the upper portion of the lower Dawson River catchment, it is a tributary of Mimosa Creek which flows into the Dawson River approximately 120 km downstream. The floodplains along this each are utilised for grazing activities, while the headwaters drain hillslopes of the Dawson Range that is primarily covered by State Forest.

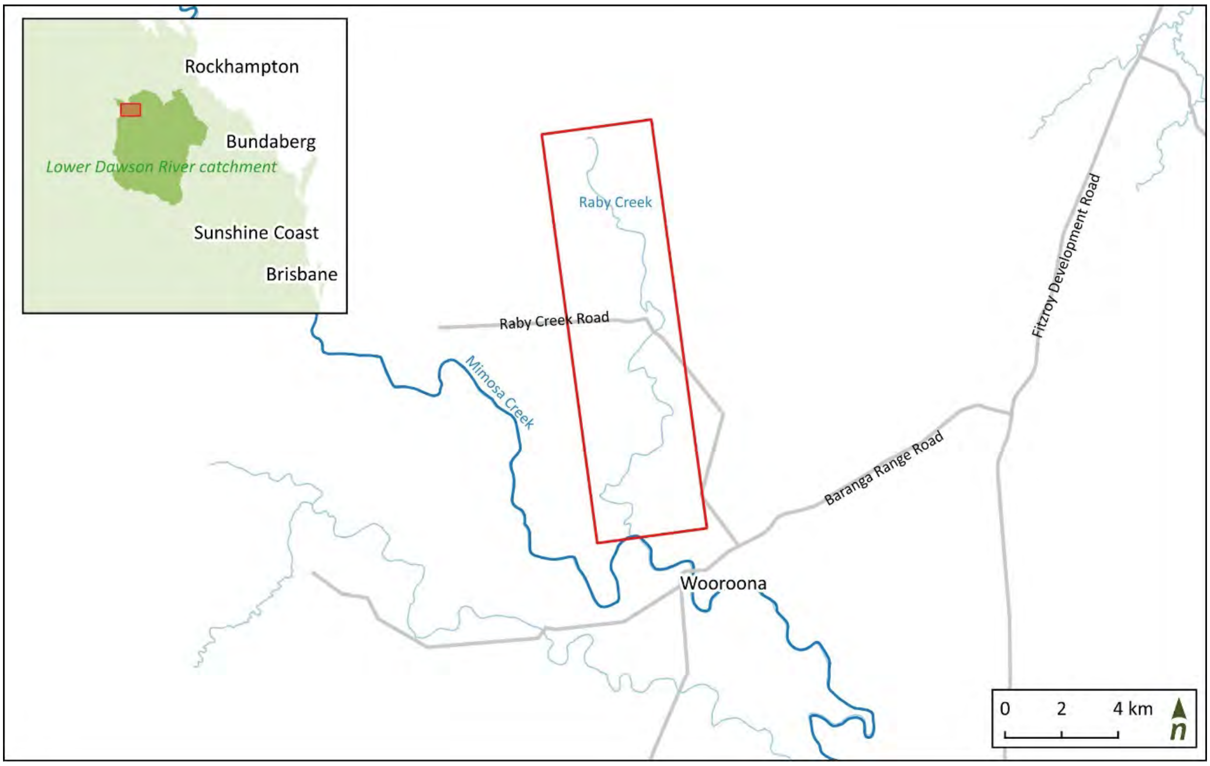


Figure 64. *The Raby Creek case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Raby Creek study area (Figure 65), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Raby Creek case study area.

In this area Raby Creek 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 less than 800 m wide. The alluvial development includes extensive fill terraces which sit 7 - 10 m above the channel bed, and inset floodplain and bench units which sit 3 - 5 m above the channel bed.

The width of the macrochannel and inset features varies significantly throughout the reach. In the upper reaches the macrochannel is up to 300 m wide. The channel width reduces to less than 70 m in the mid reaches as it flows through a valley constriction. The floodplain development increases again through the lower reaches where the low flow channel boundary intermittently abuts both terrace and hillslope boundaries. Paleochannels, evident in the aerial imagery and LiDAR, indicate the significant variation in historic channel alignment, particularly through the lower reaches.

The dominant inundation surfaces in the Raby Creek study area are genetic floodplains and hydraulic floodplains (Figure 65). Variations in the degree of channel entrenchment and geomorphic units can be seen in the three typical sections shown in Figure 58.

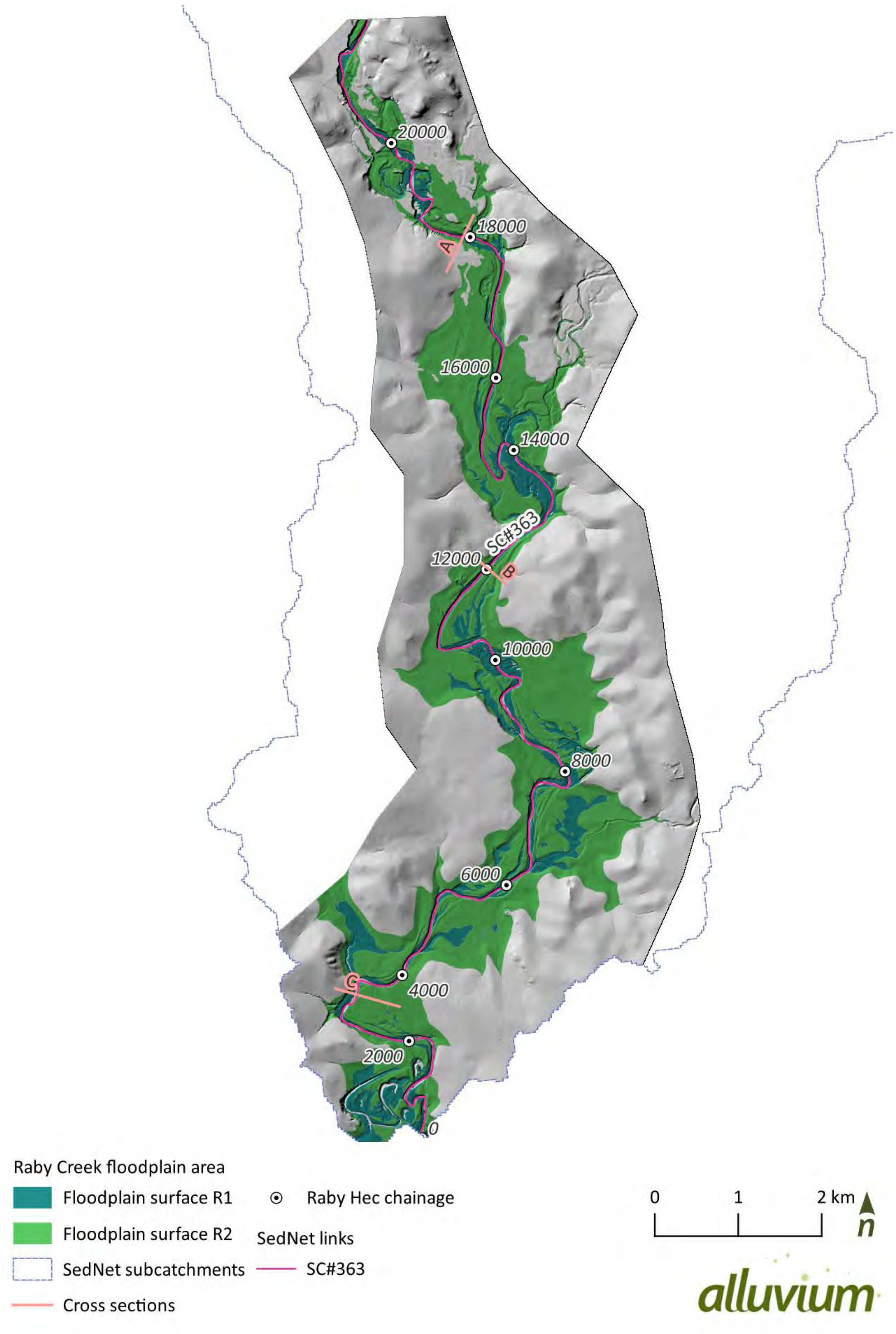


Figure 65. *The Raby Creek case study area showing two major inundation surfaces; the genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

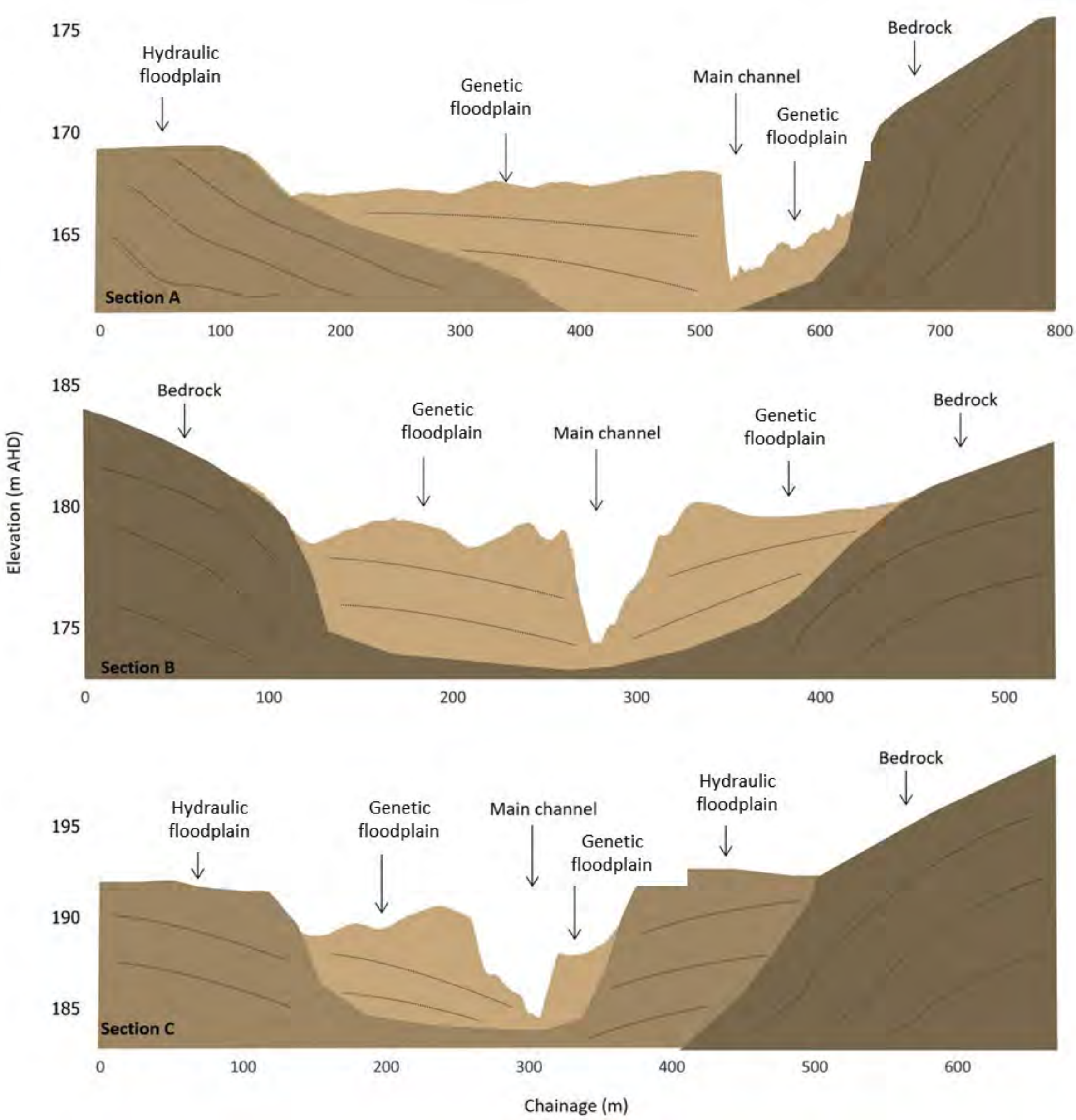


Figure 66. *The three typical sections in the Raby Creek case study area (shown in Figure 65) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Raby Creek case study area are provided in Table 27. The SedNet floodplain area are 89% of the LiDAR derived floodplain area. The input Dynamic SedNet floodplain areas align well with the LiDAR derived floodplain areas in this case study area.

Table 27. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Raby Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km^2)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km^2)	Hydraulic floodplain (km^2)	
SC #363	14.3	3.9	12.1	89%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Raby Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A range of flow events were modelled to determine the channel capacity. The water surface for two flow events, 600 m³/s and 1,500 m³/s are shown in Figure 67. Representative bankfull flows in three typical cross-section are shown in Figure 68. The channel capacity in the case study area is typically around 600 m³/s throughout except for the upstream extent where the bankfull flows are estimated closer to 1,500 m³/s. There is no stream gauge in Raby Creek, the closet gauge is on Mimosa Creek approximately 60 km downstream of the Raby Creek confluence. There are no stream gauges available to assess the likely return period of modelled events. The return period for these events has been estimated using the Regional Flood Frequency Estimation Model (Results | Regional Flood Frequency Estimation Model (arr-software.org)), and is estimated between 15 yr ARI for 600 m³/s and 100 yr ARI for 1,500 m³/s.

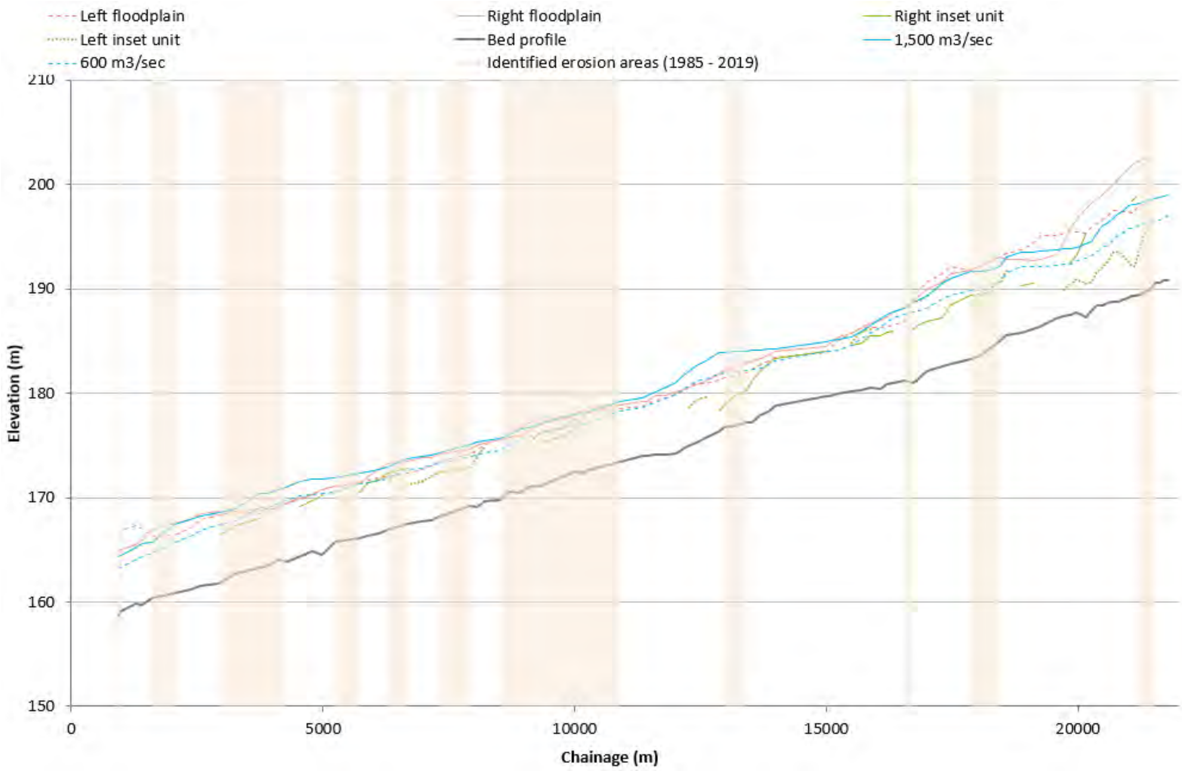


Figure 67. *The water surface elevation for a range of flow events near the bankfull elevation within the Raby Creek case study area*

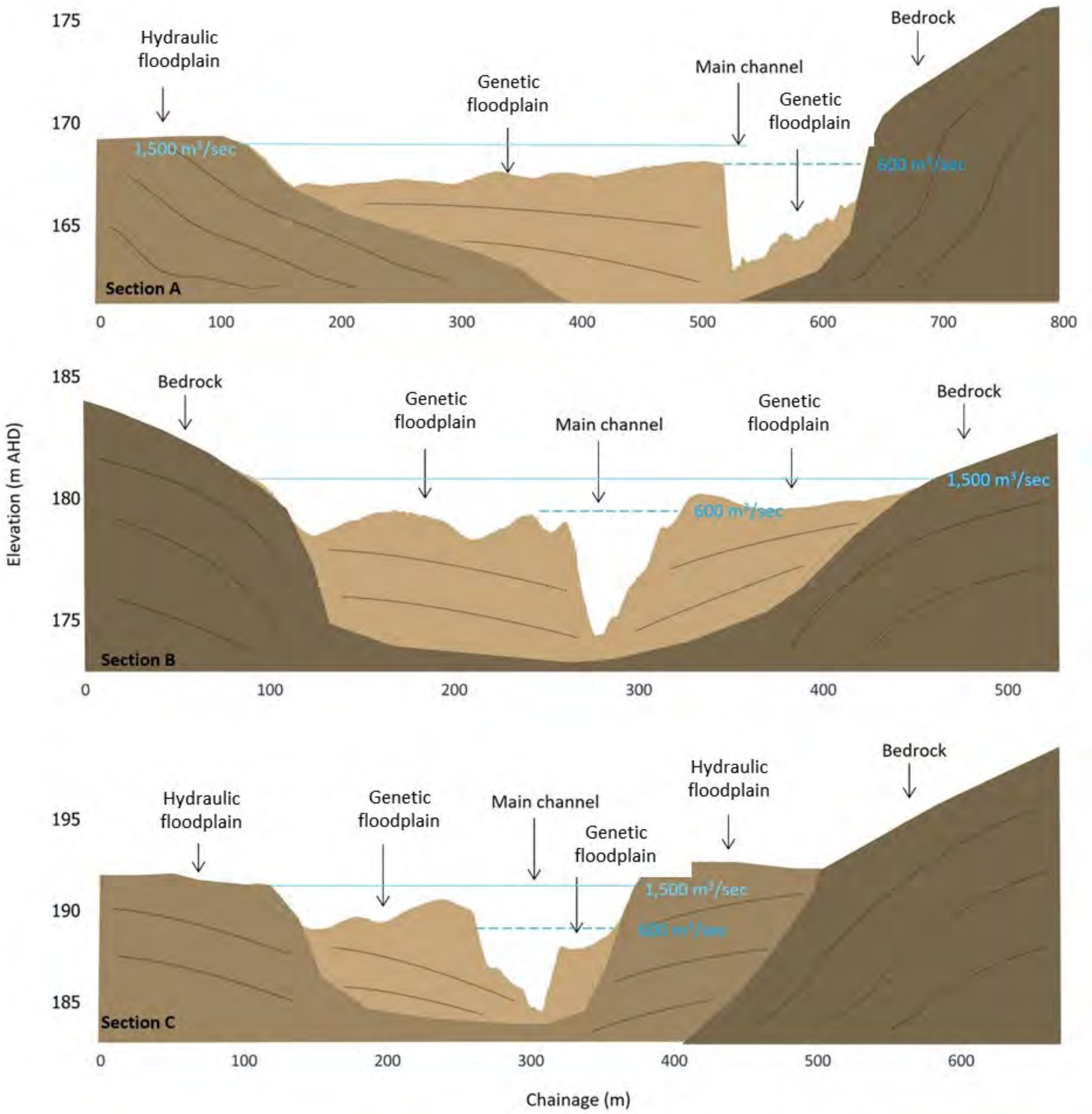


Figure 68. *The three typical sections in the Raby Creek case study area (shown in Figure 65) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Raby Creek case study area is 63 m^3/s (Table 28). Comparatively, the HEC-RAS modelled bankfull flow is approximately 600 m^3/s which has a return period of closer to 15 years (Table 28) which is considerably higher than the SedNet modelled estimate.

The SedNet bankfull is 6% of the actual modelled bank full flow. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 28). This estimate is closer to the modelled bank full flow (compared to the SedNet input bankfull flow).

Table 28. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Raby Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #363	34	600	245	6%

4.14 Fitzroy - Panorama Creek

Overview

The Panorama Creek case study extends for approximately 32 kilometres, the upstream portion includes approximately 22 km of Panorama Creek from the Consuelo Creek confluence, the lower portion then meets and becomes the Comet River near the Rolleston township (Figure 69). The floodplains along this reach are primarily used for a livestock grazing and dryland cropping.

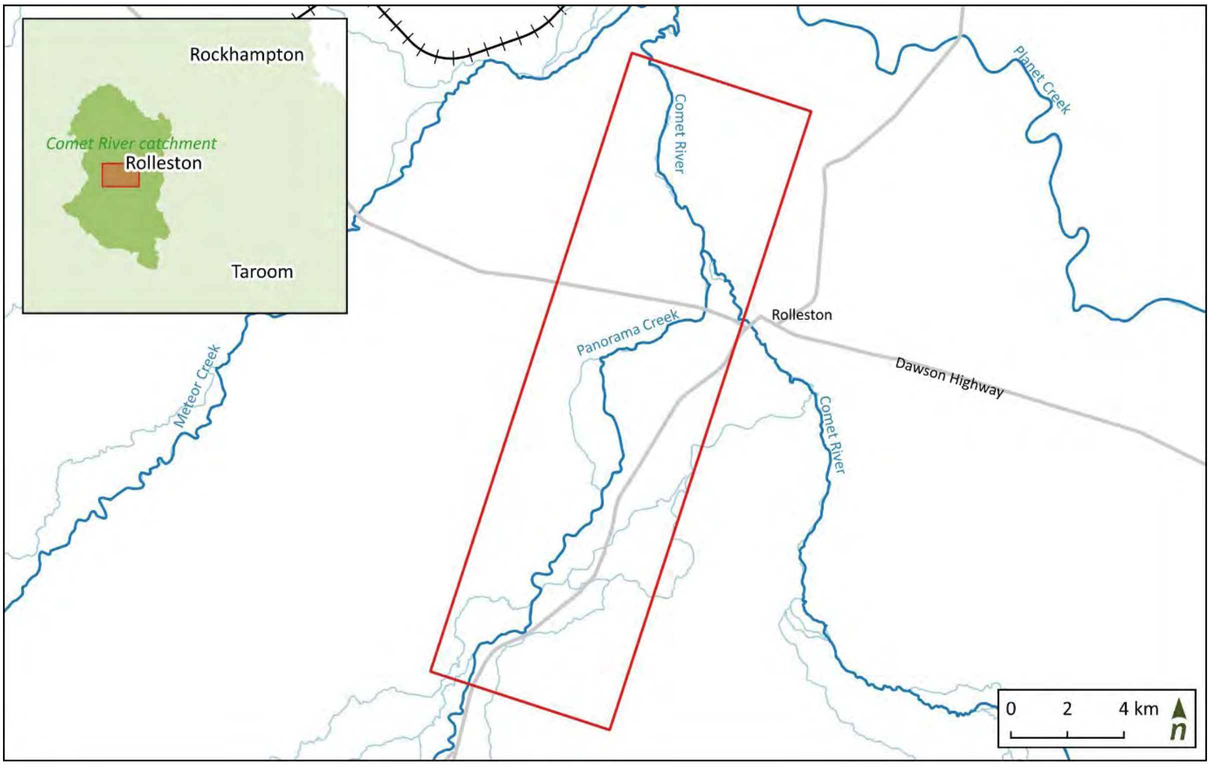


Figure 69. *The Panorama Creek case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Panorama Creek study area (Figure 62), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Panorama Creek case study area.

Through the upper reaches the channel is slightly confined by the valley margins before it emerges into a broad floodplain setting in the mid reaches with extensive floodplain, several kilometres in width. The upper reaches consist of a single channel with a low sinuosity planform and a depth of between 7 – 10 m. Through the mid reaches, the single channel continues and the bank height gradually reduces to between 3 – 5m before it flows into the multi-channel portion of the Comet River, downstream of Rolleston. The primary channel (and the study reach) has a highly sinuous planform and a typical bank height of between 2 – 4 m.

The dominant inundation surfaces in the Panorama study area are hydraulic floodplains (Figure 62). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 63. The paleo features within the floodplain indicate a significant history of channel avulsions.

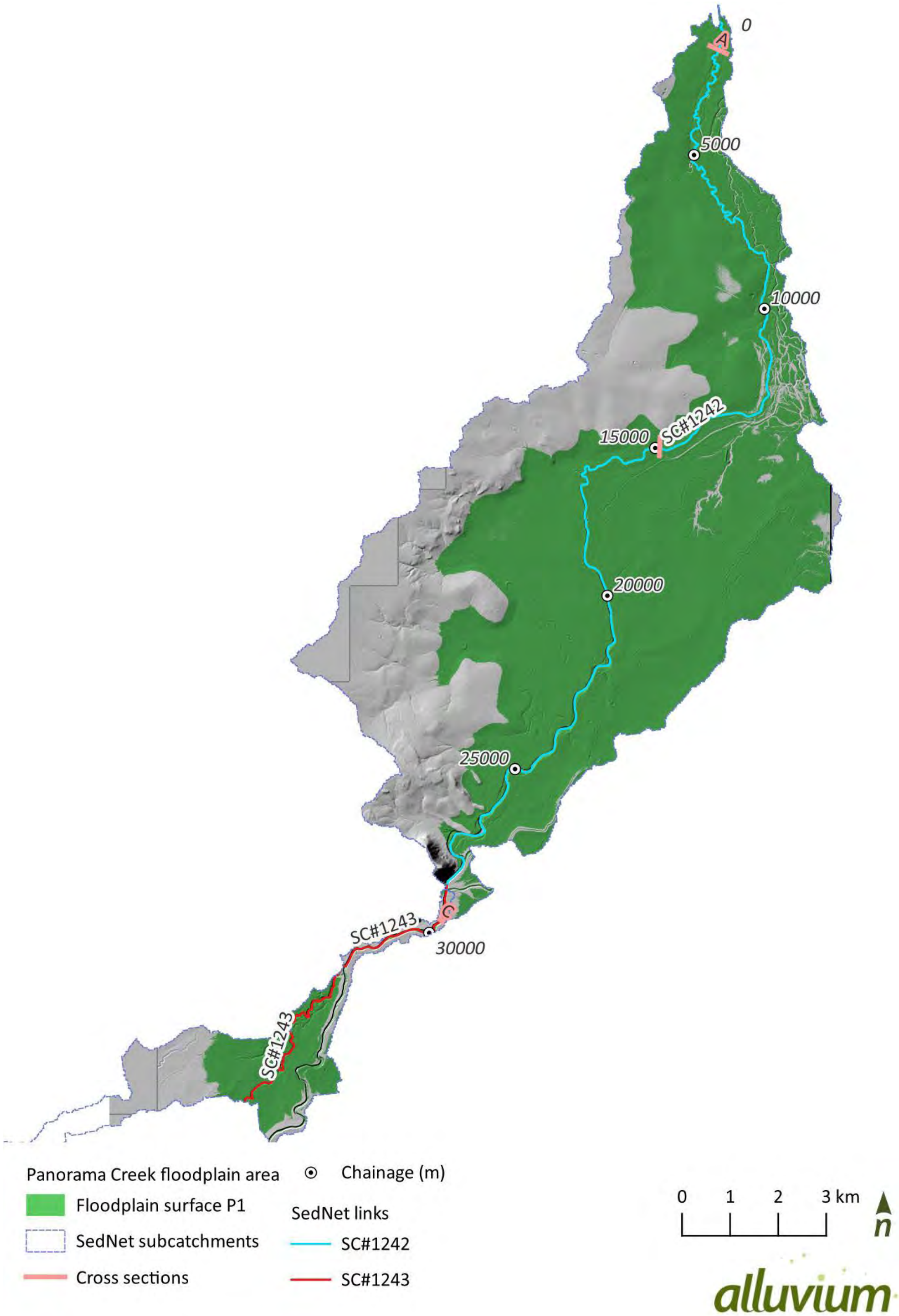


Figure 70. *The Panorama Creek case study area showing one major inundation surfaces; hydraulic floodplain. The representative cross section locations are also shown.*

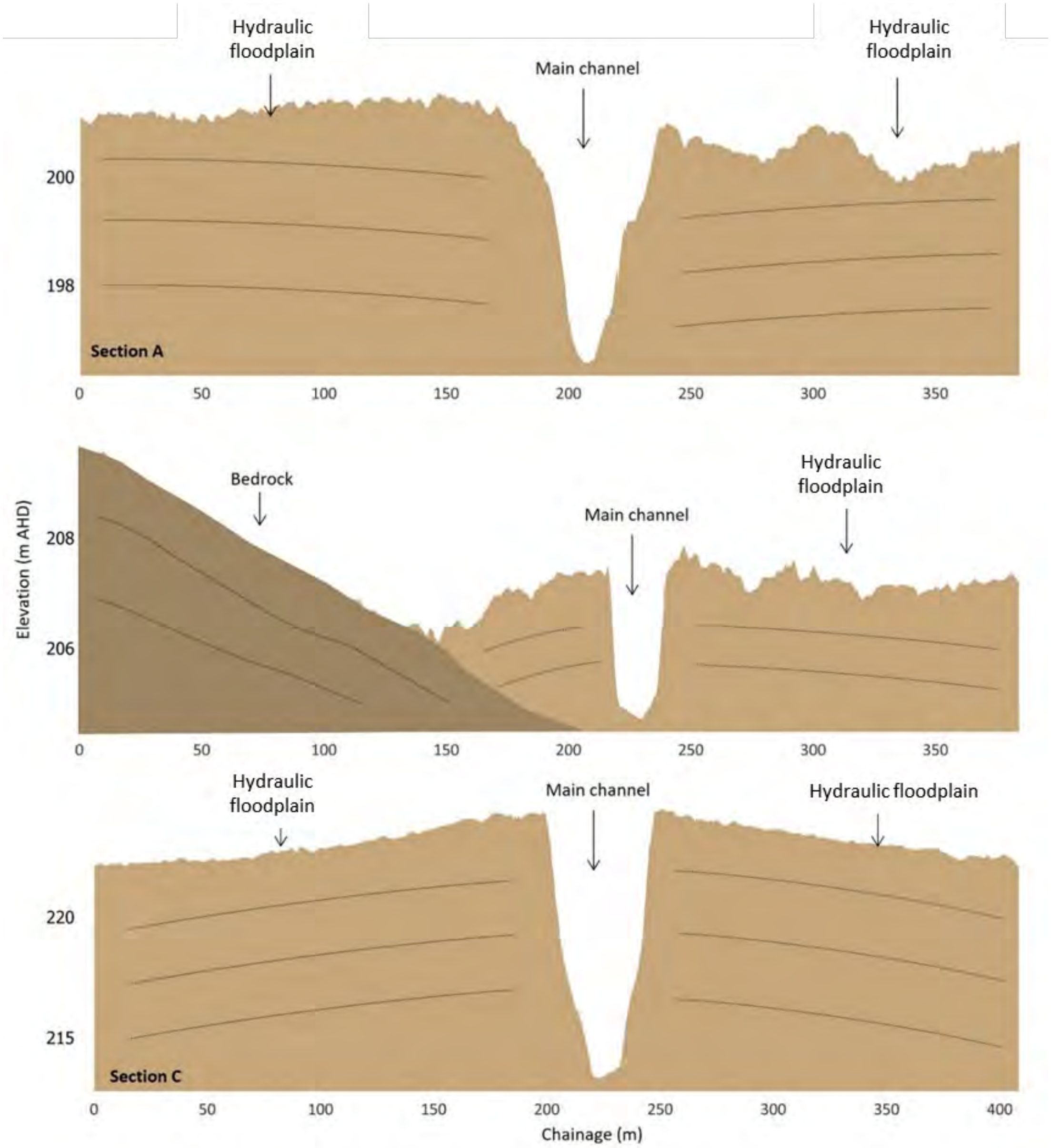


Figure 71. *The three typical sections in the Panorama Creek case study area (shown in Figure 70) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available.*

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Panorama Creek case study area are provided in Table 29. The SedNet floodplain area ranges from 10% to 32% of the LiDAR derived floodplain area. The input Dynamic SedNet floodplain areas are underpredicted in this case study area.

Table 29. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Panorama Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR Hydraulic floodplain (km²)	SedNet floodplain area as a % of LiDAR floodplain area
SC #1242	48.3	152.9	32%
SC #1243	13.3	129.4	10%

Bankfull flow discharge

Modelled floodplain deposition volumes are highly sensitive to bankflow flow. Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Panorama Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 51 years of data is present approximately 8 km downstream of the study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. Upstream of the Comet River confluence the return period has been estimated using the Regional Flood Frequency Estimation Model. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 50 m³/s, 500 m³/s and 800 m³/s are shown in Figure 72. Representative bankfull flows in three typical cross-section are shown in Figure 73. The channel capacity varies throughout the case study area. Through the upper reaches (upstream of Chainage 25,000 m) it is estimated at 800 m^3/s (approximately 20-50 year ARI), in the mid reaches (between chainage 15,000 – 25,000 m) it is estimated to be 500 m^3/s (approximately 10-20 year ARI), and in the lower reaches (downstream of chainage 15,000 m) it is estimated to be 50 m^3/s (approximately 1 year ARI).

Bankfull flow estimation is complicated by the flow interactions between the Comet River and Panorama Creek at their confluences. These processes have not been explored within this case study assessment.

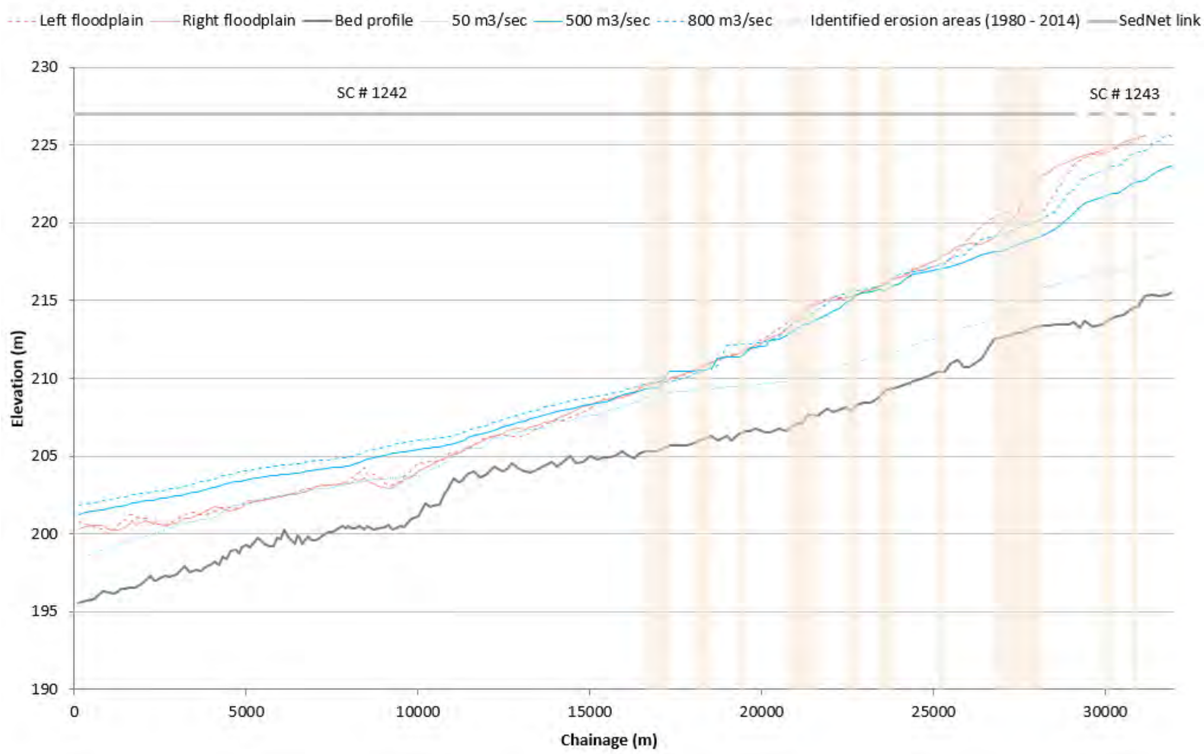


Figure 72. *The water surface elevation for a range of flow events near the bankfull elevation within the Panorama Creek area*

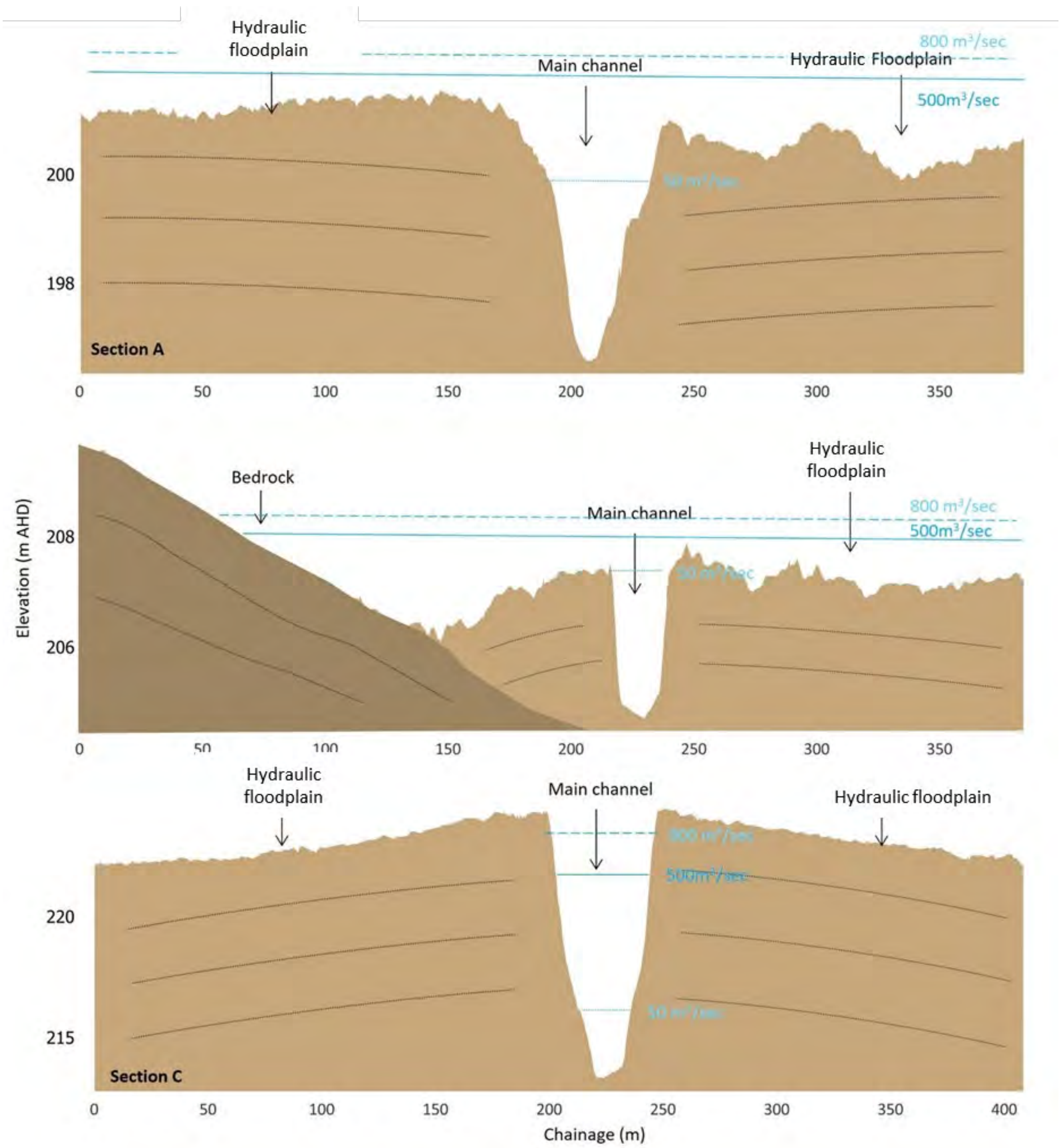


Figure 73. *The three typical sections in the Panorama Creek case study area (shown in Figure 70) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the case study area is 173 m^3/s in the downstream reach (SC # 1242), which has an estimated return period of between 1 – 2 years (Table 30) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is much more variable where below chainage 15,000 m its estimated at 50 m^3/s (1 yr ARI), and upstream of here it is between 500 – 800 m^3/s (5 – 10 yr ARI). The SedNet bankfull flows for the upstream reach (SC # 1243) is 146 m^3/s (≈1-2 yr ARI) which is significantly less than the HEC-RAS modelled estimate of 800 m^3/s (≈ 10 yr ARI) ().

The SedNet bankfull is 18% of the actual modelled bank full flow in the upper reach (SC#1243). The HEC-RAS modelled bankfull flows are more variable in the lower reach.

Bankfull flow was also estimated using Manning's equation (Table 30). In the upper reach this estimate is closer to the modelled bankfull flow (compared to the SedNet input bankfull flow).

Table 30. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Panorama Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #1242	173	50 - 800	399	22-346%
SC #1243	146	800	385	18%

4.15 Fitzroy - Dawson and Mackenzie Rivers

Overview

The case study area includes a 16 km reach of the Mackenzie River, and a 25 km reach of the Dawson River extending upstream from their confluence that forms the Fitzroy River near Duaringa (Figure 74). The floodplains along this reach are primarily used for a livestock grazing and dryland cropping.

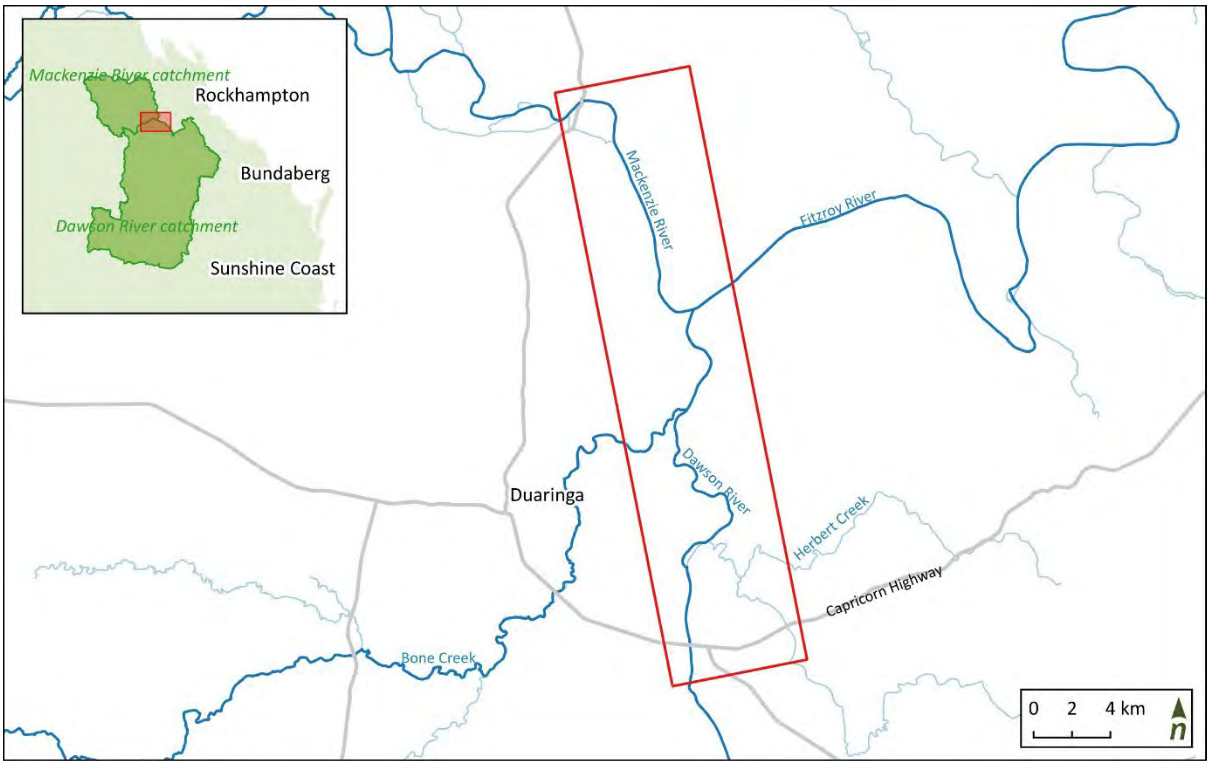


Figure 74. *The Dawson River and Mackenzie River case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Dawson River and Mackenzie River case study area (Figure 75), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Dawson River and Mackenzie Creek case study area.

The Mackenzie River through the study reach is a deeply entrenched channel with a low sinuosity planform, partially confined by the valley margins to the east, and has a broad floodplain up to 5 km wide to the west. The floodplain sits approximately 15 m above the channel bed.

Within the Dawson River reach in the study area the main channel is bound by inset floodplains (up to 700m in width) and the top of bank sits between 10 – 15 m above the channel. There is an upper floodplain/terrace throughout much of the reach which sits approximately 15-20m above the channel. The main channel intermittently abuts the terrace boundary.

The dominant inundation surfaces in the Dawson River and Mackenzie River case study area are hydraulic floodplains (Figure 75). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 76.

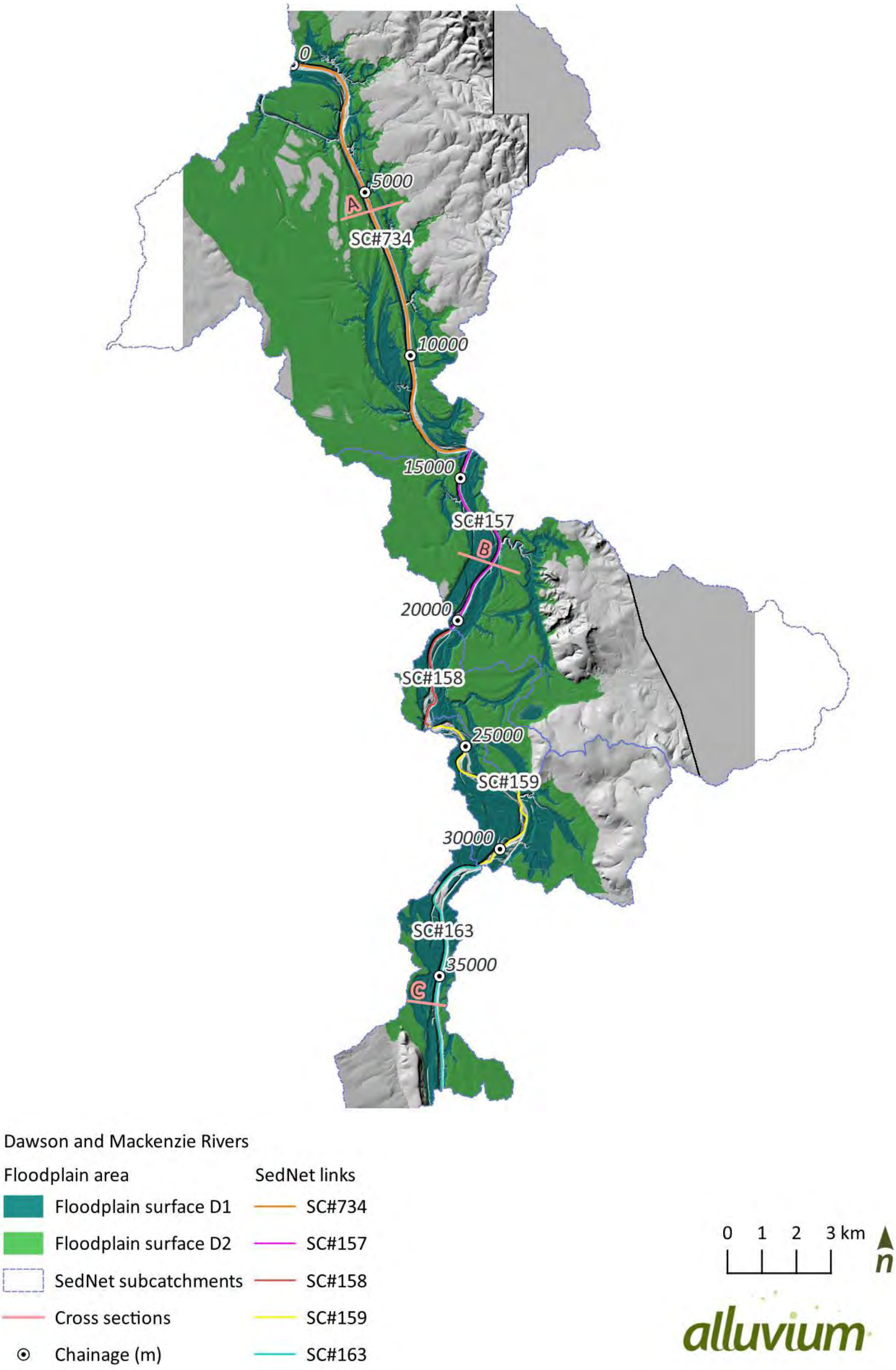


Figure 75. *The Dawson and Mackenzie River case study area showing two major inundation surfaces; genetic floodplain and terrace. The representative cross section locations are also shown.*

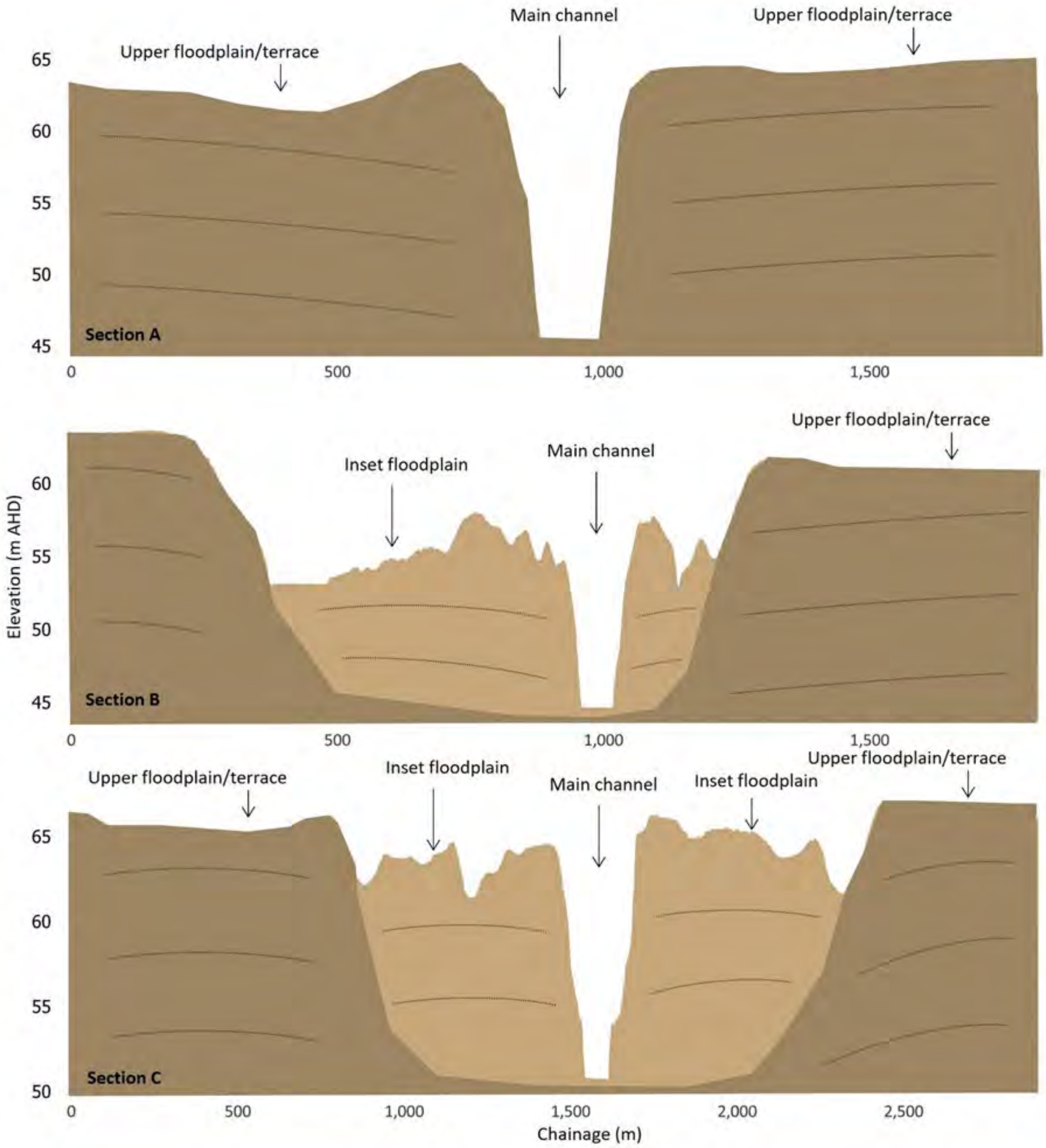


Figure 76. *The three typical sections in the Mackenzie River (Section A) and Dawson River (Section B and C) (shown in Figure 75) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Dawson and Mackenzie Rivers case study area are provided in Table 31. The SedNet floodplain area generally ranges from 16% to 46% of the LiDAR derived genetic floodplain area. There is one link in a lower reach (SC #734) where the SedNet floodplain area is 123% of the LiDAR derived genetic floodplain area. In general, the input Dynamic SedNet floodplain areas are underpredicted.

Table 31. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Dawson and Mackenzie Rivers case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km²)	Terrace (km²)	
SC #734	58.0	47.0	130.7	123%
SC #157	25.9	56.7	124.8	46%
SC #158	8.9	56.6	122.3	16%
SC #159	12.0	56.9	35.7	21%
SC #163	10.2	56.6	117.4	18%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Dawson and Mackenzie Rivers case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 67 years of data is present within the Dawson River study area. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for two flow events across the Mackenzie River reach, 1500 m^3/s and 5000 m^3/s are shown in Figure 77. The water surface for three flow events across the Dawson River reach, 1500 m^3/s, 1,850 m^3/s and 2,250 m^3/s are shown in Figure 78. Representative bankfull flows in three typical cross-section are shown in Figure 79. The channel capacity varies throughout the case study area. Through the upper reaches of the Mackenzie River (upstream of Chainage 10,000 m) it is estimated at 1,800 m^3/s (approximately 3 year ARI), in the mid to lower reaches (between chainage 0 – 10,000 m) it is estimated to be 5,000 m^3/s (approximately 7 year ARI). Through the upper reaches of the Dawson River (upstream of Chainage 13,000 m) bankfull flow is estimated at 2,250 m^3/s (approximately 30 year ARI), in the mid to lower reaches (downstream of chainage 13,000 m) it is estimated to be between 1,500 m^3/s and 1,850 m^3/s (approximately 10 year ARI).

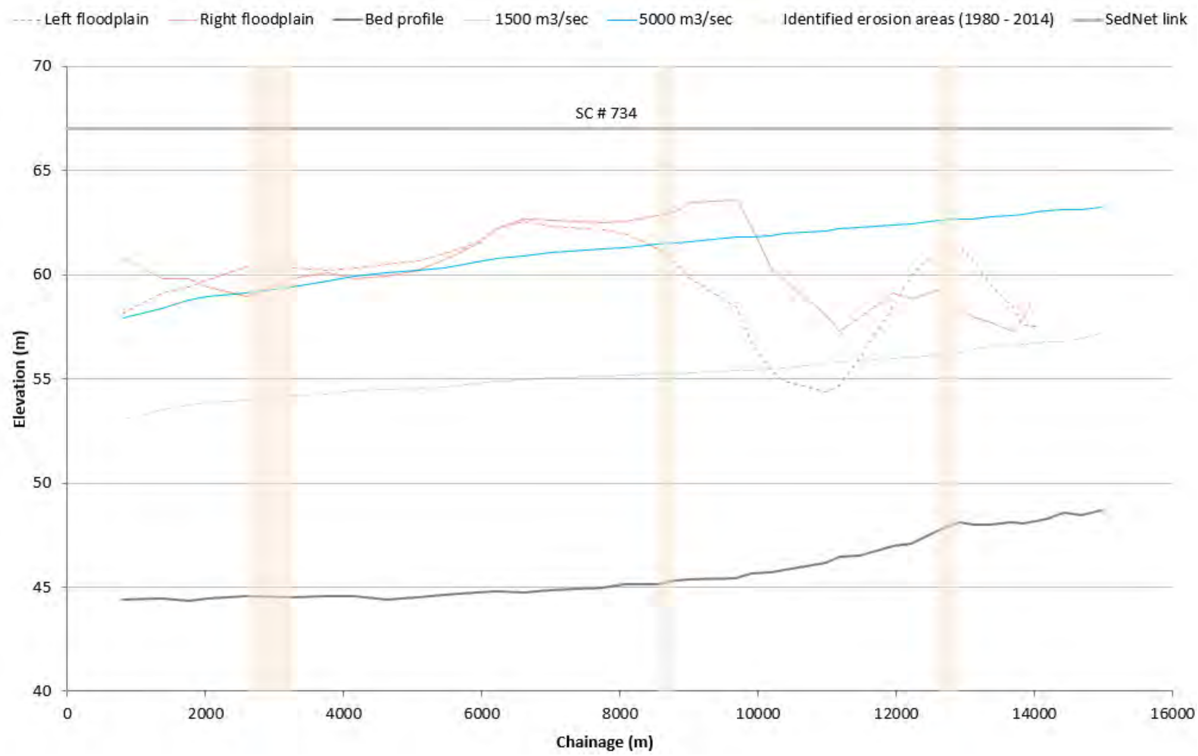


Figure 77. *The water surface elevation for a range of flow events near the bankfull elevation within the Mackenzie River case study area*

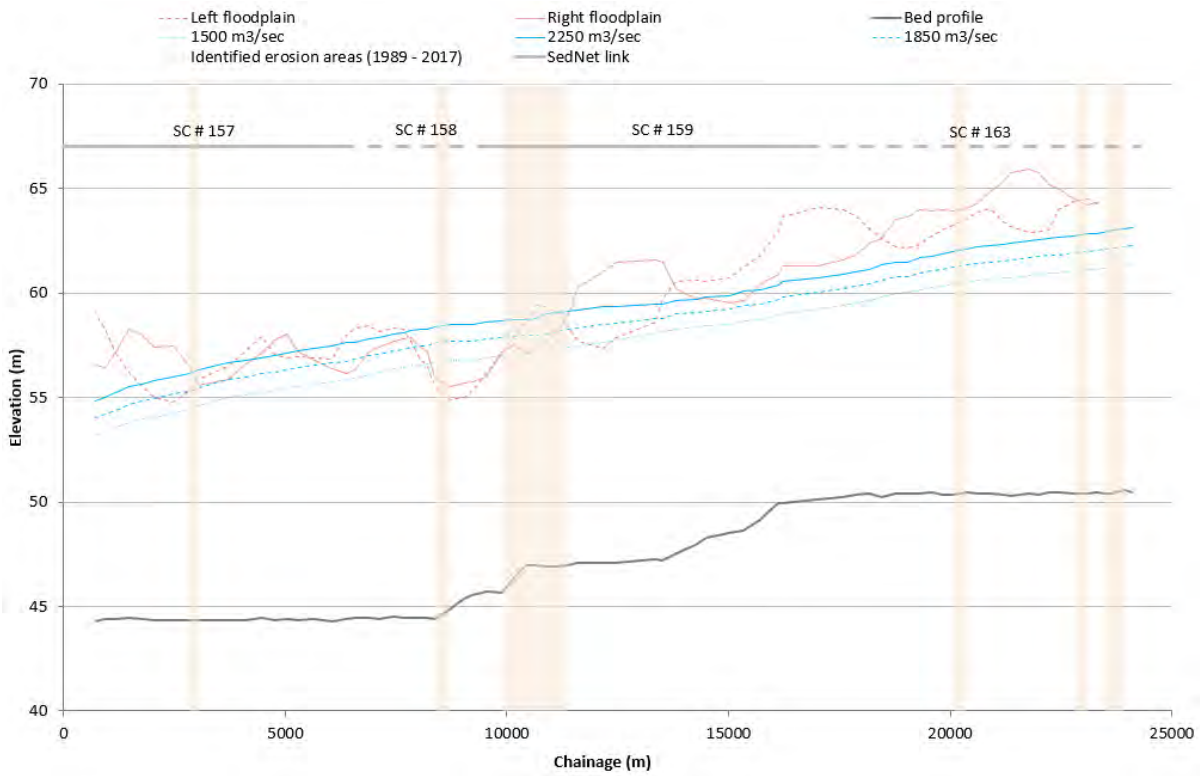


Figure 78. *The water surface elevation for a range of flow events near the bankfull elevation within the Dawson River case study area*

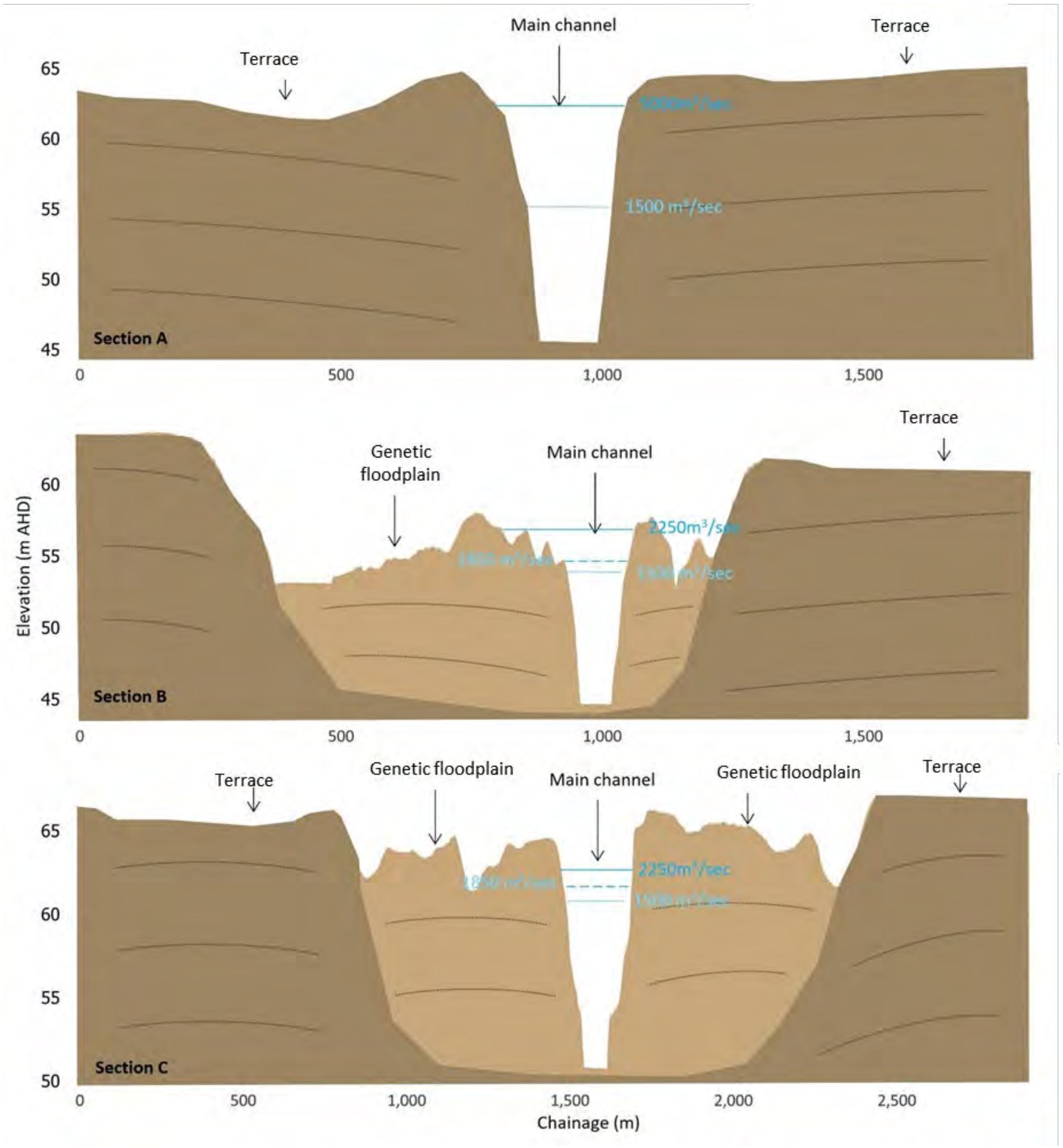


Figure 79. *The three typical sections in the Mackenzie River (Section A) and Dawson River (Section B and C) case study area (shown in Figure 75) showing the key geomorphic units and representative bankfull flows*

Bankfull flow used in the Dynamic SedNet modelled link in the Mackenzie River case study area is 5,537 m^3/s , which has an estimated return period of 7 years (Table 32) (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is lower through the upper reach (upstream of chainage 10,000) at approximately 1,500 m^3/s (1-2 yr ARI) and similar through the rest of the reach (Table 32). The bankfull flow used in the Dynamic SedNet modelled link in the Dawson River case study area is approximately 2,000 m^3/s, which has an estimated return period of approximately 12 years, this aligns reasonably well with the HEC-RAS modelled estimates (Table 32).

The SedNet bankfull is 98% to 111% of the actual modelled bank full flow in all Dawon River reaches. The bankfull flows applied in the Dynamic SedNet model for the case study area align well with the modelled bankfull flow estimates in the Dawon River. The modelled bankfull flow estimates are more variable in the Mackenzie River.

Bankfull flow was also estimated using Manning's equation (Table 32). This estimate aligns well with both the modelled bank full flow and the SedNet input bankfull flow in the Dawon River reaches.

Table 32. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Dawson and Mackenzie Rivers case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #734	5537	1500 - 5000	4,369	111% - 369%
SC #157	2102	2,000	2,851	105%
SC #158	2099	2,000	1,476	105%
SC #159	2124	2,000	692	106%
SC #163	1956	2,000	1,033	98%

4.16 Burnett Mary - 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 80). 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 80.

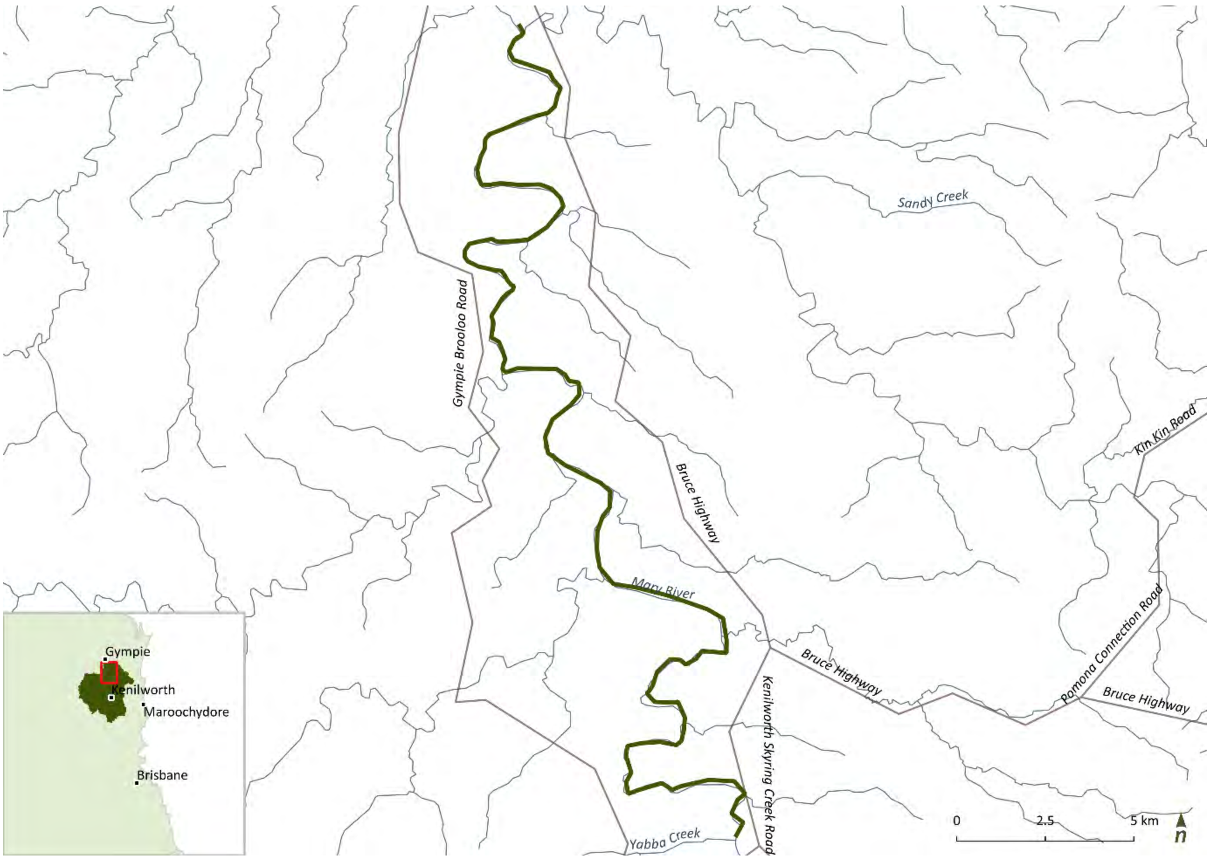


Figure 80. *The Mary River case study area.*

Floodplain classification

Modelled floodplain deposition volumes are highly sensitive to floodplain area. High resolution LiDAR data was used to assess the floodplain area in the Mary River study area (Figure 81), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Mary River case study area.

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, and inset floodplain and bench units which sit 10-12 m above the channel bed

The dominant inundation surfaces in the Mary River case study area are hydraulic floodplains (Figure 81). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 82.

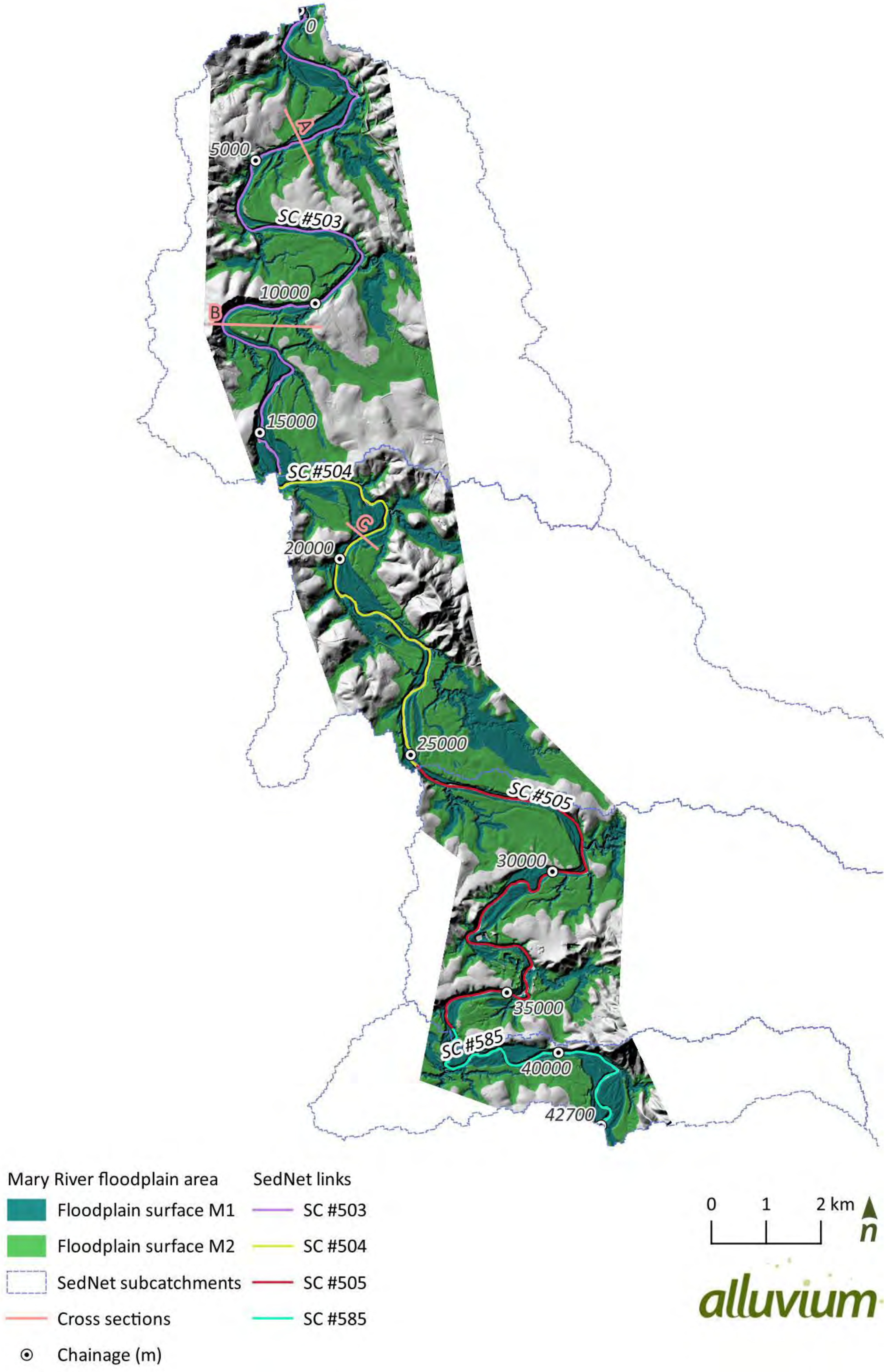


Figure 81. *The Mary River case study area showing two major inundation surfaces; genetic floodplain and terrace. The representative cross section locations are also shown.*

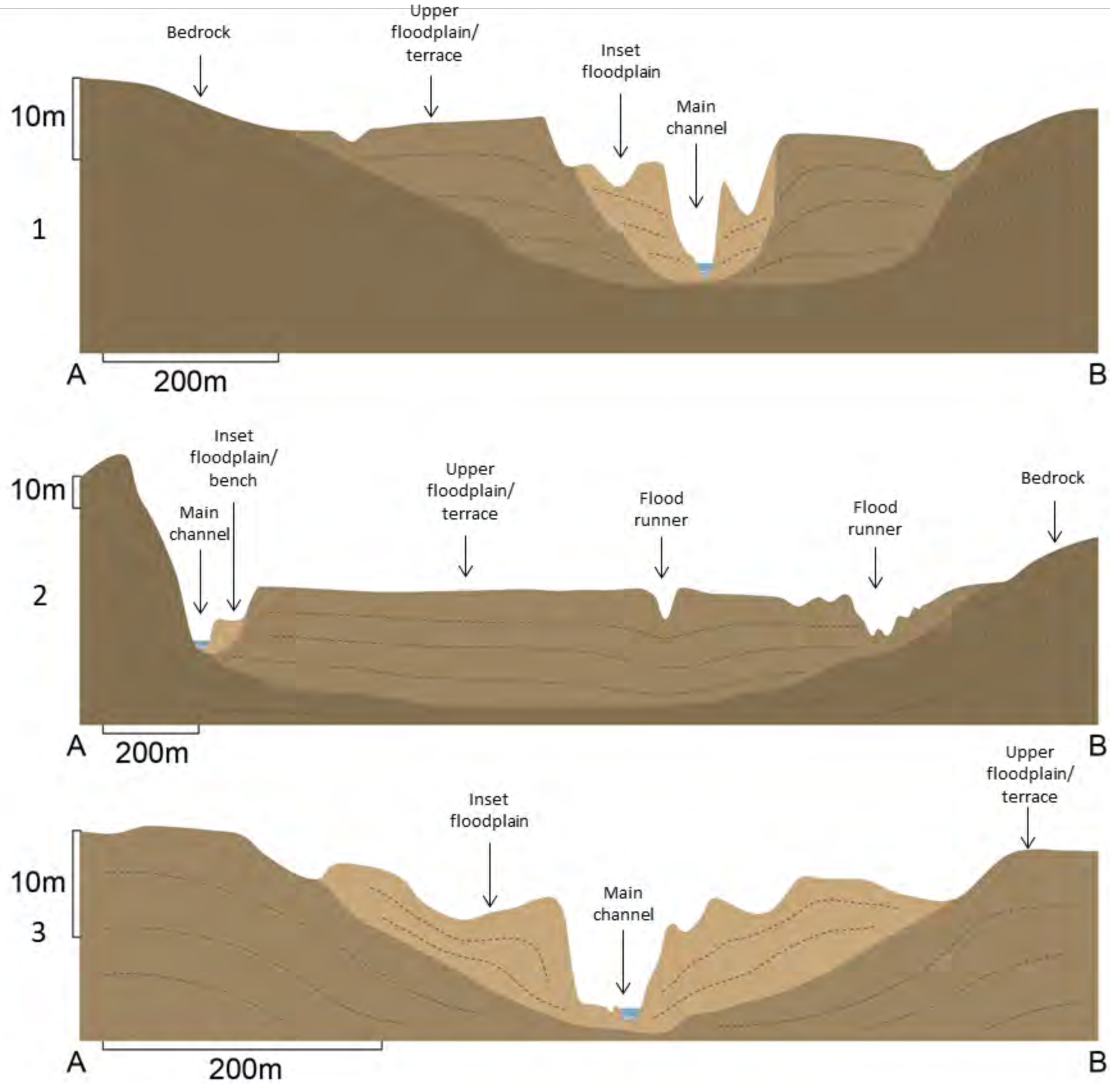


Figure 82. *The three typical sections in the Mary River case study area (shown in Figure 81) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Mary River case study area are provided in Table 33.

The SedNet floodplain area generally ranges from 81% to 105% of the LiDAR derived genetic floodplain area. There is one link in an upper reach (SC #585) where the SedNet floodplain area is 26% of the LiDAR derived genetic floodplain area. In general, the input Dynamic SedNet floodplain areas align well with the LiDAR derived floodplain areas in the lower three reaches.

Table 33. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Mary River case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet floodplain area as a % of LiDAR area
		Genetic floodplain (km²)	Terrace (km²)	
SC #503	18.9	18.0	11.5	105%
SC #504	14.6	18.1	12.3	81%

SC #505	18.5	18.0	8.8	103%
SC #585	4.7	18.0	5.1	26%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Mary River case study area.

A one-dimensional HEC-RAS model was developed for the study area. The model is uncalibrated; however the hydraulic roughness has been adjusted based on the channel characteristics and sinuosity. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events ranging from 550 m^3/s to 1,000 m^3/s are shown in Figure 83. Representative bankfull flows in three typical cross-section are shown in Figure 84. The channel capacity varies throughout the case study area, however is typically within the 550 m^3/s to 1,000 m^3/s. The return period for these events is between 2 and 3 years (BOM, 2020).

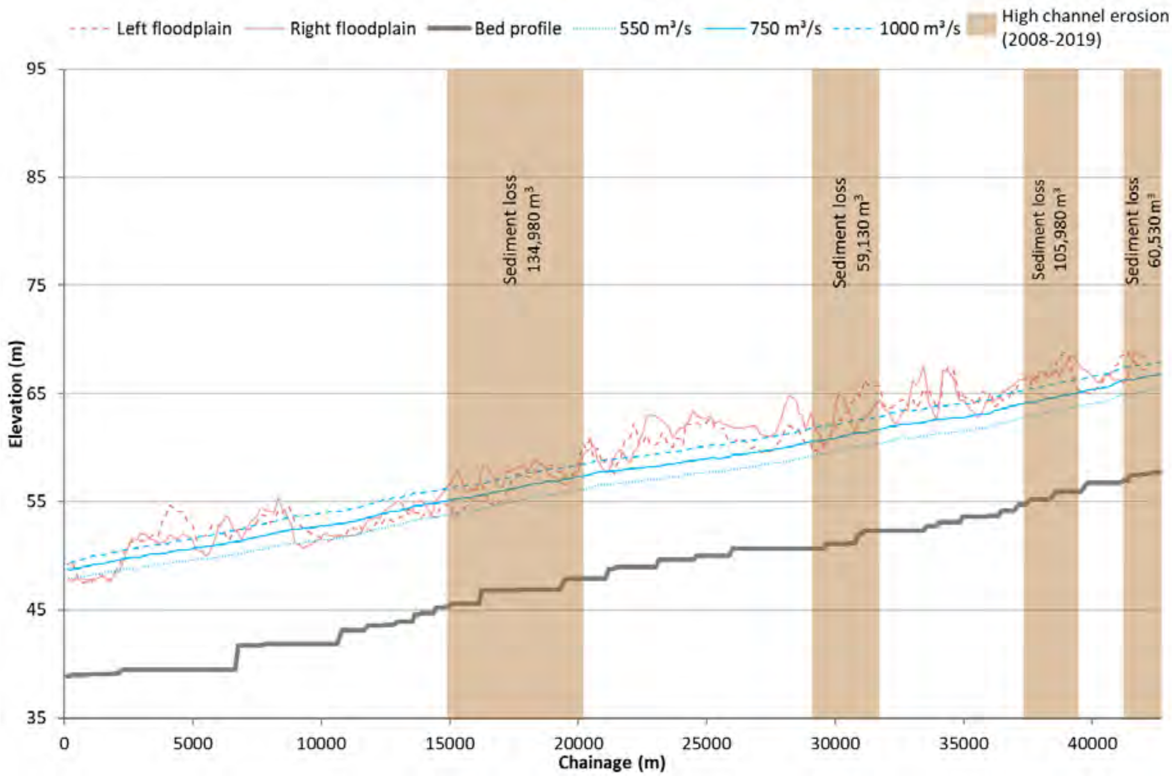


Figure 83. *The water surface elevation for a range of flow events near the bankfull elevation within the Mary River case study area*

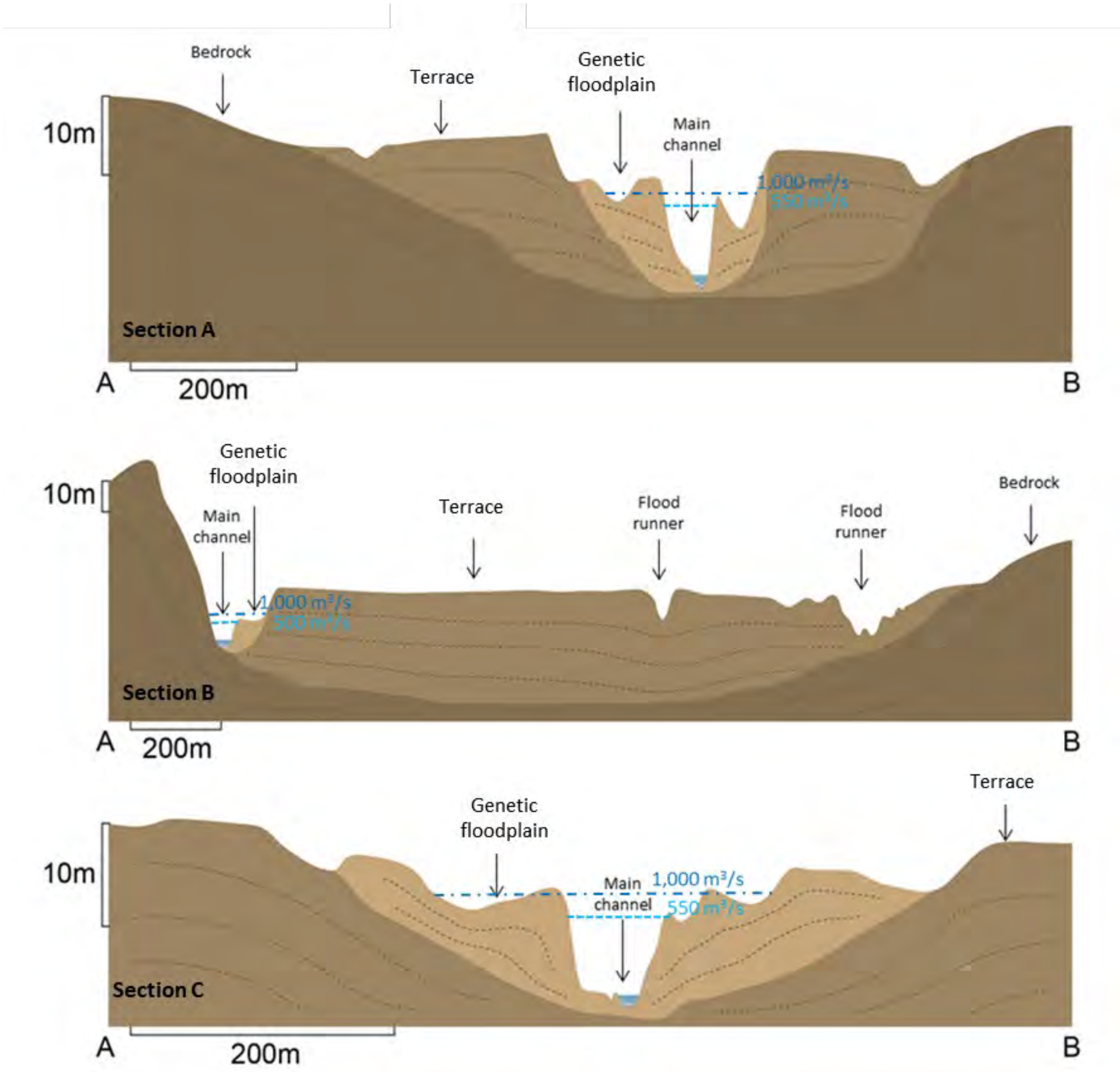


Figure 84. *The three typical sections in the Mary River case study area (shown in Figure 82) showing the key geomorphic units and representative bankfull flows.*

The HEC-RAS modelling undertaken assessed the inset channel capacity as all the recent observed erosion is occurring within the inset units which bound this channel. The inset channel capacity varies throughout the case study area however is typically between 750 m^3/s to 1,000 m^3/s (Table 34). The return period for these events is between 2 and 3 years (BOM, 2020). The macrochannel capacity was not modelled as part of this assessment due to difficulties with accurately modelling the floodplain flow in a one-dimensional model.

The SedNet bankfull flow is 321% to 499% of the actual modelled bank full flow in all reaches. The bankfull flows applied in the Dynamic SedNet model for the case study area are approximately three times higher than the modelled bankfull flow estimates.

Bankfull flow was also estimated using Manning's equation (Table 34). This estimate is significantly higher than both the modelled bank full flow and the SedNet input bankfull flow.

Table 34. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Mary River case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m³/s)	Modelled Bank Full Flow (m³/s)	Manning's calculation estimated Bank Full Flow (m³/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #503	3744	750	6,959	499%
SC #504	3543	1000	8,834	354%
SC #505	3209	1000	4,629	321%
SC #585	3232	1000	8,702	323%

4.17 Burnett Mary - Three Moon Creek

Overview

The Three Moon Creek case study extends for approximately 48 kilometres, from the Spring Creek confluence, upstream of Moonford, to Mulgildie (Figure 85). The floodplains along this reach are largely used for irrigated cropping as well as grazing with the lower hillslopes typically supporting grazing activities. The reach is downstream of Cania Dam and contains three weirs which form the Three Moon Creek water supply scheme. The water is used primarily for irrigation water for agriculture and urban water supply for the rural townships of Monto and Mulgildie.

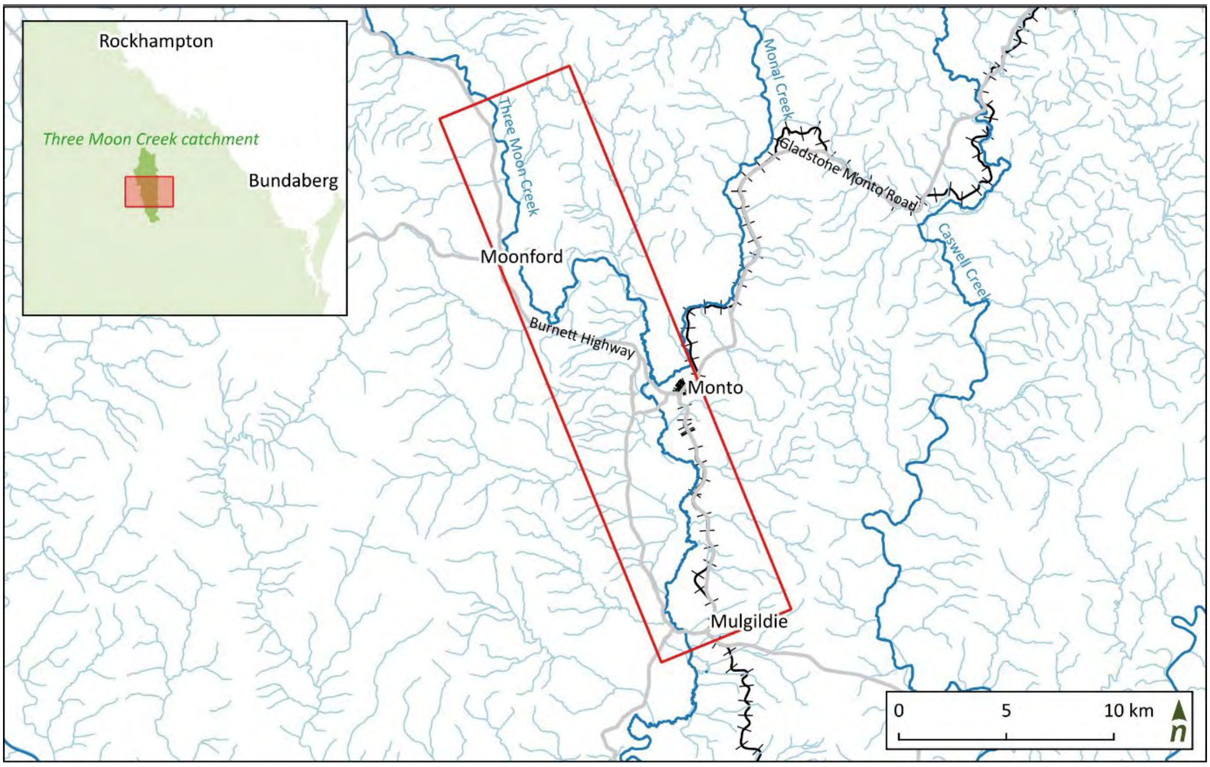


Figure 85. *The Three Moon Creek case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Three Moon Creek study area (Figure 91), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Three Moon Creek case study area.

In this area Three Moon Creek 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. In the upper reaches, the channel intermittently abuts the valley margins and floodplain widths are typically between 100m – 500m. The mid to lower reaches are slightly confined with discontinuous sections of channel abutting the valley margins and sections with broad floodplains up to 3 km in width.

The channel throughout the study reach is deeply entrenched within the alluvial floodplain/terrace material. The floodplains through the upper reaches are typically 10 – 15 m above the channel bed. Within the macrochannel area there are isolated inset units, typically benches, that sit 3 – 5 m above the bed. In the mid to lower reaches, downstream of Youlambie Weir, the bank heights reduce to between 5 – 7 m and there are limited observable inset features.

The dominant inundation surfaces in the Three Moon Creek case study area are hydraulic floodplains (Figure 86). Variations in the degree of channel entrenchment and geomorphic units can be seen in the three typical sections shown in Figure 87.

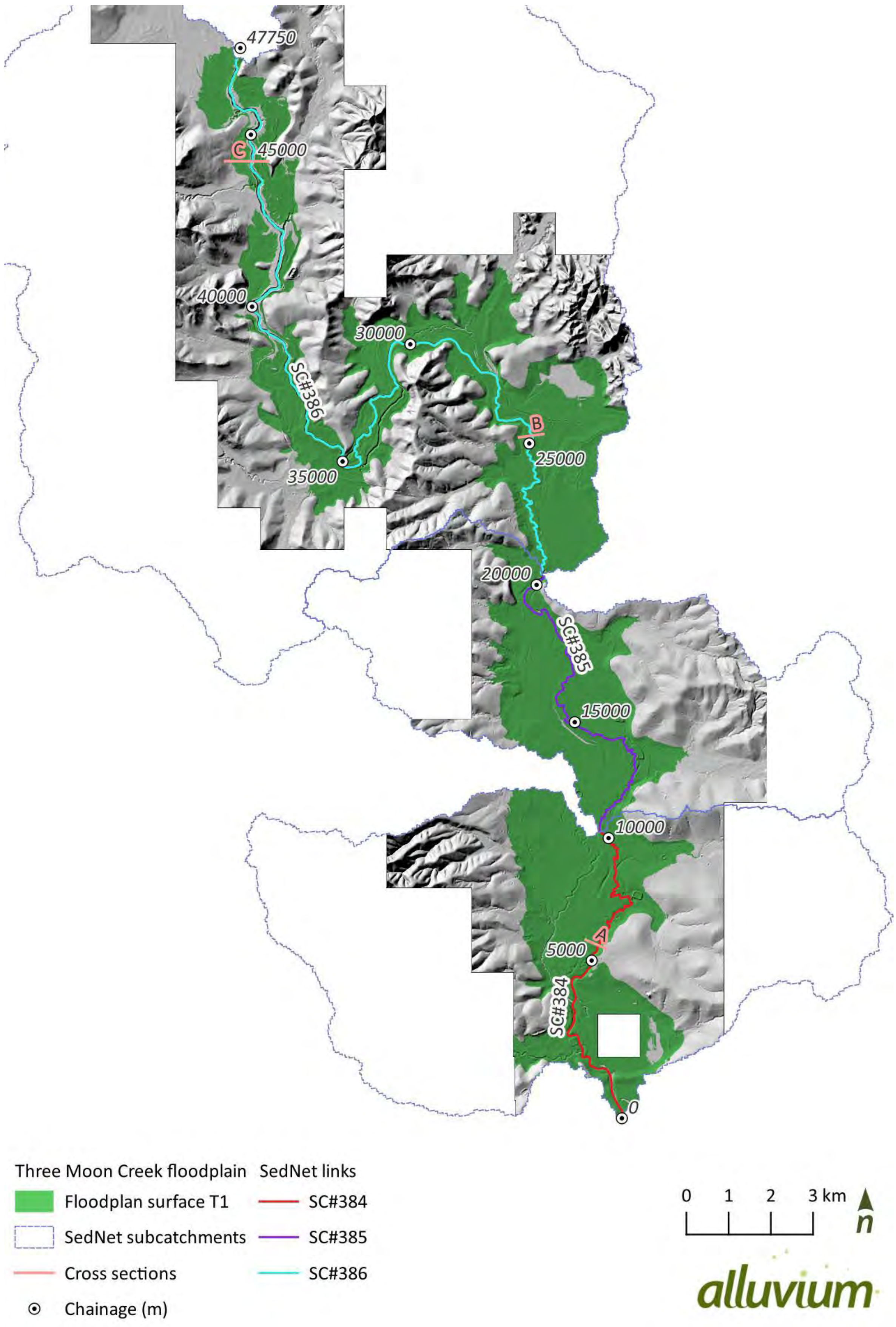


Figure 86. *Three Moon Creek case study area showing one major inundation surface; hydraulic floodplain. The representative cross section locations are also shown.*

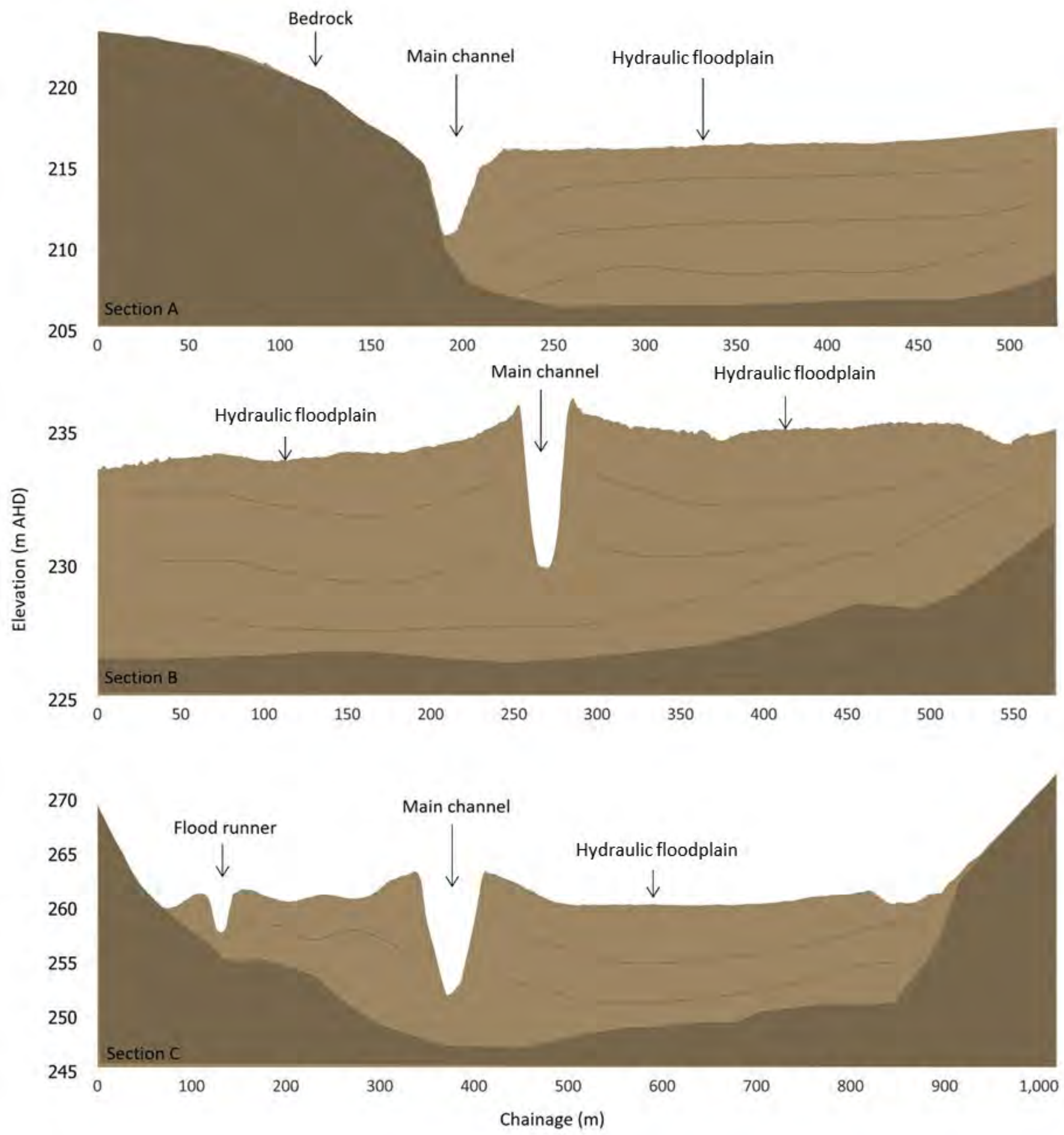


Figure 87. *The three typical sections in the Three Moon Creek case study area (shown in* Figure 86*) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Three Moon Creek case study area are provided in Table 35. The SedNet floodplain area generally ranges from 35% to 90% of the LiDAR derived floodplain area. In general, the input Dynamic SedNet floodplain areas are underpredicted in this case study area.

Table 35. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Three Moon Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	Hydraulic floodplain (km²)	SedNet floodplain area as a % of LiDAR area
SC #384	29.6	69.9	42%
SC #385	24.3	69.8	35%
SC #386	63.1	69.9	90%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Three Moon Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 13 years of data is present within the Three Moon Creek study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events ranging from 250 m³/s to 1,200 m³/s are shown in Figure 88. Representative bankfull flows in three typical cross-section are shown in Figure 89. The channel capacity varies throughout the case study area, however is typically 250 m³/s in the lower reaches to 1200 m³/s in the upper reaches. The return period for these events is between 4 and 30 years (BOM, 2020).

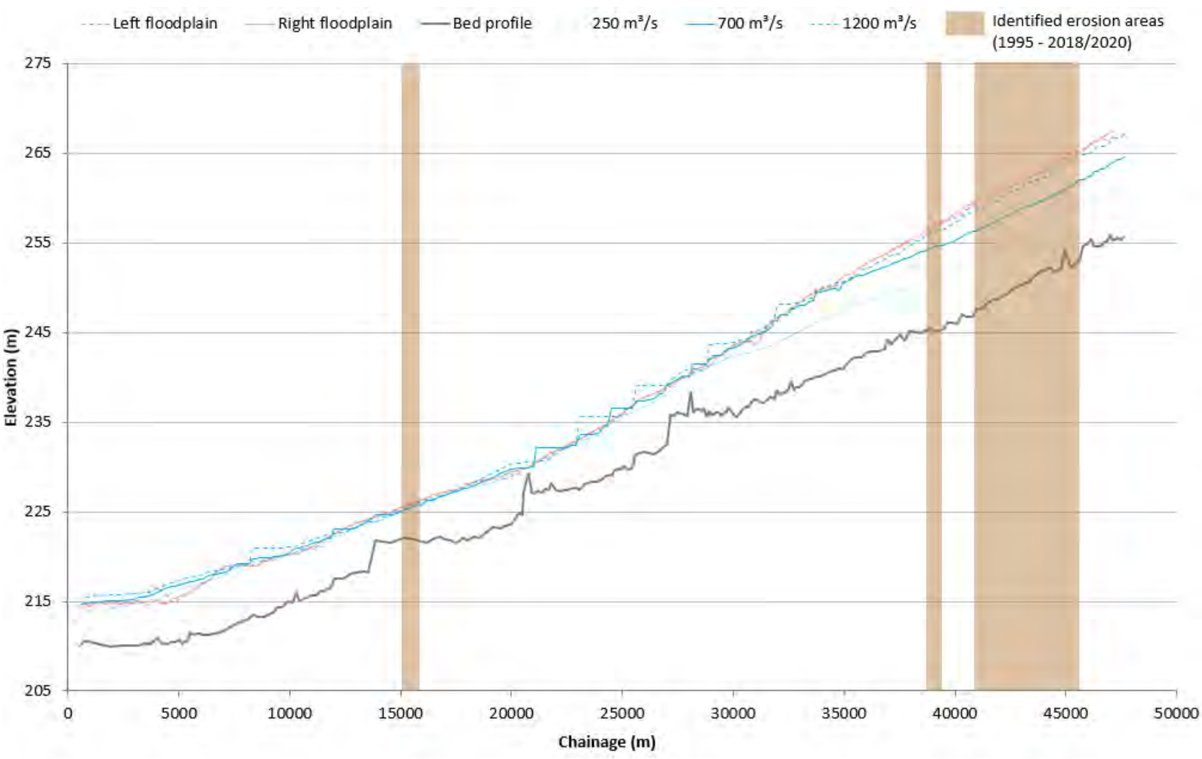


Figure 88. *The water surface elevation for a range of flow events near the bankfull elevation within the Three Moon Creek case study area*

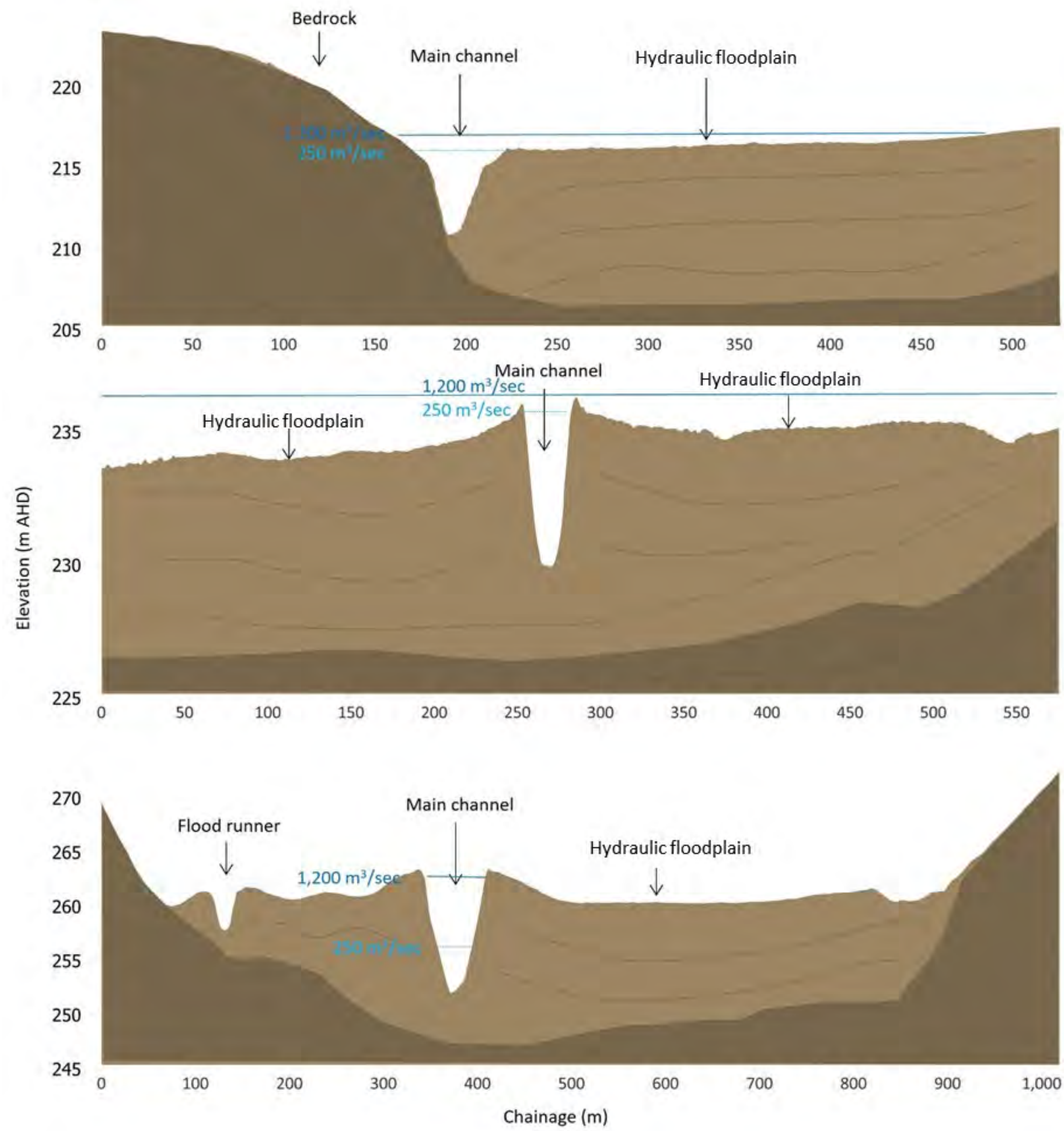


Figure 89. *The three typical sections in the Three Moon Creek case study area (shown in* Figure 86*) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the Three Moon Creek case study area range between 34 and 219 m^3/s, which have return periods of 2 and 4 years respectively (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is approximately 1,200 m^3/s in upper reaches (SC#386) and approximately 250 m^3/s in downstream reaches, which have return periods of 30 years and 4 years respectively (SC#384, SC#385) (Table 36).

The SedNet bankfull flow is 3% to 88% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 36). This estimate is significantly higher than both the modelled bank full flow and the SedNet input bankfull flow.

Table 36. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Three Moon Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #384	219	250	5,502	88%
SC #385	206	250	5,563	82%
SC #386	34	1,200	4,275	3%

4.18 Burnett Mary - Barambah Creek

Overview

The Barambah Creek case study extends for approximately 55 kilometres, from the Barker Creek confluence immediately downstream of Lake Barambah, to the Sunday Creek confluence, southwest of Mondure (Figure 90). The floodplains along this reach are used for a diverse range of agricultural enterprises including livestock grazing, pig production, and a range of irrigated crops including peanuts, lucerene and cotton. There are two weirs within the study reach – Silverleaf weir and Murgon weir, that supply water for industrial and agricultural use and supplement water supply to the townships of Murgon, Wondai, Byee and Cherburg.

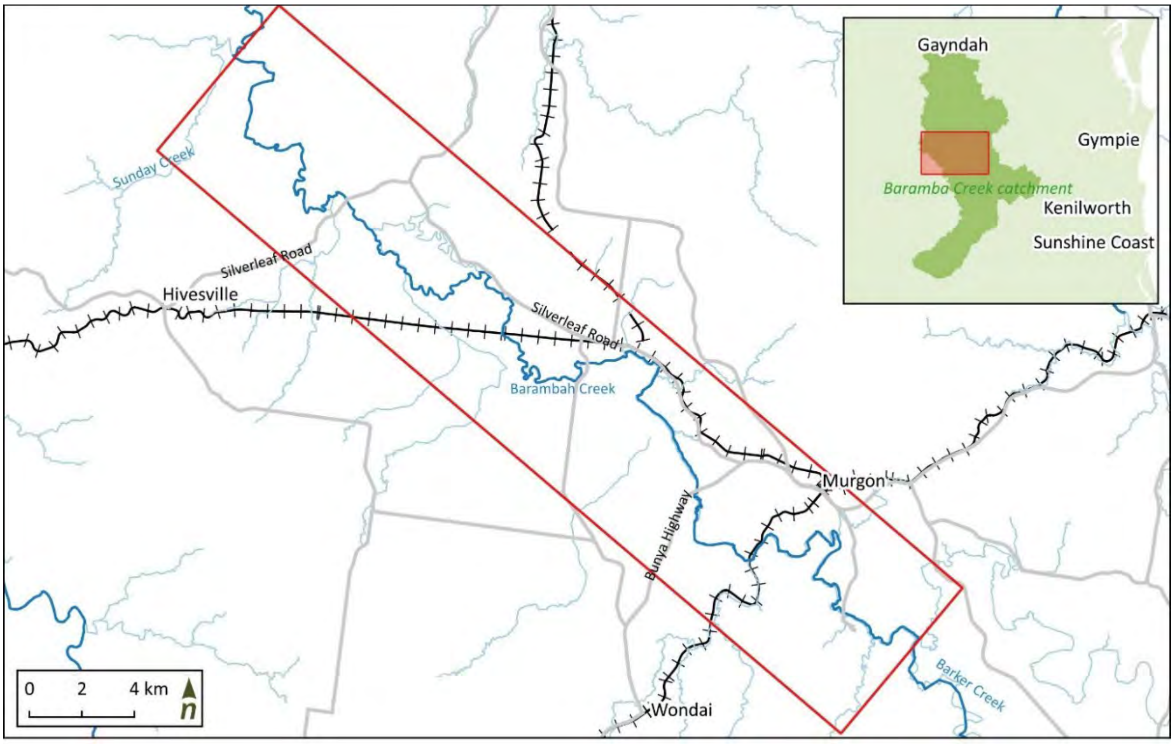


Figure 90. *The Barambah Creek case study area*

Floodplain classification

High resolution LiDAR data was used to assess the floodplain area in the Barambah Creek study area (Figure 91), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Barambah Creek case study area.

Through the mid to upper reaches the channel is significantly confined by bedrock. There are discontinuous floodplains up to 300 m wide through the upper reaches that sit approximately 5 – 8 m above the channel bed. Through the lower-mid reaches the channel emerges onto a broad unconfined valley setting with floodplains several kilometres in width. The channel has a sinuous planform and is entrenched to a depth of between 6 - 8 m.

The dominant inundation surfaces in the Barambah Creek case study area are hydraulic floodplains (Figure 91). Variations in the degree of channel entrenchment and geomorphic units across the study reach can be seen in the three typical sections shown in Figure 92.

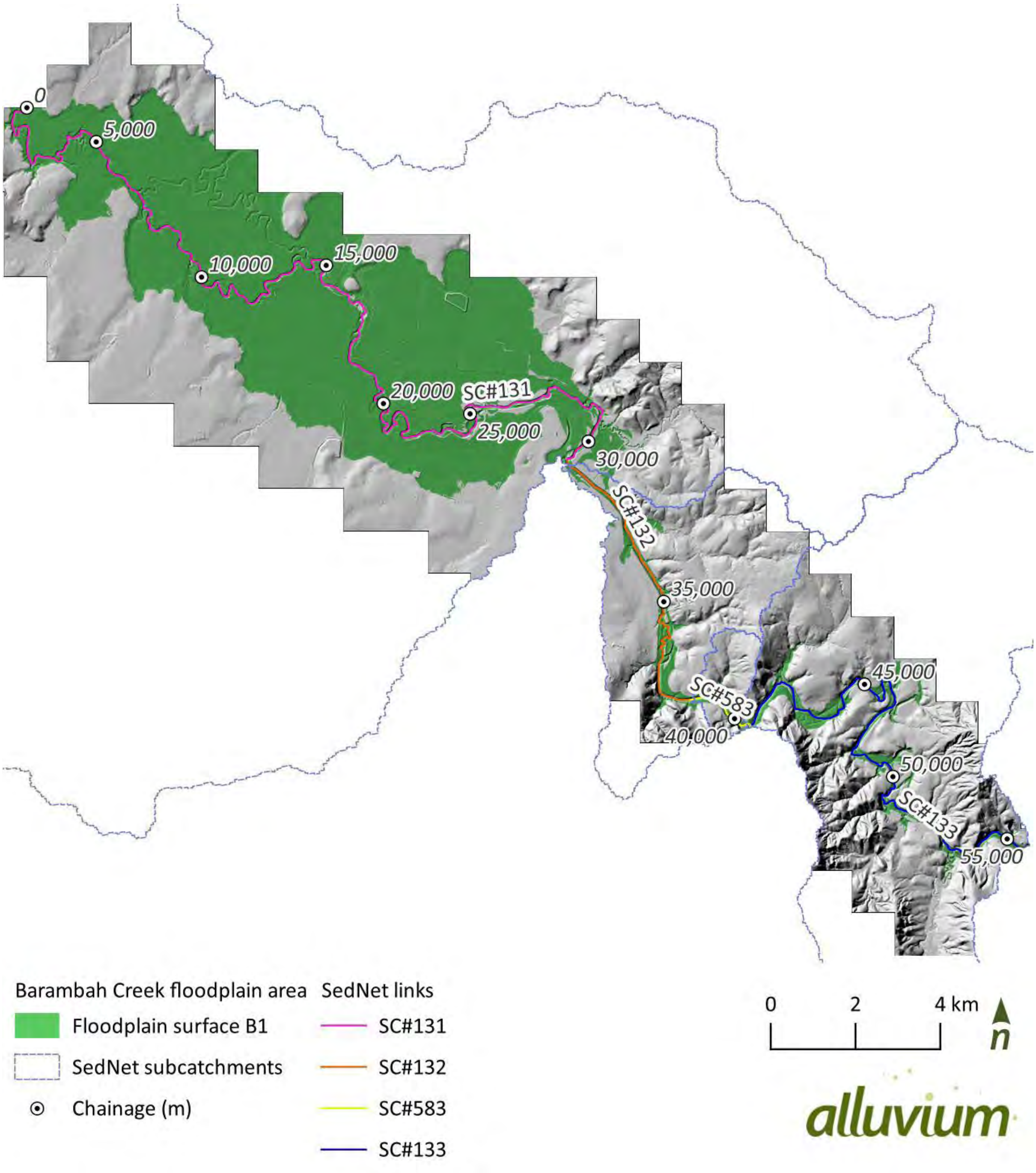


Figure 91. *The Barambah Creek case study area showing one major inundation surface; hydraulic floodplain. The representative cross section locations are also shown.*

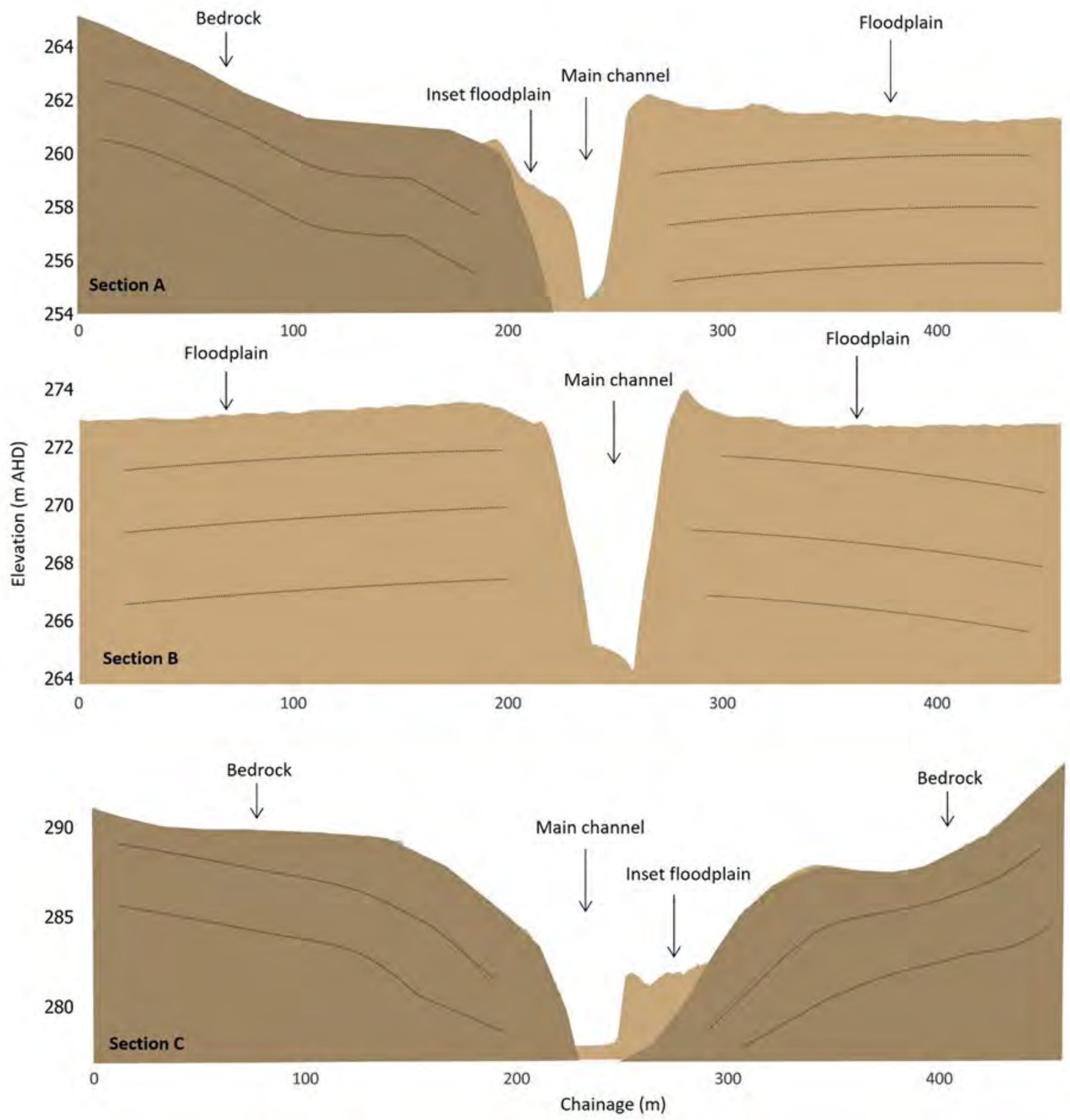


Figure 92. *The three typical sections in the Barambah Creek case study area (shown in Figure 91) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Barambah Creek case study area are provided in Table 37. The SedNet floodplain area generally ranges from 4% to 16% of the LiDAR derived floodplain area in the lower three reaches. There is one link in a lower reach (SC #131) where the SedNet floodplain area is 216% of the LiDAR derived genetic floodplain area. The input Dynamic SedNet floodplain areas are both underpredicted and overpredicted in this case study area.

Table 37. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Barambah Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR Hydraulic floodplain (km²)	SedNet floodplain area as a % of LiDAR area
SC #131	125	57.6	216%
SC #132	4	57.3	8%
SC #583	2	56.4	4%

SC #133	6	34.6	16%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Barambah Creek case study area.

A one-dimensional HEC-RAS model was developed for the study area (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 7 years of data is present within the Barambah Creek study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events, 250 m³/s, and 450 m³/s are shown in Figure 93. Representative bankfull flows in three typical cross-section are shown in Figure 94. The channel capacity varies throughout the case study area, however is higher in the lower reaches, downstream of Murgon weir. Upstream of Murgon weir the estimated bankfull flow is 250 m^3/s (approximately 4-5 year ARI). Downstream of the weir the representative bankfull flow is 450 m^3/s (7-8 yr ARI).

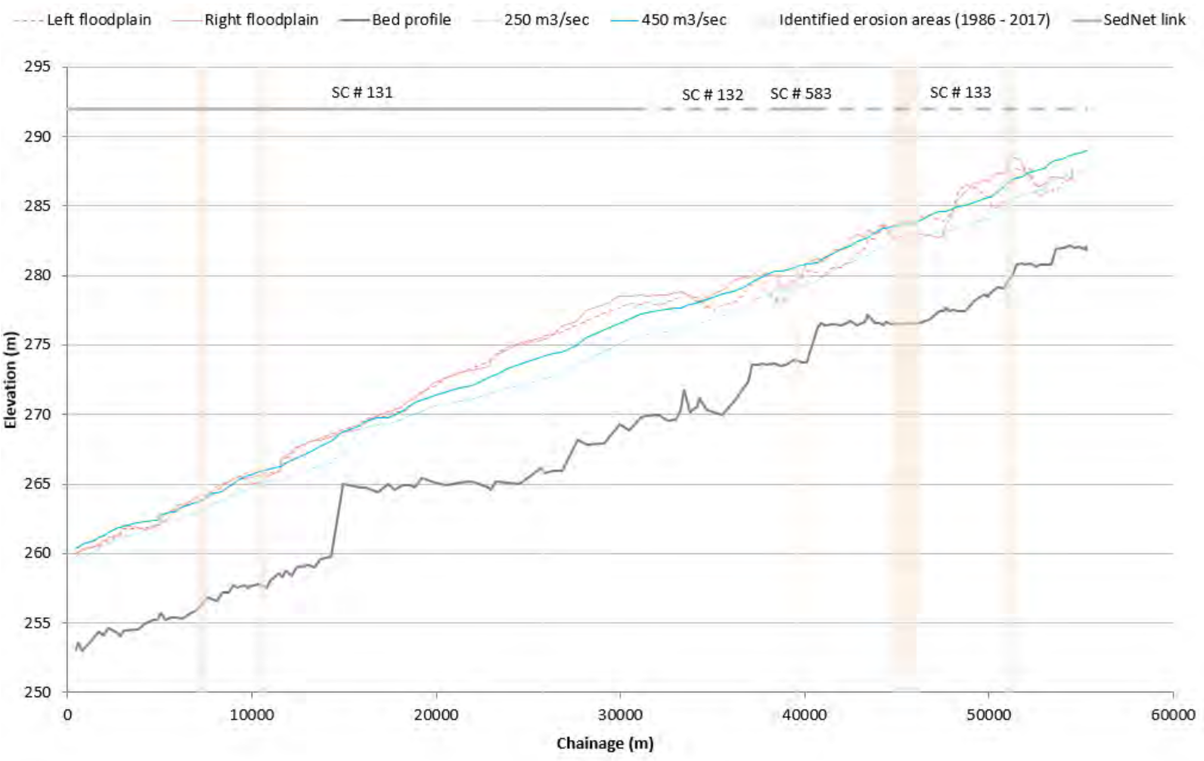


Figure 93. *The water surface elevation for a range of flow events near the bankfull elevation within the Barambah Creek area*

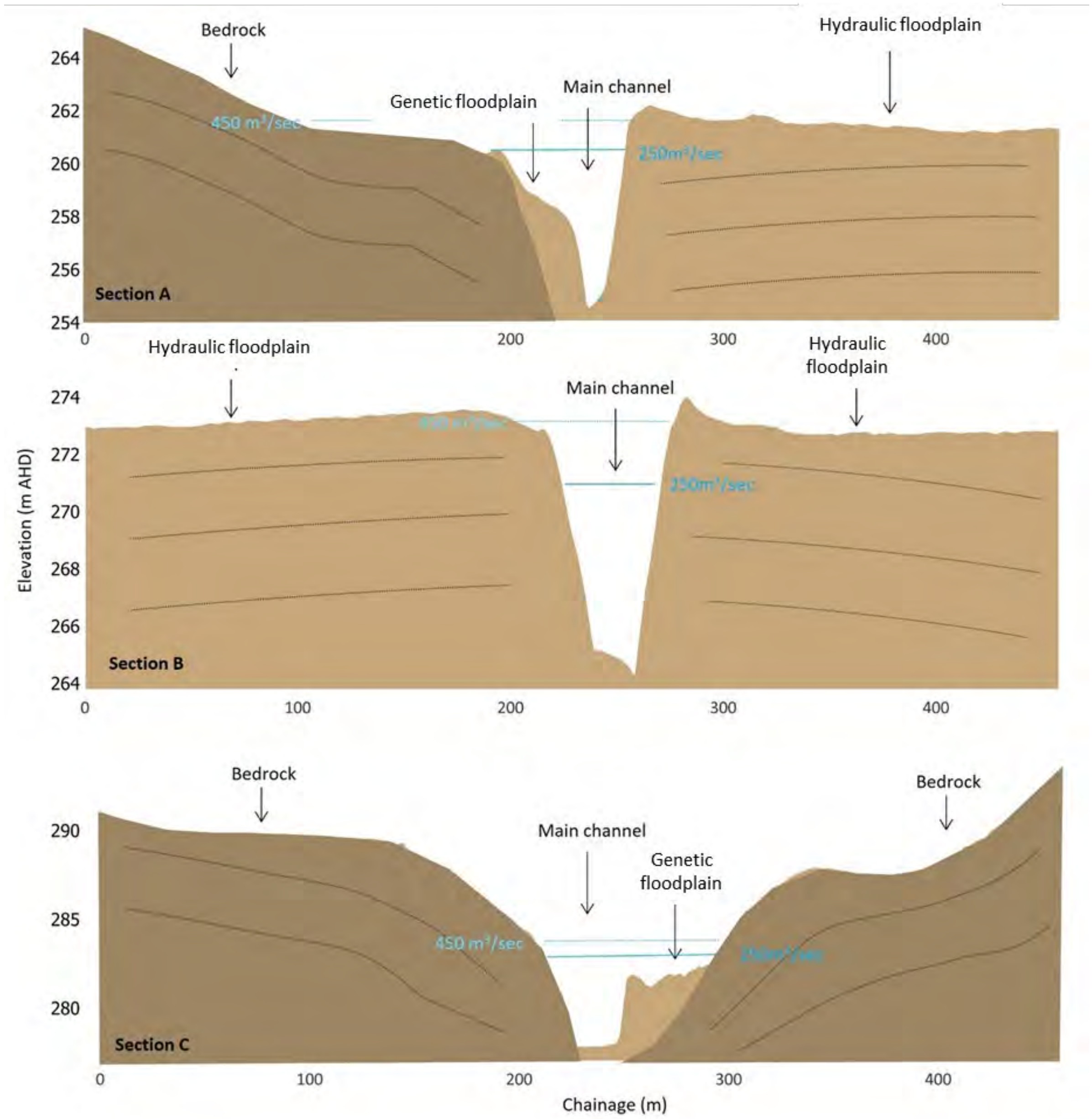


Figure 94. *The three typical sections in the Barambah Creek case study area (shown in Figure 91) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled links in the case study area is 68 m^3/s in the downstream reach (SC # 131), which has a return period of between 1 – 2 years (BOM, 2023). Comparatively, the HEC-RAS modelled bankfull flow is significantly higher at approximately 450 m^3/s which has a return period of 7 - 8 years (Table 38). The SedNet bankfull flows for the upstream reaches (SC # 132, SC # 583 and SC # 133) is between 1 and 39m^3/s (≈1 yr ARI) which is significantly less than the HEC-RAS modelled estimate of 250 m^3/s (≈ 4 -5 yr ARI).

The SedNet bankfull flow is 1% to 16% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 38). This estimate is closer to the modelled bank full flow, compared to the SedNet input bankfull flow, in SC #132 and SC #585. Whereas in SC #132 and SC #585 the bankfull flow estimated using Manning's equation was significantly higher than both the modelled and SedNet input bankfull flow.

Table 38. Comparison between Dynamic SedNet modelled and hydraulic model derived bank full flow in the Barambah Creek case study area.

Link (Sub-catchment)	SedNet Bank Full Flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	SedNet Bank Ful Flow as a % of Modelled Bank Full flow
SC #131	68	450	1,948	15%
SC #132	39	250	218	16%
SC #583	1.3	250	883	1%
SC #133	33	250	227	13%

4.19 Burnett Mary - Obi Obi Creek

Overview

The Obi Obi Creek case study area extends for approximately 18 kilometres upstream of its confluence with the Mary River at Kenilworth (Figure 95). The study reach lies approximately 10.5 km downstream from Baroon Pocket Dam, which was built in 1989 and provides the Sunshine Cost with domestic water supplies, along with recreational and tourism opportunities. The floodplains along this reach are primarily used for grazing (predominantly grazing of irrigated modified pastures in the lower reaches where there are dairies, and grazing of native vegetation in the upper reaches). Upstream from the study reach is Kondalilla National Park.

The study reach flows over Mid-Late Triassic igneous Rg/g-SEQ in the upper reaches for 6km before flowing over sedimentary Amamoor beds of Devonian to Carboniferous age for the remainder of the reach.

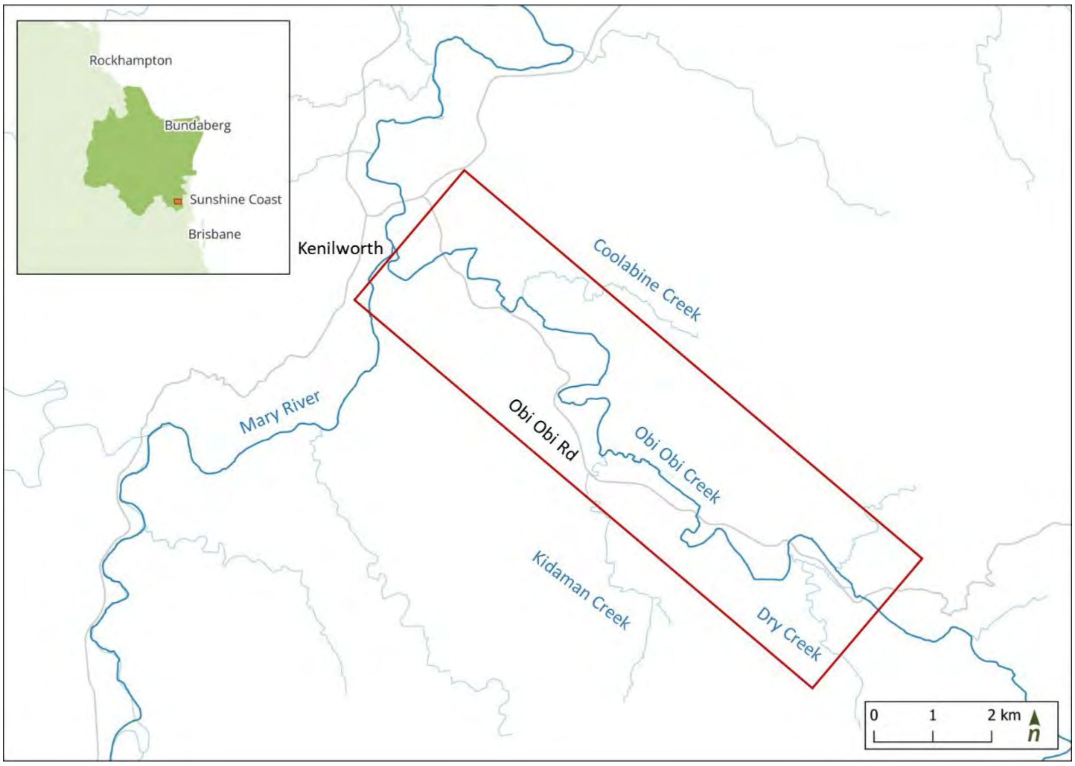


Figure 95. *The Obi Obi Creek case study area.*

Floodplain classification

Modelled floodplain deposition volumes are highly sensitive to floodplain area. High resolution LiDAR data was used to assess the floodplain area in the Obi Obi Creek study area (Figure 96), and to enable comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Obi Obi Creek case study area.

The case study area of Obi Obi Creek is a gravel bed stream that flows through a valley setting that is partly confined by bedrock. The uppermost reaches have a meandering planform in which the apexes of the meanders abut the valley margins. The valley is approximately 500-600m wide in the upper reaches, with discontinuous floodplains up to 350m-wide and a distinct narrow inset floodplain at the top of the reach, just after the first Obi Obi Rd crossing.

Obi Obi Creek then transitions into an elongated meander within a broader floodplain up to 750m-wide. Here, a shallow low flow channel sits within a wider channel constrained by floodplain (Section B in Figure 103). Obi Obi Creek then straightens as the valley narrows before entering a highly sinuous, actively eroding reach just upstream of the Kidaman Creek confluence. This reach has extensive inset floodplain development, potentially associated with flow interactions with Kidaman Creek. Obi Obi Creek then flows through a large tight meander bend controlled by bedrock, where the channel turns around 180 degrees.

After the tight meander bend, Obi Obi Creek enters a partly confined valley setting in which the valley floor width ranges from 350 m to 550 m-wide and the creek abuts terrace units (typically 10 m high above the stream bed) and floodplain units (typically 8 m above the stream bed). The terrace features are more prominent in the lower reaches than the upper reaches, likely due to floodplain development associated with the Mary River confluence.

The dominant inundation surfaces in the Barambah Creek case study area are genetic floodplains and hydraulic floodplains (Figure 96). Variations in the degree of channel entrenchment and geomorphic units across the reach are summarised by the three typical sections shown in Figure 97.

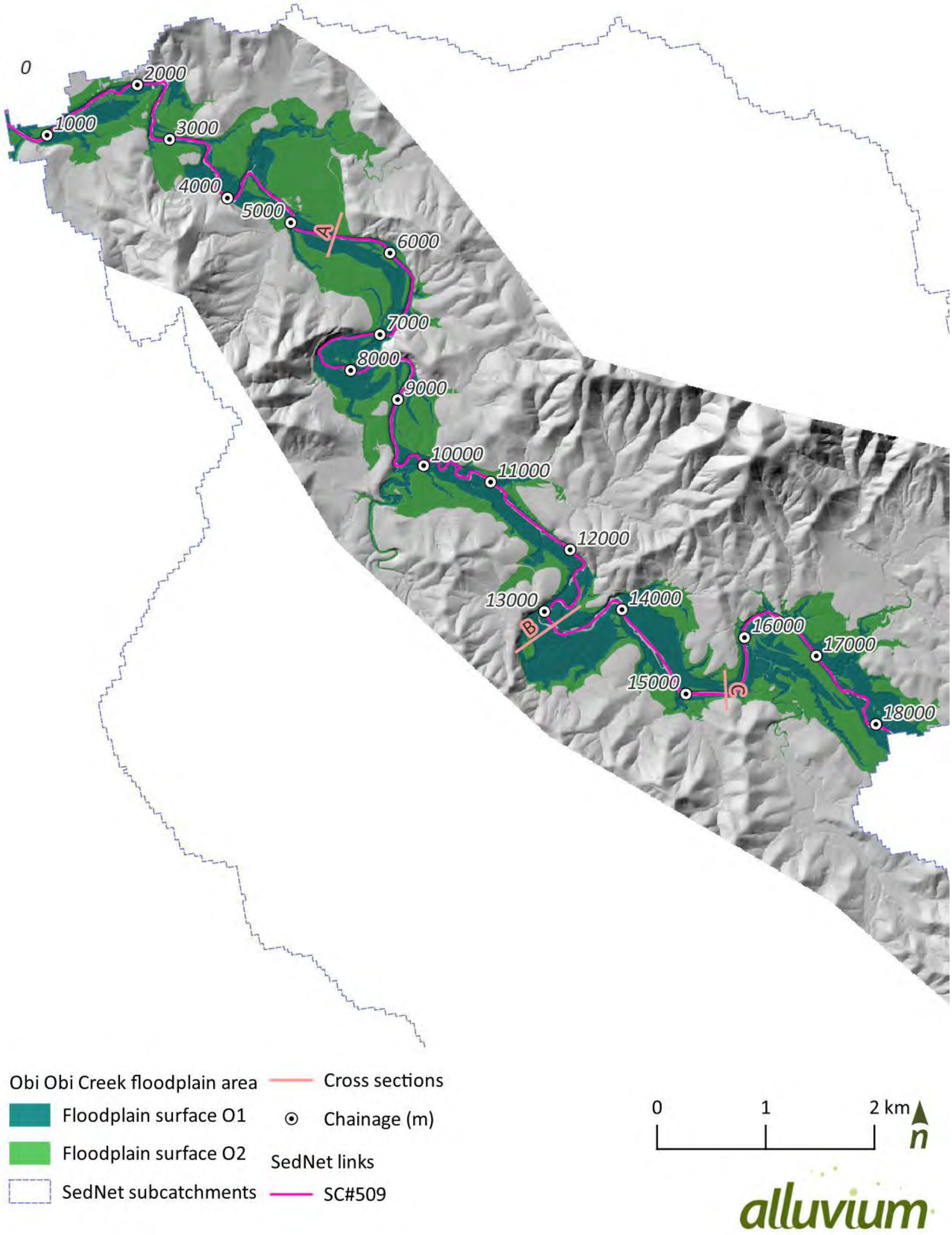


Figure 96. *The Obi Obi Creek case study area showing two major inundation surfaces; genetic floodplain and hydraulic floodplain. The representative cross section locations are also shown.*

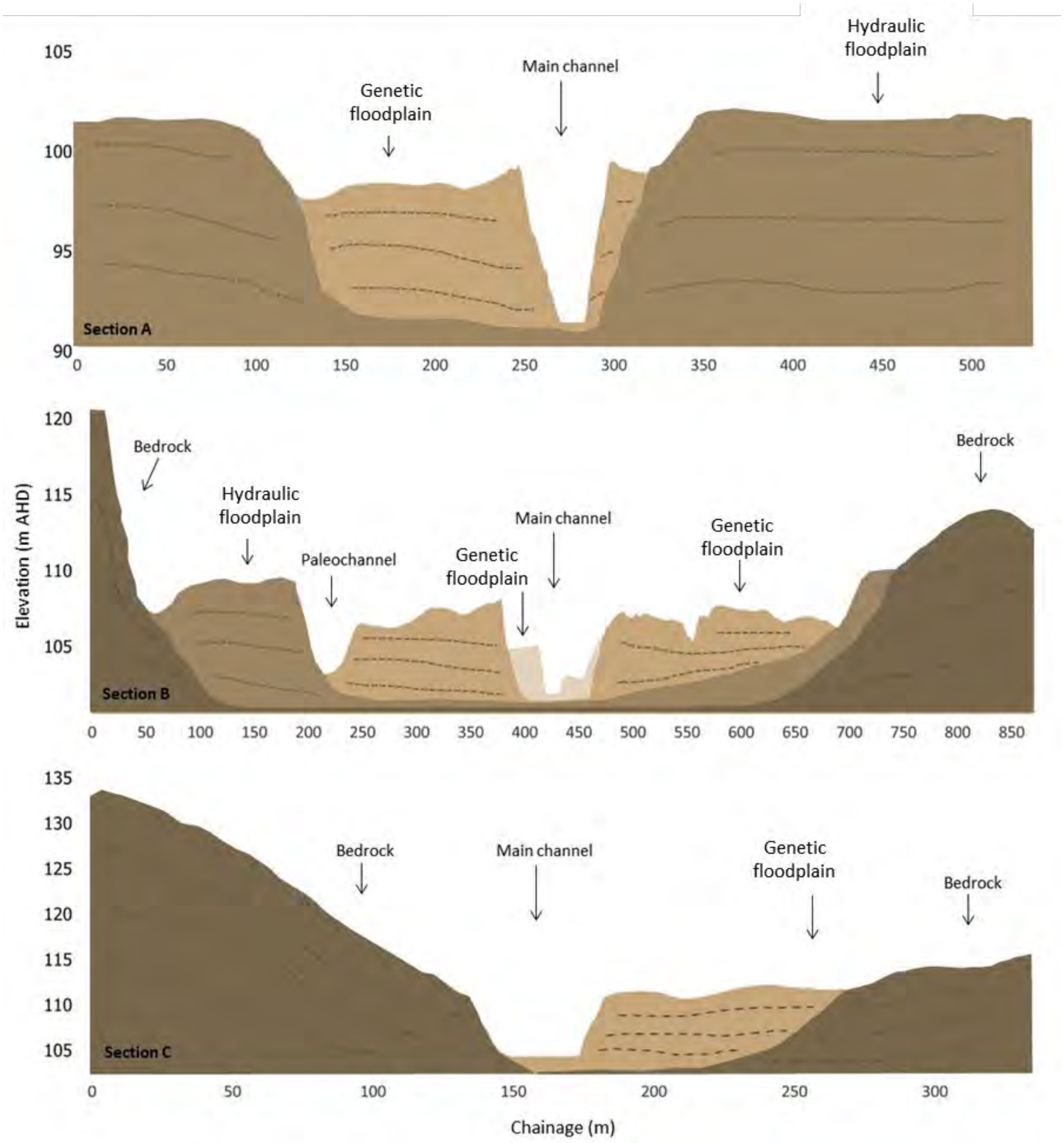


Figure 97. *The three typical sections in the Obi Obi Creek case study area (shown in Figure 96) with the key geomorphic units – note the stratigraphy has been estimated as no detailed chronostratigraphic data was available*.

The Dynamic SedNet input floodplain area and LiDAR derived floodplain area in the Obi Obi Creek case study area are provided in Table 39. The SedNet floodplain area is 143% of the LiDAR derived floodplain area. The input Dynamic SedNet floodplain areas are overpredicted in this case study area/

Table 39. Comparison between Dynamic SedNet modelled and LiDAR derived floodplain area in the Obi Obi Creek case study area.

Link (Sub-catchment)	SedNet Flood Plain Area (km²)	LiDAR area		SedNet Bank Ful Flow as a % of Modelled Bank Full flow
		Genetic floodplain (km²)	Hydraulic floodplain (km²)	
SC #509	11.85	3.93	4.3	143%

Bankfull flow discharge

Hydraulic modelling was undertaken to enable comparison between Dynamic SedNet modelled and hydraulic model derived bankfull flow in the Obi Obi Creek case study area.

A one-dimensional HEC-RAS model was developed for the study reach (Alluvium, 2023). The model is uncalibrated, but a channel roughness was assigned based on estimates of channel roughness from aerial imagery and expert judgement. A stream gauge with 44 years of data was present within the Obi Obi Creek study reach. Flood frequency analysis of this gauge was used to estimate the return periods of the modelled flow events. A range of flow events were modelled to determine the channel capacity. The water surface for three flow events ranging from 75 m³/s to 1,500 m³/s are shown in Figure 98. Representative bankfull flows in three typical cross-sections are shown in Figure 99. The channel capacity varies throughout the case study area but is typically 450 m³/s across the reach, which corresponds to a 2-year average return interval (ARR, 2023). The higher terrace units generally have a capacity of 1,500 m³/s, which corresponds to a 50-year ARI. The inset floodplain unit associated with the elongated meander near chainage 13,000 m (Typical cross section B) has a low bankfull flow of 75 m³/s. Erosion areas tend to align with floodplain and inset floodplain units, which are more recent and less stable geomorphic units than terraces.

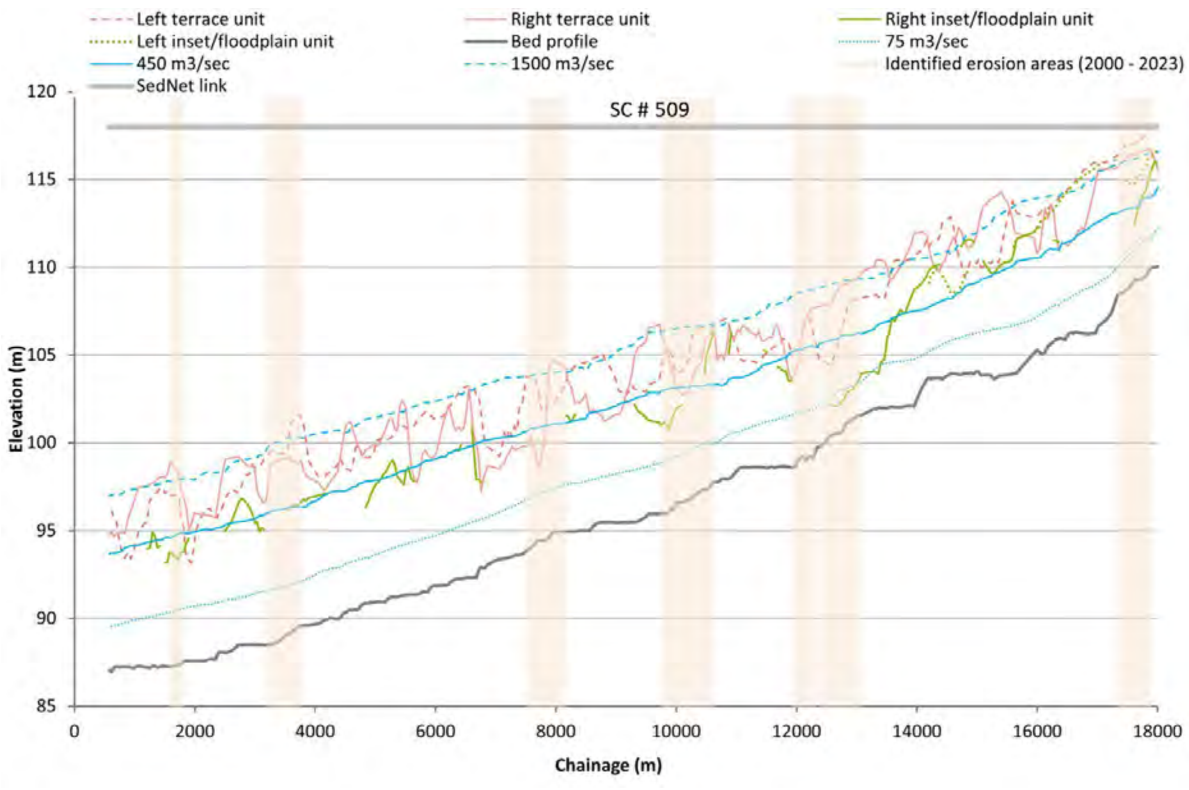


Figure 98. *The water surface elevation for a range of flow events near the bankfull elevation within the Obi Obi Creek case study area.*

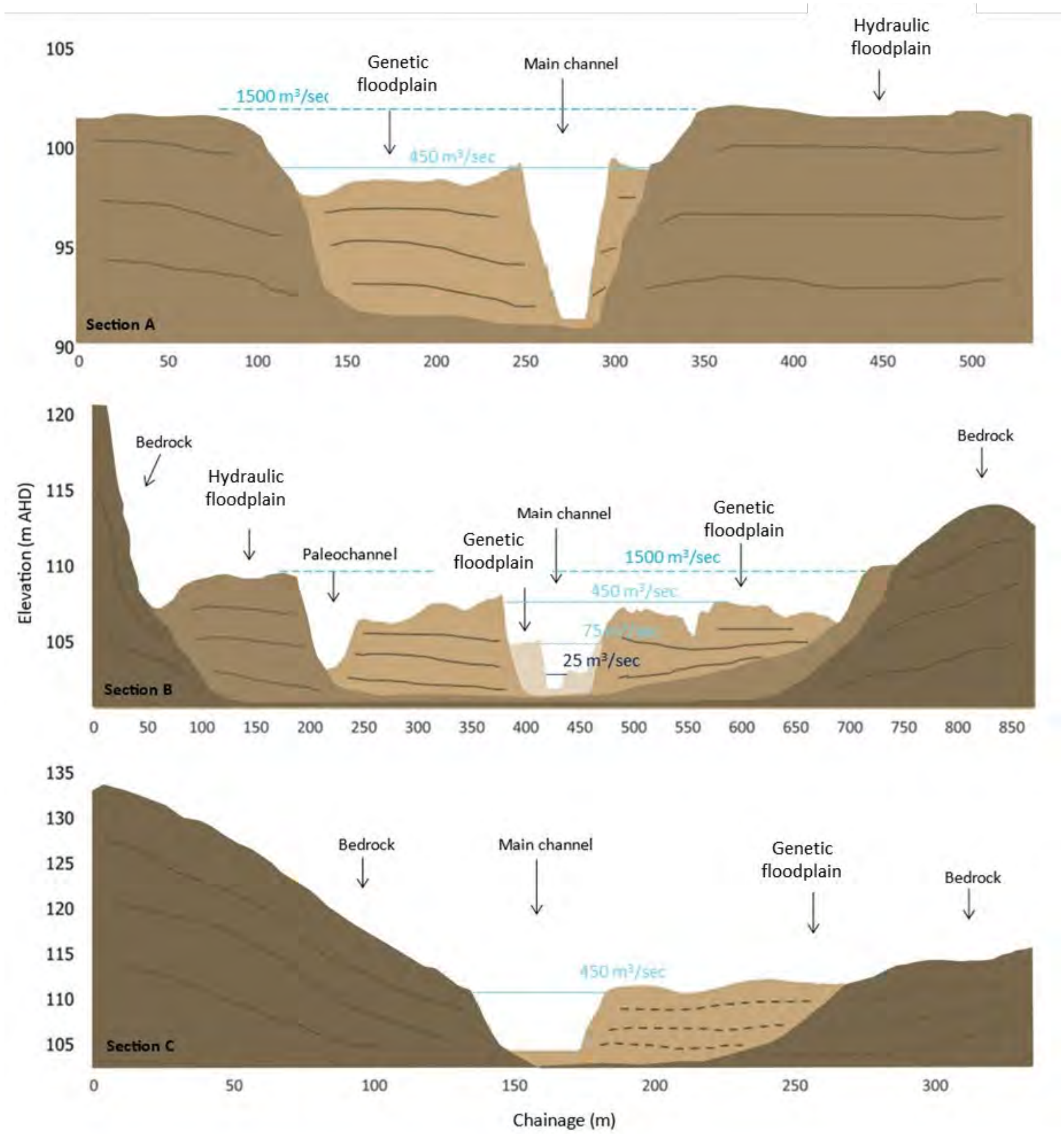


Figure 99. *The three typical sections in the Obi Obi Creek case study area (shown in* Figure 96*) showing the key geomorphic units and representative bankfull flows.*

Bankfull flow used in the Dynamic SedNet modelled link in the Obi Obi Creek case study area is 289 m^3/s, which has a return period of approximately 1 year (Table 39) (ARR, 2023). Comparatively, the HEC-RAS modelled bankfull flow is approximately 450 m^3/s across the reach, which has a return period of 2 years (Table 39). The bankfull flow applied in the Dynamic SedNet model for the case study area is lower than the HEC-RAS bankfull flow estimate.

The SedNet bankfull flow is 64% of the actual modelled bank full flow in all reaches. As a result, Dynamic SedNet likely overpredicts floodplain flow and subsequently floodplain deposition volumes in this case study area.

Bankfull flow was also estimated using Manning's equation (Table 40). This estimate is significantly higher than both the modelled bank full flow and the SedNet input bankfull flow.

Table 40. Comparison between Dynamic SedNet modelled and hydraulic model derived bankfull flow in the Obi Obi

Link (Sub-catchment)	SedNet bankfull flow (m^3/s)	Modelled Bank Full Flow (m^3/s)	Manning's calculation estimated Bank Full Flow (m^3/s)	% change between SedNet and Modelled Bank Full flow
SC #509	289	450	1,402	64%

4.20 Case study assessment summary

A summary of the bankfull flow and floodplain area analysis across each of the model links assessed in this study is provided in Table 41.

Bankfull flow

Overview

The analysis indicates that the bankfull discharge used in the Dynamic SedNet model model typically underestimate the actual bankfull flows. The bankfull flow estimates from the SedNet model are typically in the 1-2 year ARI range. However, the bankfull flows within the 17 case studies assessed for the study are often in the 5-50 year range. Across the 60 case study links:

- 63% of the links underestimated the bankfull flows
- 10% of the links overestimated the bankfull flows
- In 18% of the links the SedNet bankfull flows aligned well with the Hec-RAS modelled estimates
- 7% of the links has significant variability within the link – part of the link was underestimated, and part of the link was over estimated
- In 2% of the links it was not possible to estimate capacity (tidal reach – no bathymetric data)

Bankfull flow estimate

Currently bankfull flow is estimated within Dynamic SedNet model by assigning a flood frequency (i.e. an ARI flow, default 1.58 years). However, this study has identified varying channel morphologies and channel capacities. An approach that estimates bankfull flow based on the channel hydraulics would improve the accuracy of bankfull estimates.

The parameters within the Dynamic SedNet model (i.e. bankfull flow, slope, channel width and bank height) allow Manning's equation to be solved in terms of the Manning's roughness coefficient:

$$n = \frac{1\,A\,R^{2/3}S^{1/2}}{Q}$$

Where n = Manning's roughness coefficient
A = bankfull cross-sectional area (assume channel width x bank height)
R = hydraulic radius (A/wetted perimeter)
S = hydraulic gradient (assume equal to channel slope)
Q = bankfull flow

When this equation is solved using the parameters within the SedNet model for the 17 case studies on average the Manning's roughness coefficient is greater than 0.24. In natural waterways Manning's roughness values beyond 0.07 are relatively uncommon and might occur for highly irregular, debris-filled, or obstructed channels. As a result, many of the bankfull flow estimates within the SedNet model are hydraulically infeasible.

If a typical river Manning's roughness of 0.04 is assumed and the Manning's equation is solved for bankfull flow, then the estimate is much closer to the HEC-RAS modelled estimates in this study.

Floodplain area

The analysis indicates that floodplain area used in the SedNet model typically underestimate the actual floodplain area. Across the 60 case study links:

- 47% of the links underestimated the floodplain area
- 22% of the links overestimated the floodplain area
- In 27% of the links the SedNet floodplain area aligned well with the Hec-RAS modelled estimates
- In 5% of the links floodplain area was unable to be estimated due to lack of LiDAR across the floodplain extent.

Case study summary

This assessment identified significant variations in the bankfull flow and floodplain areas used in Dynamic SedNet compared to values identified in hydraulic modelling and LiDAR analysis. This has the potential to significantly impact on floodplain deposition volumes. The majority of links assessed (i.e. 63%) underestimated bankfull flow. As result within these links modelled floodplain flow volume and frequency of inundation is significantly higher than what actually occurs. As a result, floodplain deposition is overestimated in these links. The floodplain deposition equation within Dynamic SedNet is more sensitive to the bankfull flow than floodplain area. As a result it is likely that the variations in floodplain area have less of an impact on floodplain deposition compared to the variation in bankfull flow.

The impacts of the under estimation of floodplain deposition on overall sediment export rates is inconclusive as there are also links where bankfull flow is overestimated in the Dynamic SedNet model. Taking the Fitzroy River as an example, generally bankfull flow is underestimated in the tributary streams assessed in the catchment (i.e. Woleebee Creek, Raby Creek, Panorama Creek). In these links there would be less floodplain deposition than what is currently modelled. However, in the lower Fitzroy River bankfull flow was underestimated meaning there would be greater floodplain deposition than what is modelled. As a result, further analysis and modelling would be required to determine the overall impacts on sediment export rates.

Table 41. Summary of bankfull discharge and floodplain area analysis.

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
Laura River	SC #487	139	2800	5%	10.2	0.8	1200%	Significantly overestimated due to the low bankfull flow estimate
	SC #496	159	2800	6%	10.9	1.5	750%	Significantly overestimated due to the low bankfull flow estimate
	SC #494	143	2800	5%	2.1	1.5	143%	Significantly overestimated due to the low bankfull flow estimate
	SC #507	133	2800	5%	3.2	1.2	266%	Significantly overestimated due to the low bankfull flow estimate
	SC #520	125	2800	4%	0.0	1.0	0%	Significantly overestimated due to the low bankfull flow estimate
	SC #514	119	1200-2800	4%	0.7	1.7	42%	Significantly overestimated due to the low bankfull flow estimate
	SC #527	60	1200	5%	13.5	2.5	535%	Significantly overestimated due to the low bankfull flow estimate
Normanby River	SC #488	295	750	39%	18.8	17.0	110%	Significantly overestimated due to the low bankfull flow estimate
	SC #500	288	750	38%	19.0	17.5	108%	Significantly overestimated due to the low bankfull flow estimate
Basalt River	SC #348	128	900	14%	15.3	15.3	25%	Significantly overestimated due to the low bankfull flow estimate

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
	SC #349	146	900	16%	2.2	2.2	4%	Significantly overestimated due to the low bankfull flow estimate
	SC #350	150	900	17%	4.3	4.3	8%	Significantly overestimated due to the low bankfull flow estimate
	SC #1668	145	600	24%	7.8	7.8	14%	Significantly overestimated due to the low bankfull flow estimate
Haughton River	SC #29	765	250 - 5000	15 – 306%	80.4	36.6	220%	Undetermined due to variable bankfull flow estimate
	SC #30	254	5000	5%	54.0	261.5	21%	Significantly overestimated due to the low bankfull flow estimate
Rosella Creek	SC #191	57	600	10%	15	12.4	125%	Significantly overestimated due to the low bankfull flow estimate
	SC #193	57	600	9%	22	2.9	752%	Significantly overestimated due to the low bankfull flow estimate
	SC #194	50	600	8%	2	2.5	85%	Significantly overestimated due to the low bankfull flow estimate
	SC #196	36	600	6%	5	2.1	226%	Significantly overestimated due to the low bankfull flow estimate
	SC #197	39	600	7%	11	2.5	460%	Significantly overestimated due to the low bankfull flow estimate
Murray Creek	SC #69	400	300-1000	40 – 133%	32	24	133%	Undetermined due to variable bankfull flow estimate

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
O'Connell River	SC #45	594	1500	40%	5.8	9.9	59%	Significantly overestimated due to the low bankfull flow estimate
	SC #148	627	3000	21%	13.3	9.9	135%	Significantly overestimated due to the low bankfull flow estimate
	SC #46	405	750	54%	29.7	9.9	300%	Significantly overestimated due to the low bankfull flow estimate
Fitzroy River	SC #97	11,560	2,900	399%	54.4	58.8	93%	Significantly underestimated due to the high bankfull flow estimate
	SC #99	11,132	2,900	384%	12.1	35.8	34%	Underestimated due to the high bankfull flow estimate and low floodplain area estimate
	SC #101	11,077	2,900	382%	27.1	49.5	55%	Underestimated due to the high bankfull flow estimate and low floodplain area estimate
	SC #105	10,973	2,900	378%	21.5	25.9	83%	Significantly underestimated due to the high bankfull flow estimate
	SC #106	10,451	2,900	360%	2.3	17.6	13%	Underestimated due to the high bankfull flow estimate and low floodplain area estimate
	SC #108	10,444	5,400	193%	44.7	17.1	261%	Significantly underestimated due to the high bankfull flow estimate
	SC #110	10,435	5,400	193%	9.8	9.5	103%	Significantly underestimated due to the high bankfull flow estimate

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
Raglan Creek	SC #1766	880.5	-	-	76.8	79.5	97%	Undetermined due to lack of bankfull flow estimate
	SC #1768	220.7	1,250	18%	24.4	-	-	Significantly overestimated due to the low bankfull flow estimate
	SC #1770	182.8	650	28%	12.4	-	-	Significantly overestimated due to the low bankfull flow estimate
	SC #1771	58.04	650	9%	13.9	-	-	Significantly overestimated due to the low bankfull flow estimate
Woloobee Creek	SC #494	122	250	49%	14.1	34.0	42%	Significantly overestimated due to the low bankfull flow estimate
	SC #495	100	250	40%	20.6	51.2	40%	Significantly overestimated due to the low bankfull flow estimate
	SC #496	79	250	32%	6.5	44.2	15%	Significantly overestimated due to the low bankfull flow estimate
	SC #498	61	450	14%	5.3	44.7	12%	Significantly overestimated due to the low bankfull flow estimate
	SC #500	19	450	4%	0.7	25.8	3%	Significantly overestimated due to the low bankfull flow estimate
Raby Creek	SC #363	34	600	6%	14.3	16.0	89%	Significantly overestimated due to the low bankfull flow estimate
Panorama Creek	SC #1242	173	50-800	21 – 346%	48.3	152.9	32%	Undetermined due to variable bankfull flow estimate
	SC #1243	146	800	18%	13.3	129.4	10%	Significantly overestimated due to the low bankfull flow estimate

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
Mackenzie River	SC #734	5537	1500-5000	100 – 370%	58.0	47.0	123%	Undetermined due to variable bankfull flow estimate
Dawson River	SC #157	2,102	2000	105%	25.9	56.7	46%	Underestimated due to the low floodplain area estimate
	SC #158	2,099	2000	105%	8.9	56.6	16%	Underestimated due to the low floodplain area estimate
	SC #159	2,124	2000	106%	12.0	56.9	21%	Underestimated due to the low floodplain area estimate
	SC #163	1,956	2000	98%	10.2	56.6	18%	Underestimated due to the low floodplain area estimate
Mary River	SC #503	3744	750	499%	18.9	18.0	105%	Significantly underestimated due to the high bankfull flow estimate
	SC #504	3543	1000	354%	14.6	18.1	81%	Significantly underestimated due to the high bankfull flow estimate
	SC #505	3209	1000	321%	18.5	18.0	103%	Significantly underestimated due to the high bankfull flow estimate
	SC #585	3232	1000	323%	4.7	18.0	26%	Underestimated due to the high bankfull flow estimate and low floodplain area estimate
Three Moon Creek	SC #384	219	250	88%	29.6	69.9	42%	Underestimated due to the low floodplain area estimate
	SC #385	206	250	82%	24.3	69.8	35%	Underestimated due to the low floodplain area estimate

		Bankfull flow			Floodplain area			Summary
Stream	Link	SedNet	Hec-RAS	SedNet % of measured	SedNet	LiDAR	SedNet % of measured	Impacts on floodplain deposition
	SC #386	34	1200	3%	63.1	69.9	90%	Significantly overestimated due to the low bankfull flow estimate
Barambah Creek	SC #131	67	450	15%	125	57.6	216%	Significantly overestimated due to the low bankfull flow estimate
	SC #132	39	250	16%	4	57.3	8%	Significantly overestimated due to the low bankfull flow estimate
	SC #133	32	250	13%	2	56.4	4%	Significantly overestimated due to the low bankfull flow estimate
	SC #583	1.3	250	1%	6	34.6	16%	Significantly overestimated due to the low bankfull flow estimate
Obi Obi Creek	SC #509	289	450	64%	11.9	3.9	143%	Significantly underestimated due to the low bankfull flow estimate

Underestimated	*Well estimated (80%-120%)*	*Overestimated*	*Under and over estimated within a link or not modelled*	*Overestimated floodplain deposition*	*Underestimated floodplain deposition*

5 Hydraulic modelling of case studies

Prosser (2018) recommended the use of large-scale hydrodynamic modelling to explore floodplain deposition processes which can help test and improve SedNet model assumptions. For this study two-dimensional hydrodynamic models for three case study areas have been developed to help explore floodplain deposition processes as they relate to this study's objectives. The model allows us to analyse spatial and temporal patterns of inundation, and determine the floodplain inundation area, and how this varies spatially based on flood frequency and floodplain type. This can help inform future floodplain deposition modelling.

The model can be used to investigate many aspects of floodplain deposition, but we review two specific questions here. The first question evaluates a specific assumption in the SedNet model. The model assumes that all flow above bankfull flow goes onto the floodplain. The parameterisation of the model can then result in the majority of the sediment that is carried by the flow to be deposited on the floodplain (dependent on floodplain area). This area is shown in Figure 100 where the area 'A' shows the flow above the river channel that SedNet assumes is distributed onto the floodplain. In reality this volume does not contribute to deposition on the floodplain (although suspended sediment does move from this channel flow out onto the floodplain). In the next section we estimate the 'non floodplain' component of the floodplain flow (i.e. the flow volume in the area 'A' in Figure 100). In the following section we describe the non-floodplain proportion of floodplain flow as being 'within the channel margins'.

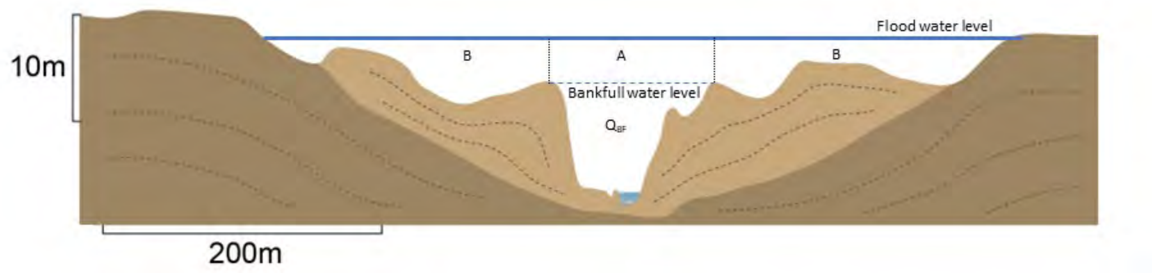


Figure 100. *An overview of the different flow areas during floods once bankfull flow (Q_{BF}) is exceed. A portion of the flow (i.e. Area A) still flows within the channel margins and not over the floodplains (i.e. Area B).*

The second question relates to how revegetating the channel and the floodplain could alter the distribution and velocity of flows due to changed hydraulic roughness. This can help determine the efficacy of floodplain management as a sediment reduction approach. To address this question we look at two more specific questions:

- *Question 2a: How will changing in-stream roughness affect floodplain flow*
- *Question 2b: How will changes in channel and floodplain roughness affect flood velocities*

5.1 Case study selection

Three case study areas were selected for the hydraulic modelling based on the case study assessment undertaken in Section 4. The case study waterways include Fitzroy River, Raby Creek, and Mary River. These case study areas were selected as they represent varying degrees of confinement, a range of different floodplain inundation surfaces characteristic of Queensland waterways, and a range of channel-floodplain connectivity processes (Table 42). Hydraulic modelling of the case study area will therefore be used to investigate a range of fine sediment deposition processes representative of Queensland floodplains.

Table 42. Case study waterway characteristics.

Waterway	Degree of confinement	Inundation surface/s	Connectivity process/s	Land use
Fitzroy River	The reach flows through a broad floodplain 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. Both the tidal barrage and the Eden Bann Weir have impacted river hydraulics, sediment transport and bank saturation processes within this area.	Genetic floodplains and hydraulic floodplains	Overbank flows and floodplain channels	Livestock grazing, and cropping.
Raby Creek	The reach 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. The alluvial development includes extensive fill terraces which sit 7 - 10 m above the channel bed, and inset floodplain and bench units which sit 3 - 5 m above the channel bed.	Genetic floodplains and hydraulic floodplains	Overbank flows, backwater inundation	
Mary River	The reach flows through a spurred valley setting which controls the planform alignment significantly. 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 are rarely engaged), genetic floodplains, and bench units.	Benches, genetic floodplains and terraces	Overbank flows, backwater inundation, and floodplain channels	Improved pasture for numerous dairies as well as grazing

5.2 Hydraulic model setup

A two-dimensional (2D) unsteady hydrodynamic model of each case study area was constructed using 2D HEC-RAS version 6.3.1 developed by the U.S. Army Corps of Engineers. The terrain surface was constructed from 1 m LiDAR data (5 m LiDAR was also used across the broader floodplains of Fitzroy River). A 2D computational mesh was used to delineate the model domain with a base cell spacing of 15 m for Mary River and Raby Creek, and a base cell spacing of 30 m for Fitzroy River (due to the broader channel width). Break lines were enforced along the river channel centreline and banks, and macro channel banks (with a cell spacing of 10 m for Mary River and Raby Creek, and 20 m for Fitzroy River).

The downstream boundary was set as normal depth. Flow at the upstream boundary was specified based on gauge data for the Mary River (138111A) and the Fitzroy River (130005A)(Table 43). The Regional Flood Frequency Estimation (RFFE) Model was used to estimate flows for Raby Creek (as is no stream gauge in Raby Creek)(Table 43). A range of flow events from frequent flows to rare events (i.e. 40% AEP to 2% AEP) were modelled to represent key discharge dependant phases including single thread, multithread, and fully inundated (as per Czuba et al., 2019). Steady state conditions were simulated in 2D HEC-RAS by holding each flood event flow constant before incrementing to a higher flow. Channel and floodplain vegetation was mapped using high resolution aerial imagery. Manning's roughness values were assigned based on reference values (Chow, 1959). The model is uncalibrated, channel and floodplain roughness values were assigned based on landcover using aerial imagery and reference Manning's values (Chow, 1959).

Table 43. Model input flow rates.

Case study area	Flow rate (m/s)				
	40% AEP	20% AEP	10% AEP	5% AEP	2% AEP
Fitzroy River	2025	4481	7337	10754	16240
Raby Creek	122	298	484	737	1160
Mary River	535	1514	2834	4557	7526

5.3 Results

Raby Creek

The Raby Creek case study area, floodplain surfaces and 10 cross-sections used for this analysis are shown in Figure 102. The hydraulic results for the modelled events for both flow depth and velocity are shown in Figure 103 and Figure 104 respectively. A summary of the results from the 10 cross-sections showing the percentage of floodplain flow conveyed within the Raby Creek channel for each flow event is shown in Figure 101. A more thorough review of the results at each cross-section can be found in Attachment 1.

The percentage of floodplain flow conveyed within the channel for each cross-section is shown in Figure 105 with a summary of the hydraulics at each cross-section provided in Table 44. A summary of the cross-section analysis is provided with a box and whisker plot representing the percentage of floodplain flow conveyed within the Raby Creek channel for each flow event across the 10 modelled cross-sections in Figure 101.

The inset floodplain units begin to be engaged in the 20% AEP events, however the majority of floodplain flow (≈75-90%) is conveyed within the channel margins. As flood stage increases the upper floodplains begin to be engaged with low velocities, flow and the velocities on the confined inset floodplains increases with flood stage. The lowest floodplain velocities occur in wider valley settings typically upstream of valley constrictions. Higher velocities occur on floodplains through valley constrictions. In larger flood events (i.e. 2% and 1% AEP events) it is still common for 50% of the floodplain flow to be conveyed within the channel margins.

Likely impacts on SedNet floodplain deposition volumes for the Raby Creek

In Section 4.13 the SedNet modelled bankfull flow for Raby Creek was significantly underpredicted from the value determined from the hydraulic modelling (i.e. 34 m^3/s compared to 122 m^3/s for the inset floodplains and 600 m^3/s for the higher floodplain). As a result, the SedNet floodplain deposition model assumes all flow above 34 m^3/s (and its associated fine sediment loads) engages with the floodplain surface and the fine sediment can be deposited on the floodplain. This analysis indicates that the upper floodplains are not engaged until much larger events (i.e. 600 m^3/s) and even when that flow is exceeded, the majority of the floodplain flow (i.e. flow above the bankfull flow) is still conveyed within the channel margins.

As an example by the time the flow engages the inset floodplain (i.e. 122 m^3/s) the SedNet equation has already predicted that 72% of the link daily sediment load has been deposited on the floodplain. By the time flow engages the upper floodplain (i.e. 600 m^3/s) the SedNet equation has already predicted that 94% of the link daily sediment load has been deposited on the floodplain.

Based on this analysis it's likely the deposition volumes estimate for the Raby Creek case study area are orders of magnitudes higher than the actual deposition volumes.

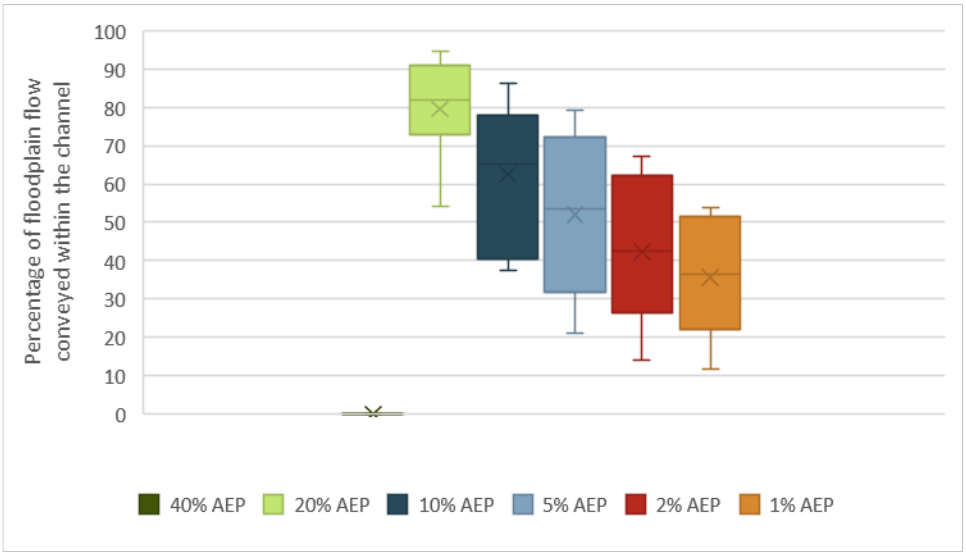


Figure 101. *Box and whisker plot representing the percentage of floodplain flow conveyed within the Raby Creek channel for each flow event across the 10 modelled cross-sections, showing the minimum, maximum, lower and upper quartile values, mean and median.*

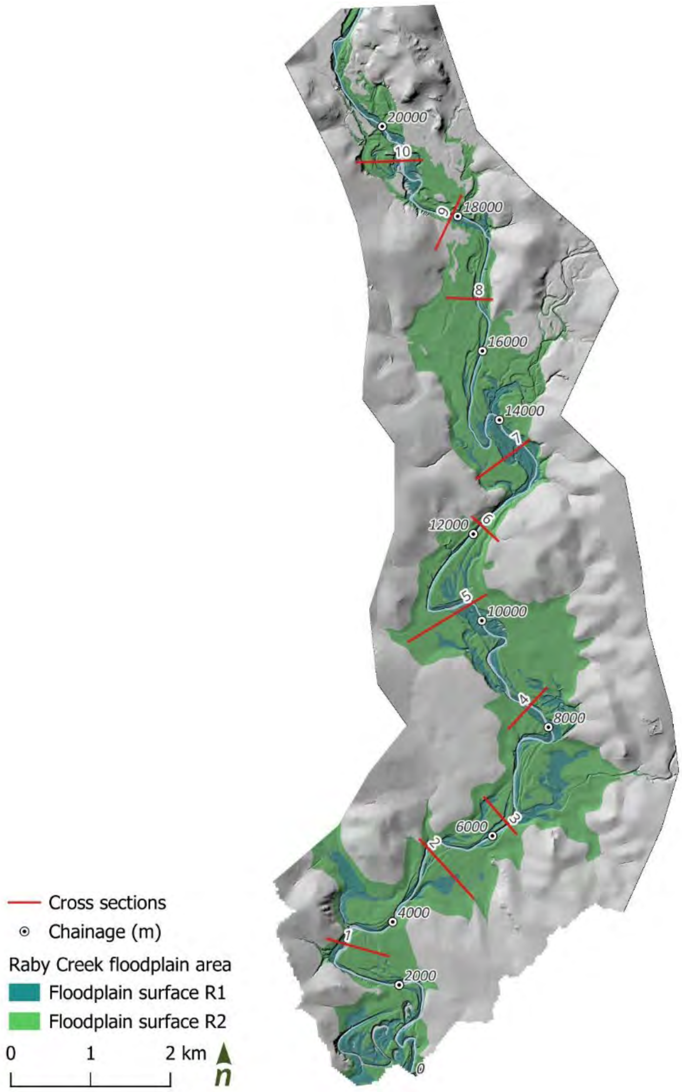


Figure 102. *Overview of Raby Creek study area showing the two floodplain units identified and locations of the ten cross sections.*

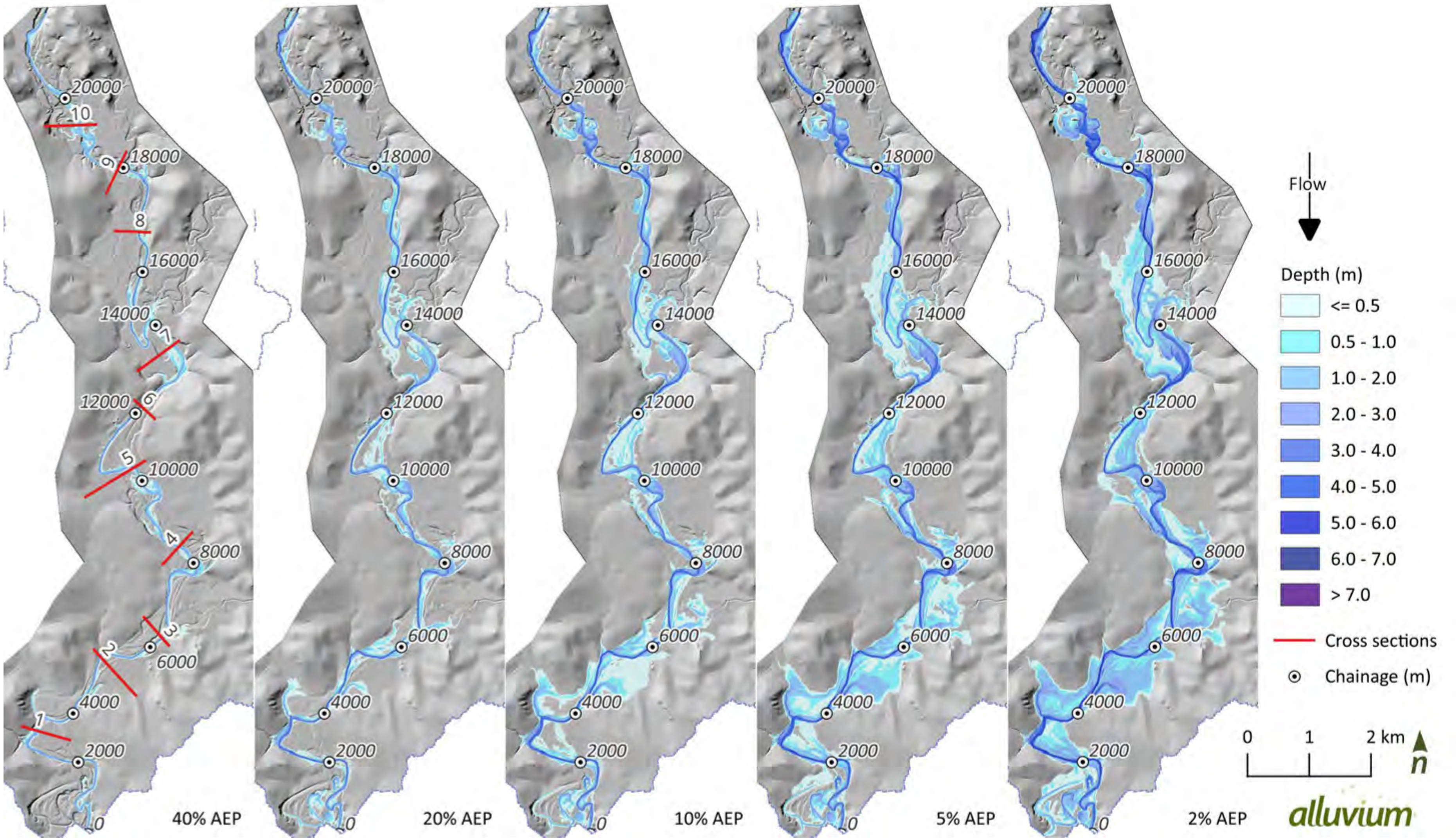


Figure 103. *Raby Creek depth results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*

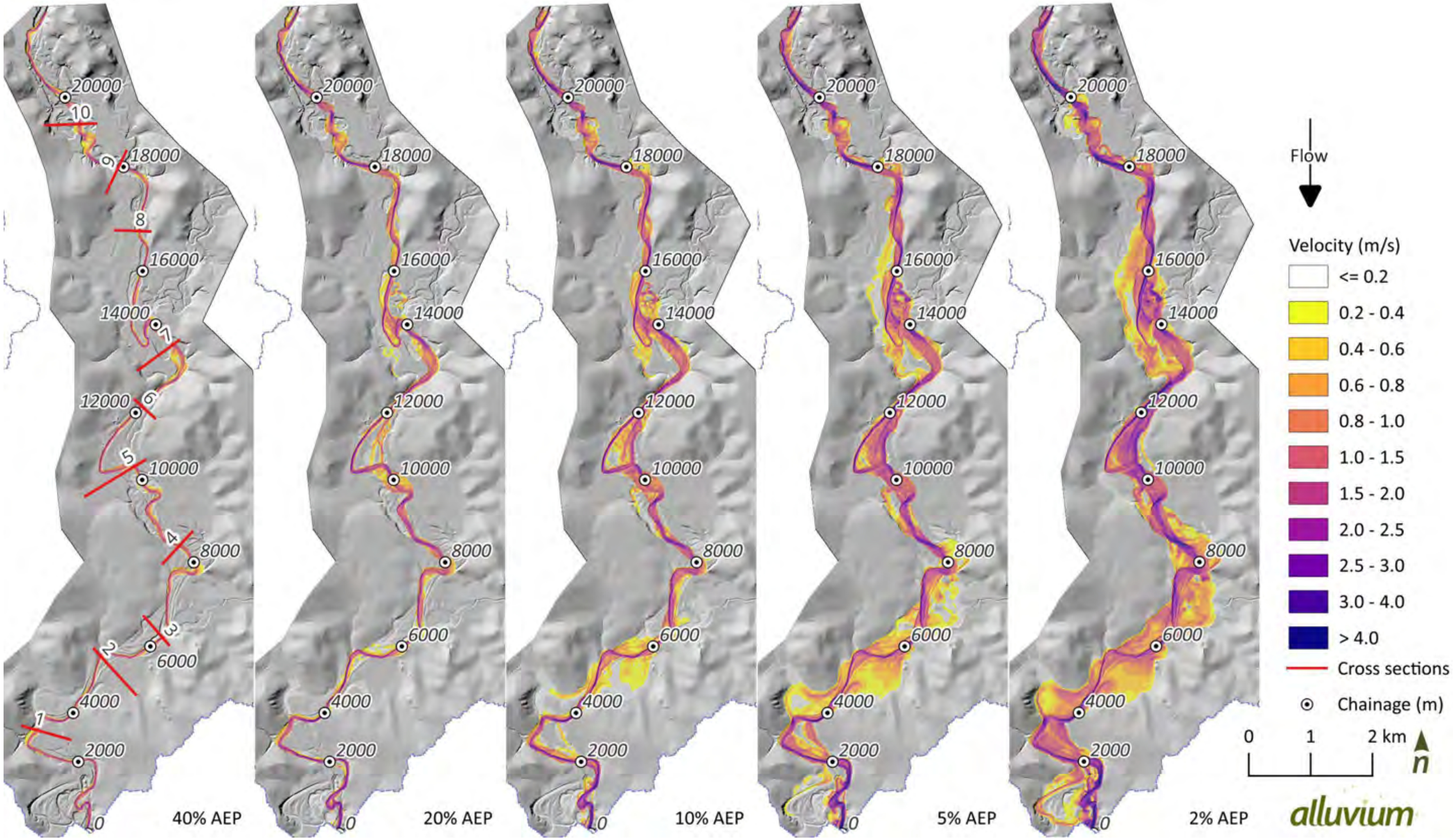
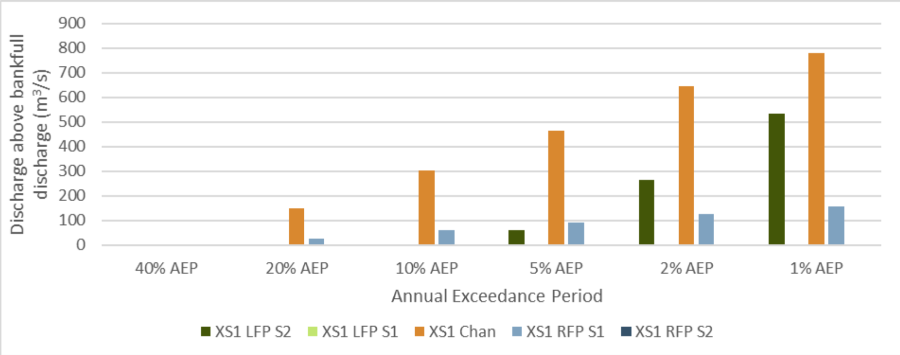
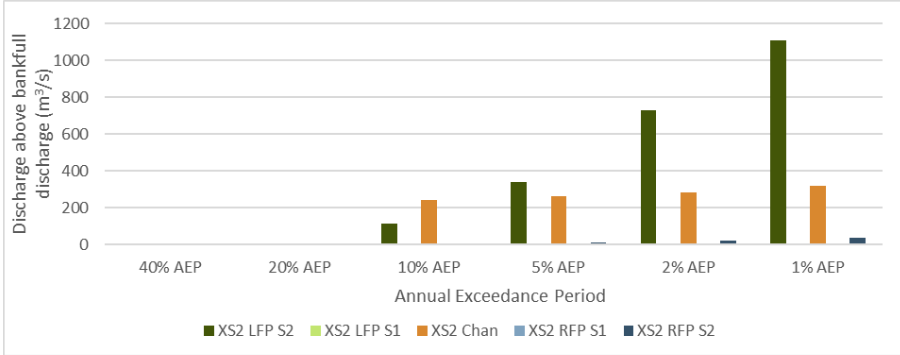


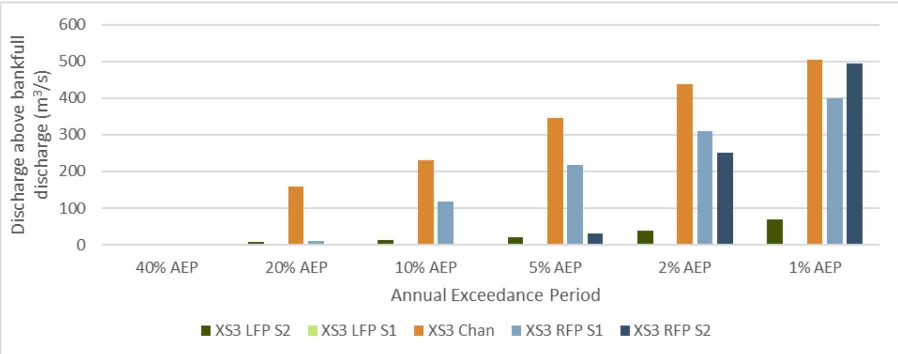
Figure 104. *Raby Creek velocity results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*



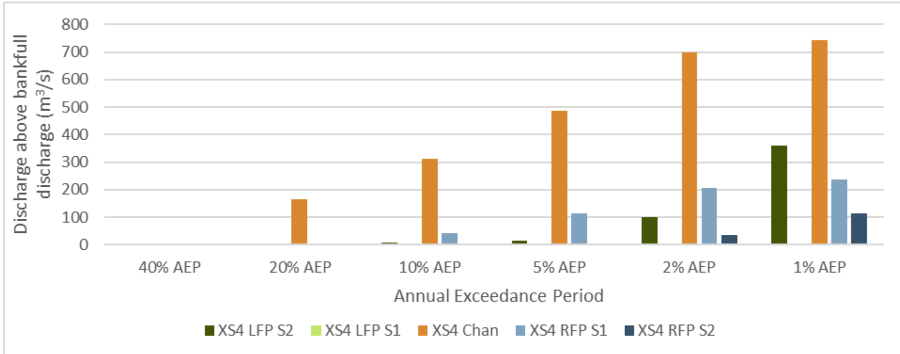
Discharge above bankfull discharge (m³/s)
900
800
700
600
500
400
300
200
100
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS1 LFP S2
XS1 LFP S1
XS1 Chan
XS1 RFP S1
XS1 RFP S2



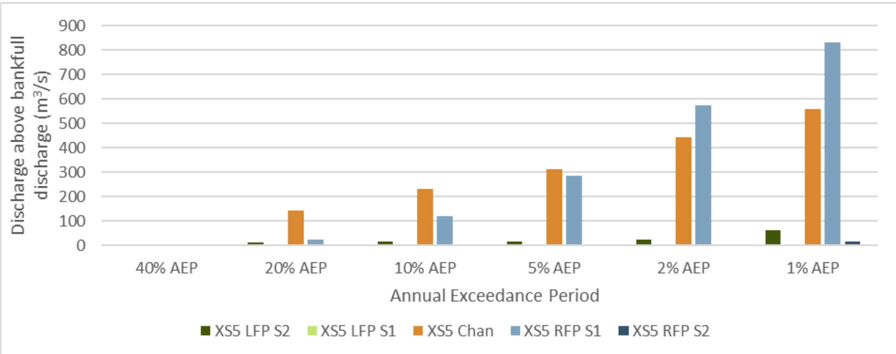
Discharge above bankfull discharge (m³/s)
1200
1000
800
600
400
200
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS2 LFP S2
XS2 LFP S1
XS2 Chan
XS2 RFP S1
XS2 RFP S2



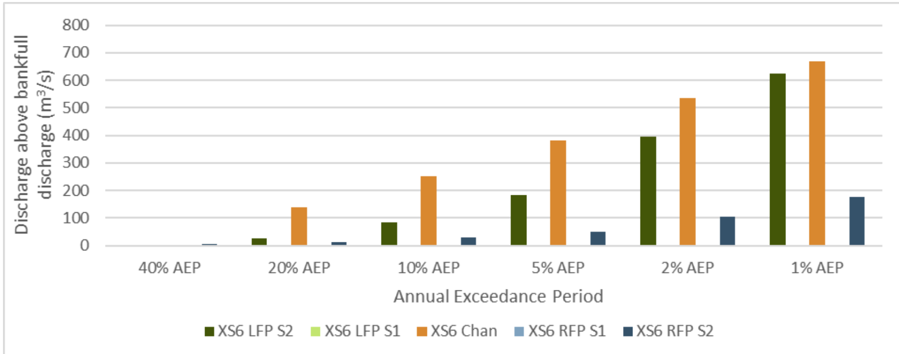
Discharge above bankfull discharge (m³/s)
600
500
400
300
200
100
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS3 LFP S2
XS3 LFP S1
XS3 Chan
XS3 RFP S1
XS3 RFP S2



Discharge above bankfull discharge (m³/s)
800
700
600
500
400
300
200
100
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS4 LFP S2
XS4 LFP S1
XS4 Chan
XS4 RFP S1
XS4 RFP S2



Discharge above bankfull discharge (m³/s)
900
800
700
600
500
400
300
200
100
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS5 LFP S2
XS5 LFP S1
XS5 Chan
XS5 RFP S1
XS5 RFP S2



Discharge above bankfull discharge (m³/s)
800
700
600
500
400
300
200
100
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS6 LFP S2
XS6 LFP S1
XS6 Chan
XS6 RFP S1
XS6 RFP S2

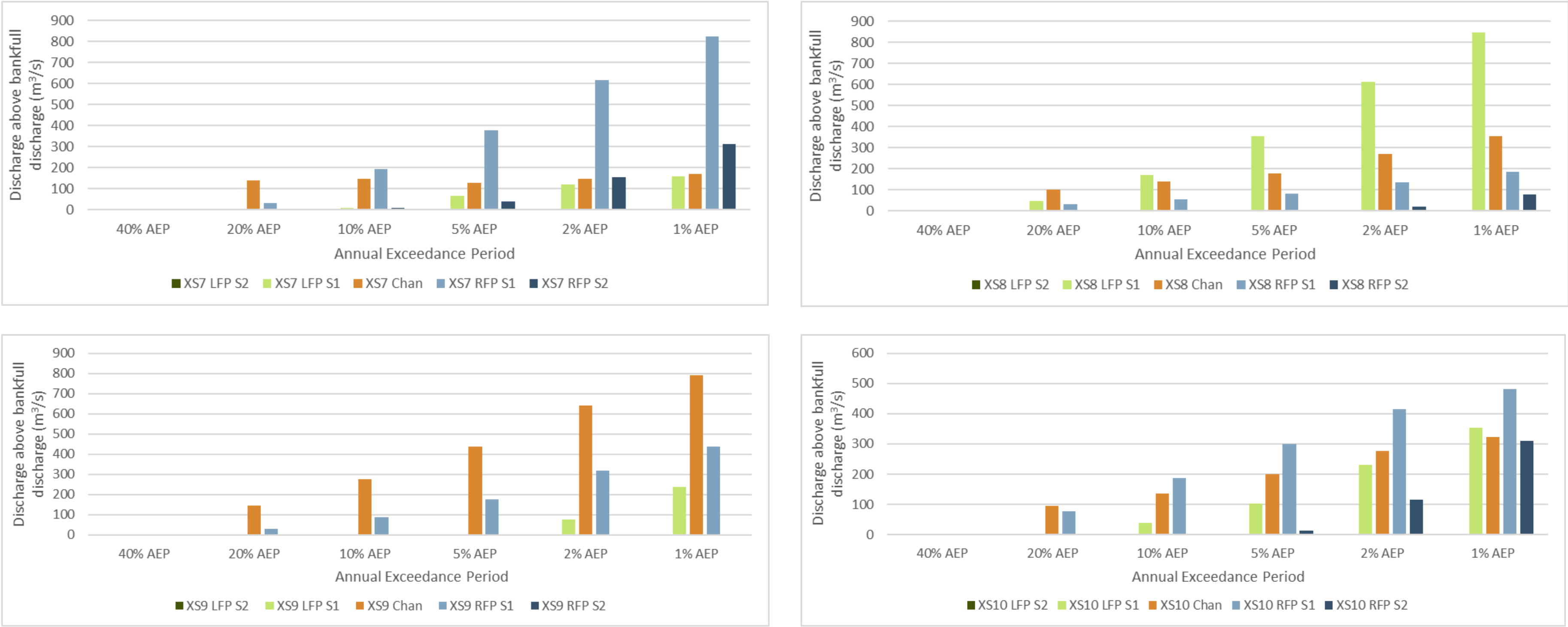


Figure 105. *Bar graphs showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces (S1 lower floodplain surface, S2 higher floodplain surface) for each of the ten cross sections within the Raby Creek study area. See Attachment 1 for individual cross section modelling results.*

Table 44. Overview of cross-sections for Raby Creek case study area.

Cross section	Floodplain characteristics	Overview of floodplain flow characteristics	Percentage of floodplain flow conveyed within the channel for each event (AEP)					
			40%	20%	10%	5%	2%	1%
XS1	Confined inset floodplains (R1) with unconstricted floodplain (R2) at higher stages (> 5 % AEP)	Channel conveys bulk of floodplain flow (greater than 50% at 1% AEP) and increases for each event. Velocities on inset floodplain increases with stage. High R2 velocities in large events as flow short-circuits the channel.	0	84.6	83.2	75.4	62.3	53.1
XS2	Broad unconfined floodplain (R2) with a moderate downstream valley constriction.	Floodplain flow short circuits main channel a higher stages (> 5 % AEP). Floodplain takes bulk of flow at higher stages, channel flow does not increase after 10% AEP. Relatively low velocities across floodplain indicating high deposition potential.	0	94.7	66.4	42.5	27.3	21.7
XS3	Confined inset floodplains (R1) with unconstricted floodplain (R2) at higher stages (> 10 % AEP).	Channel conveys bulk of floodplain flow (greater than 50% at 5% AEP) and increases for each event. For very large floods proportion of floodplain flow increases. Velocities on Inset floodplain increases with stage. Very low velocities on floodplain (R2) after initial floodplain engagement (i.e. 10% AEP and 5 % AEP) indicating good potential for deposition. Floodplain velocities increase for larger events.	0	89.9	63.9	56.2	42.2	34.5
XS4	Confined inset floodplains (R1) with unconstricted floodplain (R2) at higher stages (> 2 % AEP).	Channel conveys bulk of floodplain flow (greater than 80% at 1% AEP) and increases for each event. Very high velocities on inset floodplains, low velocities on floodplain (SF2) at higher stages (> 2 % AEP)	0	94.4	86.4	79.2	67.2	51.0
XS5	Confined inset floodplains (R1) with unconstricted floodplain (R2) at higher stages (> 1 % AEP)	Channel conveys bulk of floodplain flow up to 5% AEP, and increases for each event. In large floods (>5% AEP) inset floodplain (R1) conveys majority of the floodplain flow with high velocities.	0	81.2	63.4	50.9	42.7	38.1
XS6	Unconfined floodplain (R2) with a moderate downstream flow constriction	floodplain flow short circuits main channel a higher stages (> 5 % AEP). Channel conveys majority of floodplain flow in all events, flow over floodplain increases to approximately 50% in larger events (1% AEP and 2 % AEP). High velocities along floodplain flow path.	0	78.3	69.5	62.1	51.7	45.5

XS7	Broad inset floodplain (r1) and broad floodplain (R2) with significant downstream valley constriction.	Inset floodplain conveys bulk of flow at higher stages with high velocities, channel flow does not increase in events greater than 20% AEP	0	79.6	41.2	21.1	14.1	11.6
XS8	Confined inset floodplains (R1) with broad, unconstricted floodplain (R2) only engaged at very higher stages (> 1 % AEP).	Inset floodplain convey majority of floodplain flow in events >10% AEP with high velocities. Flow in channel increases in each event and is approximately 30% of all floodplain flow in large events (1% and 2% AEPs)	0	56.7	38.2	29.0	26.1	24.2
XS9	Confined inset floodplains (R1) with broad, floodplain (R2) only engaged at very higher stages (> 1 % AEP).	Channel conveys bulk of floodplain flow (greater than 50% at 1% AEP) and increases for each event. High velocities on inset floodplain due to confinement.	0	82.4	76.0	71.3	61.9	53.8
XS10	Moderately confined inset floodplains (R1 - more confined on right side), broad floodplain (R2) with paleo channel features, a downstream valley constriction.	In events greater than 10% AEP the majority of flood flow is over right inset floodplain, proportion of flow over left inset floodplain increases with stage. Channel flow increases for all events. High velocities due to confinement.	0	54.0	37.4	32.4	26.7	22.0

Mary River

The Mary River case study area, floodplain surfaces and 10 cross-sections used for this analysis are shown in Figure 107. The hydraulic results for the modelled events for both flow depth and velocity are shown in Figure 108 and Figure 109, respectively. A summary of the results from the 10 cross-sections showing the percentage of floodplain flow conveyed within the Mary River channel margin for each flow event is shown in Figure 106. A more thorough review of the results at each cross-section can be found in Attachment 1.

The percentage of floodplain flow conveyed within the channel for each cross-section is shown in Figure 110 with a summary of the hydraulics at each cross-section provided in Table 45. A summary of the cross-section analysis is provided with a box and whisker plot representing the percentage of floodplain flow conveyed within the Mary River channel margins for each flow event across the 10 modelled cross-sections in Figure 106.

The inset floodplains units begin to be engaged in the 20% AEP events, however the majority of floodplain flow (≈60-80%) is conveyed within the channel margins. The velocities on the inset floodplains increase with stage due to the confinement. In very large floods (i.e. 2% and 1% AEP) the upper floodplains/terrace begin to be engaged with low velocities. The lowest floodplain velocities occur through backwater inundation processes due to the valley constrictions. Higher velocities occur through valley or terrace constrictions. In larger flood events (i.e. 2% and 1% AEP events) it is still common for 40% of the floodplain flow to be conveyed within the channel margins.

Likely impacts on SedNet floodplain deposition volumes

In Section 4.16 the SedNet modelled bankfull flow was significantly overpredicted from the value determined from the hydraulic modelling (i.e. 3500 m^3/s compared to 1000 m^3/s for the inset floodplains). As a result, the SedNet floodplain deposition model assumes all flow above 3500 m^3/s (and its associated fine sediment loads) engages with the floodplain surface and the fine sediment can be deposited. This analysis indicates that the expansive inset floodplains are engaged at much lower events (i.e. 1000 m^3/s). However, once the SedNet bankfull flow is achieved it is likely that at least 50% of that flow is still conveyed within the channel margins and not across any floodplain units.

Based on this analysis it is difficult to draw conclusions on the deposition volumes estimates for this case study area.

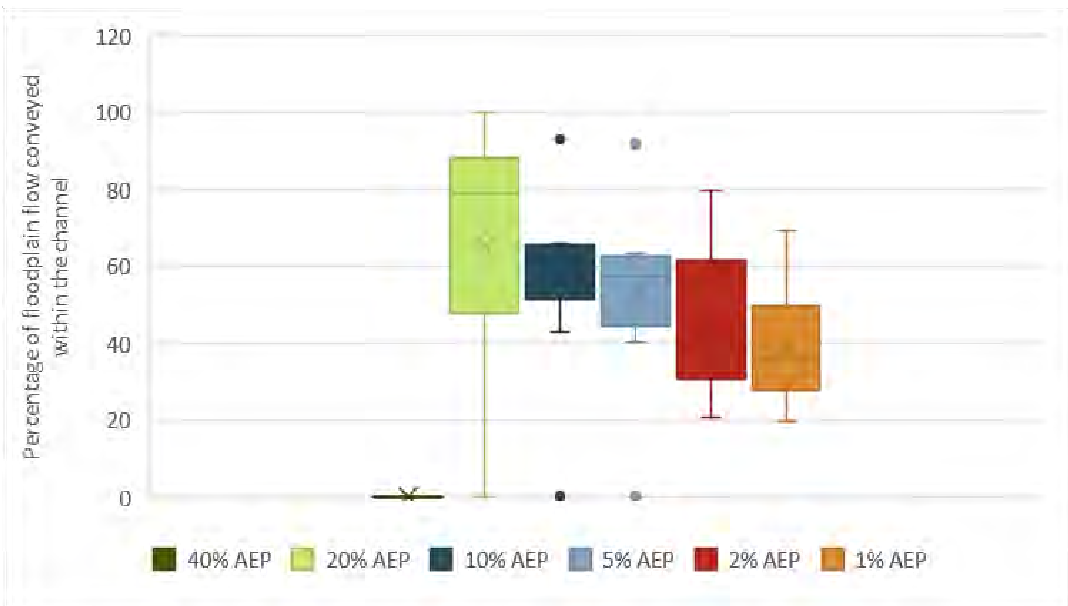


Figure 106. *Box and whisker plot representing the percentage of floodplain flow conveyed within the Mary River channel for each flow event across the 10 modelled cross-sections, showing the minimum, maximum, lower and upper quartile values, mean, median, and outliers.*

Figure 107. *Overview of the Mary River study area showing floodplains units and locations of the ten cross sections.*

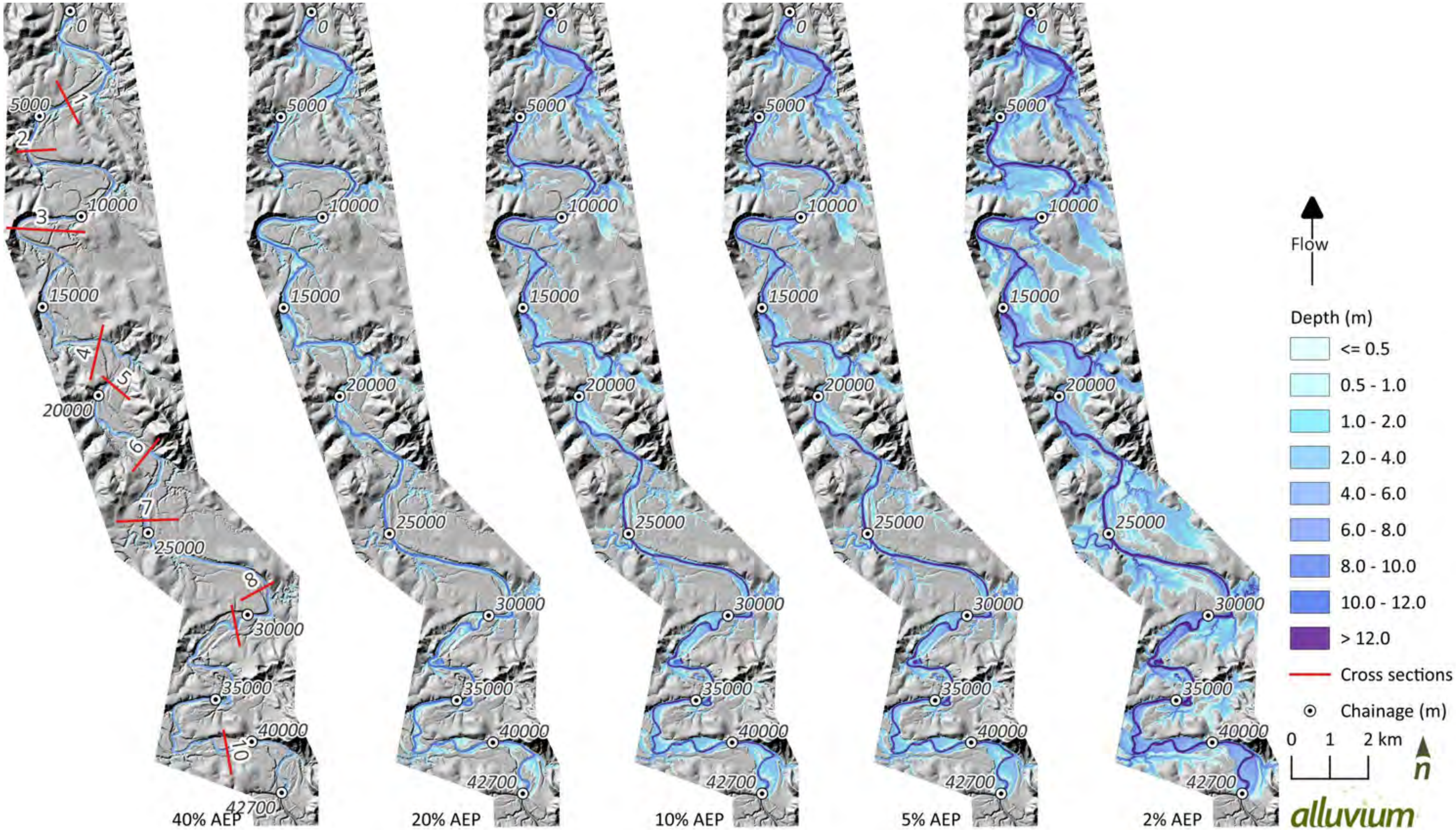


Figure 108. *Mary River depth results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*

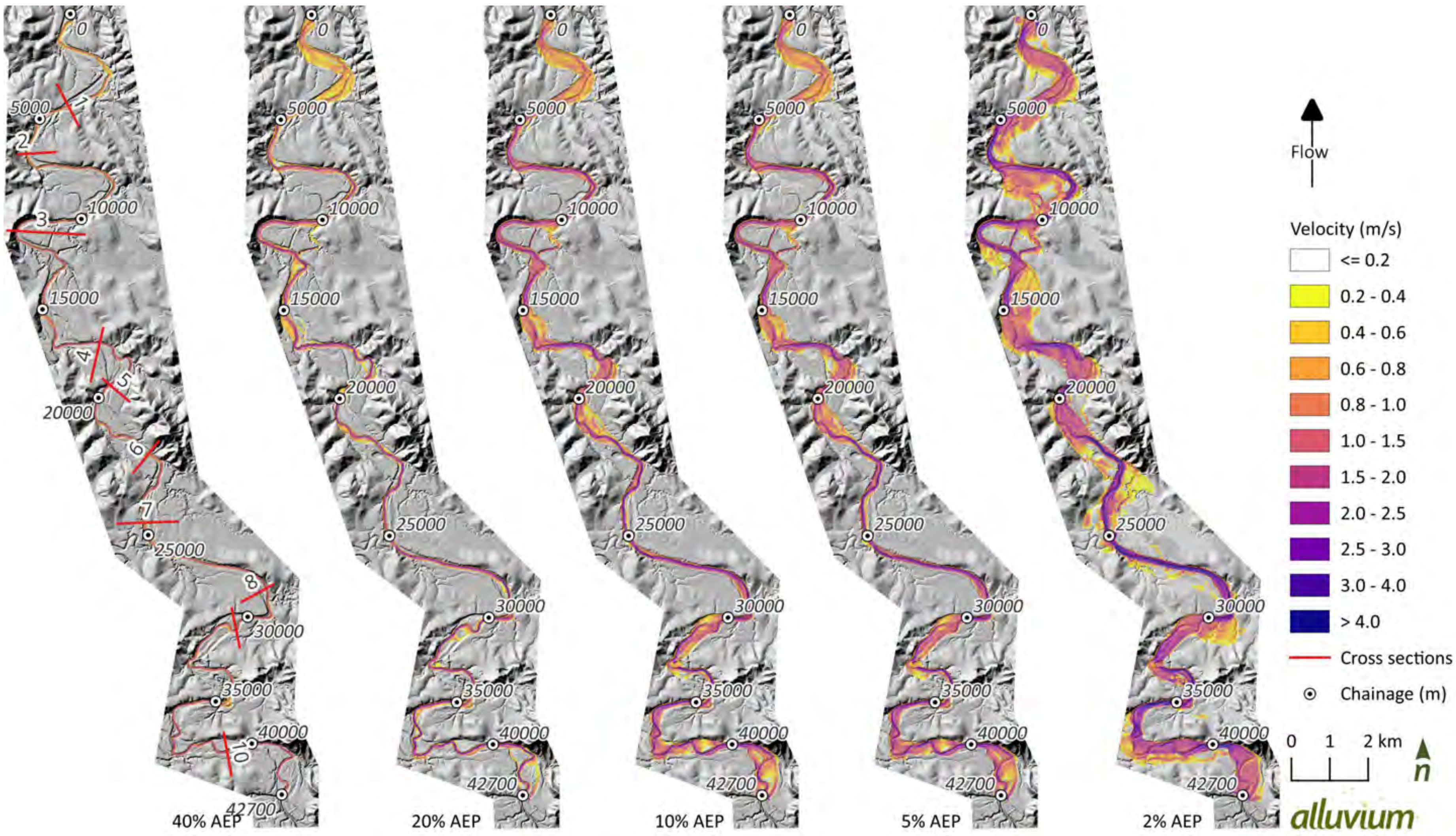
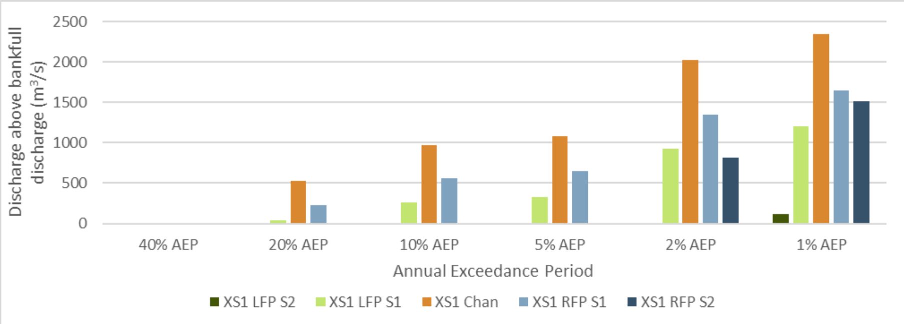
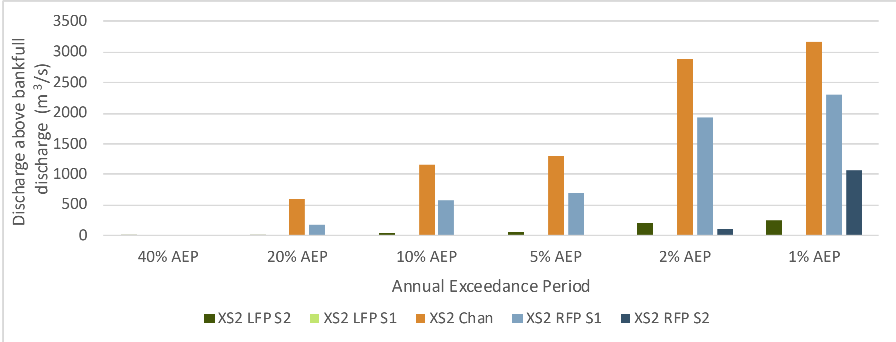
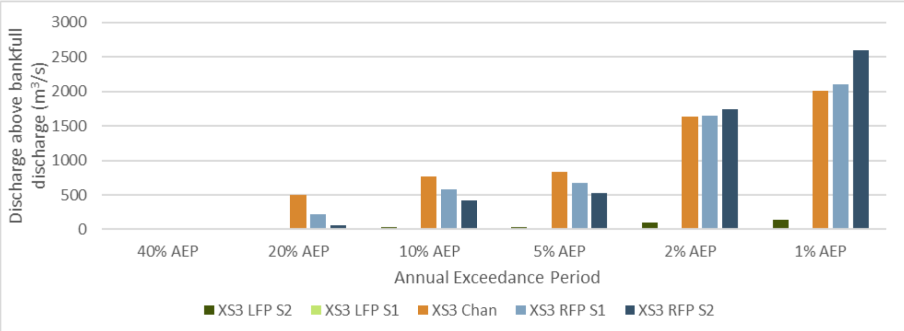
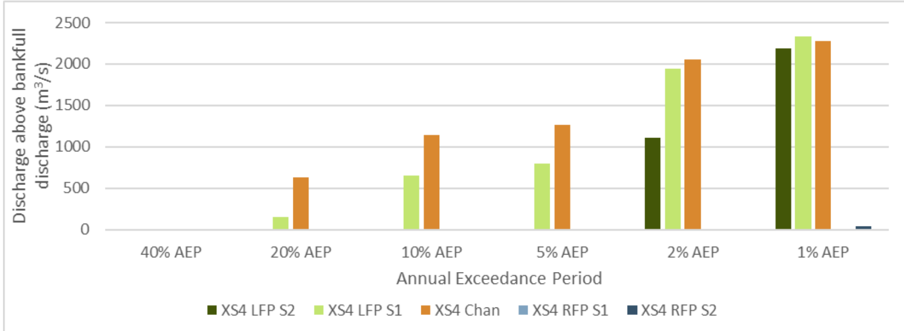


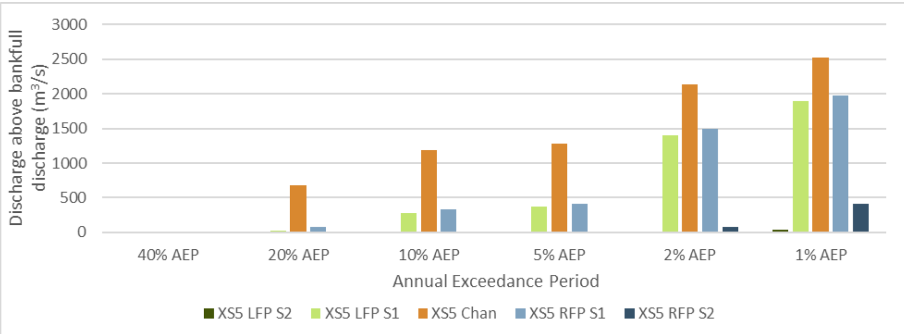
Figure 109. *Mary River velocity results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*

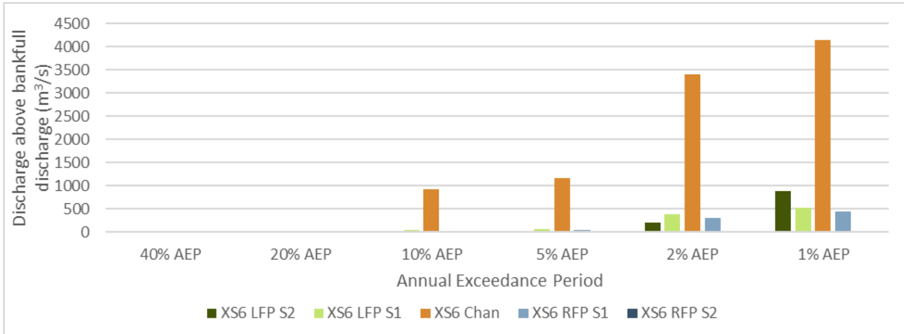

Discharge above bankfull discharge (m³/s)
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS1 LFP S2
XS1 LFP S1
XS1 Chan
XS1 RFP S1
XS1 RFP S2


Discharge above bankfull discharge (m ³/s)
3500
3000
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS2 LFP S2
XS2 LFP S1
XS2 Chan
XS2 RFP S1
XS2 RFP S2


Discharge above bankfull discharge (m³/s)
3000
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS3 LFP S2
XS3 LFP S1
XS3 Chan
XS3 RFP S1
XS3 RFP S2


Discharge above bankfull discharge (m³/s)
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS4 LFP S2
XS4 LFP S1
XS4 Chan
XS4 RFP S1
XS4 RFP S2


Discharge above bankfull discharge (m³/s)
3000
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS5 LFP S2
XS5 LFP S1
XS5 Chan
XS5 RFP S1
XS5 RFP S2


Discharge above bankfull discharge (m³/s)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS6 LFP S2
XS6 LFP S1
XS6 Chan
XS6 RFP S1
XS6 RFP S2

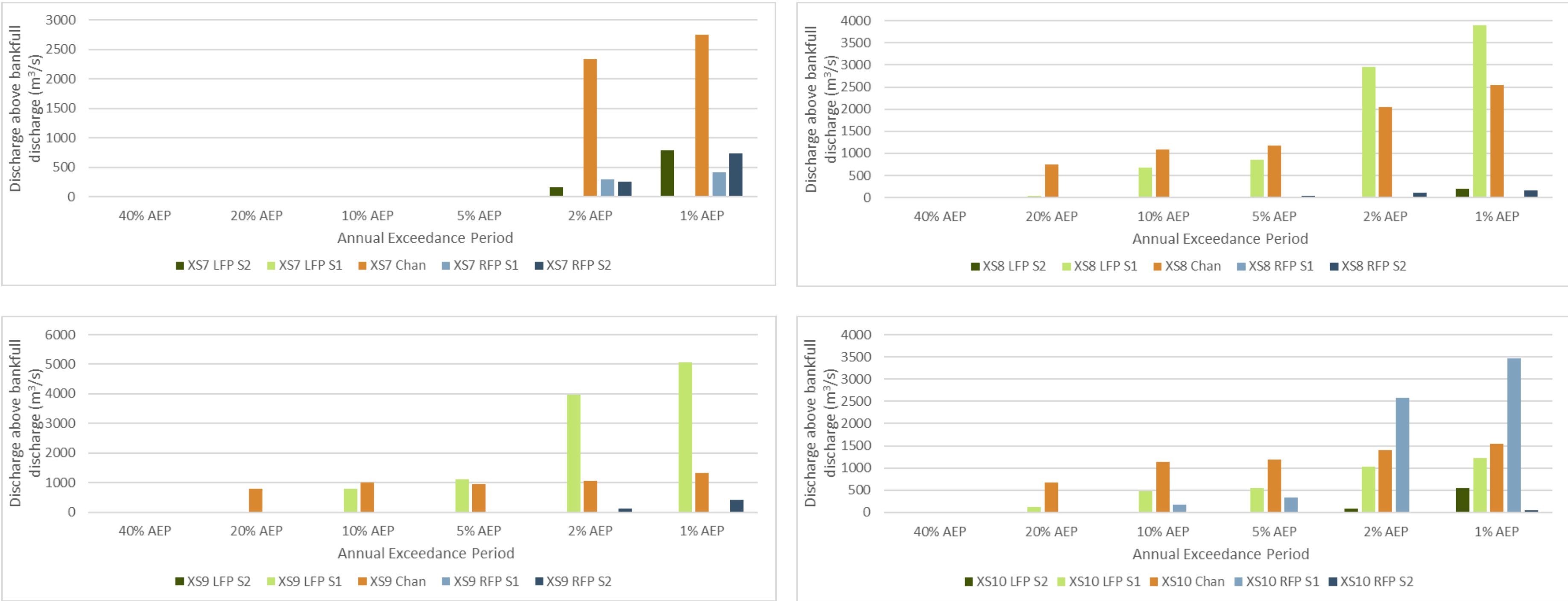


Figure 110. *Bar graphs showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces for each of the ten cross sections within the Mary River study area. See Attachment 1 for individual cross section modelling results.*

Table 45. Overview of cross-sections for Mary River case study area.

Cross section	Floodplain characteristics	Overview of floodplain flow characteristics	Percentage of floodplain flow conveyed within the channel for each event (AEP)					
			40%	20%	10%	5%	2%	1%
XS1	Confined inset floodplains (S1) on both sides of channel abutted by floodplain/terraces (S2) also on both sides with a relatively straight flow alignment.	Majority of flow conveyed within channel for all events. Inset floodplains engaged in events greater than 20% with high velocities due to confinement and floodplain/terraces (S2) engaged in large floods (1% and 2%).	N/A	67.0	54.3	52.3	39.5	34.3
XS2	Confined inset floodplains (S1) with broad floodplain/terraces (S2) on right side. Concave bank abuts bedrock on left side.	Majority of flow conveyed within channel for all events. Inset floodplains engaged in events greater than 20% with high velocities due to confinement and floodplain/terraces (S2) engaged in large floods (1% and 2%) with low velocities but only conveys a small portion of the flow.	0.0	77.4	65.3	63.4	56.4	46.5
XS3	Confined inset floodplains (S1) with broad floodplain/terraces (S2) on right side with chute channels. Concave bank abuts bedrock on left side.	Channel flow increases for all events, inset floodplains engaged in events greater than 20% with high velocities due to confinement and chute channels within floodplain/terraces (S2) engaged in events greater than 20%. In large floods the majority of flood flow is through chute channels in floodplain/terrace with high velocities.	0.0	63.8	42.7	40.2	31.9	29.3
XS4	Confined inset floodplains (S1) with broad floodplain/terraces (S2) on left side. Concave bank abuts bedrock on right side	Channel flow increases for all events, inset floodplains engaged in events greater than 20% and chute channels within floodplain/terraces (S2) engaged in events greater than 2%. In large floods (1%) flood flow equally split between channel, inset floodplain and floodplain/terrace with similar velocities.	0.0	80.0	63.6	61.2	40.1	33.6
XS5	Confined inset floodplains (S1) on both sides of channel abutted by floodplain/terraces (S2) also on both sides with a relatively straight flow alignment.	Majority of flow conveyed within channel for all events. Inset floodplains engaged in events greater than 20% with high velocities due to confinement and floodplain/terraces (S2) engaged in large floods (1% and 2%).	N/A	86.2	65.8	62.0	41.7	36.9
XS6	Confined inset floodplains (S1) with broad floodplain/terraces (S2) on left side. Right inset floodplain abuts bedrock. Relatively straight alignment.	Majority of flow conveyed within channel for all events. Inset floodplains engaged in events greater than 5% however only convey a small portion of flood flow.	N/A	0.0	92.9	91.7	79.5	69.0

XS7	Highly entrenched channel confined by broad floodplain/terraces (S2) on both sides. Minimal inset floodplain development other than narrow bench on right side.	Very high channel capacity meaning most flow events were below bankfull flow. In large floods (i.e. 2% and 1%) floodplains are engaged but 58-76%% of flood flows are still conveyed within the channel with high velocities.	N/A	N/A	0.0	0.0	76.5	58.6
XS8	Broad inset floodplains (S1) on the left side abuts a broad floodplain/terraces (S2). Concave bank abuts bedrock on right side.	Inset floodplain is engaged in the 10% event and flow begins to short-circuit the main channel with high velocities. In large flood events (2% and 1%) the majority of flow is across the inset floodplain. Very small amount of flow on floodplain/terraces (S2) in large flood events (2% and 1%)	0.0	94.4	60.7	56.9	39.9	37.5
XS9	Broad inset floodplains (S1) on the left side abuts a broad floodplain/terraces (S2). Concave bank abuts bedrock on right side.	Inset floodplain is engaged in the 10% event initially with lower velocities and flow begins to short-circuit the main channel. In large flood events (2% and 1%) the majority of flow is across the inset floodplain at high velocities. Very small amount of flow on floodplain/terraces (S2) in large flood events (2% and 1%)	0.0	100.0	55.9	45.9	20.5	19.5
XS10	Narrow inset floodplains (S1) on the left side abuts a broad floodplain/terraces (S2). Broad inset floodplain on right side with some remnants of a terrace adjacent to the channel.	Channel flow conveys majority of flood flow up to 5% event but does not increase in large events. In large flood events (2% and 1%) the additional flow is conveyed through the right inset floodplain at high velocities which makes of the majority of the flood flow.	0.0	84.8	63.3	57.5	27.4	22.6

Fitzroy River

The Fitzroy River case study area, floodplain surfaces and 10 cross-sections used for this analysis are shown in Figure 112. The hydraulic results for the modelled events for both flow depth and velocity are shown in Figure 113 and Figure 114, respectively. A summary of the results from the 10 cross-sections across the case study area showing the percentage of floodplain flow conveyed within the Fitzroy River channel for each flow event is shown in Figure 111. A more thorough review of the results at each cross-section can be found in Attachment 1.

The percentage of floodplain flow conveyed within the channel for each cross-section is shown in Figure 115 with a summary of the hydraulics at each cross-section provided in Table 46. A summary of the cross-section analysis is provided with a box and whisker plot representing the percentage of floodplain flow conveyed within the Fitzroy River channel margins for each flow event across the 10 modelled cross-sections in Figure 111.

The upper sections of the case study area have very high channel capacity due to terrace/hillslope confinement and the majority of flow ins conveyed within the channel margins. For the majority of the case study area flow exits the main channel through floodplain channels and paleo features in frequent flood events (i.e. 20% AEP events). Often these floodplain channel convey the majority of floodplain flow. Once the broader floodplain is engaged in events greater than 10% AEP there are expansive zones of low velocity flow areas. In most flood events it is still common for 20-40% of the floodplain flow to be conveyed within the channel margins.

Likely impacts on SedNet floodplain deposition volumes on the Fitzroy River

In Section 4.10 the SedNet modelled bankfull flow was significantly overpredicted from the value determined from the hydraulic modelling (i.e. 11000 m^3/s compared to 2900 m^3/s for the inset floodplains). As a result, the SedNet floodplain deposition model assumes all flow above 11000 m^3/s (and its associated fine sediment loads) engages with the floodplain surface and the fine sediment can be deposited. This analysis indicates that the floodplain channels are engaged at much lower events (i.e. 2000 m^3/s) however these floodplain channels have higher velocities as the discharge increases. Once the SedNet bank fullflow is achieved it is likely that at least 30% of that flow is still conveyed within the channel margins and not across any floodplain units.

Based on this analysis it is difficult to draw conclusions on the deposition volumes estimates for this case study area however it may be underpredicted

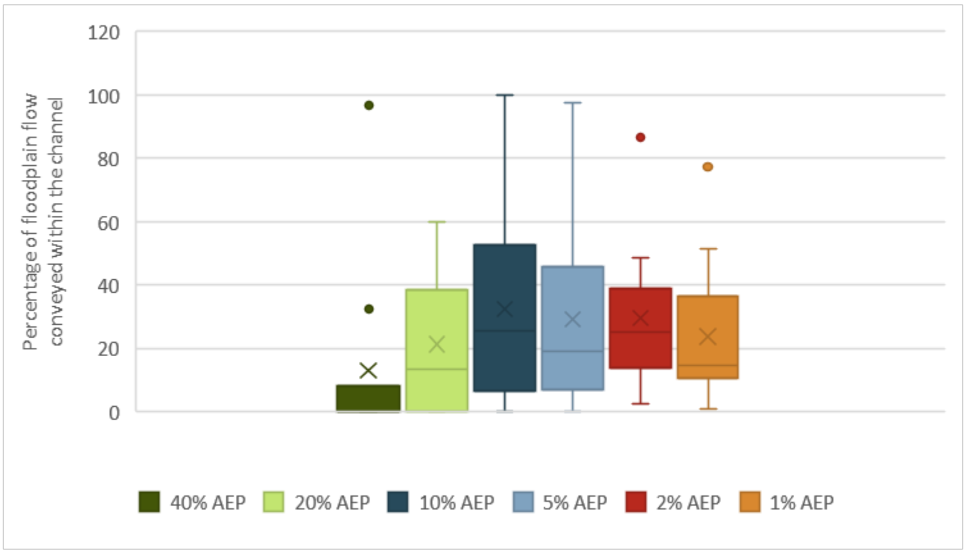


Figure 111. *Box and whisker plot representing the percentage of floodplain flow conveyed within the Fitzroy River channel for each flow event across the 10 modelled cross-sections, showing the minimum, maximum, lower and upper quartile values, mean, median, and outliers.*

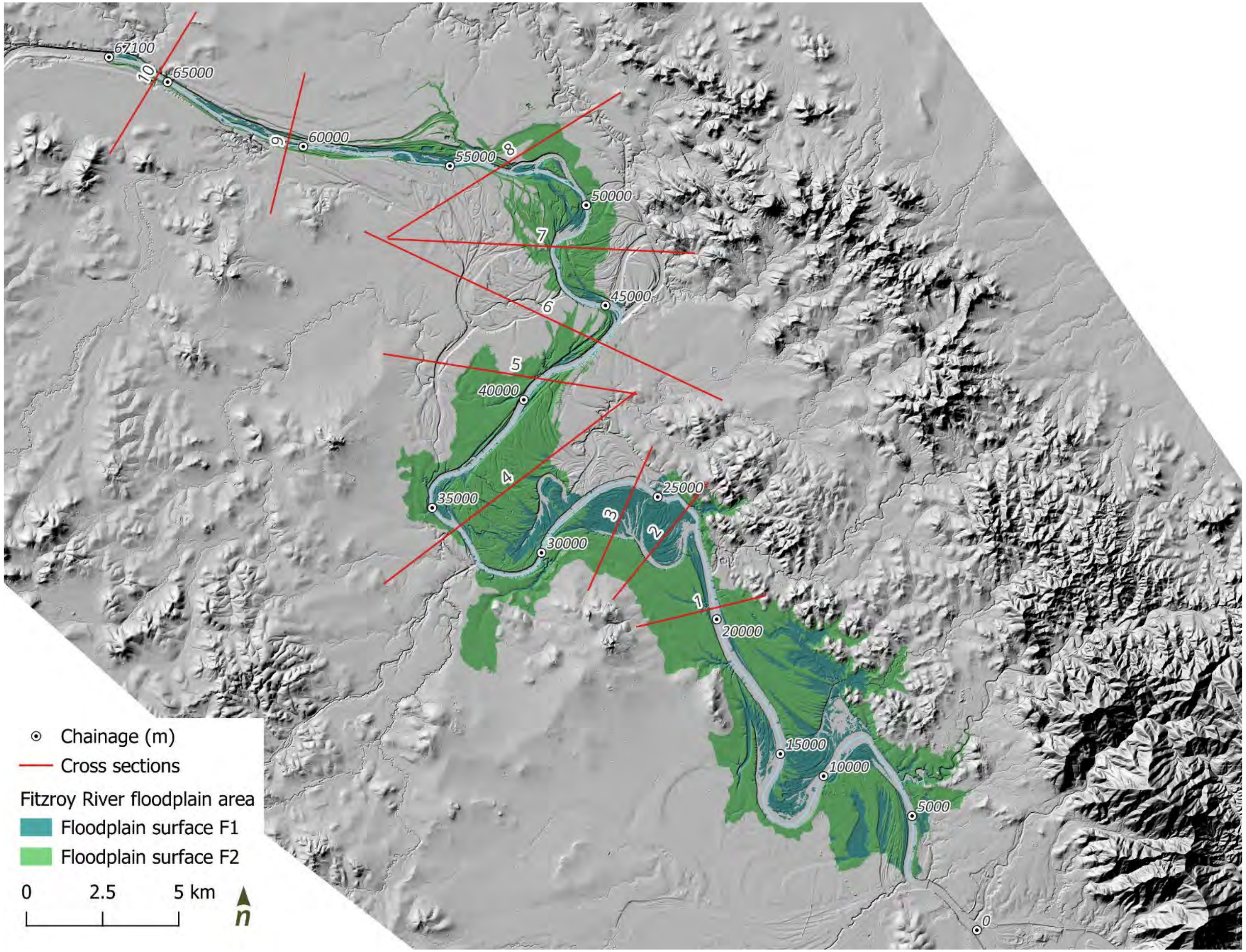


Figure 112. *Overview of Fitzroy River study area showing floodplains units and locations of the ten cross sections.*

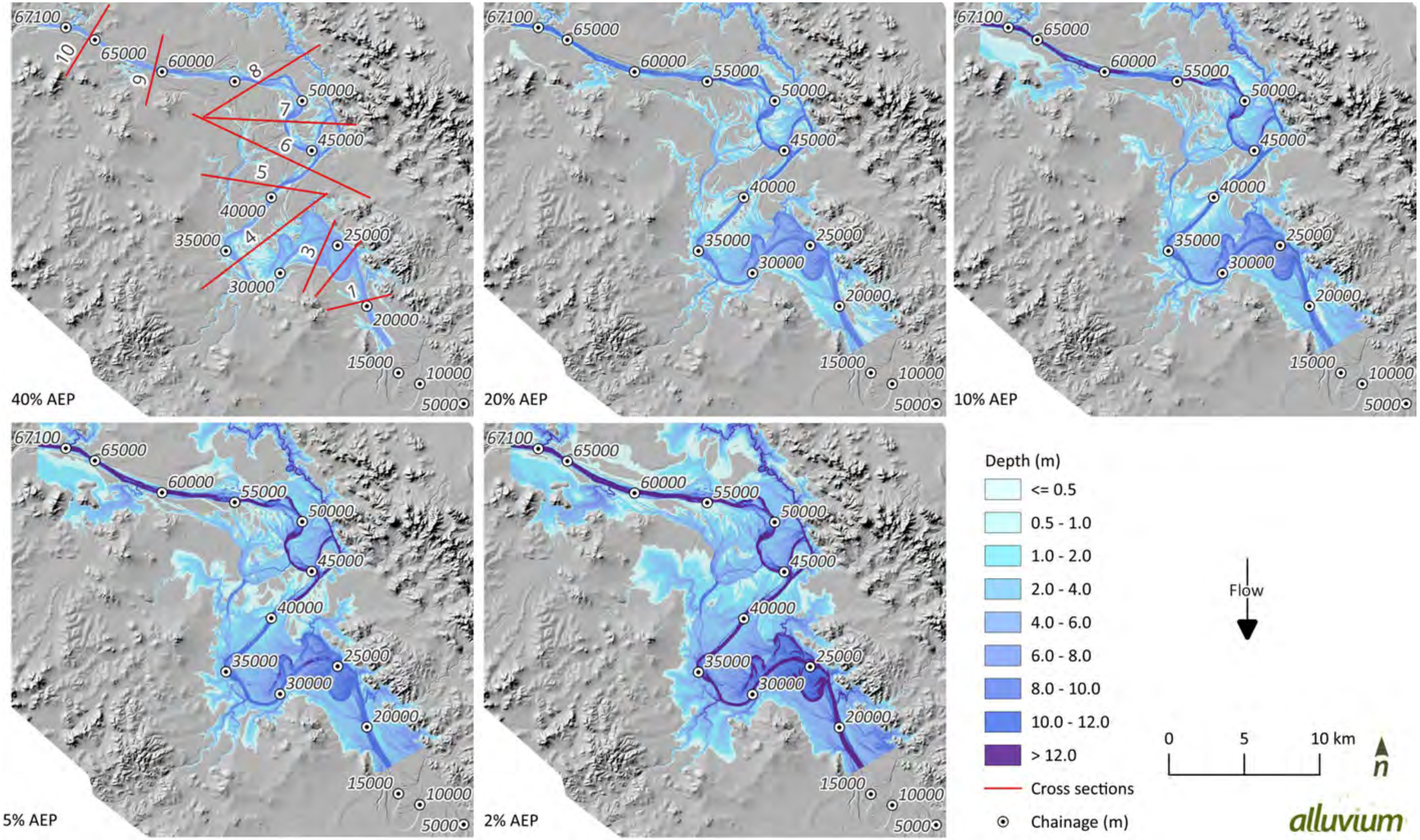


Figure 113. *Fitzroy River depth results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*

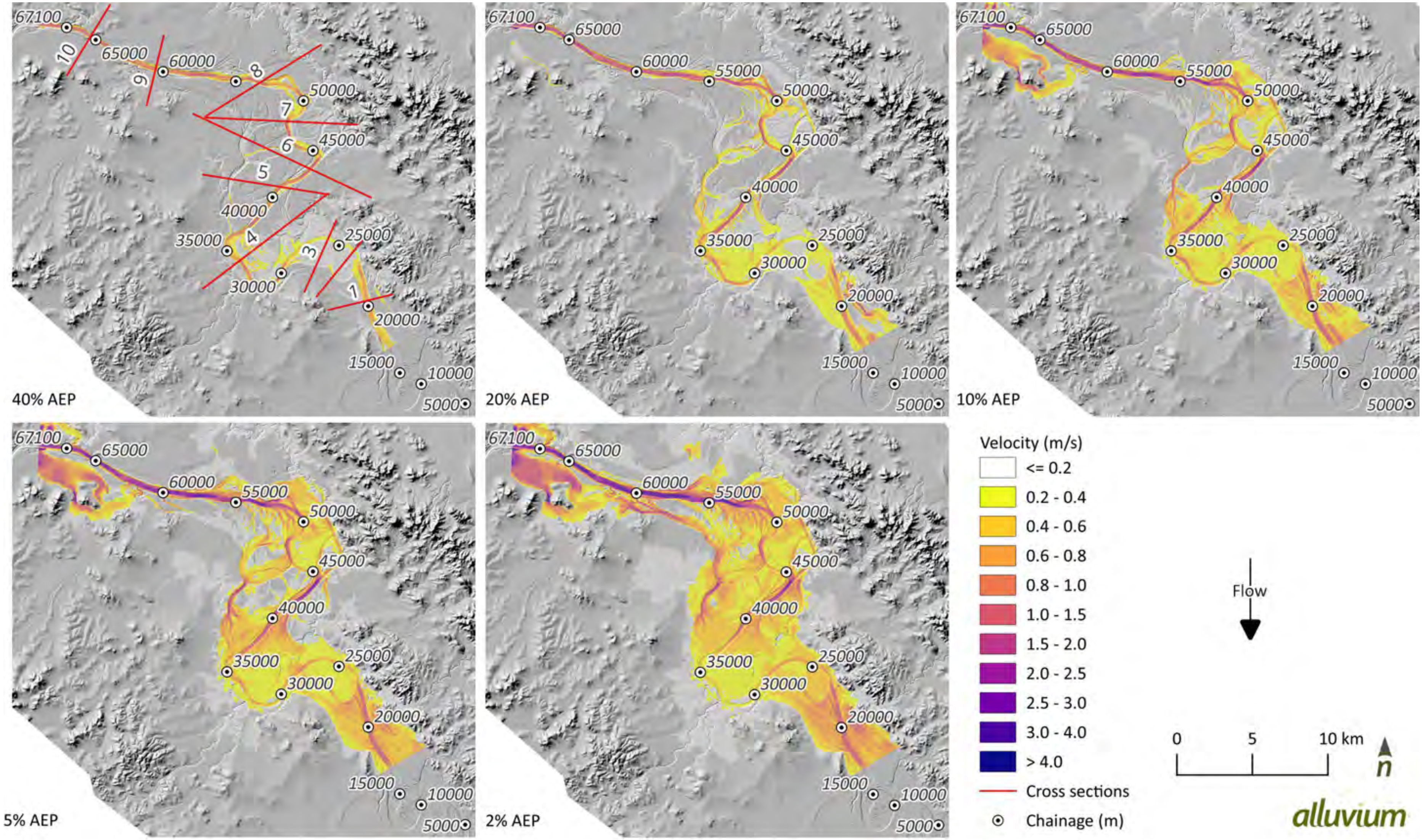
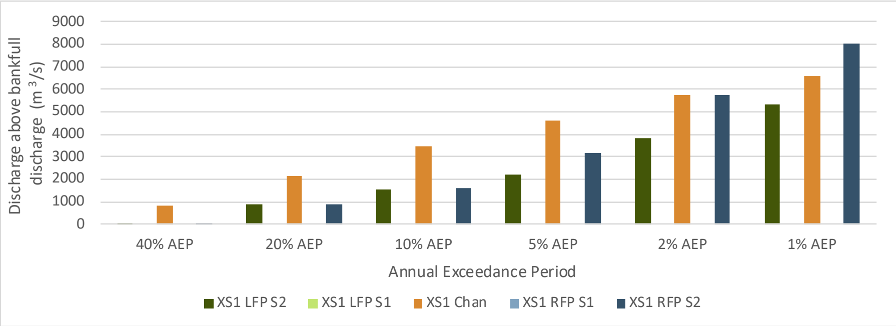
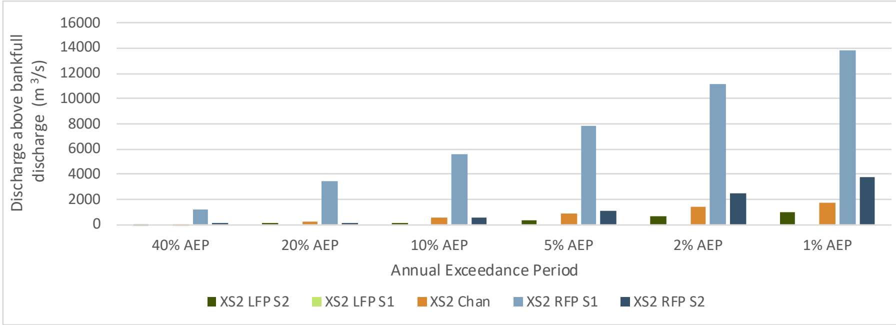


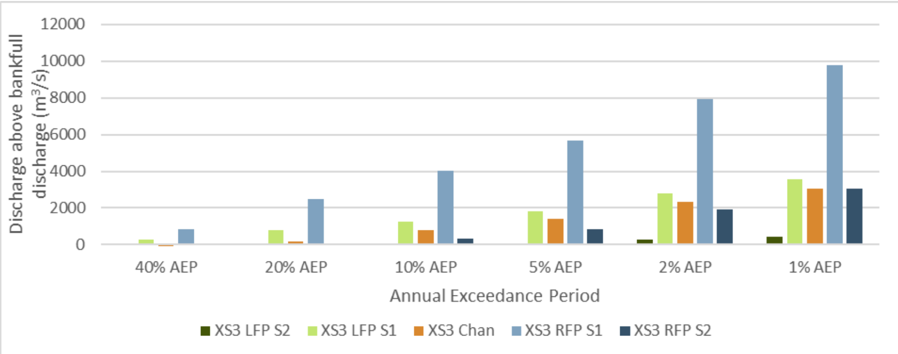
Figure 114. *Fitzroy River velocity results showing river-floodplain connectivity for the 40% AEP, 20% AEP, 10% AEP, 5% AEP, and 2% AEP events.*



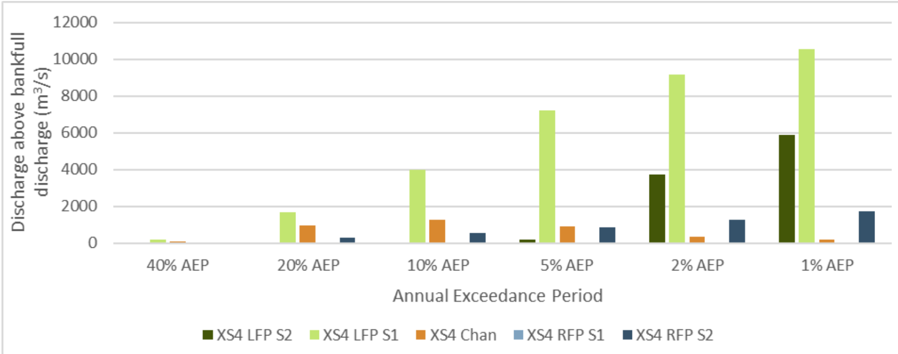
Discharge above bankfull discharge (m 3/s)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS1 LFP S2
XS1 LFP S1
XS1 Chan
XS1 RFP S1
XS1 RFP S2



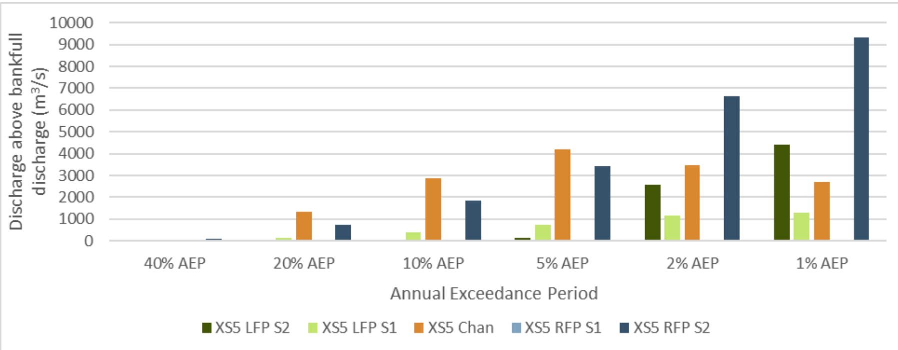
Discharge above bankfull discharge (m 3/s)
16000
14000
12000
10000
8000
6000
4000
2000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS2 LFP S2
XS2 LFP S1
XS2 Chan
XS2 RFP S1
XS2 RFP S2



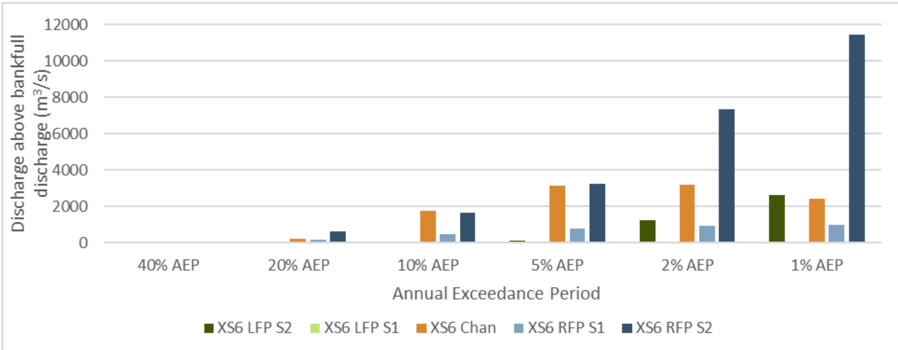
Discharge above bankfull discharge (m3/s)
12000
10000
8000
6000
4000
2000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS3 LFP S2
XS3 LFP S1
XS3 Chan
XS3 RFP S1
XS3 RFP S2



Discharge above bankfull discharge (m3/s)
12000
10000
8000
6000
4000
2000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS4 LFP S2
XS4 LFP S1
XS4 Chan
XS4 RFP S1
XS4 RFP S2



Discharge above bankfull discharge (m3/s)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS5 LFP S2
XS5 LFP S1
XS5 Chan
XS5 RFP S1
XS5 RFP S2



Discharge above bankfull discharge (m3/s)
12000
10000
8000
6000
4000
2000
0
40% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
Annual Exceedance Period
XS6 LFP S2
XS6 LFP S1
XS6 Chan
XS6 RFP S1
XS6 RFP S2

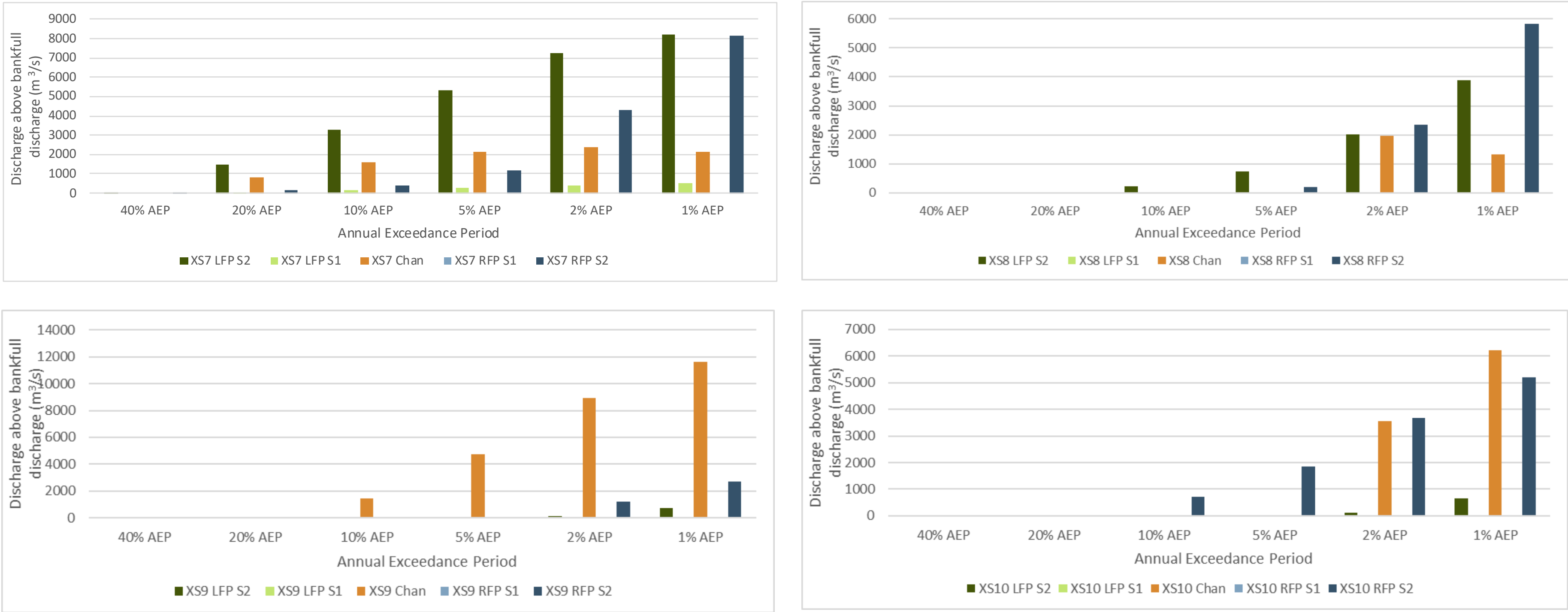


Figure 115. *Bar graphs showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces for each of the ten cross sections within the Fitzroy River study area. See Attachment 1 for individual cross section modelling results.*

Table 46. Overview of cross-sections for Fitzroy River case study area.

Cross section	Floodplain characteristics	Overview of floodplain flow characteristics	Percentage of floodplain flow conveyed within the channel for each event (AEP)					
			40%	20%	10%	5%	2%	1%
XS1	Floodplains on both banks up to 1000 m wide with a relatively straight flow alignment. Floodplain constricted on right side due to downstream valley constriction.	Large proportion of flow conveyed within channel for all events. Flow engages floodplains equally during the 20% AEP event with low velocities, portion of floodplain flow increases in larger events as does velocities.	96.7	54.7	51.4	44.5	35.9	31.5
XS2	Right bank inset floodplain (S1) due to large ox-bow lake from meander cutoff. Narrow constricted floodplain (S2) on left side.	The majority of flow in all events is conveyed within paleochannel features on the right inset floodplain and across this unit - low velocities on this unit.	0.0	7.2	9.0	9.2	9.0	8.7
XS3	Right bank inset floodplain (S1) due to large ox-bow lake from meander cutoff. Similar characteristics on the left side too with another ox-bow lake adjacent to a very narrow constricted floodplain (S2) .	The majority of flow in all events is conveyed within paleochannel features on the right inset floodplain and across this unit - low velocities on this unit.	0.0	5.3	12.1	14.1	15.4	15.5
XS4	Broad inset floodplain on the left bank with significant paleofeatures and floodplain channels. Narrow constricted floodplain (S2) on right side.	The majority of flow in all events is conveyed within paleochannel features on the left inset floodplain and across this unit - low velocities on this unit.	32.5	32.6	21.6	9.9	2.4	1.0
XS5	Narrow confined inset floodplain (S1) on the left bank. Broad floodplains (S2) on the left and right side several floodplain channels.	Floodplain channel on right side begin to be engaged in 20% and 10% AEP with high velocities. In larger events the flow spreads across the floodplains with lower velocities. Portion of channel flow decreases with flood magnitude however is still 50% in the 5 % AEP event.	0.0	60.0	56.1	49.4	25.1	15.1
XS6	Narrow confined inset floodplain (S1) on the right bank. Broad floodplains (S2) on the left and right side several floodplain channels.	Floodplain channel on right side begin to be engaged in 40% AEP with low velocities. High velocities on inset floodplain. Portion of channel flow decreases with flood magnitude however is still 43 % in the 5 % AEP event.	0.0	19.9	45.5	43.1	24.9	13.9
XS7	Narrow, confined, inset floodplain on left side. Broad floodplains (S2) on the left and right side several floodplain channels.	Floodplain channel on left side begin to be engaged in 20% AEP and conveys the largest portion of flow for all events. High velocities on inset floodplain. Portion of channel flow decreases with flood magnitude however is still 24 % in the 5 % AEP event.	0.0	33.0	29.1	23.9	16.5	11.2

XS8	Broad floodplains (S2) on the left and right side with several floodplain channels.	Very high channel capacity. Floodplain channels begin to be engaged in 10% and 5% events with high velocities. Floodplain channels convey bulk of flow, however once whole floodplain is engaged in the 2% AEP event, 31 % of flow is within the channel.	N/A	N/A	0.0	0.0	31.3	12.0
XS9	Broad floodplains (S2) on the left and right side. Shallow floodplain channel on the right side. Very entrenched channel.	Very high channel capacity. Floodplain channels begin to be engaged in 2% event. Majority of flow conveyed within the channel.	N/A	0.0	99.7	97.3	86.6	77.1
XS10	Broad floodplains (S2) on the left and right side. Shallow floodplain channel on the right side. Very entrenched channel.	Very high channel capacity. Floodplain channels begin to be engaged in 10% event and conveys bulk of flow in 10% and 5% AEP event with high velocities.	N/A	0.0	0.0	0.0	48.4	51.4

Summary

The three case study assessments presented above show significant variations in floodplain depth and velocity characteristics due to variations in floodplain width and valley constriction. Valley constrictions control the flood hydraulics, these constrictions can create backwater zones across floodplains which encourage deposition. However, this process also leads to more flow being conveyed within the channel and directly above the channel (i.e. not interacting with the floodplain surface). This study has found that often a large proportion of the flow above the bankfull flow (≈ 30-70%) is conveyed within the channel margins (i.e. above the channel banks) and not across the floodplain surfaces. This finding has significant implications for how floodplain deposition is currently modelled in GBR catchments.

5.4 Impact of more Floodplain Vegetation on flooding and flood velocities

Assessed reach

The impact of increasing floodplain roughness on floodplain engagement was assessed using a reach on the Mary River. The location of the reach relative to the Mary River case study area is shown in Figure 116. This reach was selected as it has expansive inset floodplains upstream of valley/terrace constrictions which could be targeted to enhance floodplain deposition.

This section describes the hydraulic modelling approach and presents the results.

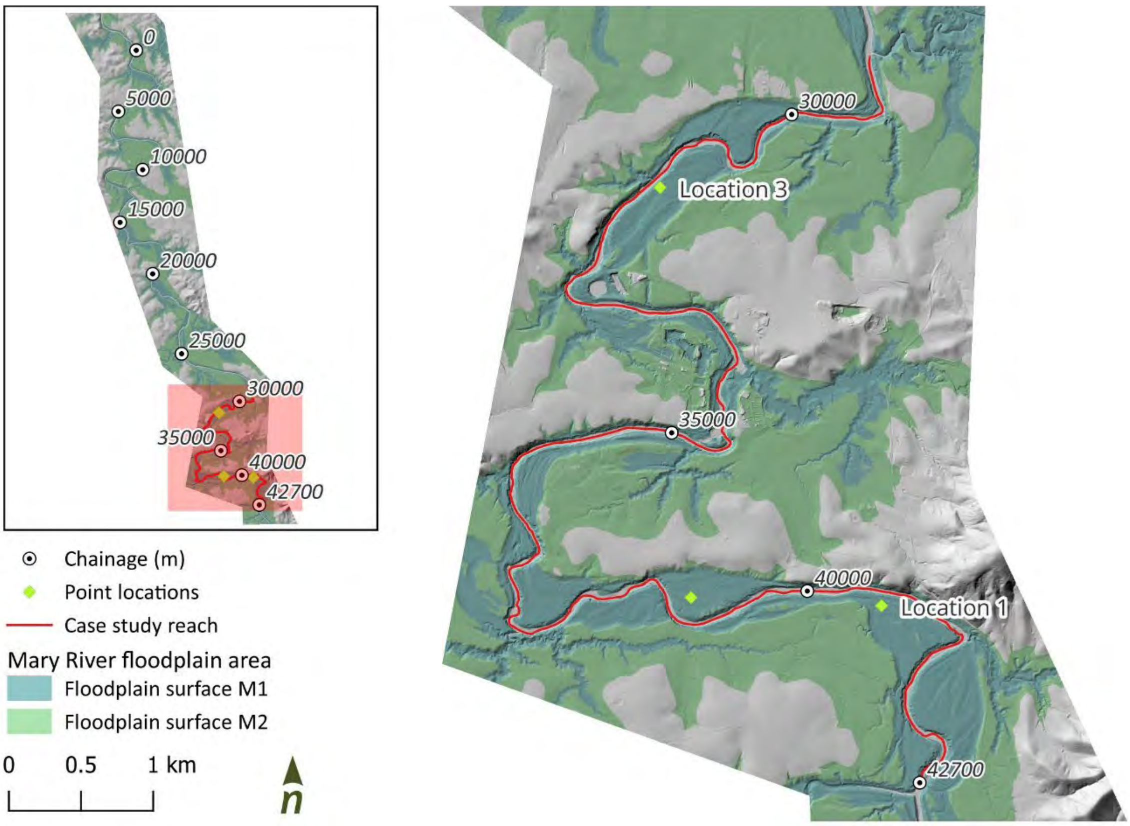


Figure 116. *Location of the case study reach used in the floodplain engagement assessment.*

Modelled events

The 20% AEP and 5% AEP events were modelled using real event data from the Mary River at Moy Pocket gauge (138111A). An event matching the 20% AEP flow was extracted from between 10 October 2010 to 27 October 2010 and was then scaled to match the 5% AEP flow event. These events were run through a cut-down HEC-RAS model to assess only the case study area. The model utilised shallow water equations to undertake the hydraulic computations.

Scenarios

Five scenarios were modelled to assess the impact of increasing vegetation and therefore roughness of the channel, riparian zone and inset floodplain (**Table 47**). The five scenarios included:

- **Scenario 1** - a base case scenario where there was moderate bank vegetation and no floodplain vegetation (see Figure 117)
- **Scenario 2a** – Dense riparian vegetation on the riverbanks (Figure 118),
- **Scenario 2b –** Dense riparian vegetation on the riverbanks a 20 m overbank planting zone (Figure 118),
- **Scenario 3** – Moderate bank vegetation and dense vegetation on the inset floodplains (Figure 119), and
- **Scenario 4** - Dense riparian vegetation on the riverbanks and inset floodplains. (Figure 119) .

The Manning's roughness coefficients assigned to the four distinct zones (inundated section of channel, vegetated section of channel, vegetated overbank i.e. riparian zone, and inset floodplain) are summarised in Table 47. The vegetation zones for each scenario are shown in Figure 117to Figure 119.

Table 47. Manning's roughness coefficients used in the five modelled scenarios.

		Manning's n			
ID	Scenario	*Water – low flow channel*	*Vegetated channel*	*Vegetated overbank*	*Inset floodplain*
1	Base case	0.04	0.055		0.03
2 a	Channel roughening	0.04	0.1		0.03
2 b	Channel roughening with overbank vegetation	0.04	0.1	0.1	0.03
3	Inset floodplain roughening	0.04	0.055		0.1
4	Combined (channel and inset floodplain roughening)	0.04	0.1		0.1

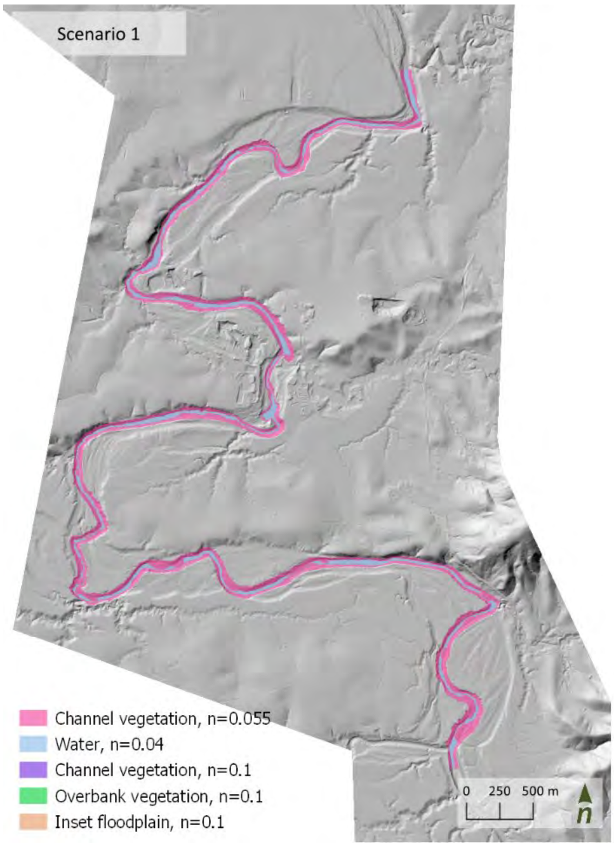


Figure 117. *Scenario 1 Manning's n delineation*

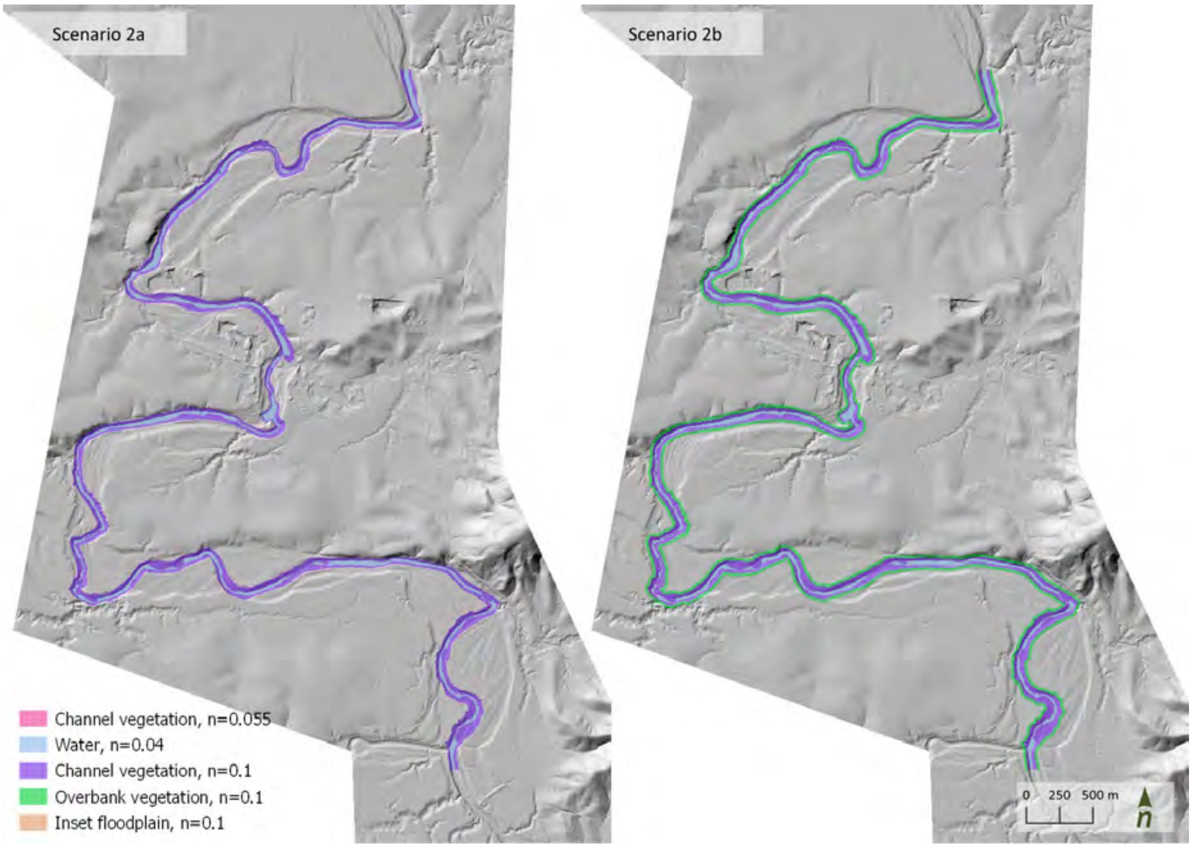


Figure 118. *Scenario 2a and 2b Manning's n delineation*

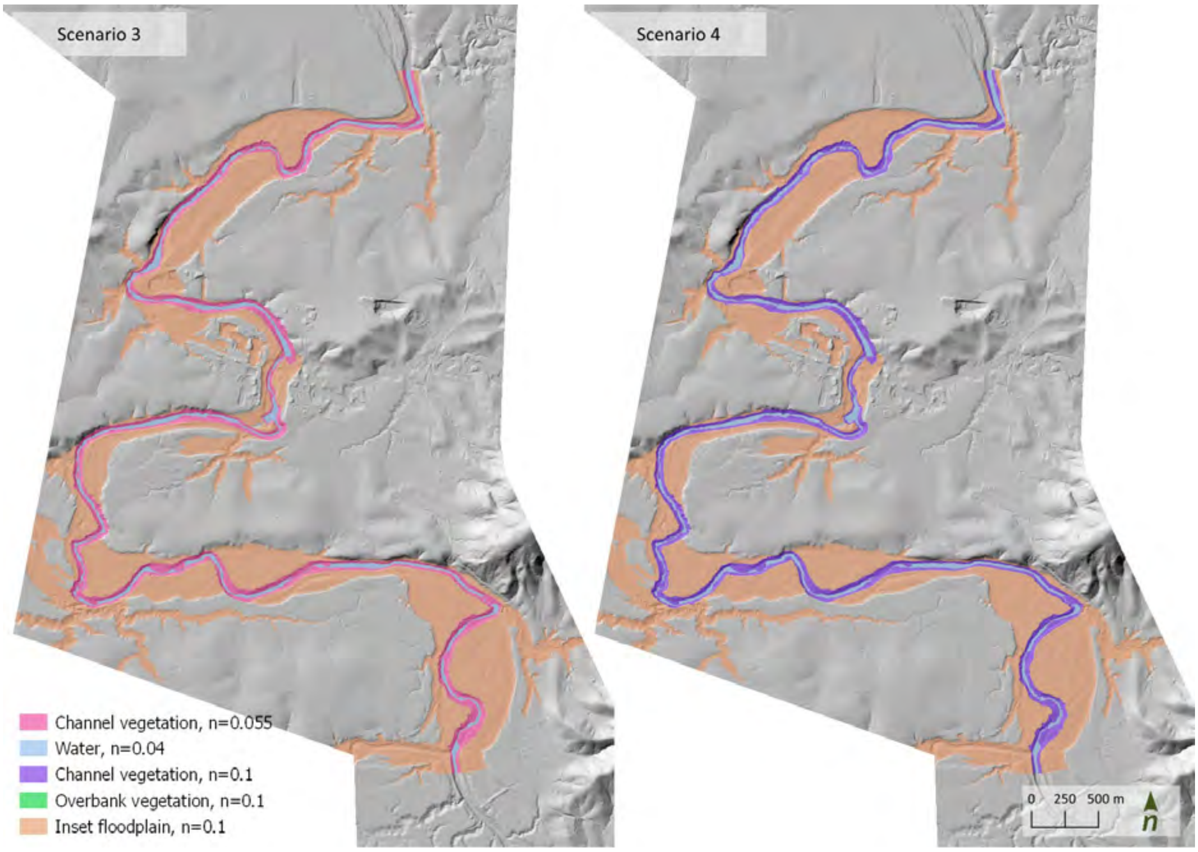


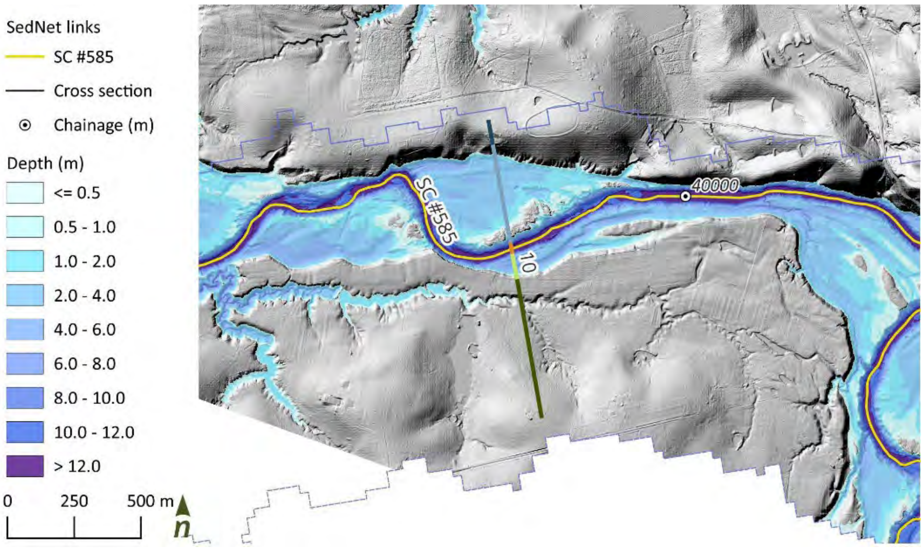
Figure 119. *Scenario 3 and 4 Manning's n delineation*

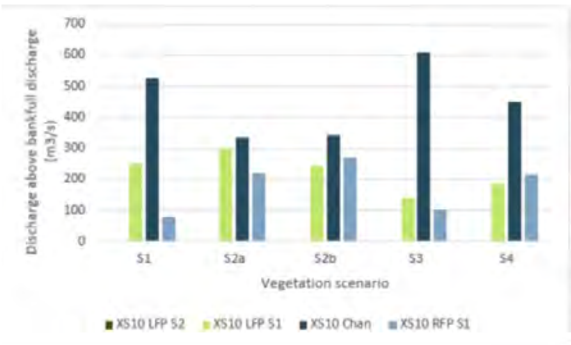
Results

Question 2a: How will changing in-stream roughness affect floodplain flow

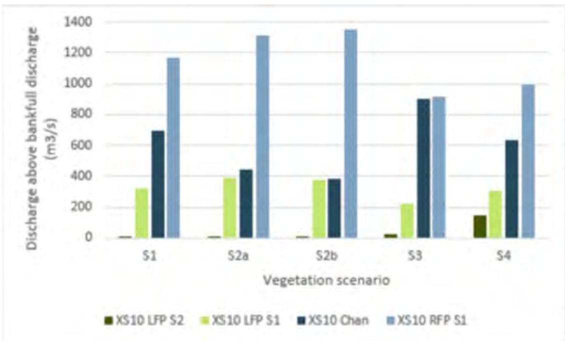
The results of the modelling of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross-section 10 for both events is presented in Figure 120. The key findings show:

- The scenarios which increased channel roughness (i.e. Scenario 2a and 2b) resulted in a significant increase in floodplain flow for the 20% AEP event. In Scenario 2a, the left inset floodplain flow increases by 20% and the right inset floodplain increases by 180%. For Scenario 2b, the left inset floodplain remains the same and the right inset floodplain increases by 250%. As a result, more flow and its fine sediment load would be conveyed across the floodplains.
- The scenarios which increased channel roughness (i.e. Scenario 2a and 2b) resulted in a slight increase in floodplain flow for the 5% AEP event. In Scenario 2a and 2b, both inset floodplains had an increase in flow by between 12-20% while channel flow decreased by 35-45%.
- Adding roughness to the floodplain only (i.e. Scenario 3) results in more flow being conveyed within the channel margins and less flow across the floodplain.





Results for the 20% AEP event



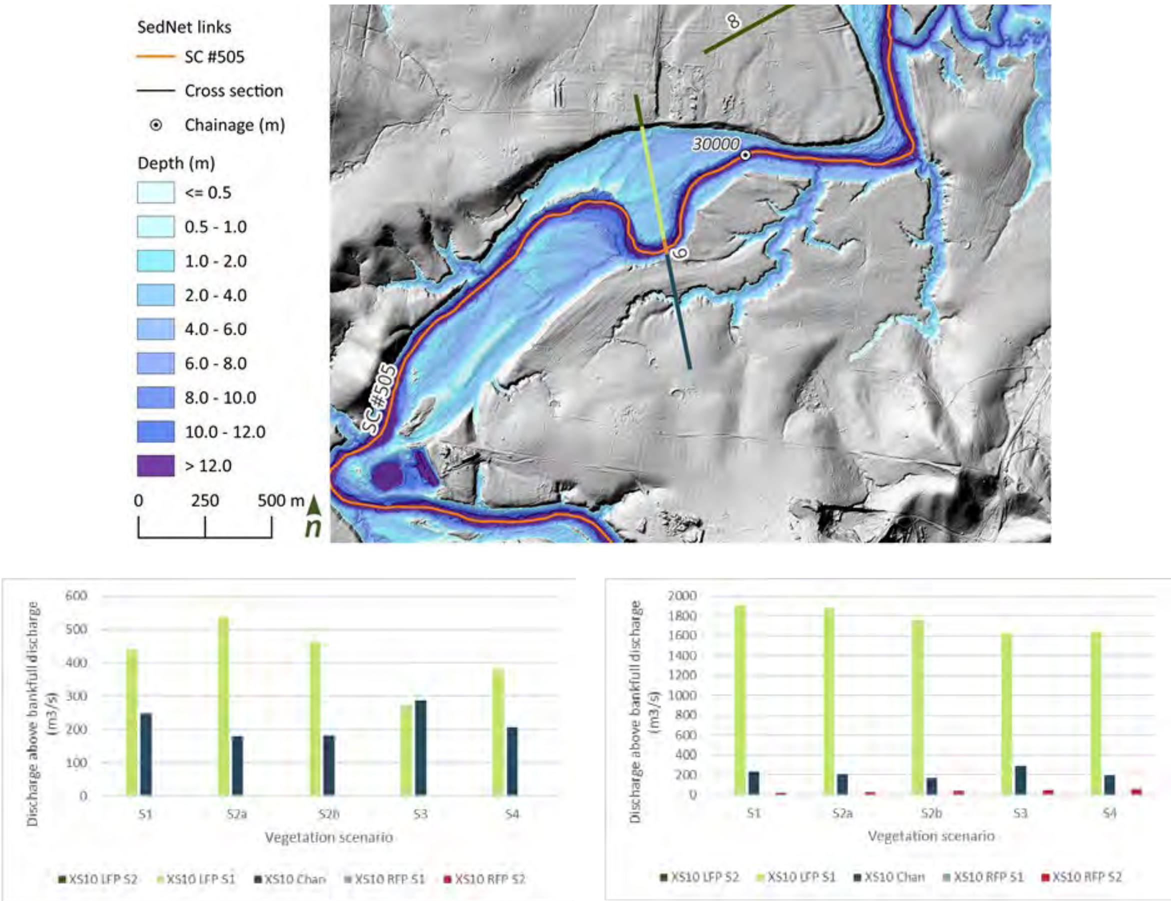
Results for the 5% AEP event

Figure 120. *The amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross-section 10 (see top) for the 20% AEP (bottom left) and 5% AEP (bottom right) for each of the five modelled scenarios*

The results of the modelling of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross-section 9 for both events is presented in Figure 122. The key findings show:

- The scenarios which increased channel roughness (i.e. Scenario 2a and 2b) resulted in some increase in floodplain flow for the 20% AEP event. In Scenario 2a, the left inset floodplain flow increases by 20% while in Scenario 2b, the left inset floodplain increases by 5%.

- In the 5% AEP event there are negligible changes in the flow as floodwater are largely bypassing the channel and flowing along the shorter floodplain flowpath (LFP S1).
- Increasing roughness to the floodplain only (i.e. Scenario 3) results in more flow being conveyed within the channel margins and less flow across the floodplain.



Results for the 20% AEP event *Results for the 5% AEP event*

Figure 121. *The amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross-section 9 (see top) for the 20% AEP (bottom left) and 5% AEP (bottom right) for each of the five modelled scenarios*

Question 2b: How will changes in channel and floodplain roughness affect flood velocities

The changes to peak velocities during the 20% AEP event for the four management scenarios compared to the base case scenario (i.e. Scenario 1) is shown in Figure 122 and Figure 123. The temporal changes in floodplain velocity at the three locations shown in Figure 116 are presented in . The key findings from these results include:

- The scenarios which increased channel roughness (i.e. Scenario 2a and 2b) resulted in a significant increase in floodplain velocity for the 20% AEP event. In some locations this resulted in a reduction in the duration that the flow velocity is less than 0.1 to 0.2 m/s (fine sediments begin to deposit when the flow velocity drops below this range (Knighton, D. (1998)).
- Increasing roughness to the floodplain only (i.e. Scenario 3) results in significant areas of reduced floodplain velocity which can slightly increase the duration that that the flow velocity is less than 0.1 to 0.2 m/s.

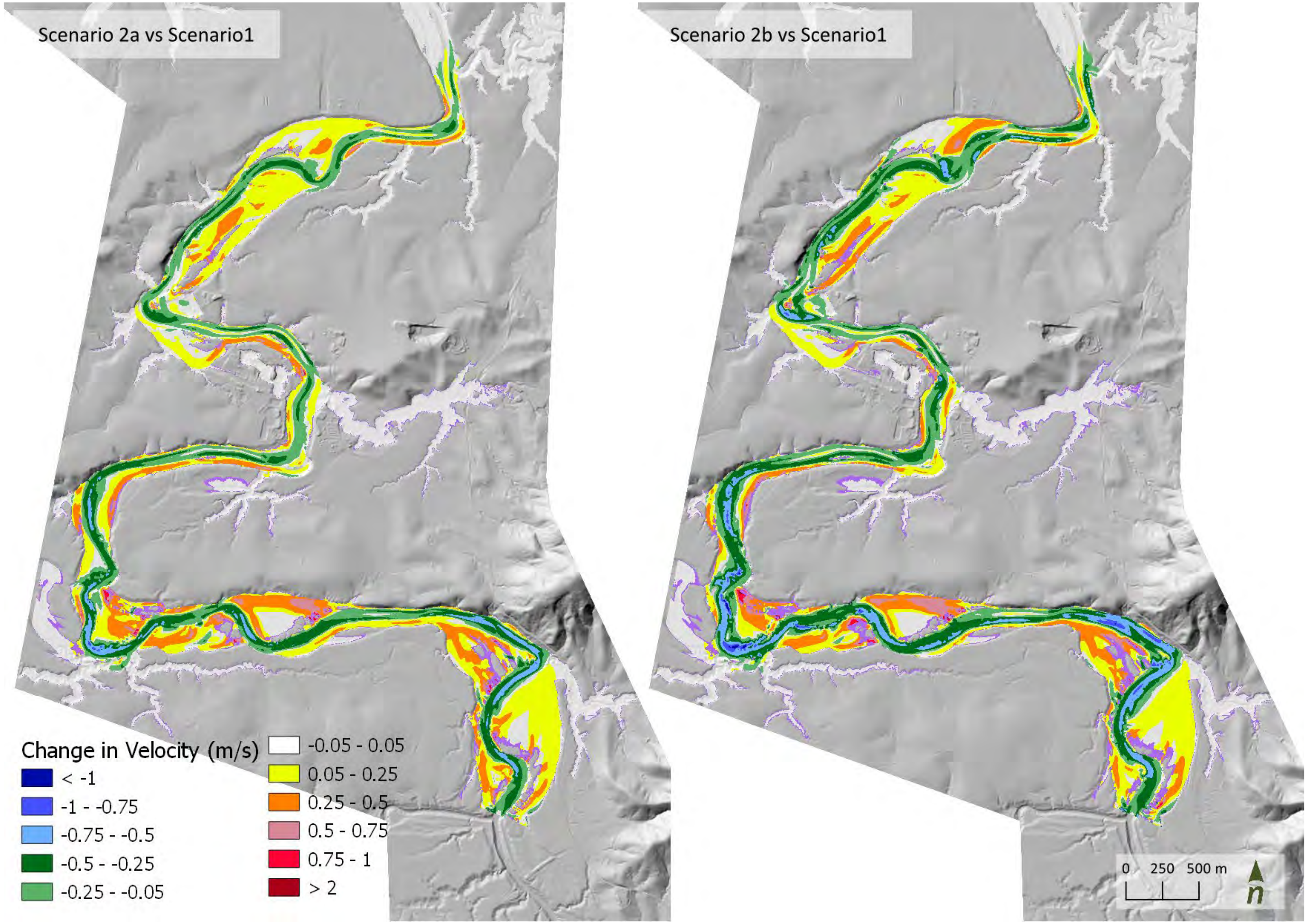


Figure 122. *Changes in peak velocities for the 20 % AEP event for Scenario 2a (left) and Scenario 2b (right) compared to the base case (i.e. Scenario 1)*

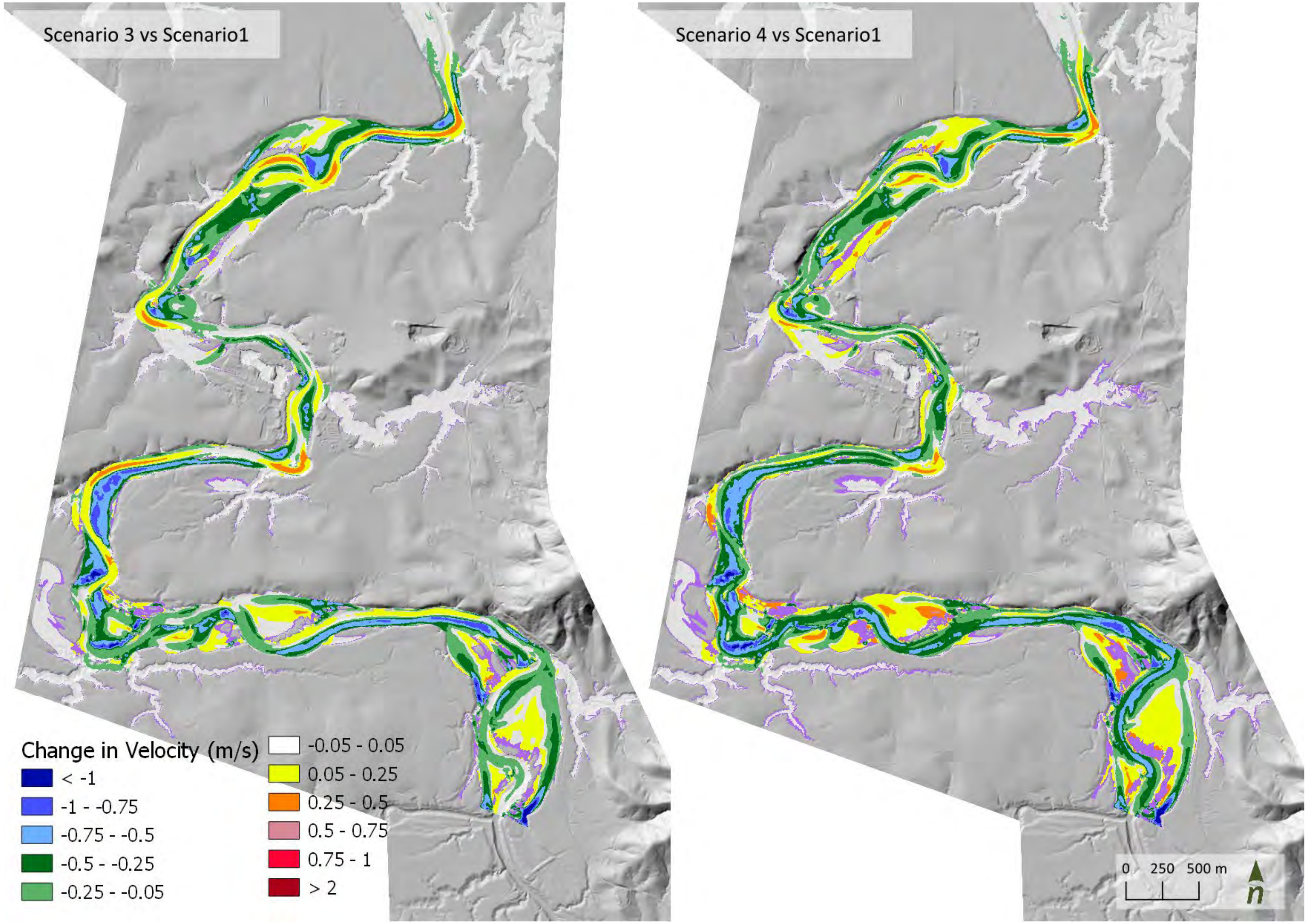


Figure 123. *Changes in peak velocities for the 20 % AEP event for Scenario 3 (left) and Scenario 4 (right) compared to the base case (i.e. Scenario*

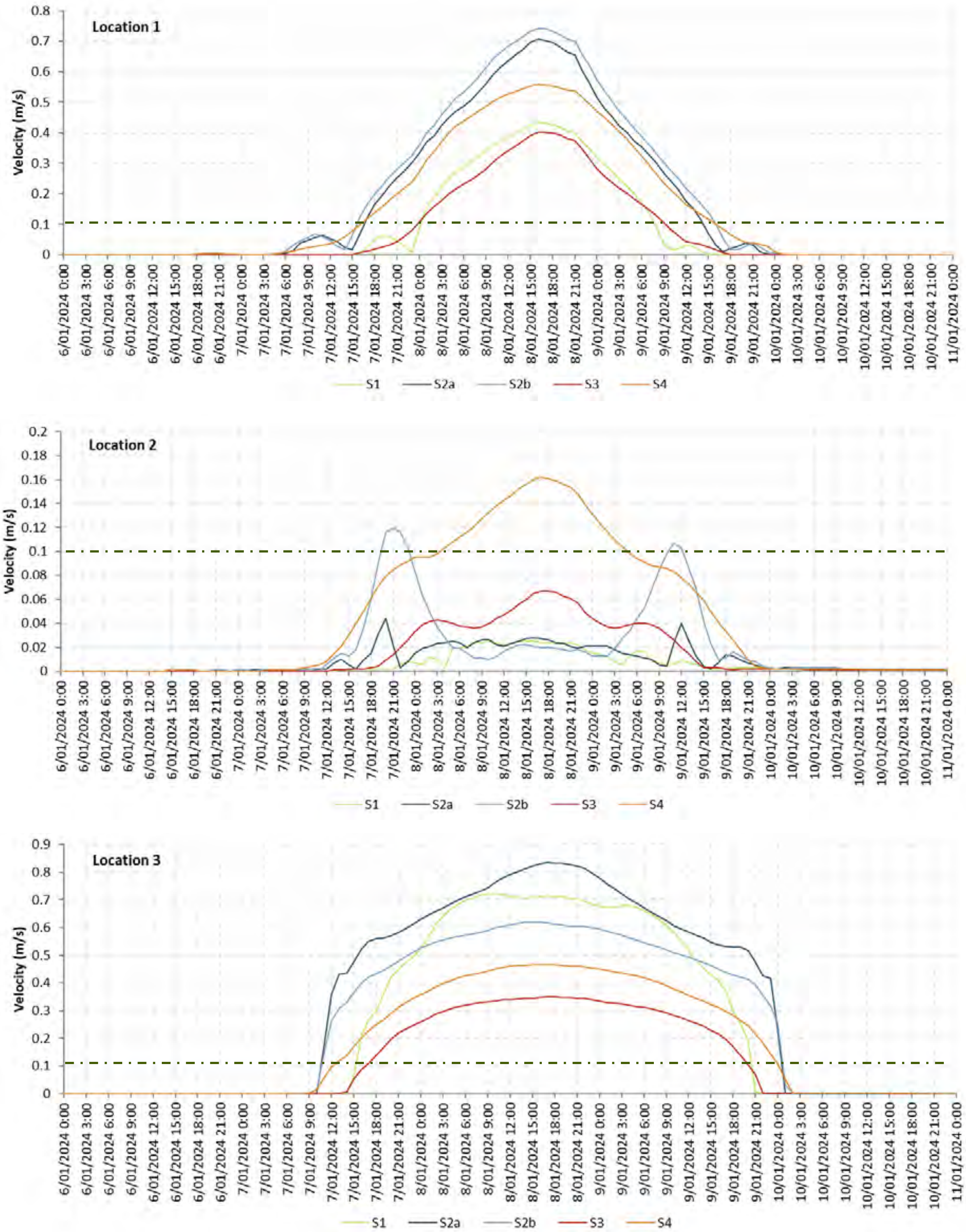


Figure 124. *Time series showing change in velocity over a 24-hour period for a 20% AEP event at locations 1, 2 and 3 of the case* study reach (**Figure 116**).

Summary

The modelling of different scenarios indicates that increasing the channel and/or floodplain roughness can result in significant changes to the key metrics that impact floodplain deposition i.e. floodplain flow and floodplain velocities. However, the impacts are highlight dependent on the floodplain characteristics. This indicates there is significant potential for reach scale stream management programs to consider floodplain deposition as a key design criteria, in addition to stream stability. This could be undertaken by targeting specific geomorphic channel/floodplain attributes and scenarios testing similar to this study.

6 Summary and recommendations

The Dynamic SedNet model makes some assumptions about the hydrology and geomorphology of floodplains in the GBR catchments. Specifically, the model assumes that:

a) Water moves onto the floodplain (and hence begins deposition of sediment) when the bankfull flow is exceeded
b) All flows above bankfull engage with the floodplain and move sediment onto the floodplain.

We assessed these assumptions. In general, the results demonstrate that channel dimensions (and bankfull flows) as well as floodplain widths (confinement) and elevations are extremely variable. We have not investigated why GBR channels are so variable in their dimensions, but the implication is that it introduces substantial uncertainty to estimates of floodplain deposition rates produced by the Dynamic SedNet model.

Section 3 of this report identified that bankfull flow recurrence interval, floodplain flow volumes, floodplain vegetation, valley confinement and constrictions, floodplain area and morphology, and sediment supply are important drivers of floodplain deposition. The variation in all these variables across GBR streams makes floodplain deposition predictions a very complex task.

Section 4 reviewed 17 case study areas which consisted of 60 Dynamic SedNet modelled links. As part of this review both bankfull flow and floodplain area was assessed and compared to the SedNet parametrisation. This assessment identified significant variations in the bankfull flow and floodplain areas used in Dynamic SedNet compared to values identified in hydraulic modelling and LiDAR analysis. The majority of links assessed (i.e. 63%) underestimated bankfull flow. The bankfull flow estimates from the SedNet model are typically in the 1-2 year ARI range. However, the bankfull flows within the 17 case studies assessed for the study are typically in the 5-50 year range.

Section 5 presented results of two-dimensional hydrodynamic modelling for three case study areas. The findings highlighted that valley and terrace constrictions, which are widespread in GBR catchments, exert significant control on floodplain hydraulics. A significant portion of the flow (≈ 30-70%) above the bankfull flow is still conveyed within the channel margin and not across the floodplain.

This study has identified that for the majority of SedNet links underestimated bankfull flow and that often the majority of flow greater than bankfull flow is conveyed within the channel margins and not on the floodplain. As a result, the likely floodplain flow discharges for the majority of modelled links are significantly less than the current modelling predictions. ***Based on these findings it is likely that the floodplain deposition volumes for the majority of links are significantly overestimated.***

The following recommendations are based on the outcomes of this study and will substantially improve the modelled floodplain deposition results of the SedNet model:

6. It is recommended all bankfull flow estimates within the Dynamic SedNet model are updated by using the Manning's equation approach outlined in Section 4. The effectiveness of this approach relies on the accuracy of the other channel geometry parameters (i.e. slope, channel width and bank height). However, if these parameters are correct then the Manning's equation approach, which accounts for the geomorphic variability of the channels, should significantly improve bankfull flow estimates compared to the current hydrological approach (i.e. assuming a recurrence interval).
7. The percentage of floodplain flow (i.e. flow above the bankfull flow) within the SedNet model should be reduced from 100% to 50% ***as an interim measure*** to more accurately reflect the floodplain flow. . The 50% interim measure is based on the findings in this study that a significant portion of the flow (≈

30-70%) above the bankfull flow is still conveyed within the channel margin and not across the floodplain. Eventually the proportion of flow moving onto the floodplain can be estimated more accurately for each reach based on a floodplain classification approach (see below).

8. A floodplain classification approach should be developed, and more detailed two-dimensional hydraulic modelling should be undertaken to understand the channel-floodplain connectivity processes for each main floodplain type. This will help refine the floodplain deposition model in SedNet for different floodplain types.
9. Undertake monitoring of deposition post flood events for different floodplain types to test some of the assumptions in the SedNet model, and test the conclusions from this study. These results will improve model calibration.

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Attachment 1. Hydraulic modelling results

Raby Creek

Cross section 1

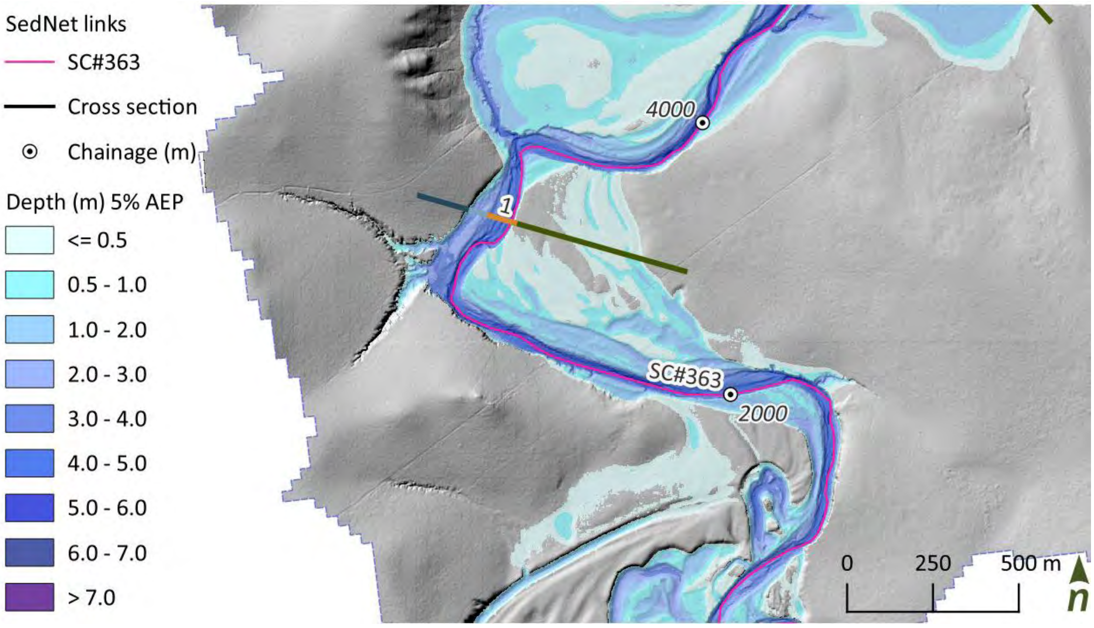

Figure 125. *Location of cross section 1 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

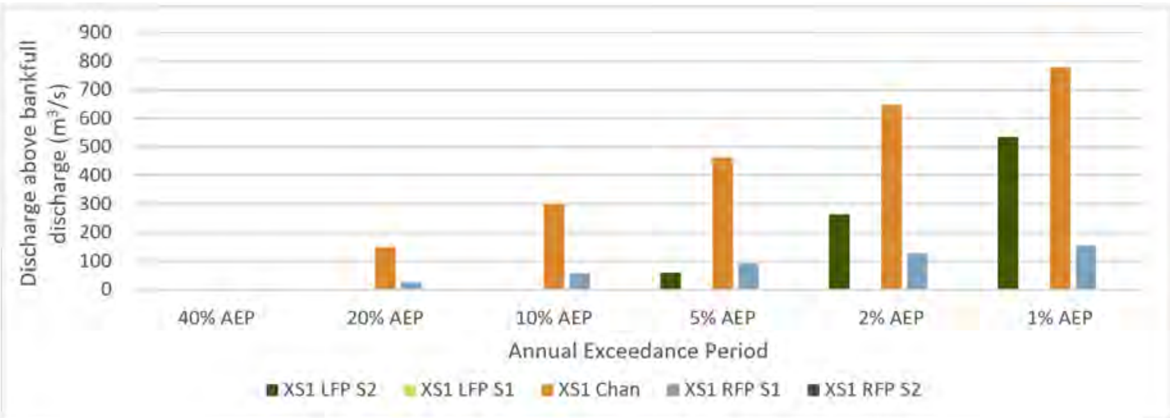

Figure 126. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 1 within the Raby Creek study area.*

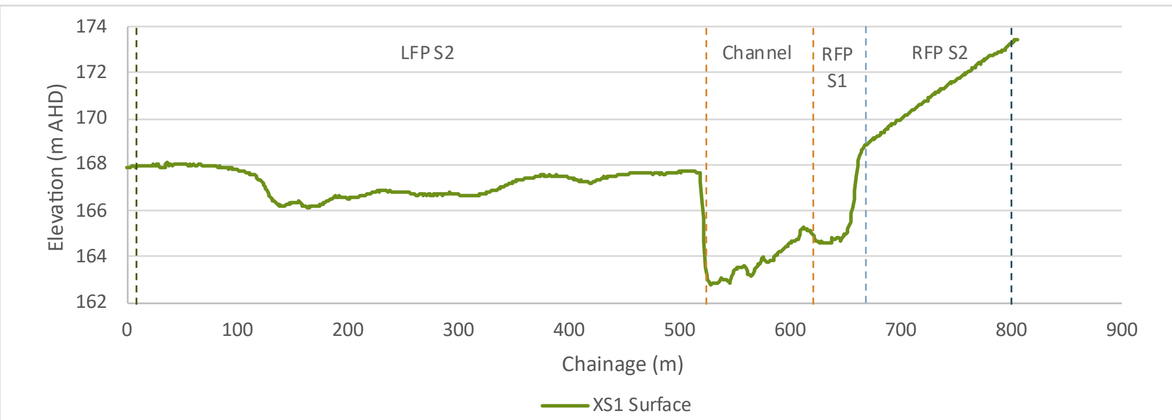

Figure 127. *Cross section 1 within Raby Creek study area (cross-section location shown in Figure 125).*

Cross section 2

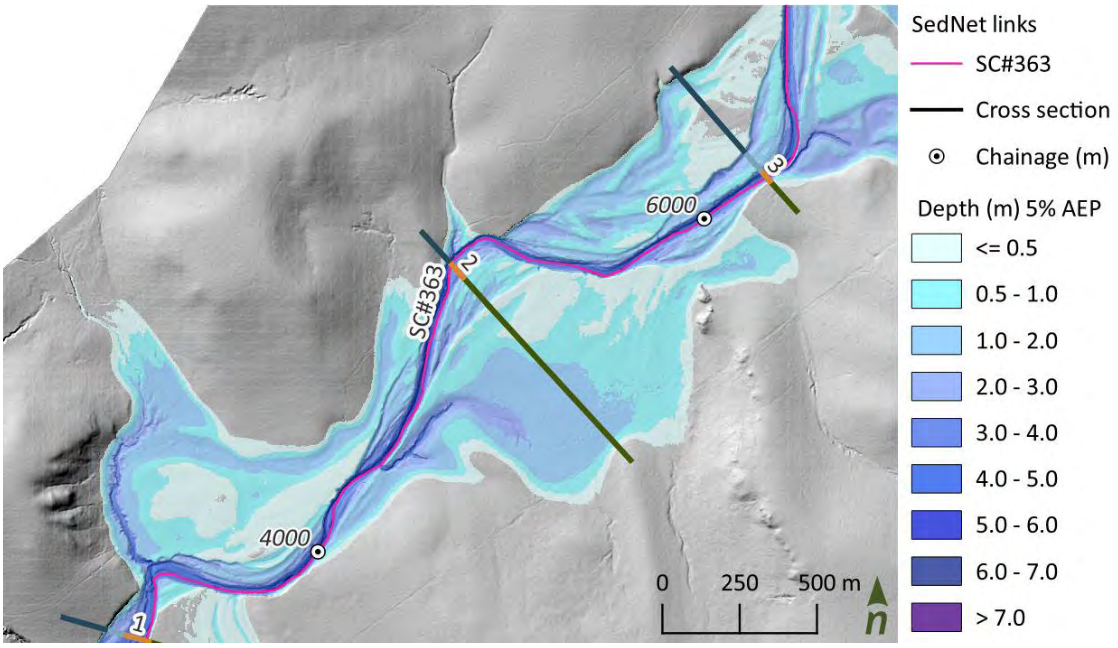

Figure 128. *Location of cross section 2 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

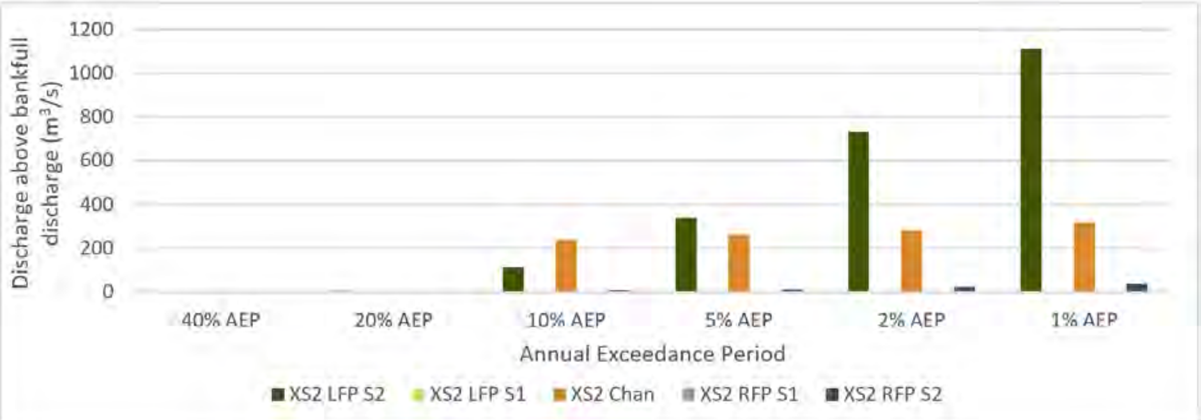

Figure 129. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 2 within the Raby Creek study area.*

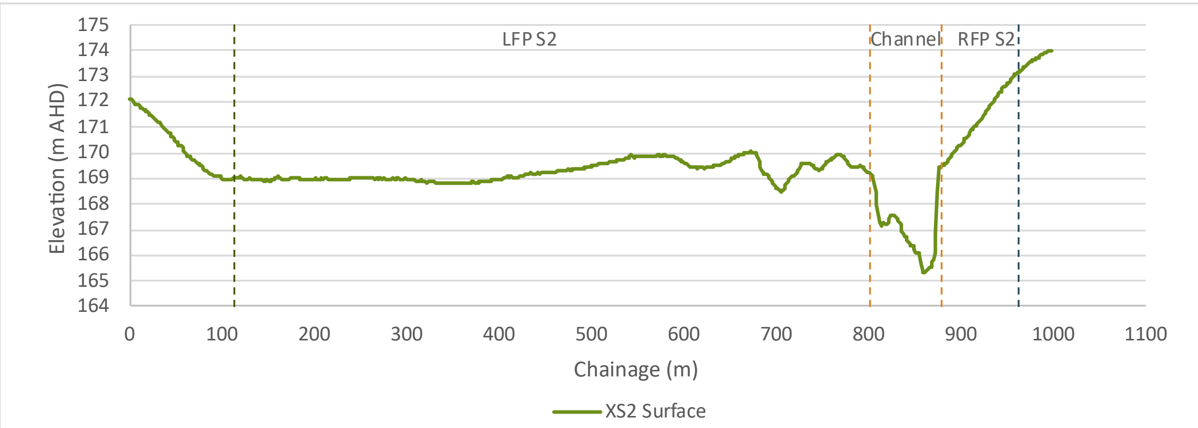

Figure 130. *Cross section 2 within Raby Creek study area (cross-section location shown in Figure 128).*

Cross section 3

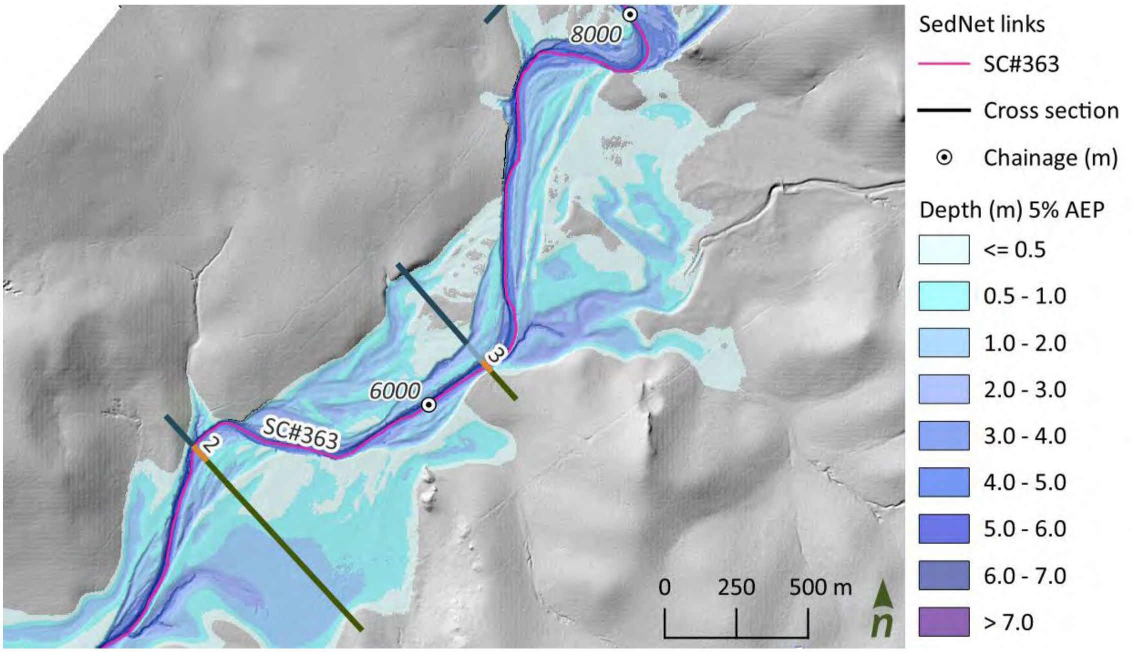

Figure 131. *Location of cross section 3 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

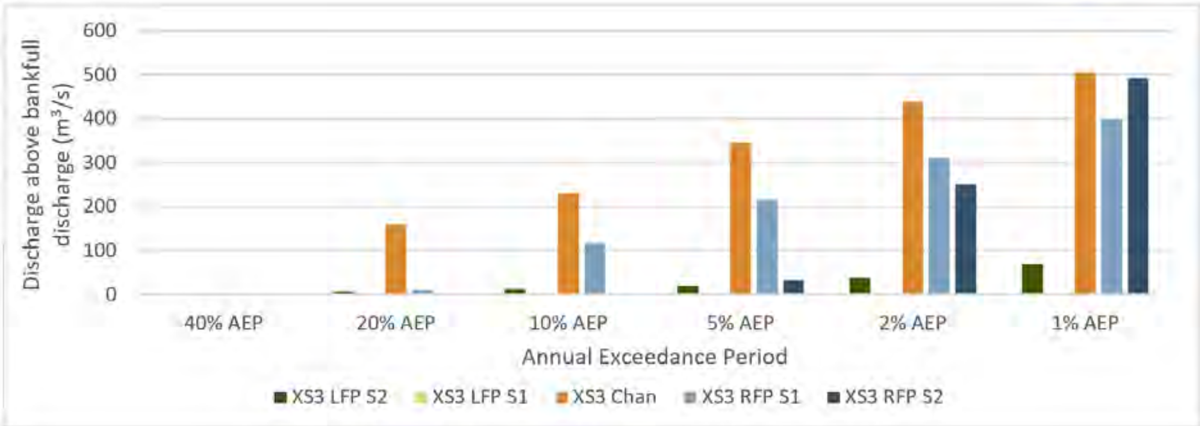

Figure 132. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 3 within the Raby Creek study area.*

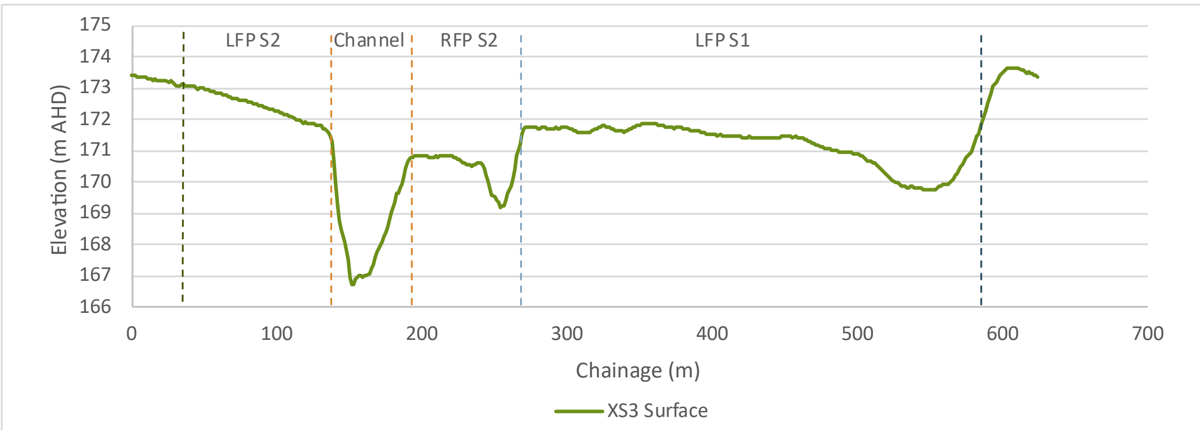

Figure 133. *Cross section 3 within Raby Creek study area (cross-section location shown in Figure 131).*

Cross section 4

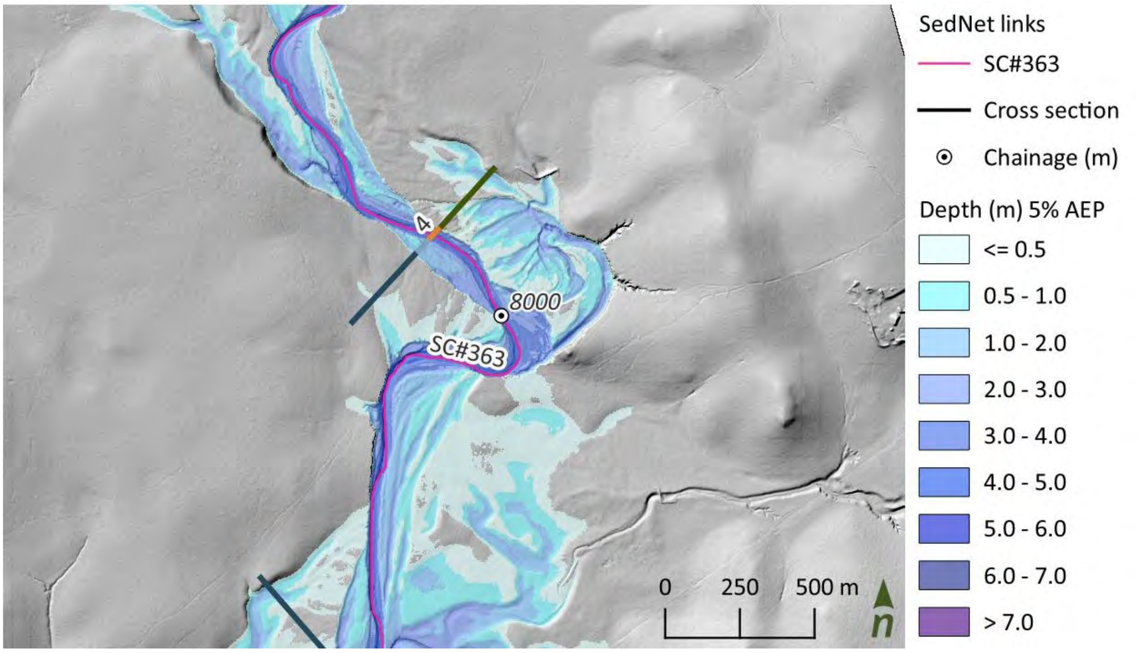

Figure 134. *Location of cross section 4 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

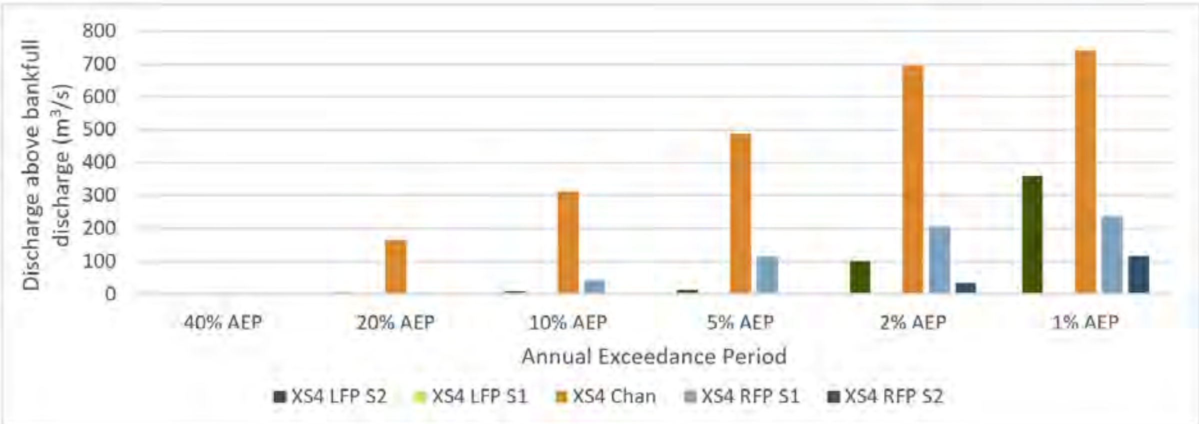

Figure 135. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 4 within the Raby Creek study area.*

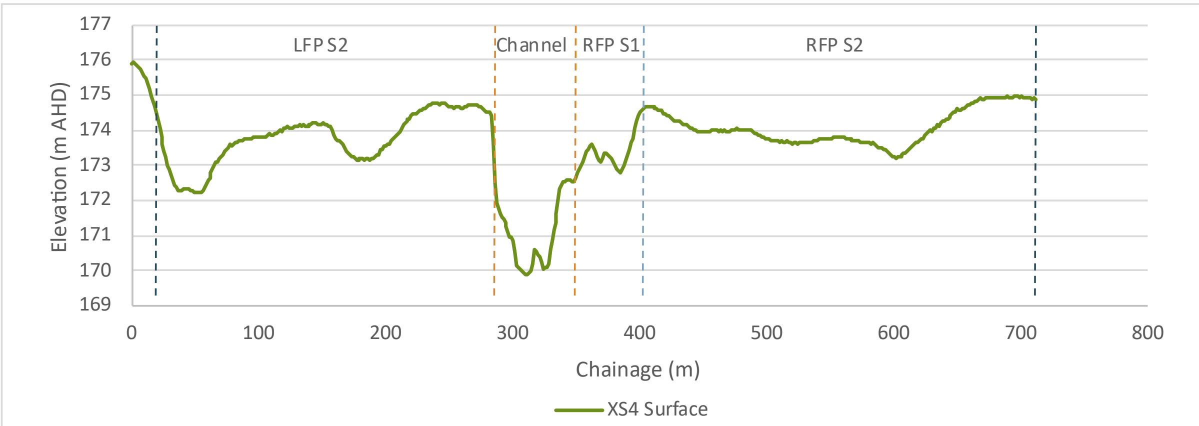

Figure 136. *Cross section 4 within Raby Creek study area (cross-section location shown in Figure 134).*

Cross section 5

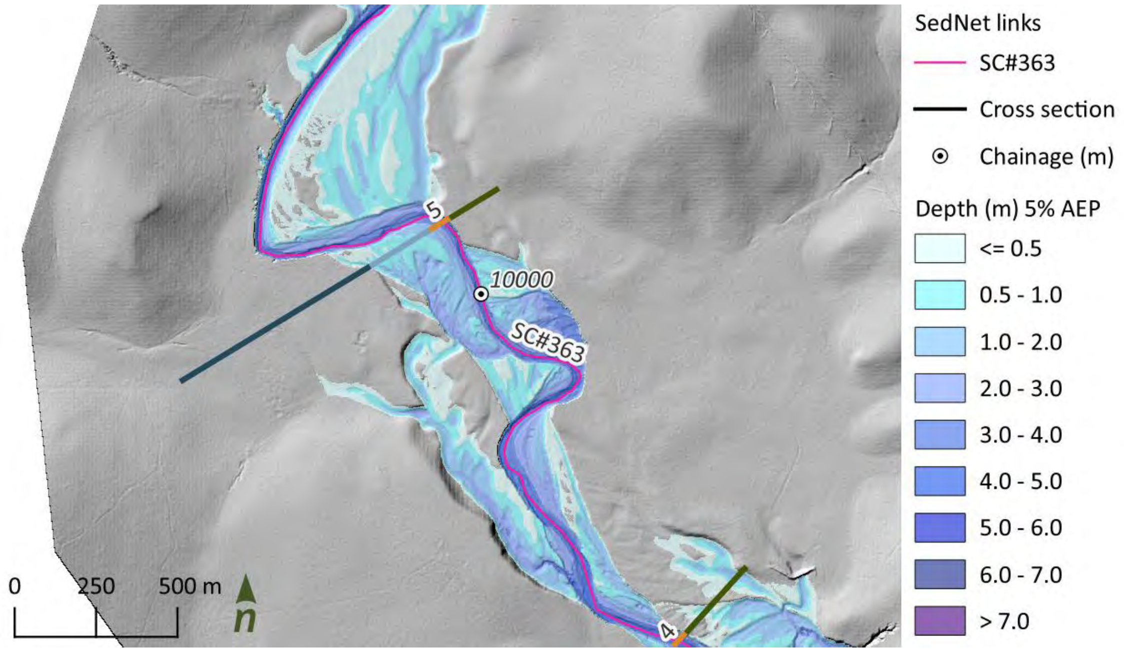

Figure 137. *Location of cross section 5 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

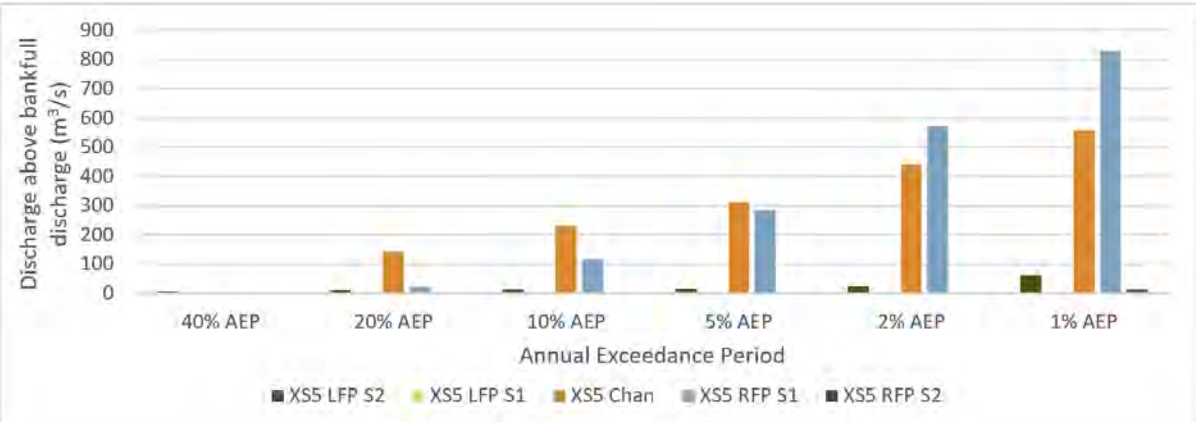

Figure 138. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 5 within the Raby Creek study area.*

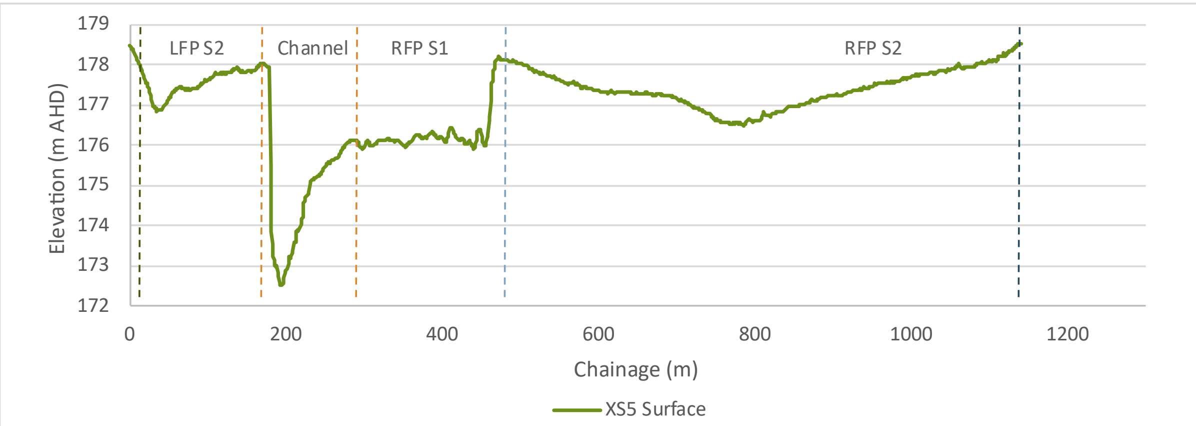

Figure 139. *Cross section 5 within Raby Creek study area (cross-section location shown in Figure 137).*

Cross section 6

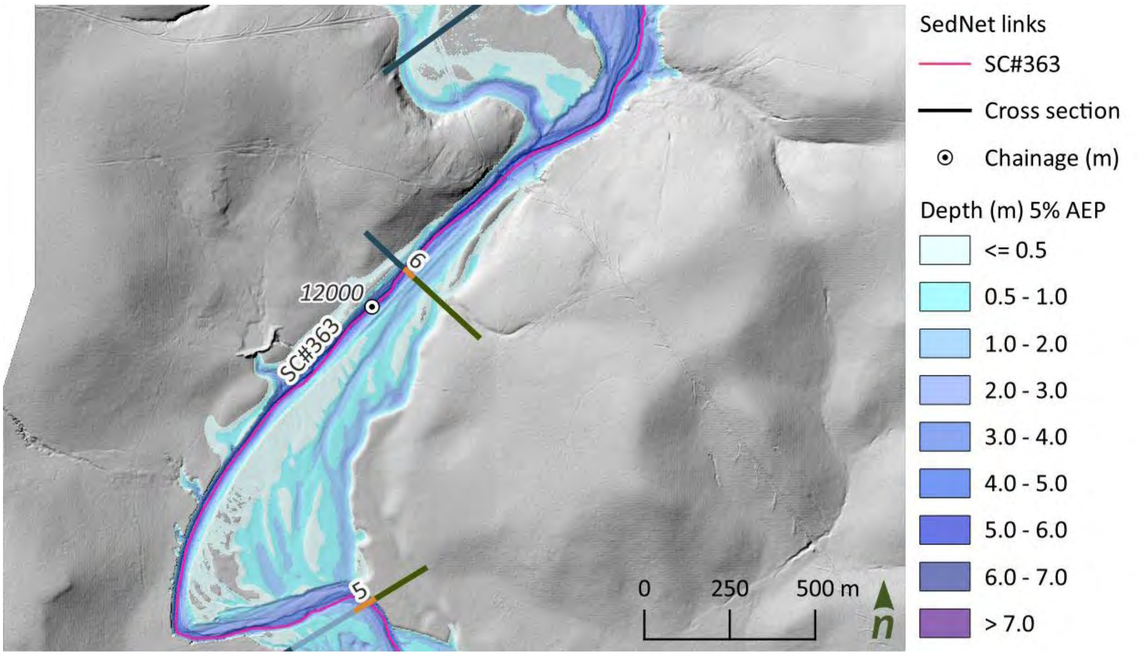

Figure 140. *Location of cross section 6 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

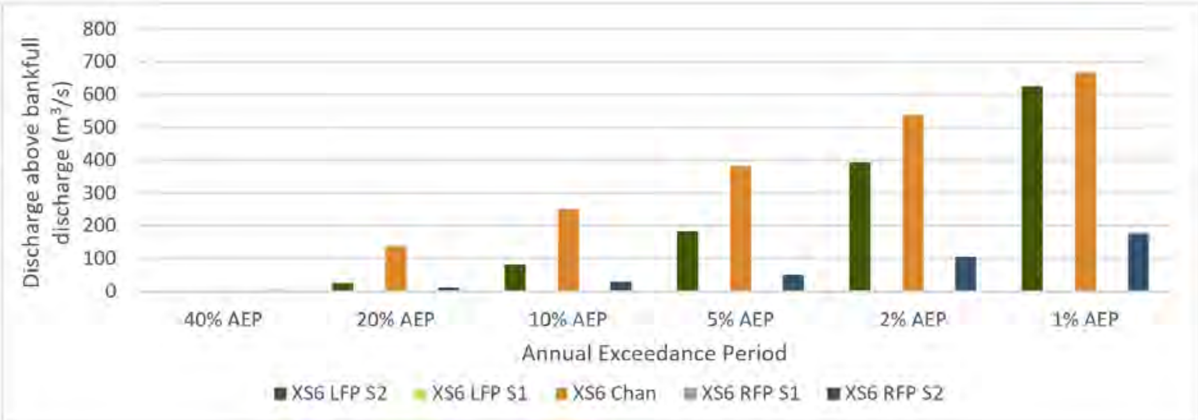

Figure 141. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 6 within the Raby Creek study area.*

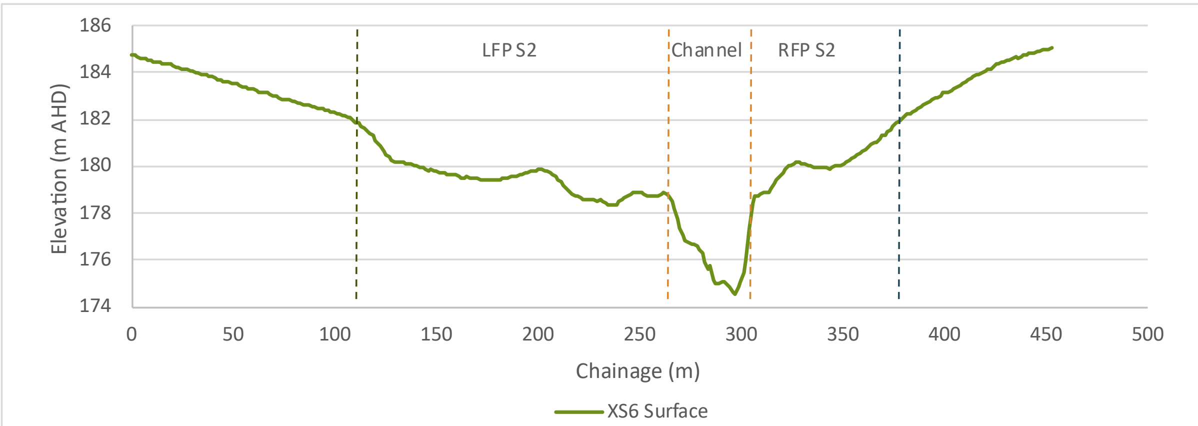

Figure 142. *Cross section 6 within Raby Creek study area (cross-section location shown in Figure 140).*

Cross section 7

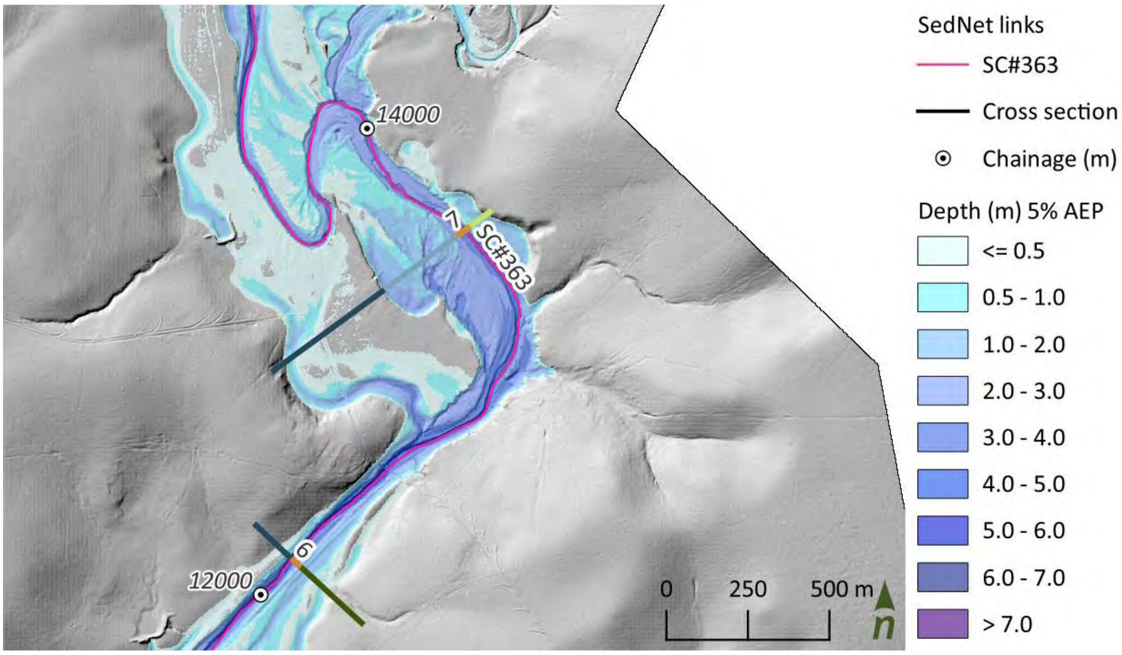

Figure 143. *Location of cross section 7 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

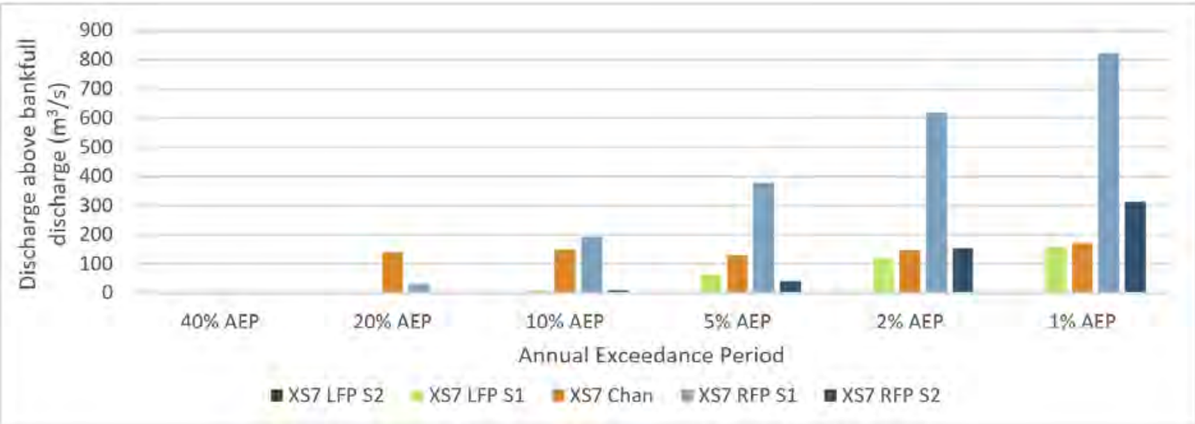

Figure 144. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 7 within the Raby Creek study area.*

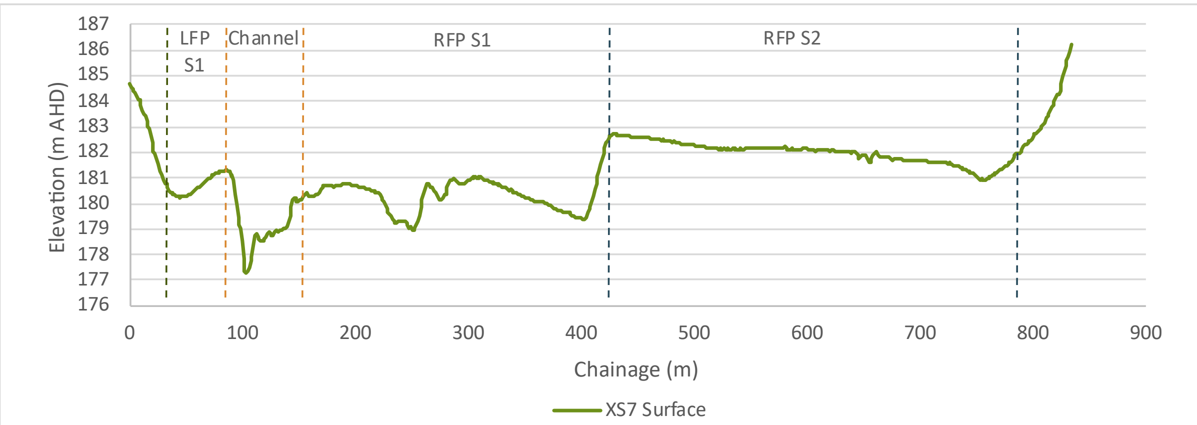

Figure 145. *Cross section 7 within Raby Creek study area (cross-section location shown in Figure 143).*

Cross section 8

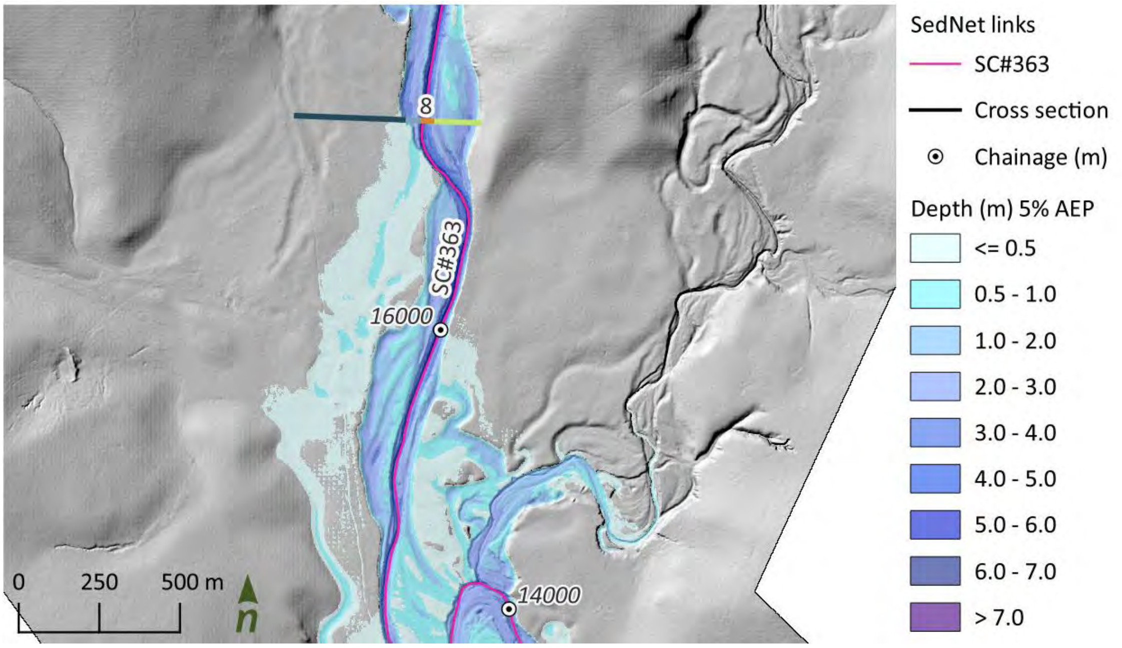

Figure 146. *Location of cross section 8 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

Figure 147. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 8 within the Raby Creek study area.*

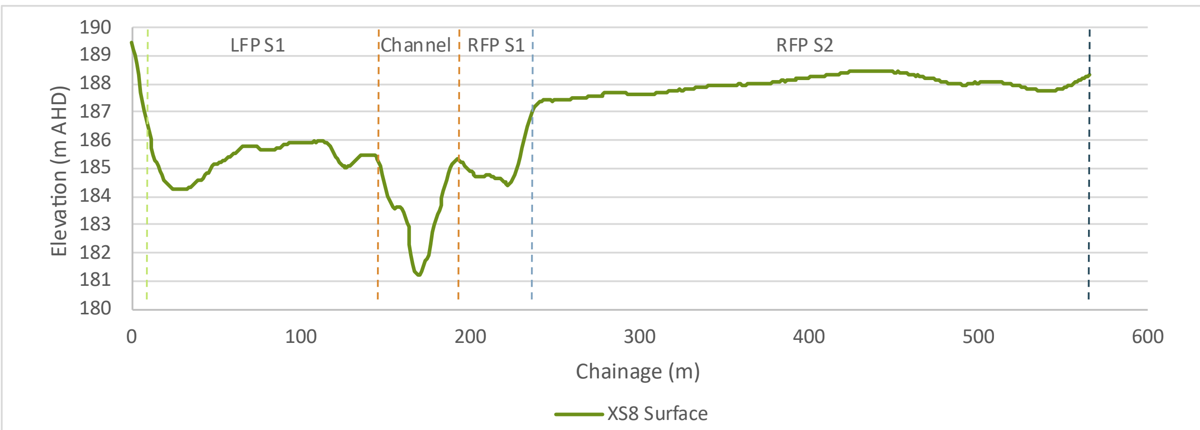

Figure 148. *Cross section 8 within Raby Creek study area (cross-section location shown in Figure 146).*

Cross section 9

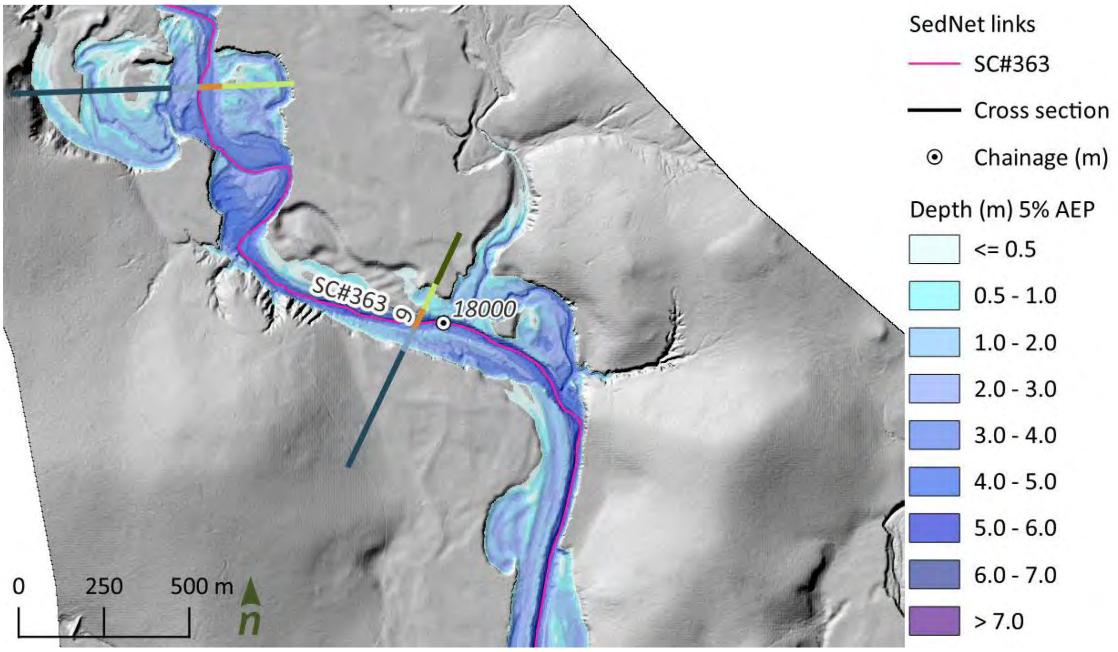

Figure 149. *Location of cross section 9 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

Figure 150. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 9 within the Raby Creek study area.*

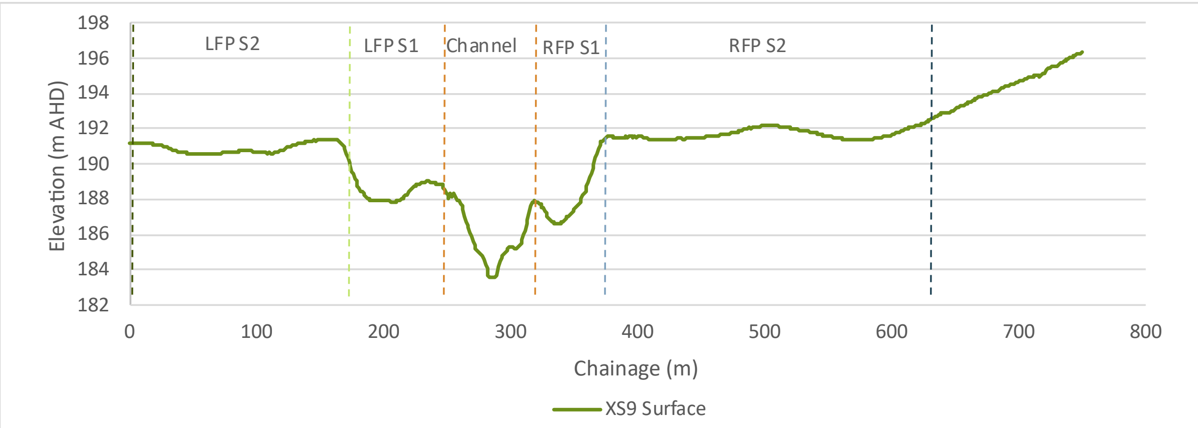

Figure 151. *Cross section 9 within Raby Creek study area (cross-section location shown in Figure 149).*

Cross section 10

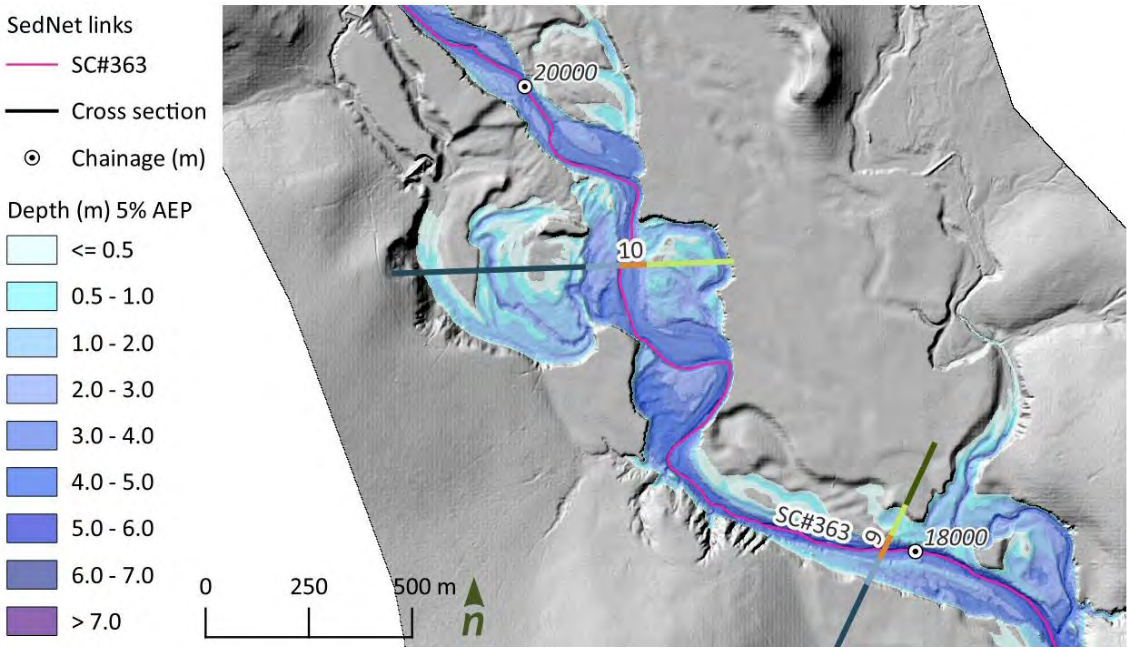

Figure 152. *Location of cross section 10 within Raby Creek study area showing model simulation results of the 5% AEP depth.*

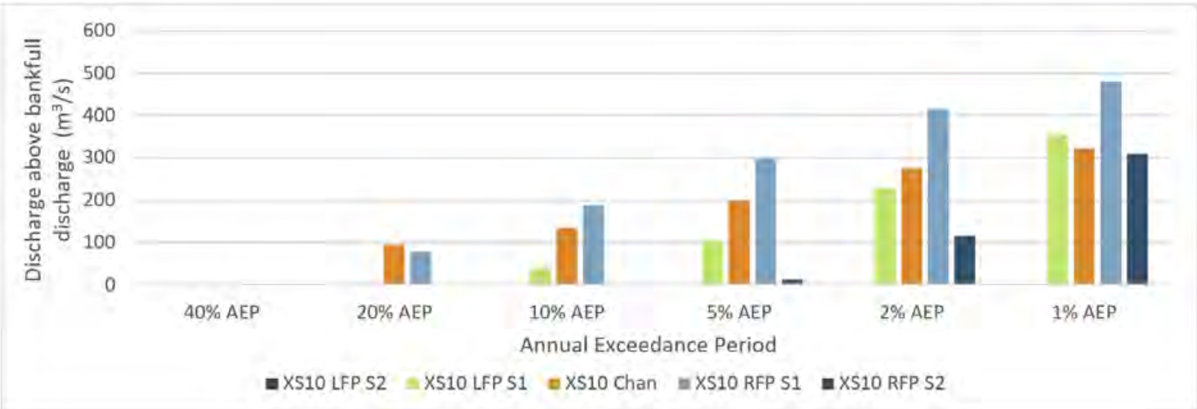

Figure 153. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 10 within the Raby Creek study area.*

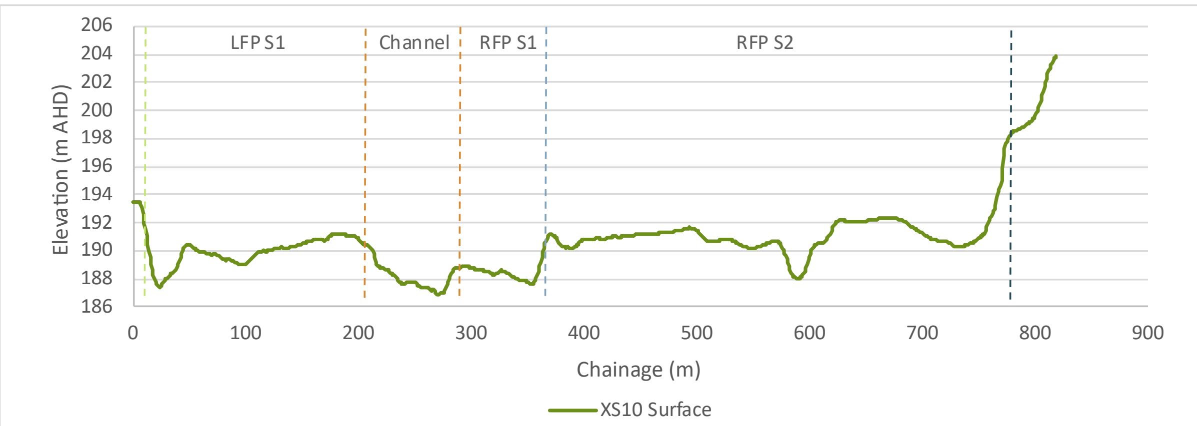

Figure 154. *Cross section 10 within Raby Creek study area (cross-section location shown in **Figure 152**).*

Mary River

Cross section 1

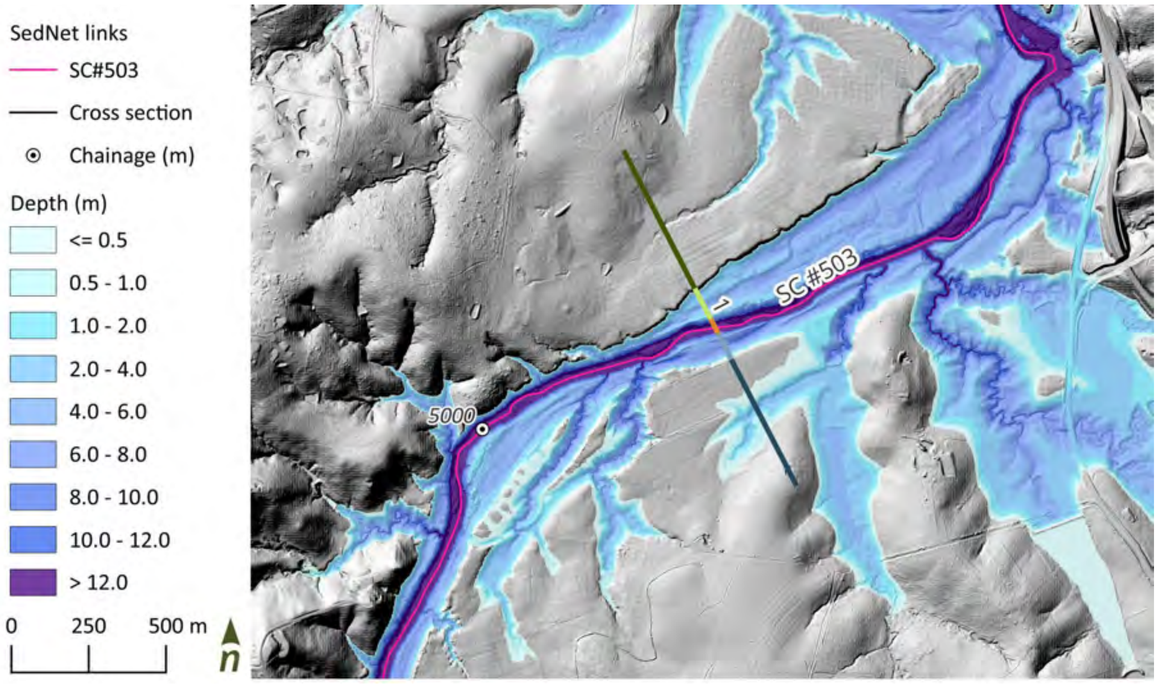

Figure 155. *Location of cross section 1 within the Mary River study area showing model simulation results of the 5% AEP depth.*

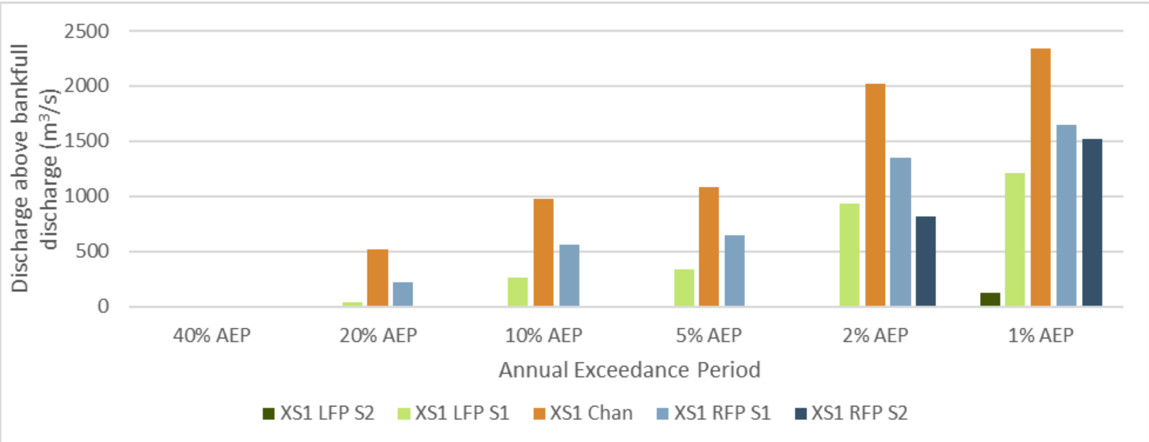

Figure 156. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 1 within the Mary River study area.*

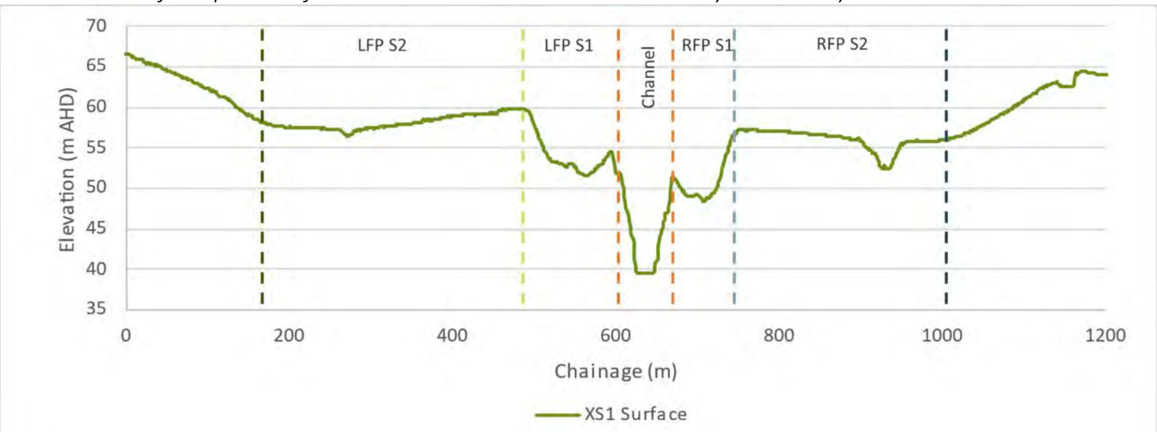

Figure 157. *Cross section 1 within the Mary River study area (cross section location shown in Figure 155).*

Cross section 2

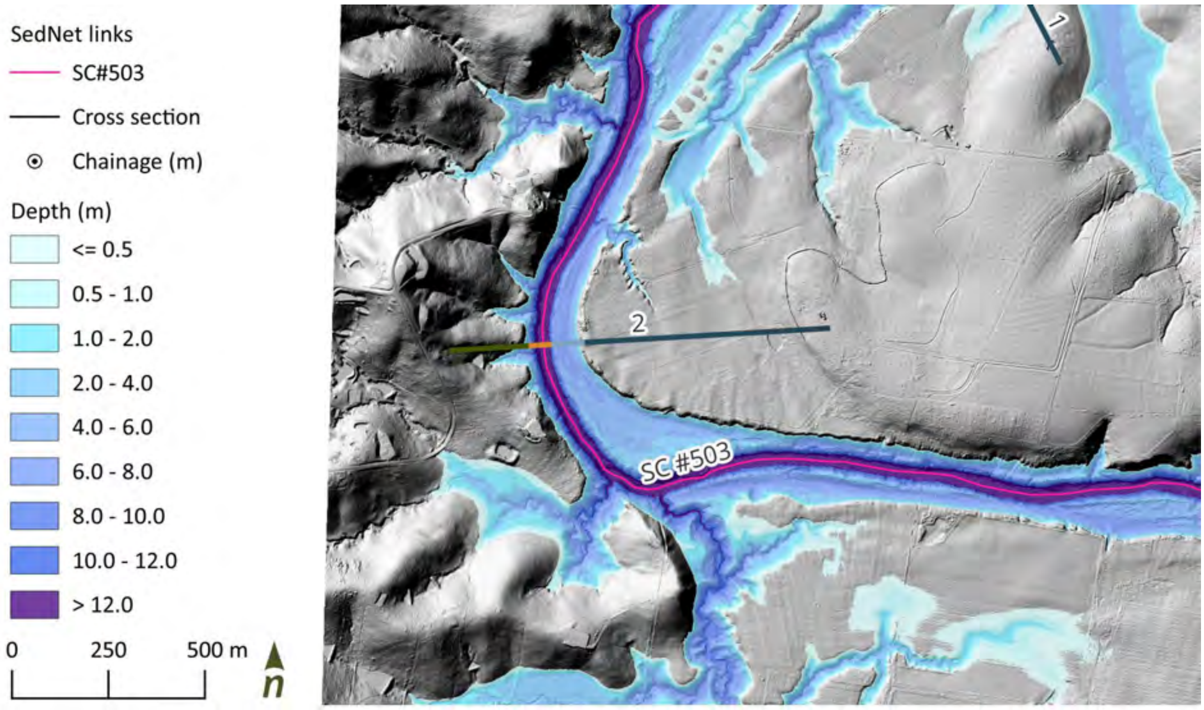

Figure 158. *Location of cross section 2 within the Mary River study area showing model simulation results of the 5% AEP depth.*

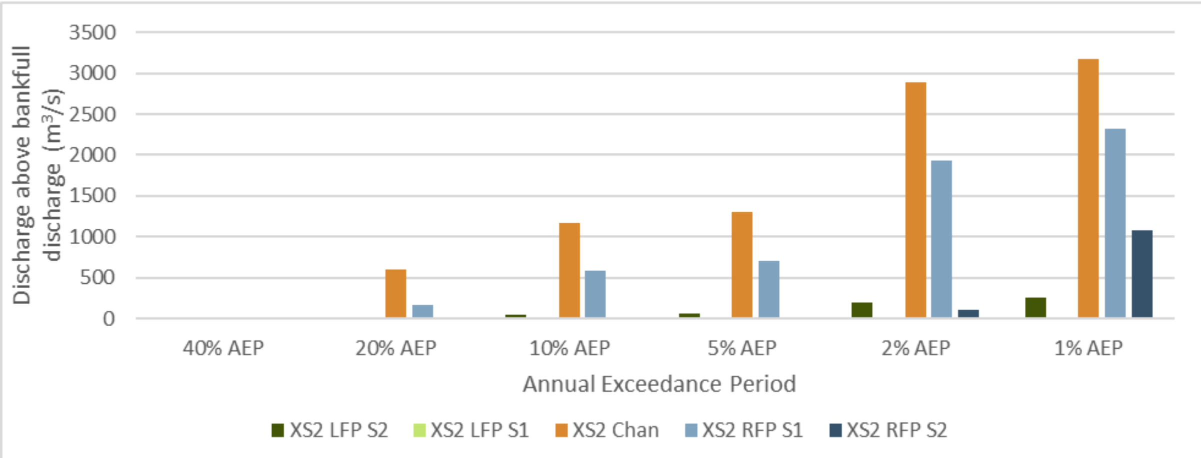

Figure 159. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 2 within the Mary River study area.*

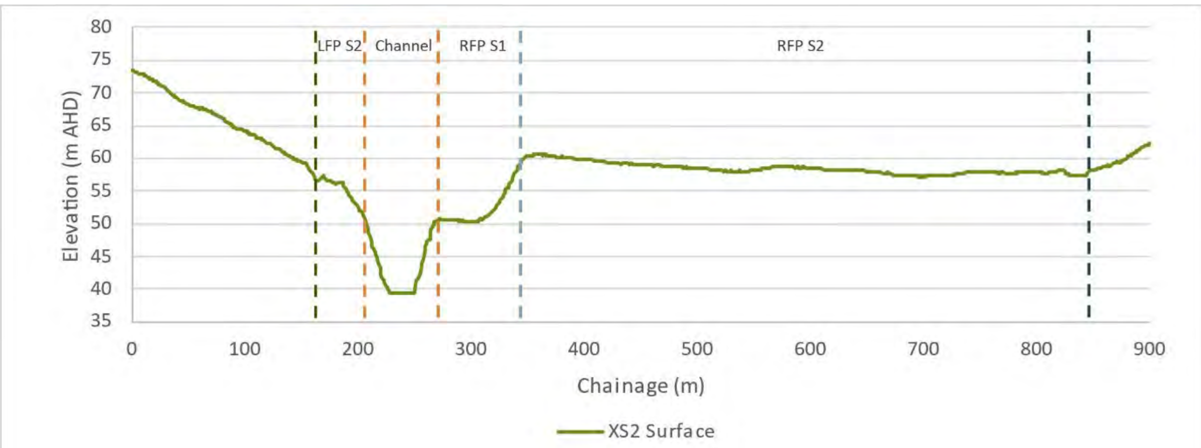

Figure 160. *Cross section 2 within the Mary River study area (cross section location shown in Figure 158).*

Cross section 3

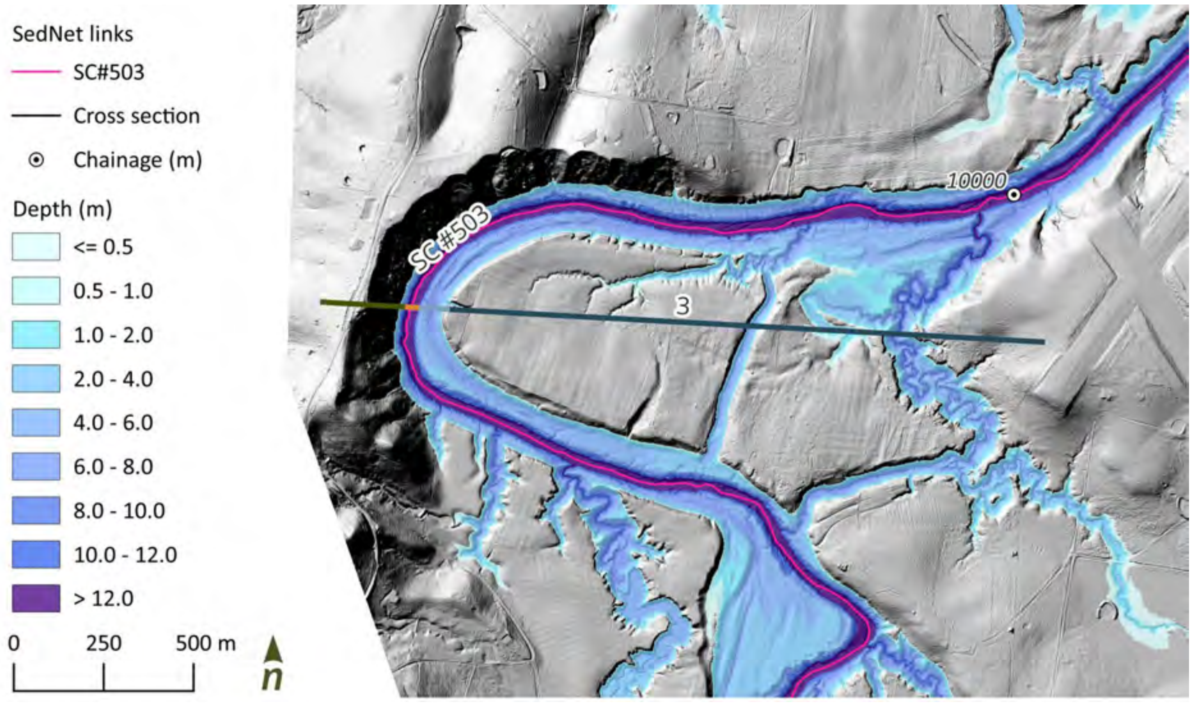

Figure 161. *Location of cross section 3 within the Mary River study area showing model simulation results of the 5% AEP depth.*

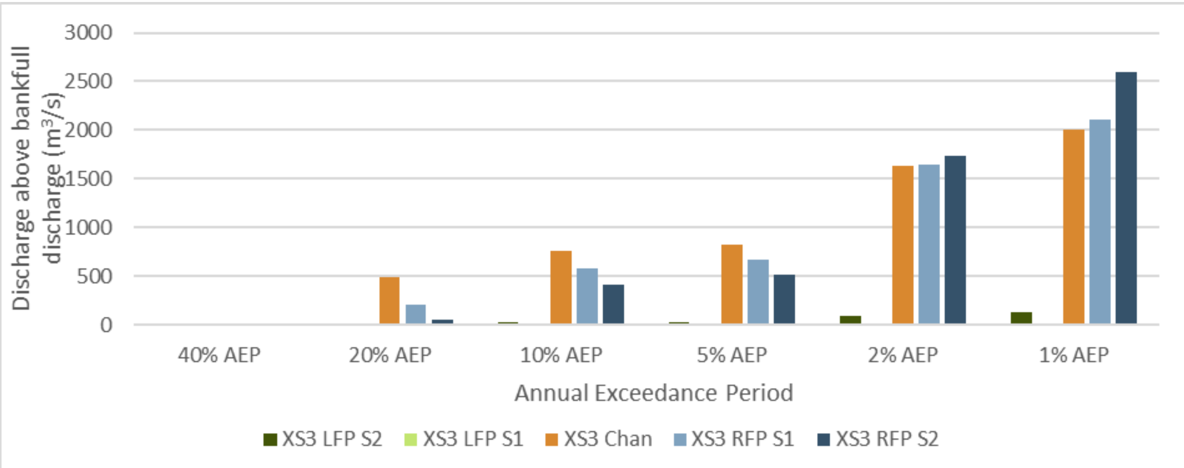

Figure 162. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 3 within the Mary River study area.*

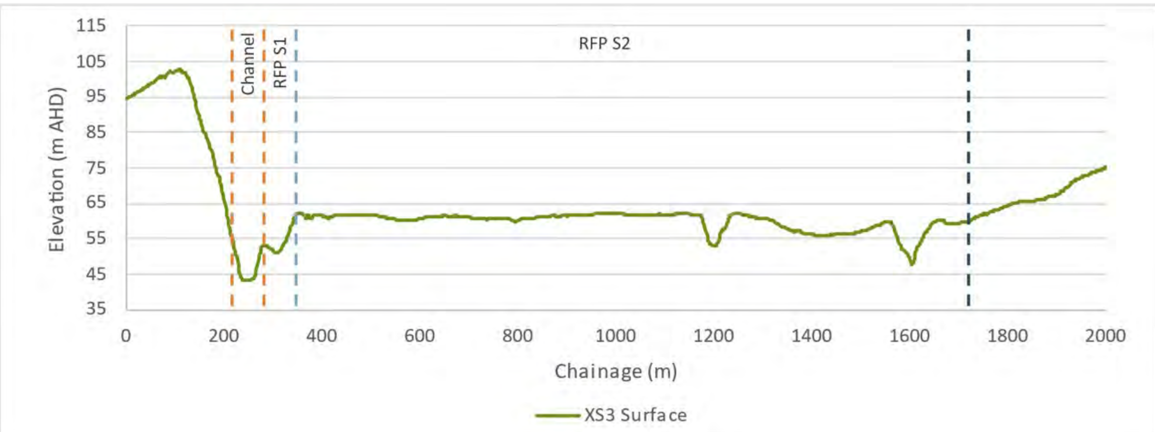

Figure 163. *Cross section 3 within the Mary River study area (cross section location shown in Figure 161).*

Cross section 4

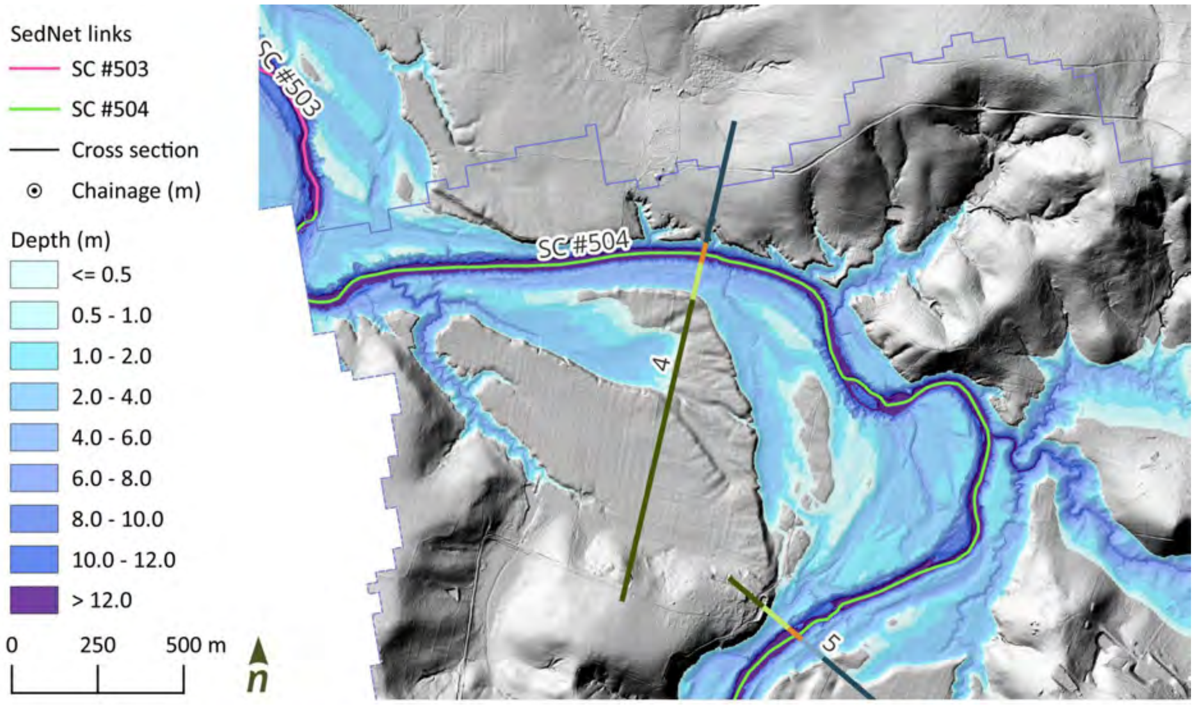

Figure 164. *Location of cross section 4 within the Mary River study area showing model simulation results of the 5% AEP depth.*

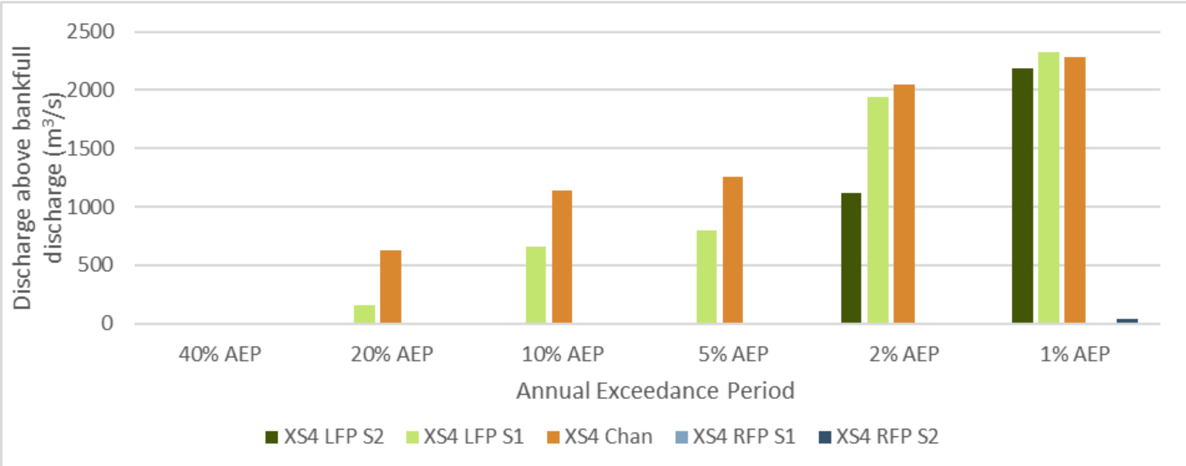

Figure 165. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 4 within the Mary River study area.*

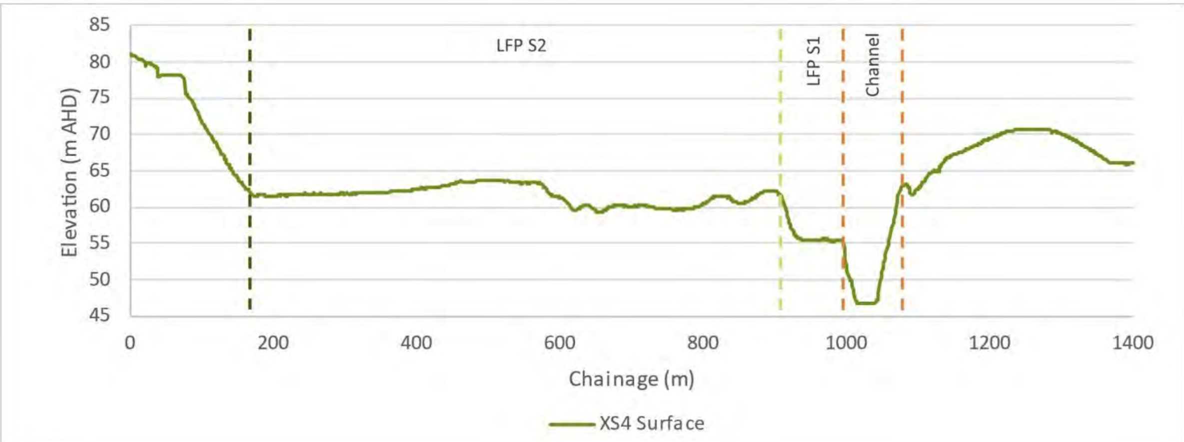

Figure 166. *Cross section 4 within the Mary River study area (cross section location shown in Figure 164).*

Cross section 5

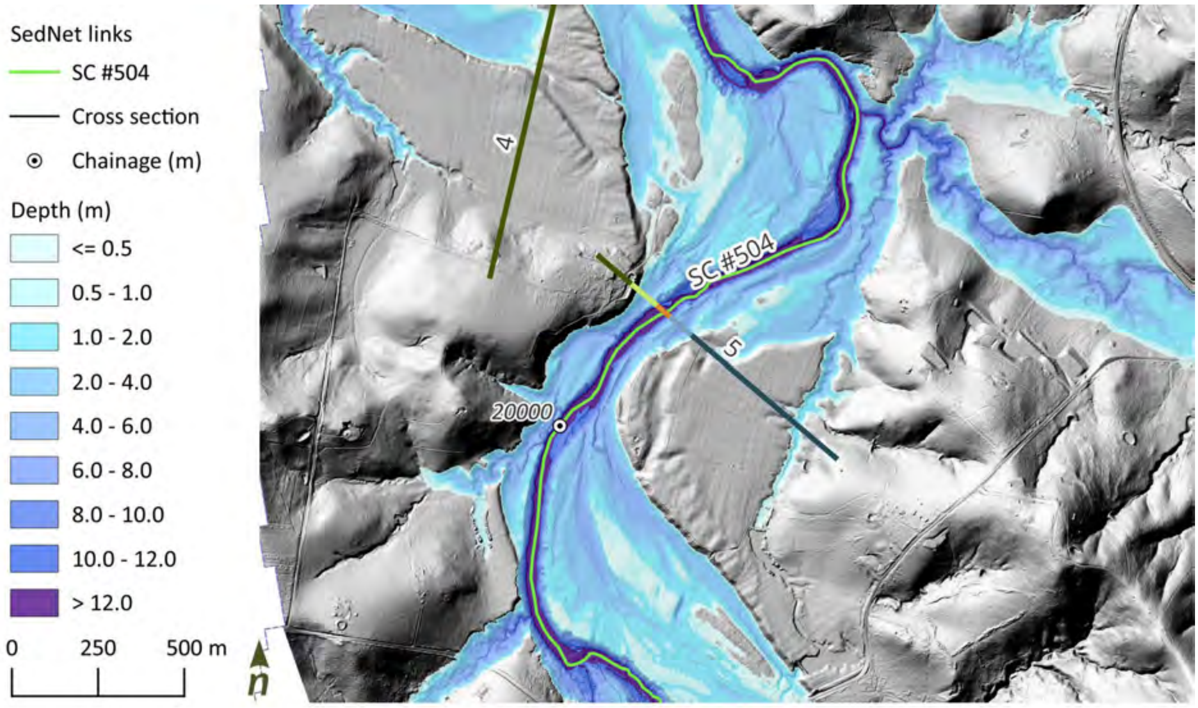

Figure 167. *Location of cross section 5 within the Mary River study area showing model simulation results of the 5% AEP depth.*

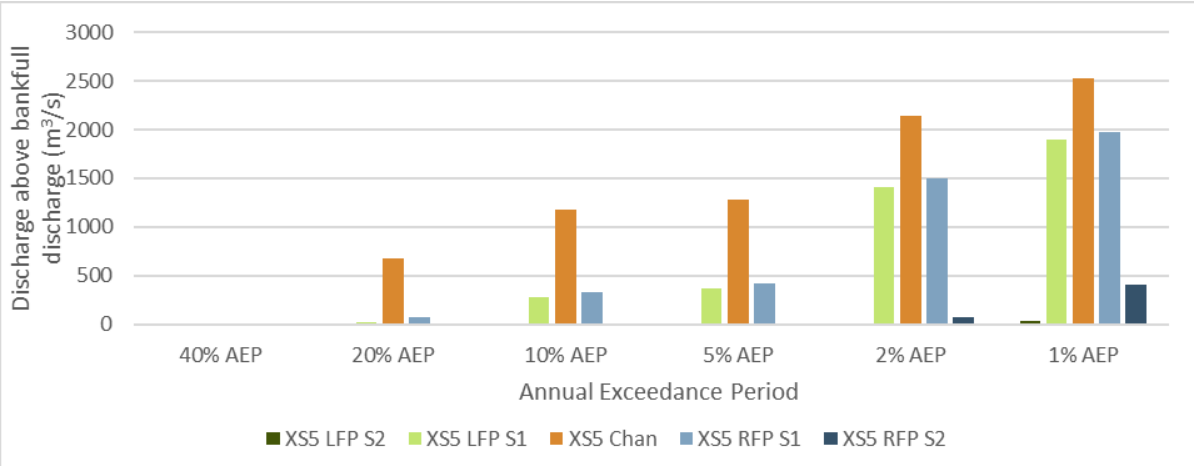

Figure 168. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 5 within the Mary River study area.*

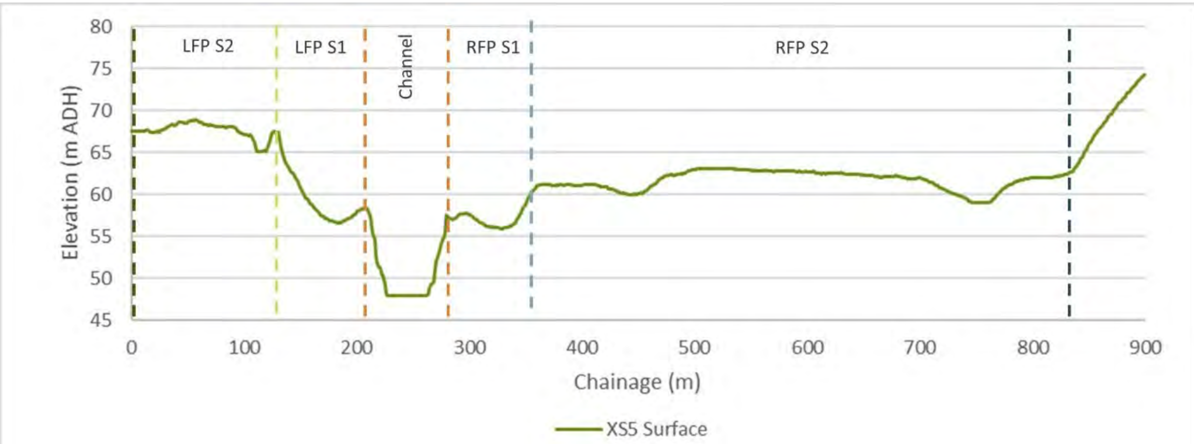

Figure 169. *Cross section 5 within the Mary River study area (cross section location shown in Figure 167).*

Cross section 6

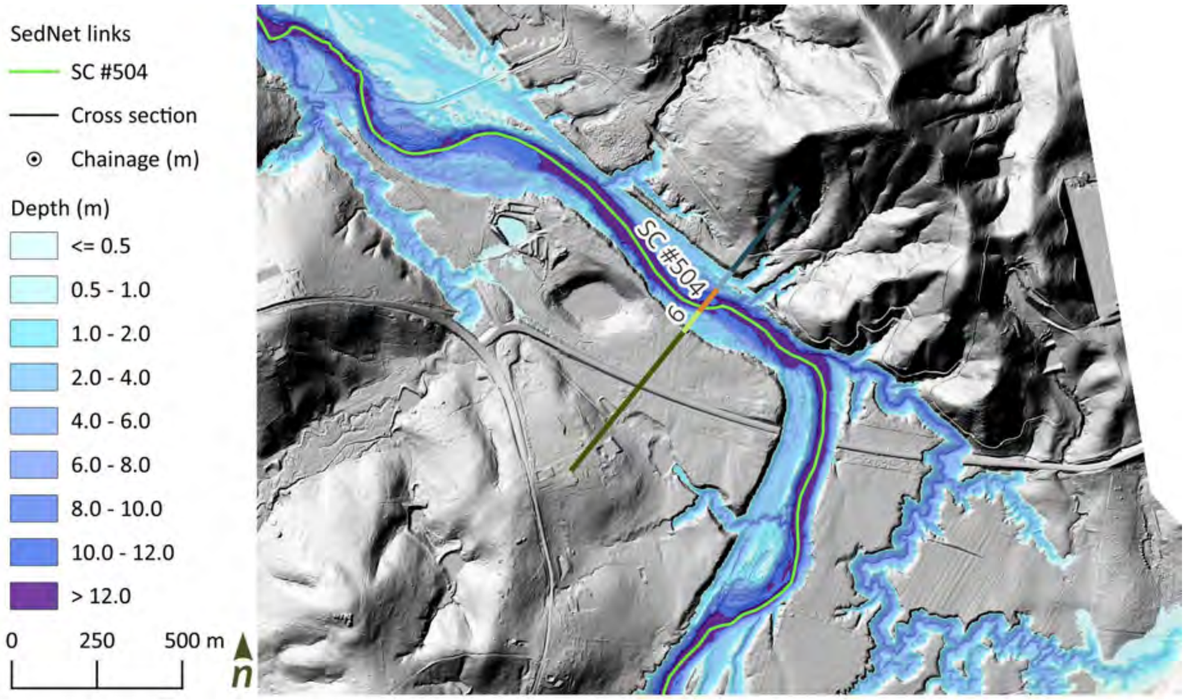

Figure 170. *Location of cross section 6 within the Mary River study area showing model simulation results of the 5% AEP depth.*

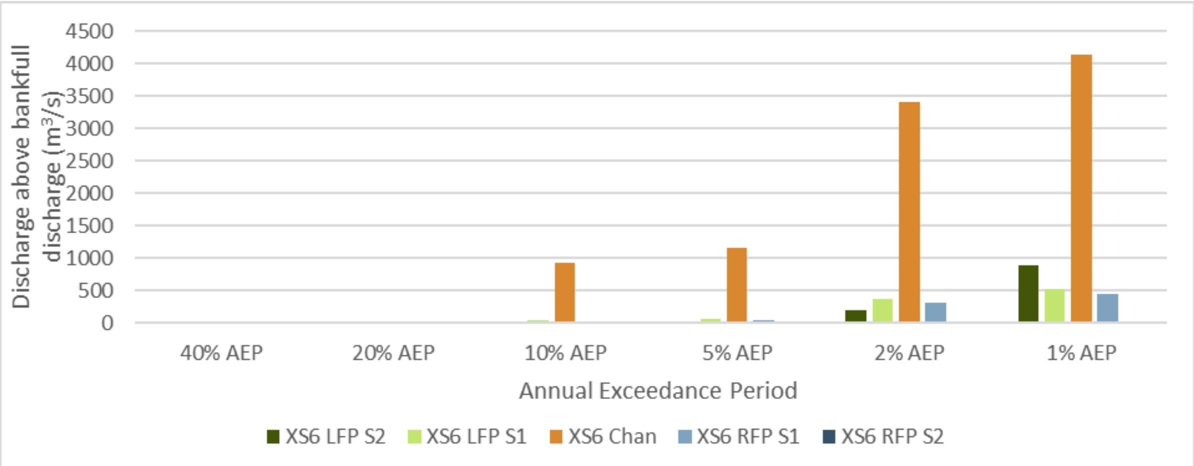

Figure 171. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 6 within the Mary River study area.*

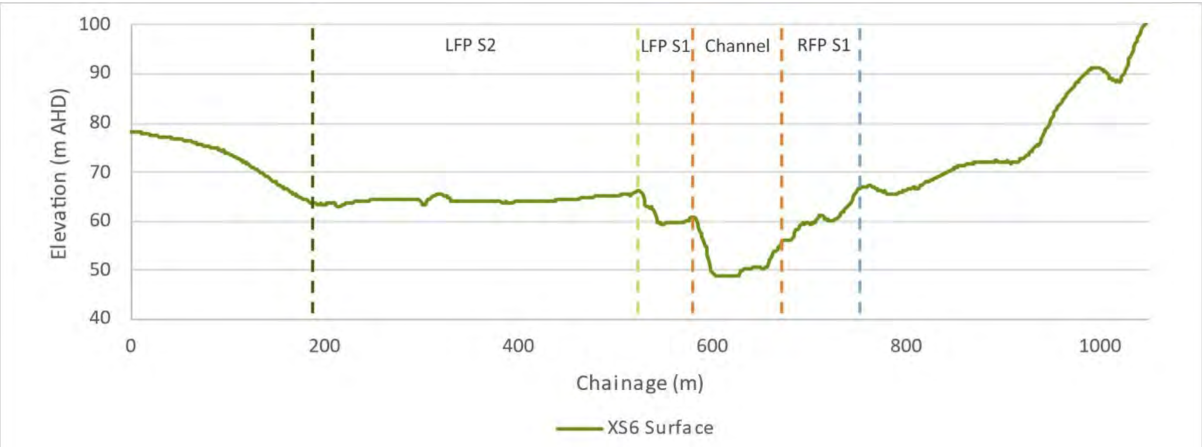

Figure 172. *Cross section 6 within the Mary River study area (cross section location shown in Figure 170).*

Cross section 7

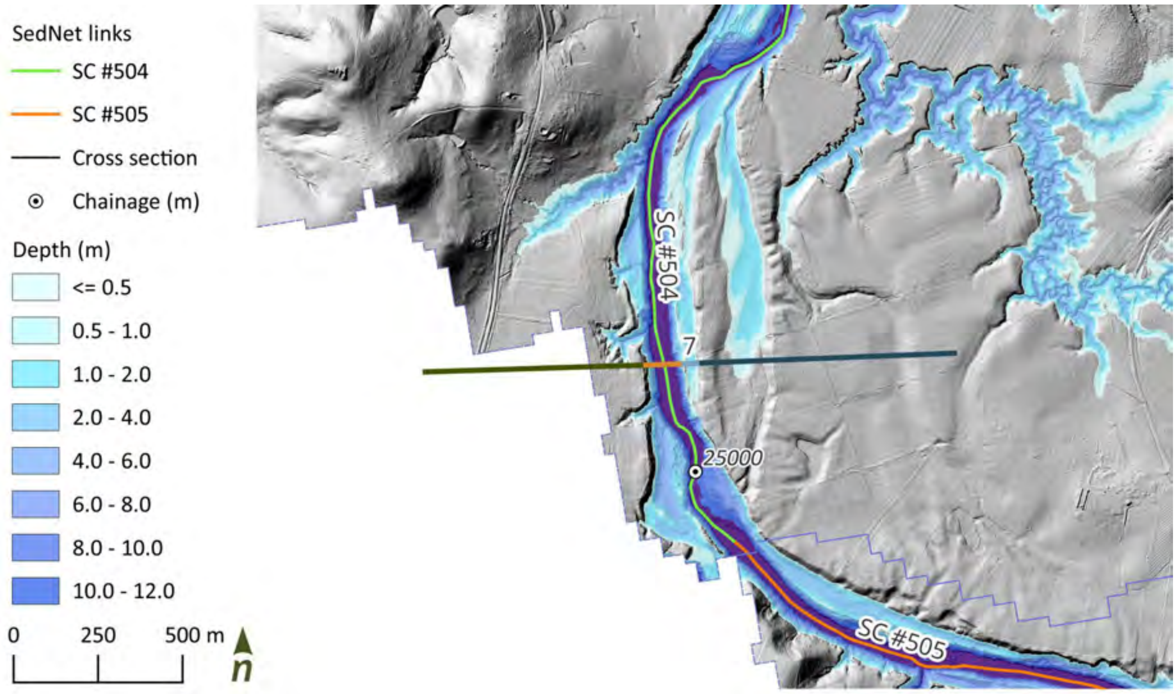

Figure 173. *Location of cross section 7 within the Mary River study area showing model simulation results of the 5% AEP depth.*

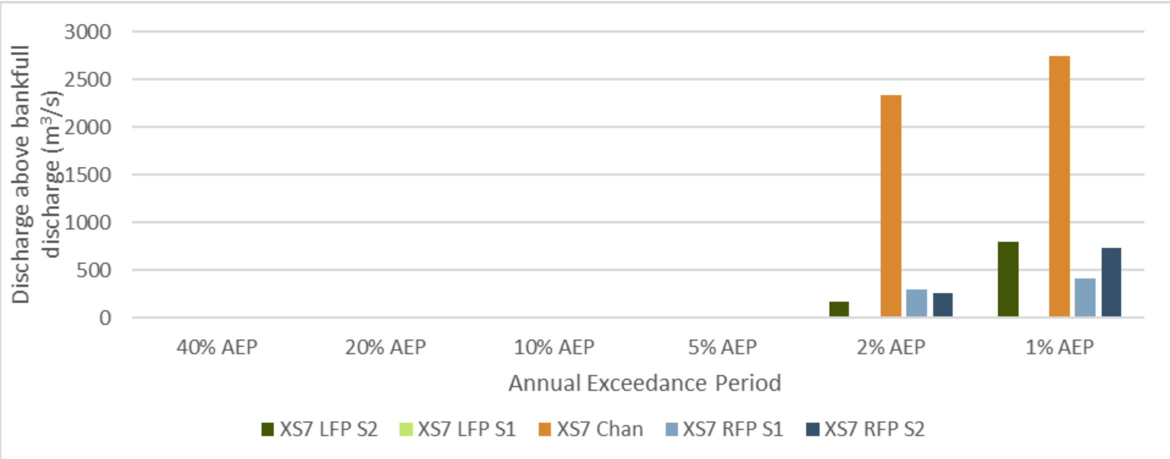

Figure 174. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 7 within the Mary River study area.*

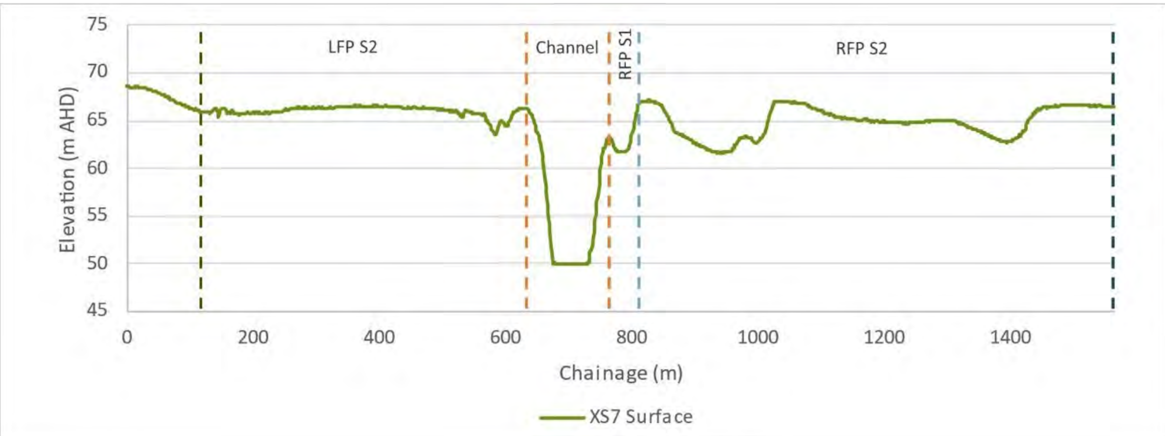

Figure 175. *Cross section 7 within the Mary River study area (cross section location shown in Figure 173).*

Cross section 8

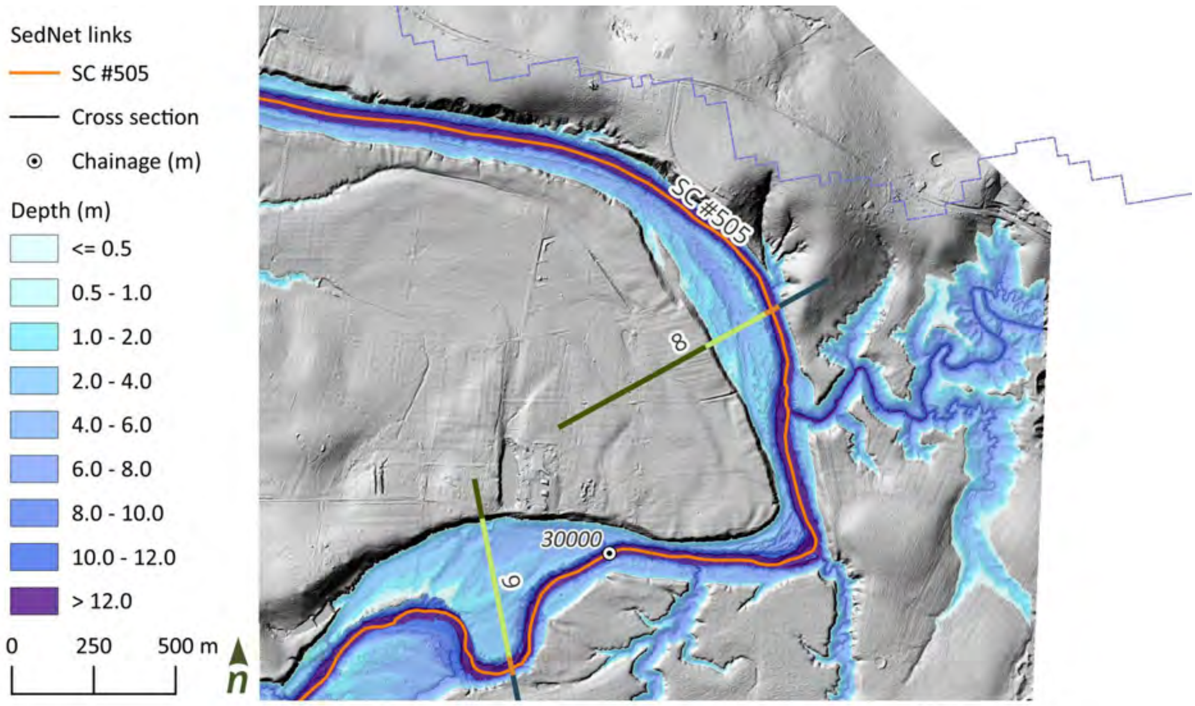

Figure 176. *Location of cross section 8 within the Mary River study area showing model simulation results of the 5% AEP depth.*

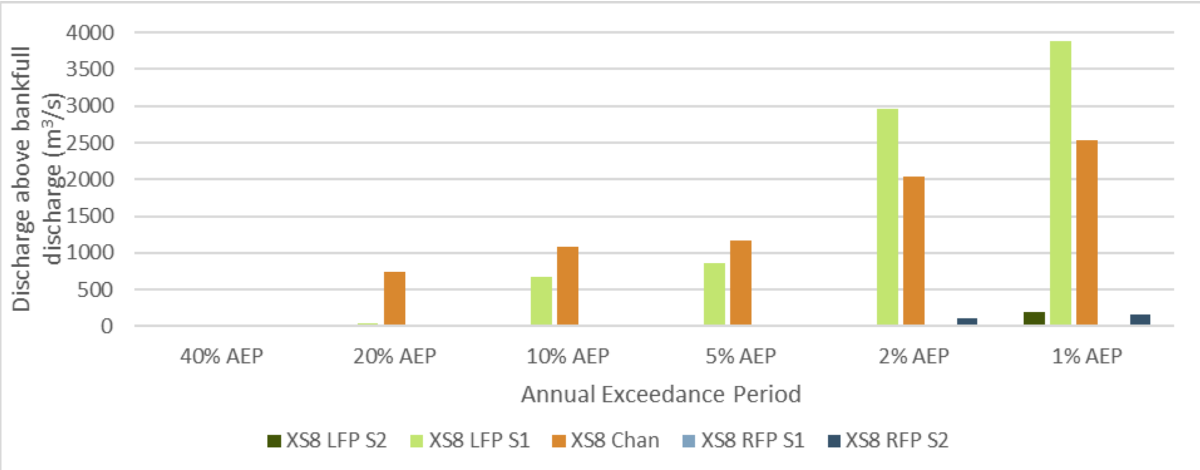

Figure 177. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 8 within the Mary River study area.*

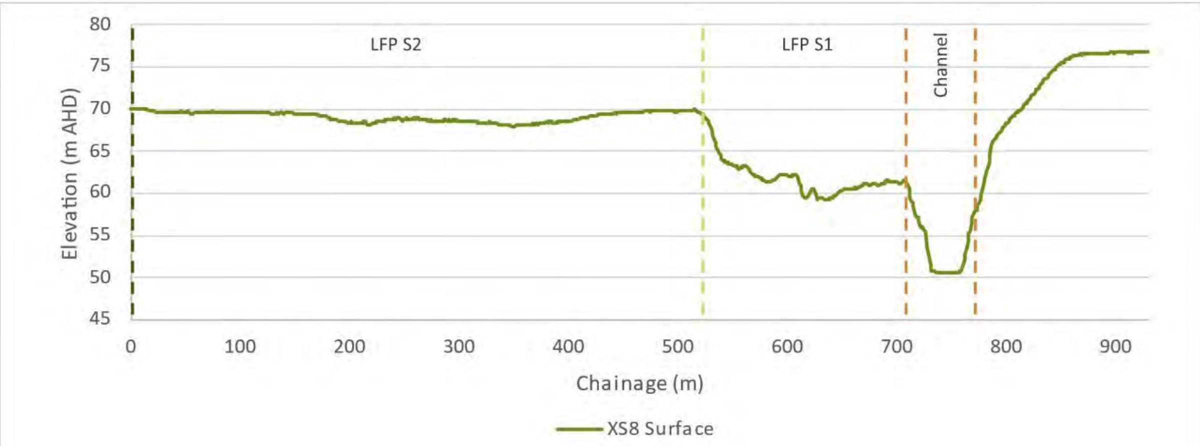

Figure 178. *Cross section 8 within the Mary River study area (cross section location shown in Figure 176).*

Cross section 9

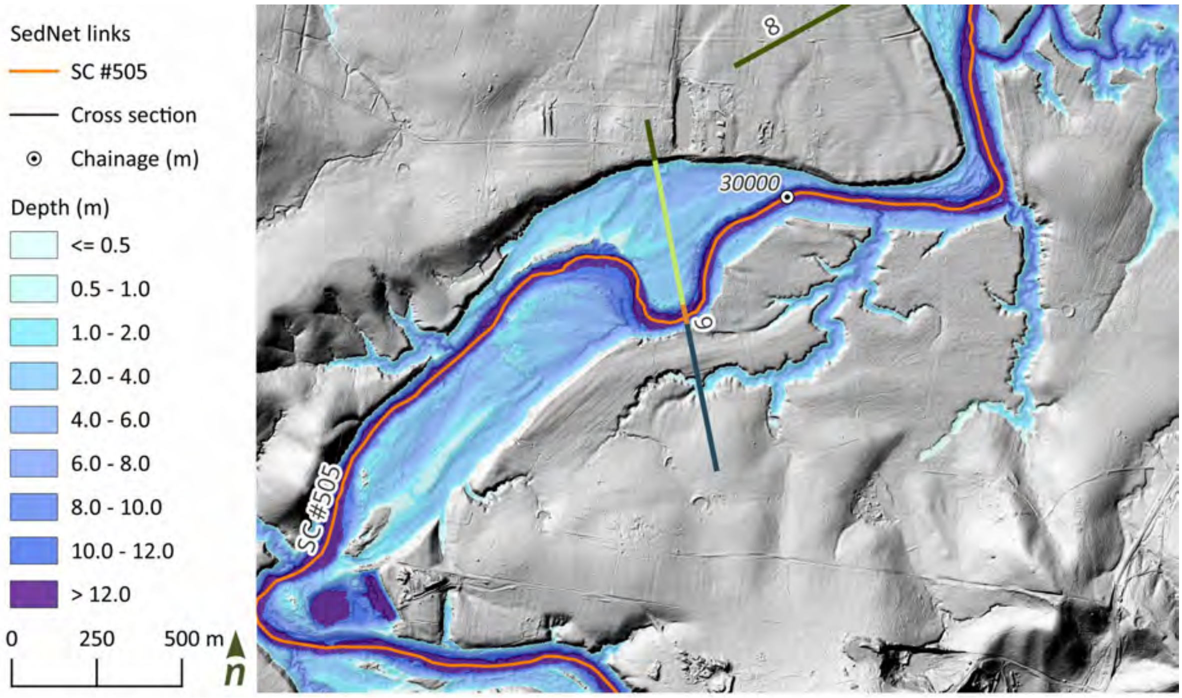

Figure 179. *Location of cross section 9 within the Mary River study area showing model simulation results of the 5% AEP depth.*

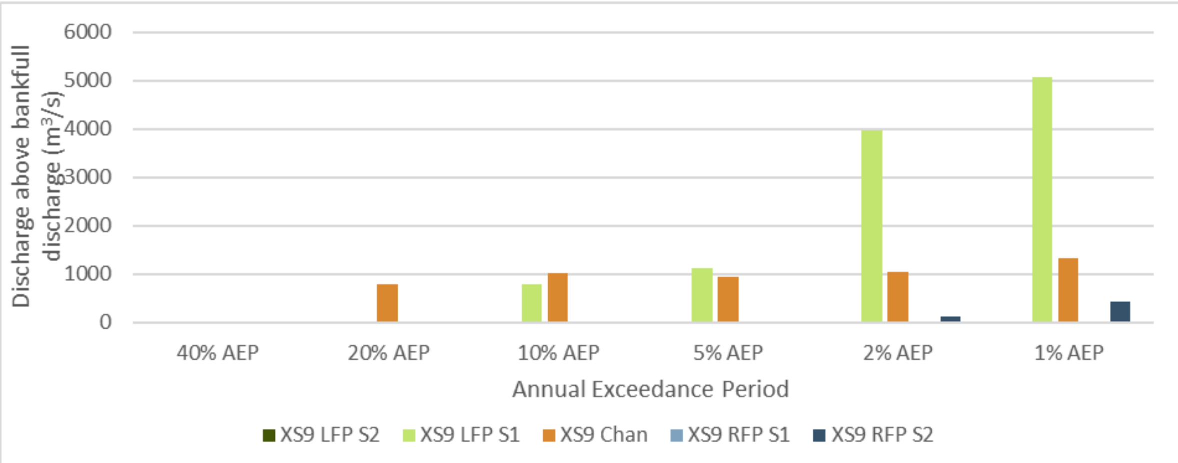

Figure 180. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 9 within the Mary River study area.*

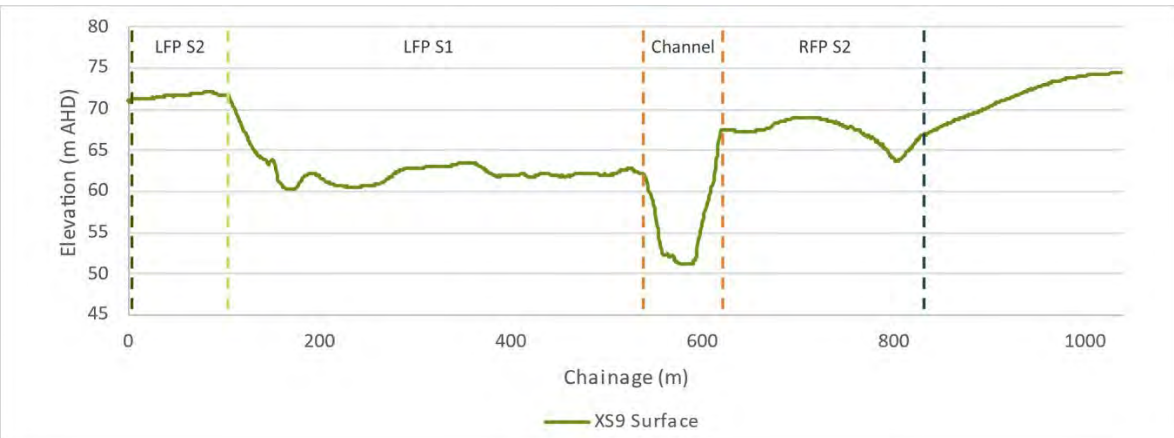

Figure 181. *Cross section 9 within the Mary River study area (cross section location shown in Figure 179).*

Cross section 10

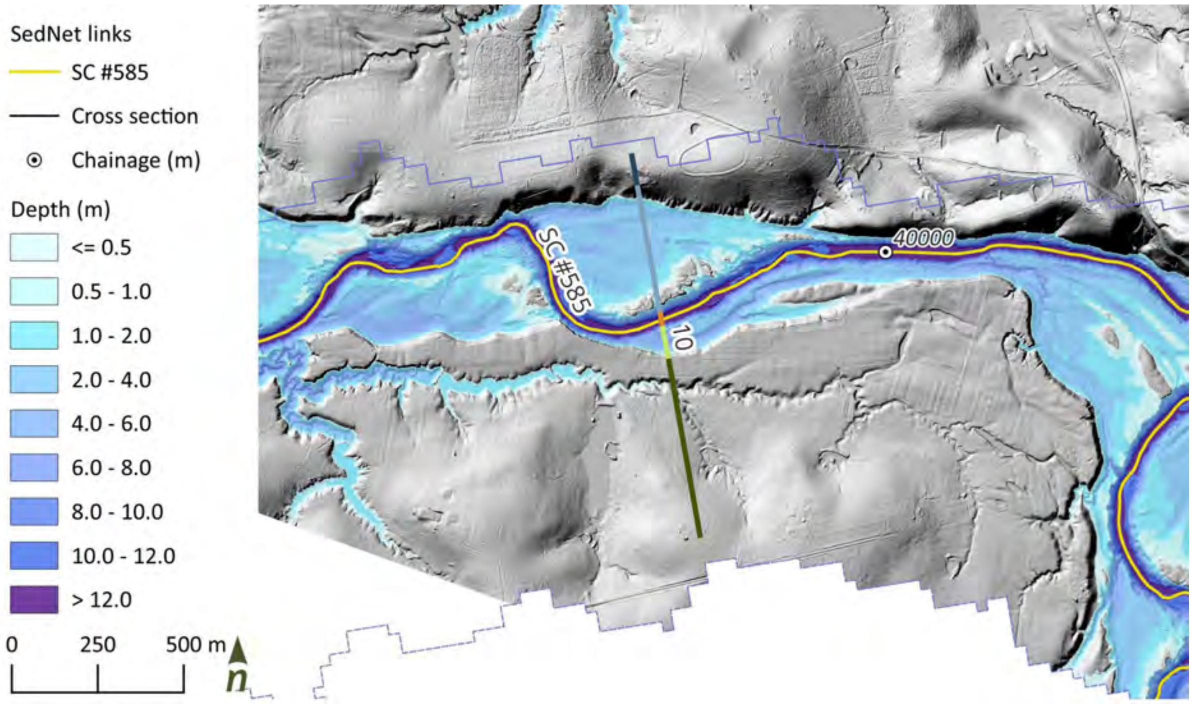

Figure 182. *Location of cross section 10 within the Mary River study area showing model simulation results of the 5% AEP depth.*

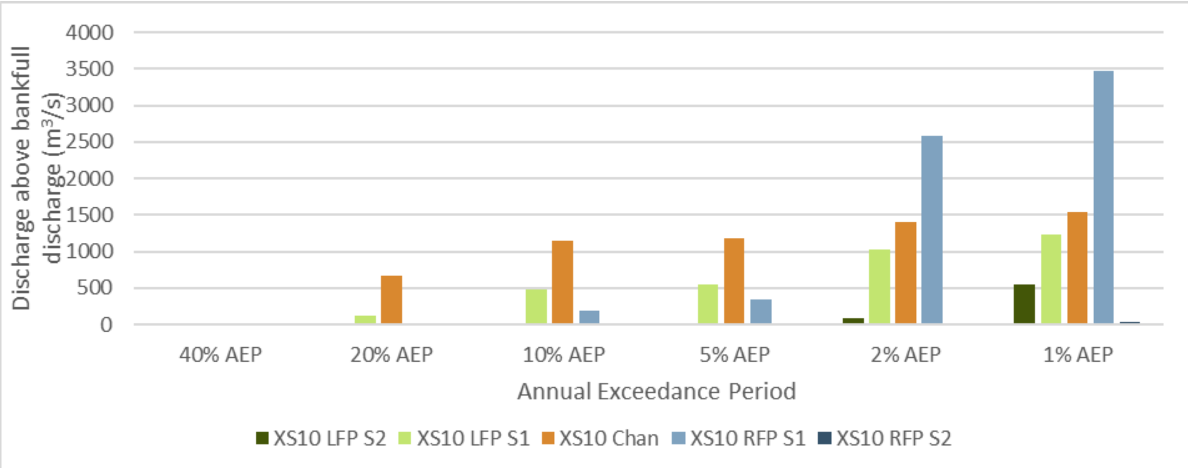

Figure 183. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 10 within the Mary River study area.*

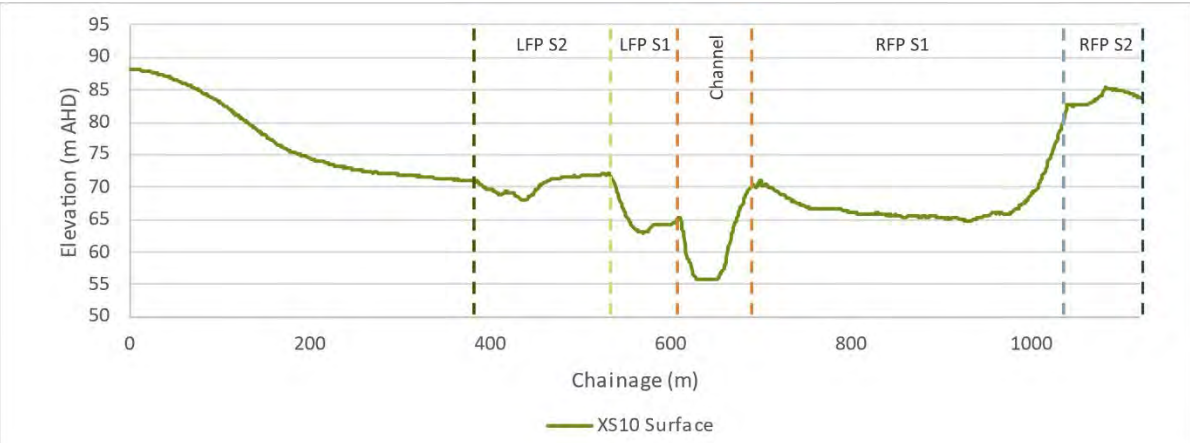

Figure 184. *Cross section 10 within the Mary River study area (cross section location shown in Figure 182).*

Fitzroy River

Cross section 1

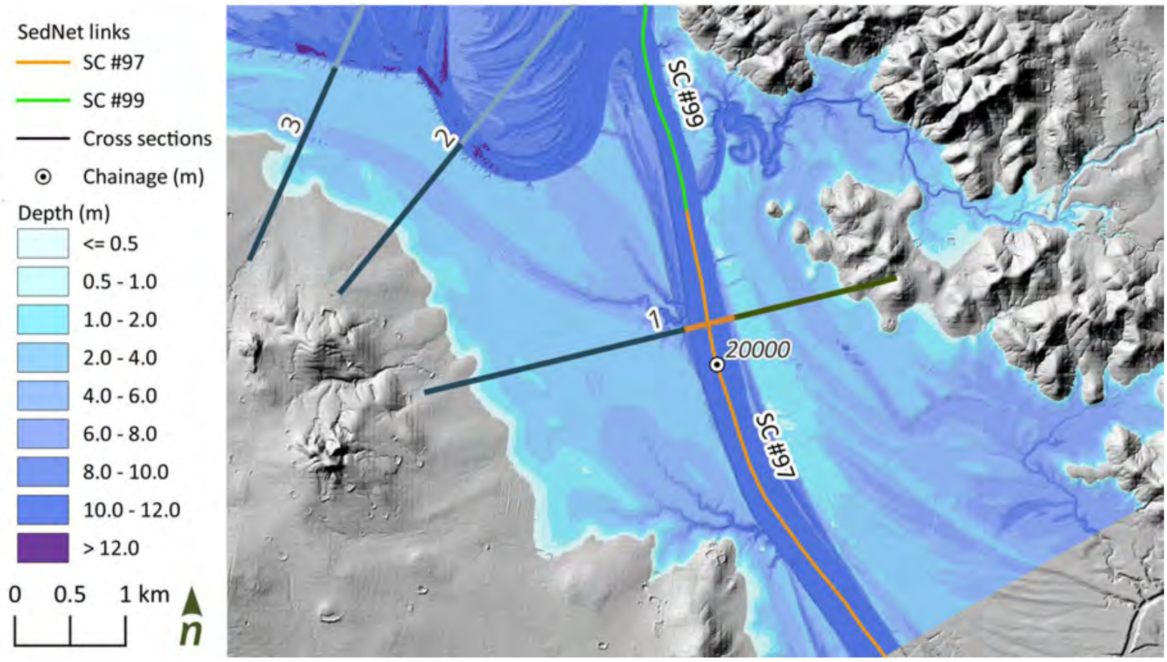

Figure 185. *Location of cross section 1 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

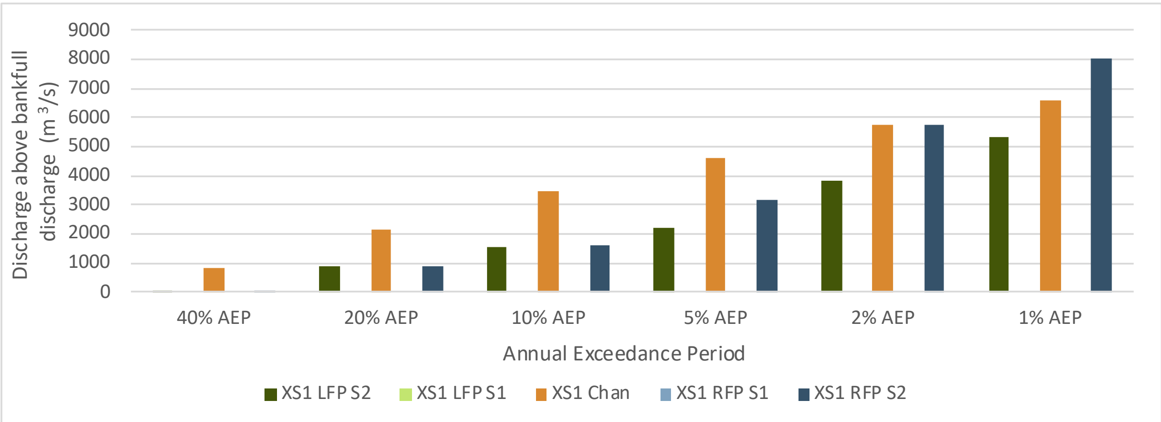

Figure 186. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 1 within the Fitzroy River study area.*

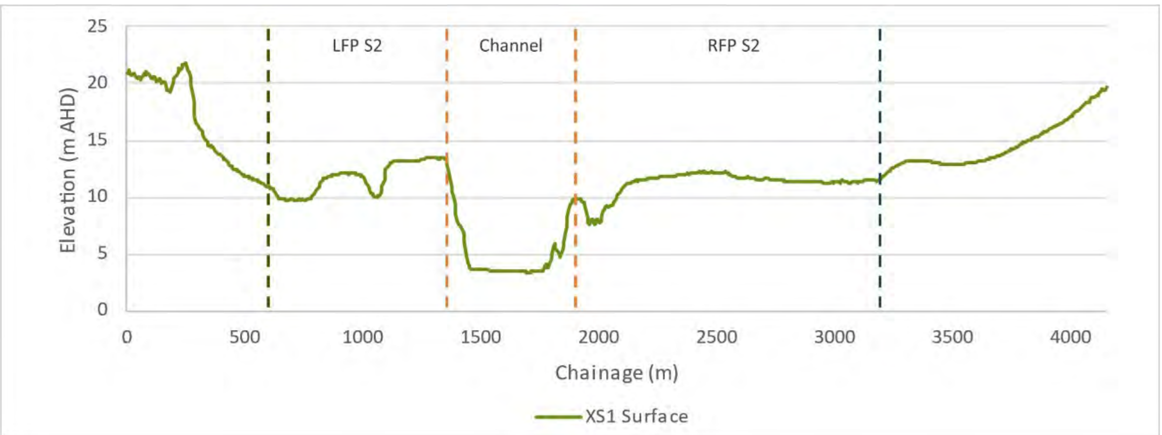

Figure 187. *Cross section 1 within the Fitzroy River study area (cross section location shown in Figure 185).*

Cross section 2

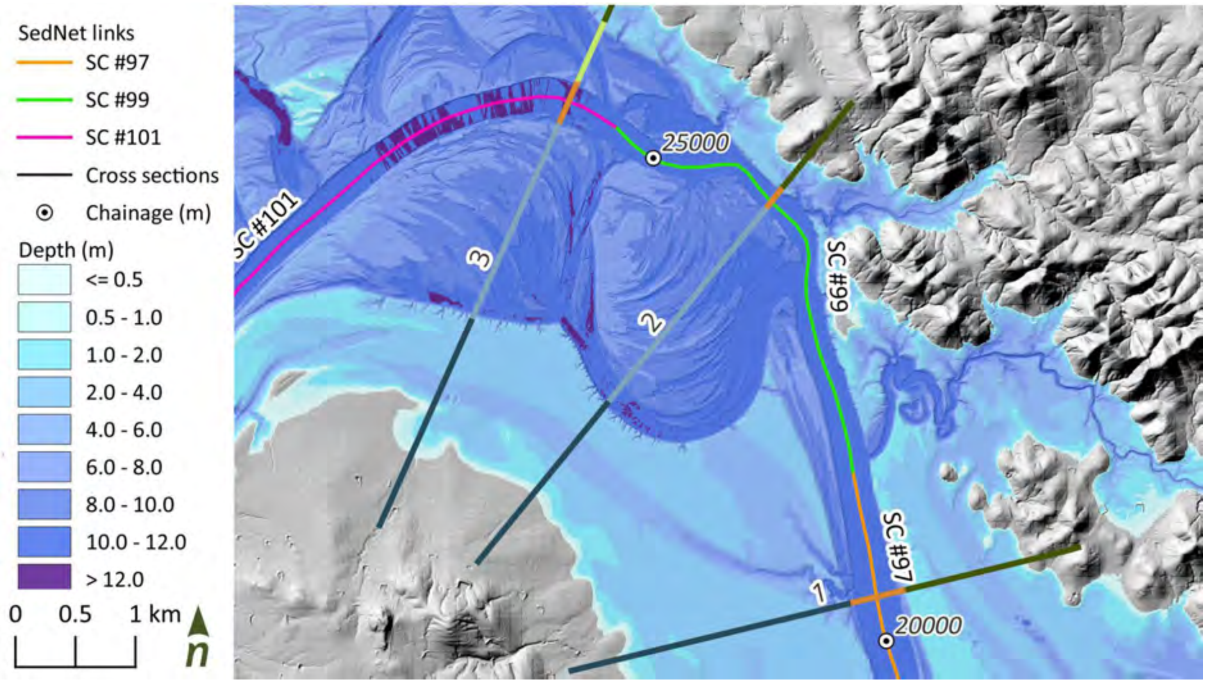

Figure 188. *Location of cross section 2 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

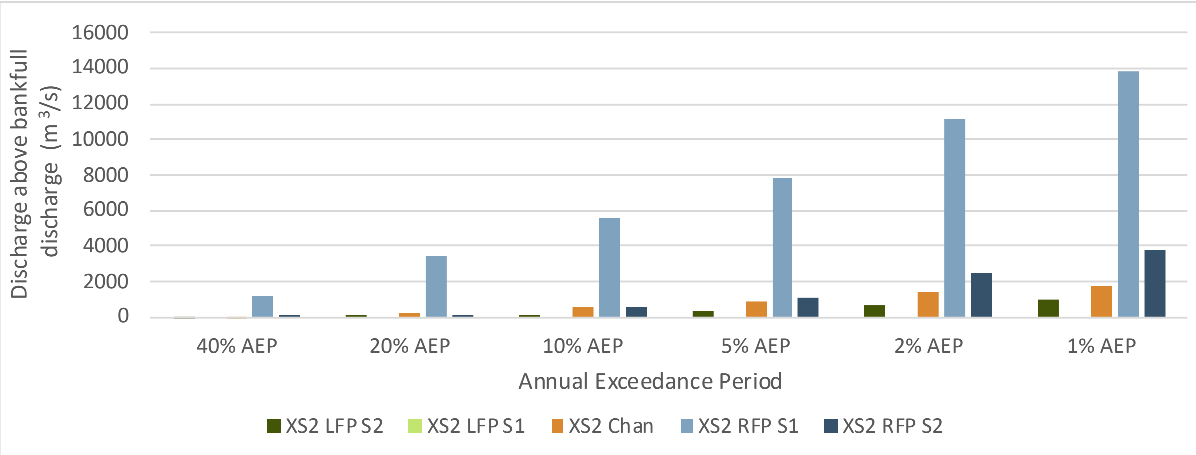

Figure 189. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 2 within the Fitzroy River study area.*

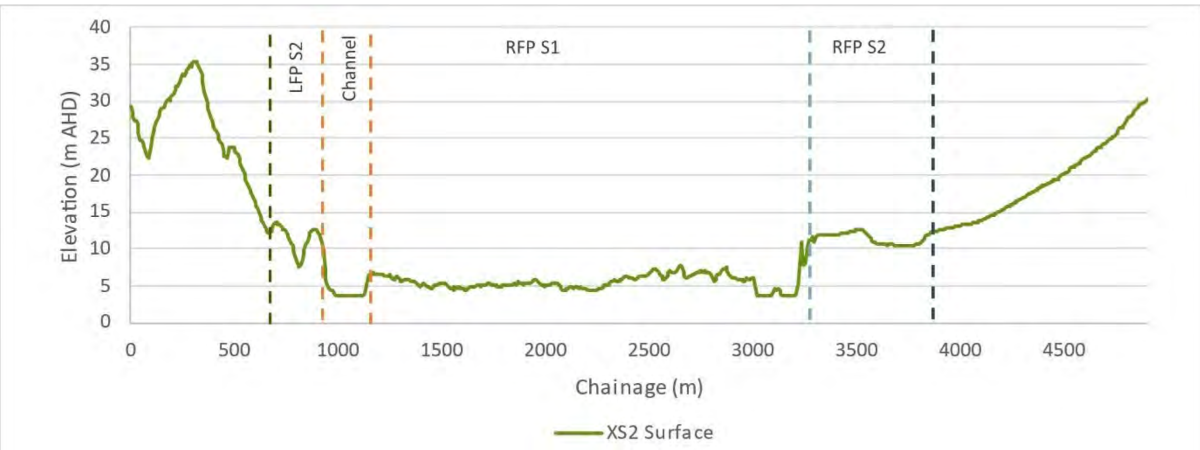

Figure 190. *Cross section 3 within the Fitzroy River study area (cross section location shown in Figure 188).*

Cross section 3

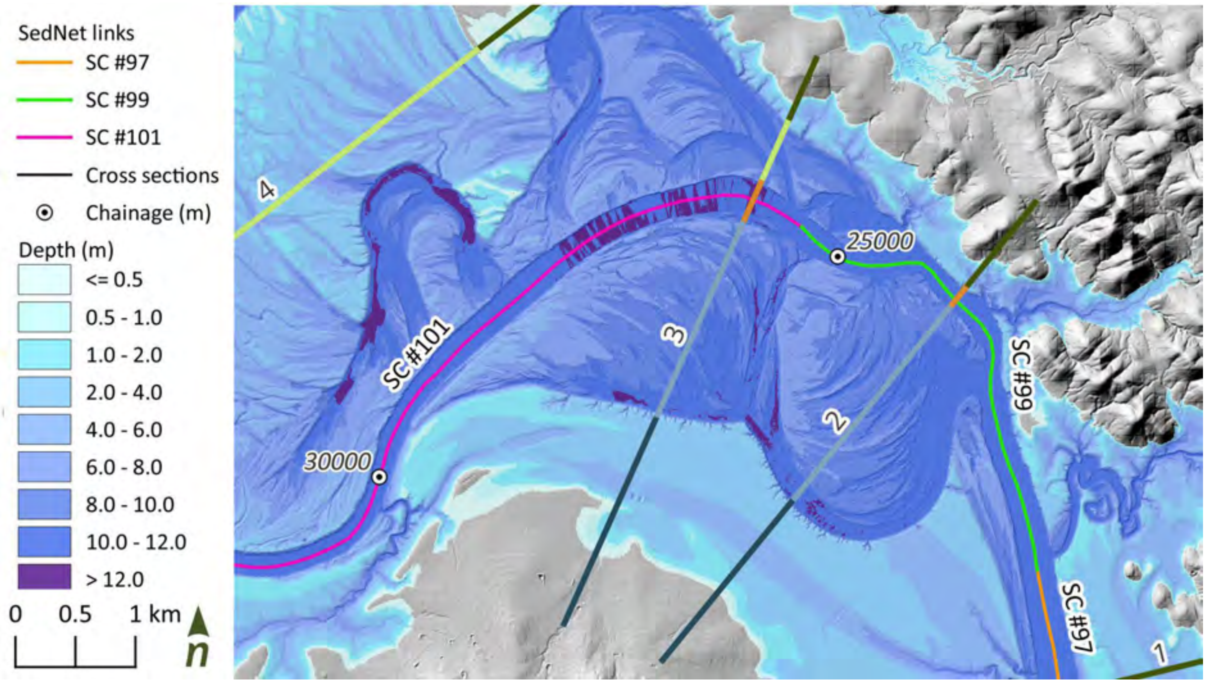

Figure 191. *Location of cross section 3 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

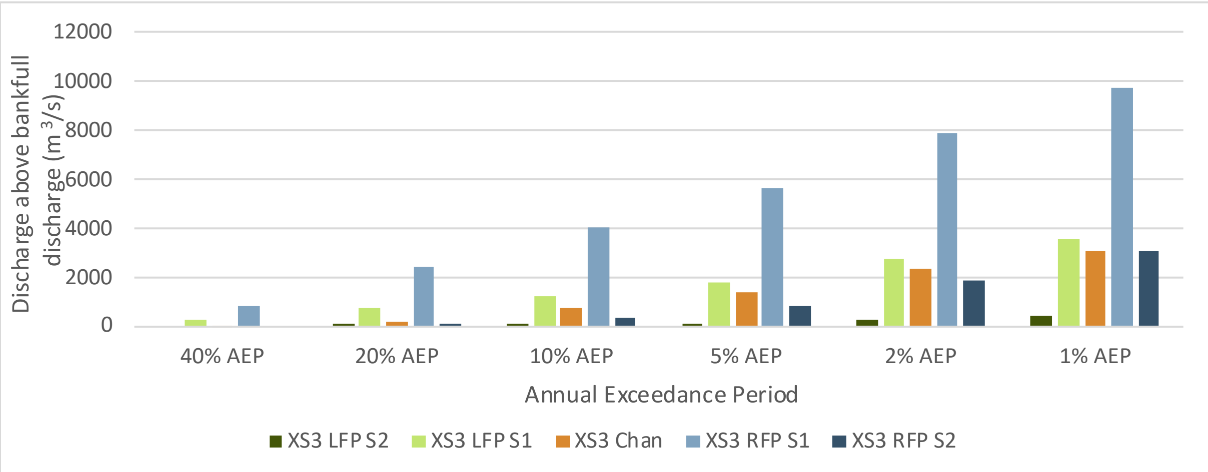

Figure 192. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 3 within the Fitzroy River study area.*

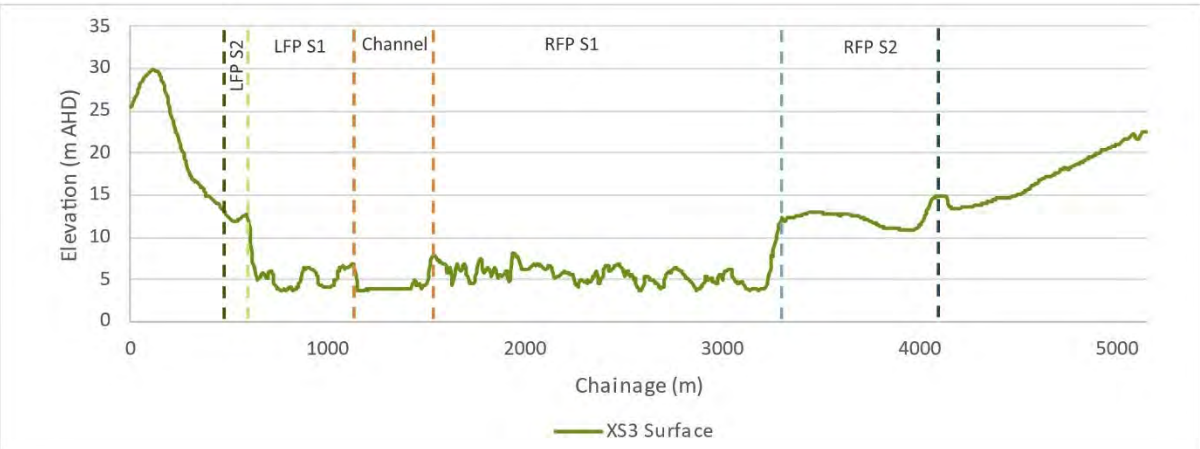

Figure 193. *Cross section 3 within the Fitzroy River study area (cross section location shown in Figure 191).*

Cross section 4

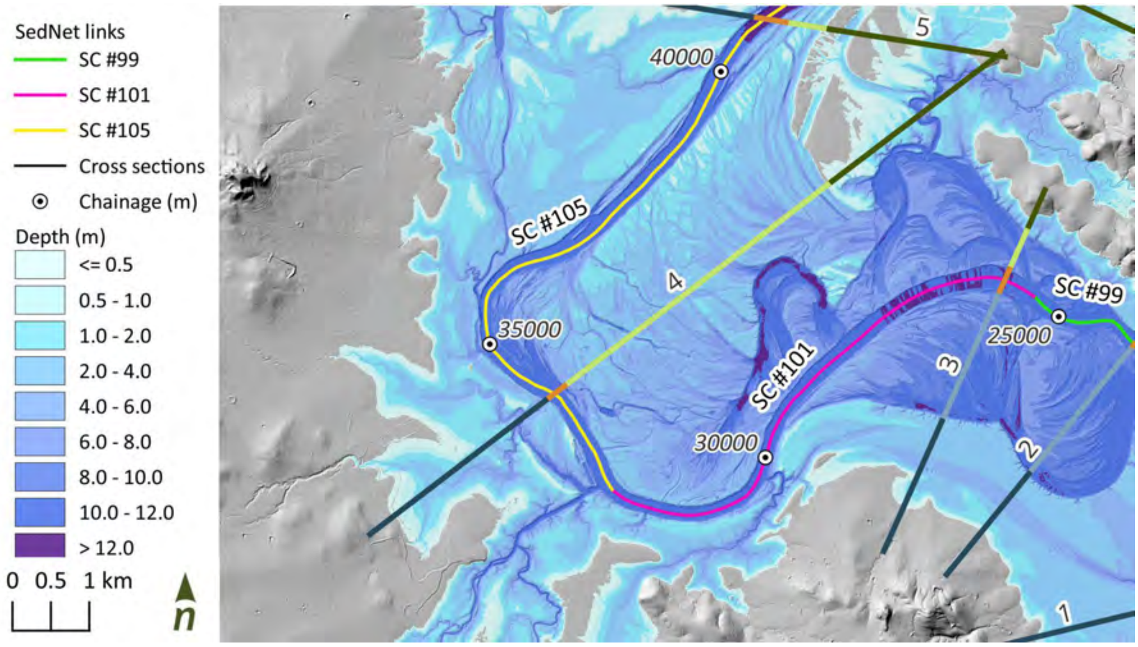

Figure 194. *Location of cross section 4 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

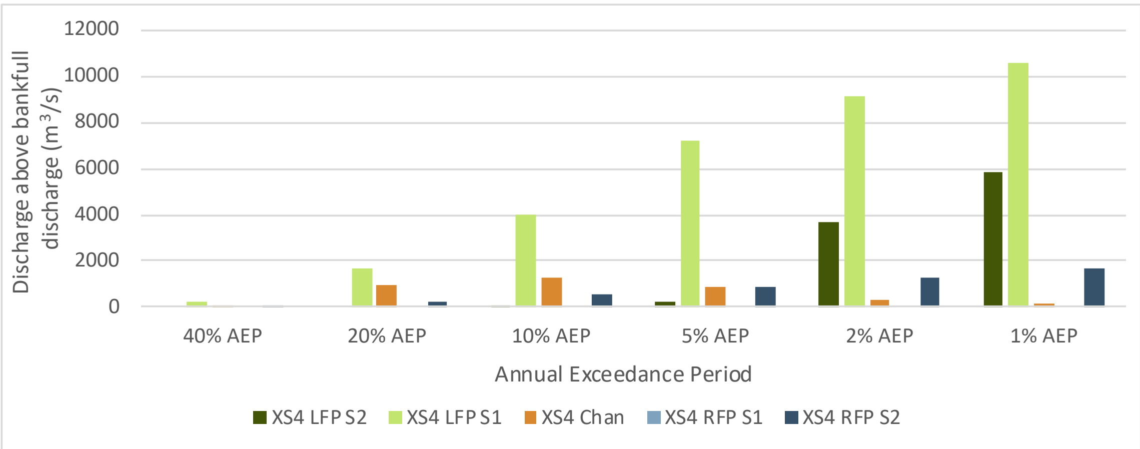

Figure 195. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 4 within the Fitzroy River study area.*

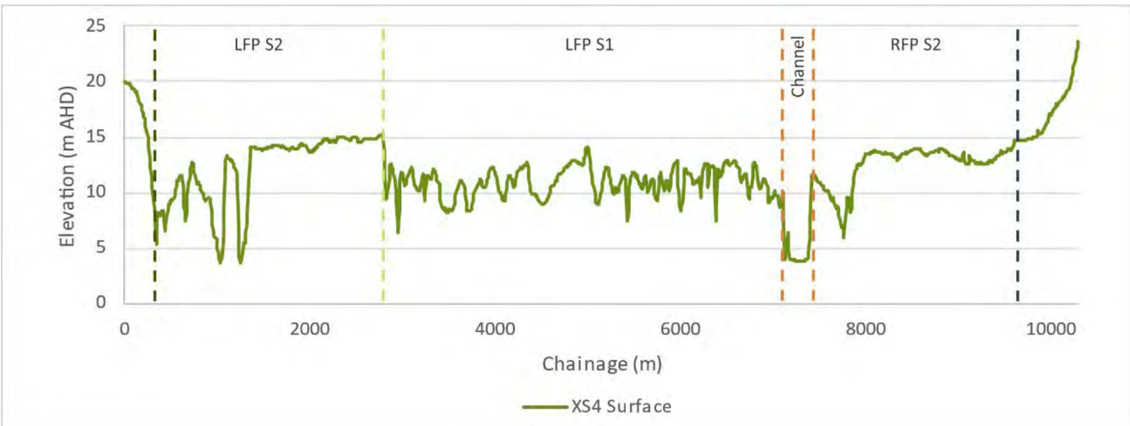

Figure 196. *Cross section 4 within the Fitzroy River study area (cross section location shown in Figure 194).*

Cross section 5

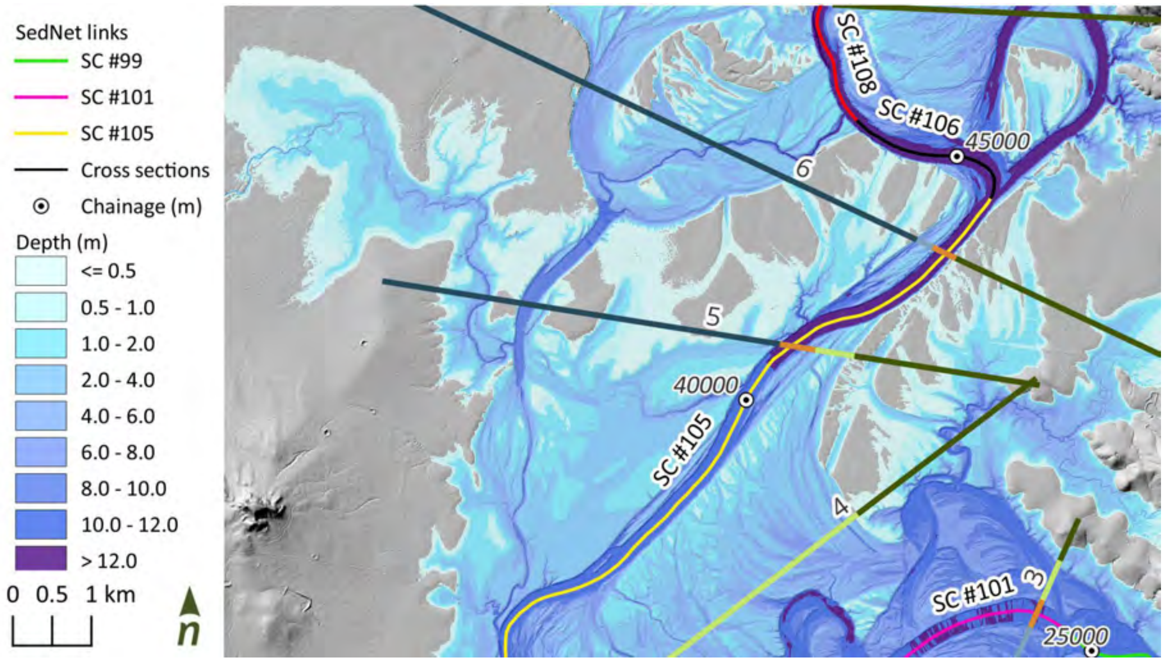

Figure 197. *Location of cross section 5 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

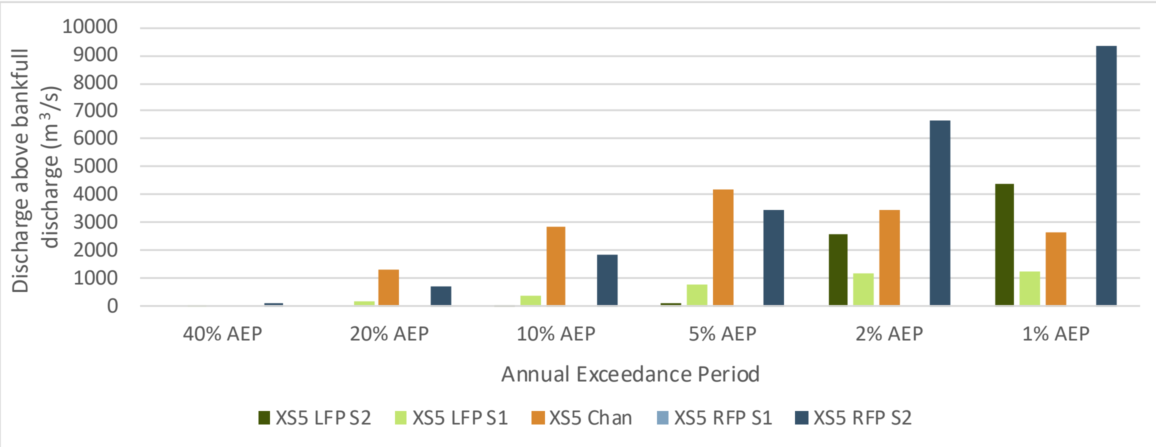

Figure 198. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 5 within the Fitzroy River study area.*

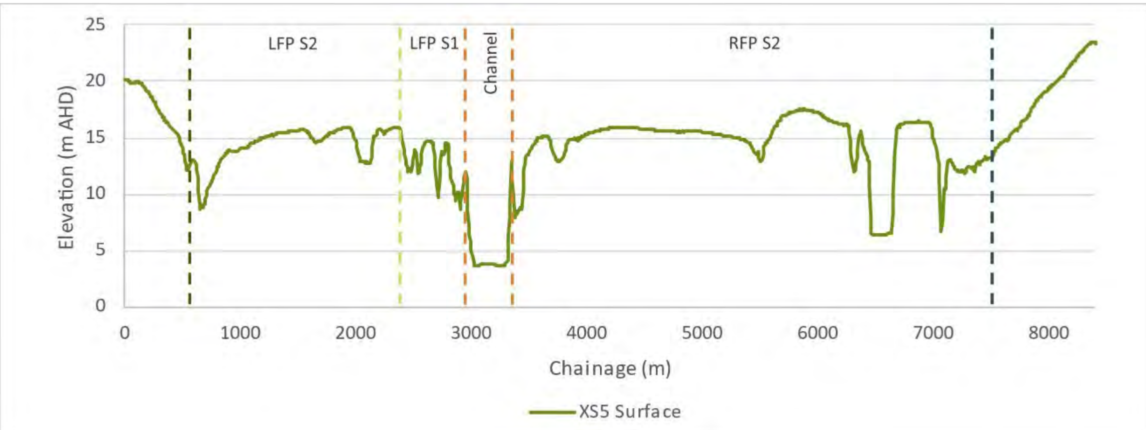

Figure 199. *Cross section 5 within the Fitzroy River study area (cross section location shown in Figure 197).*

Cross section 6

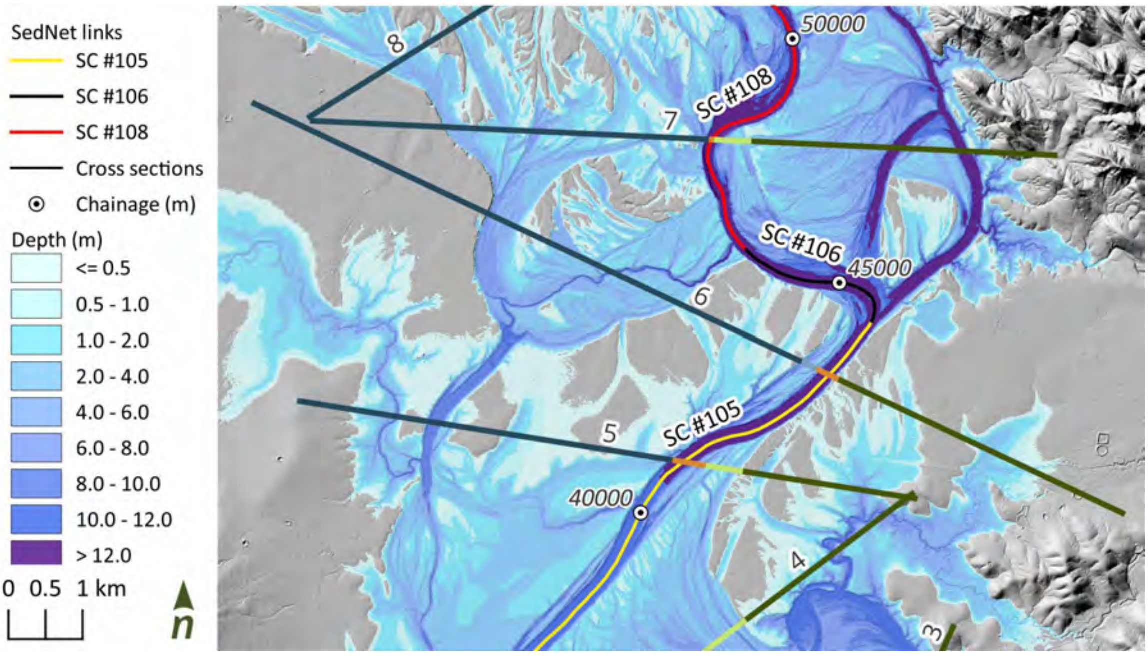

Figure 200. *Location of cross section 6 within the Fitzroy River study area showing model simulation results of the 5% AEP depth. REMOVE INSET UNIT ON PLANVIEW*

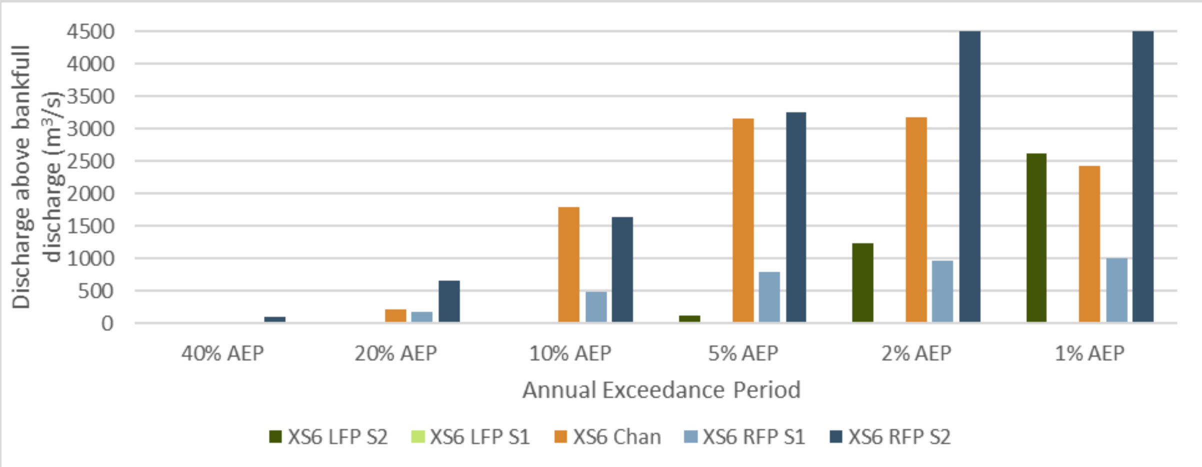

Figure 201. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 6 within the Fitzroy River study area.*

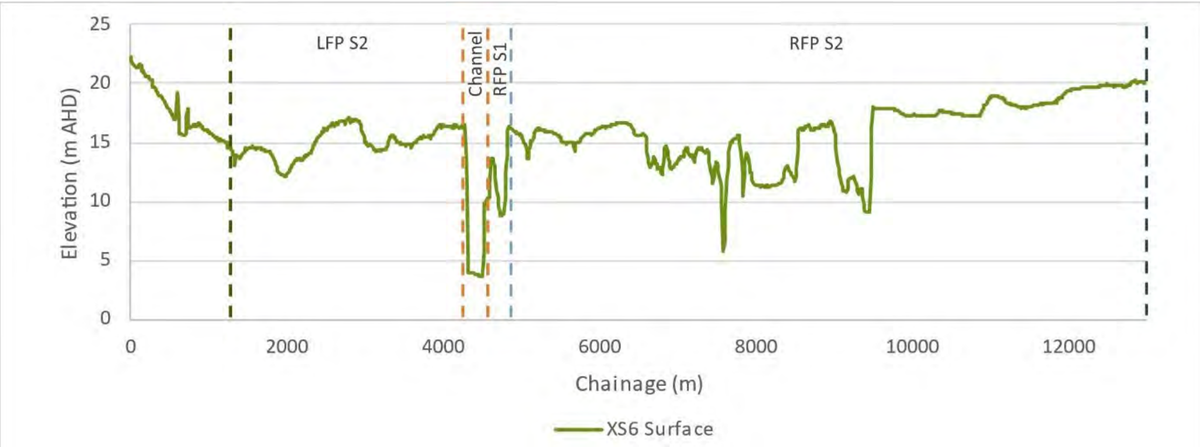

Figure 202. *Cross section 6 within the Fitzroy River study area (cross section location shown in Figure 200).*

Cross section 7

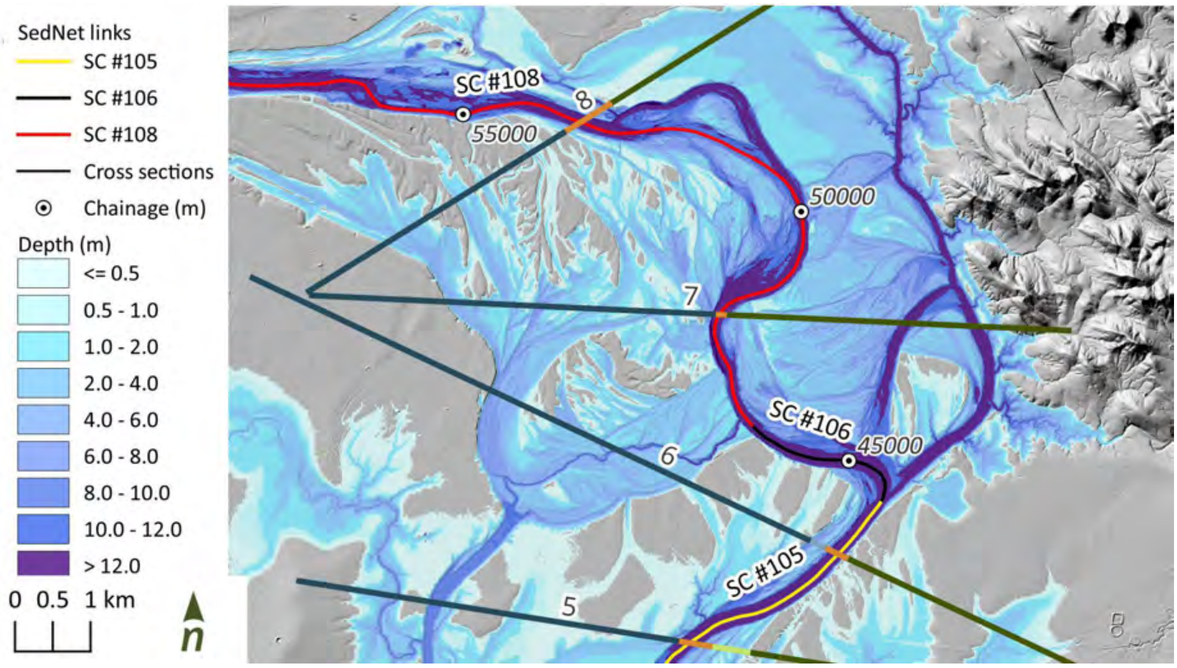

Figure 203. *Location of cross section 7 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

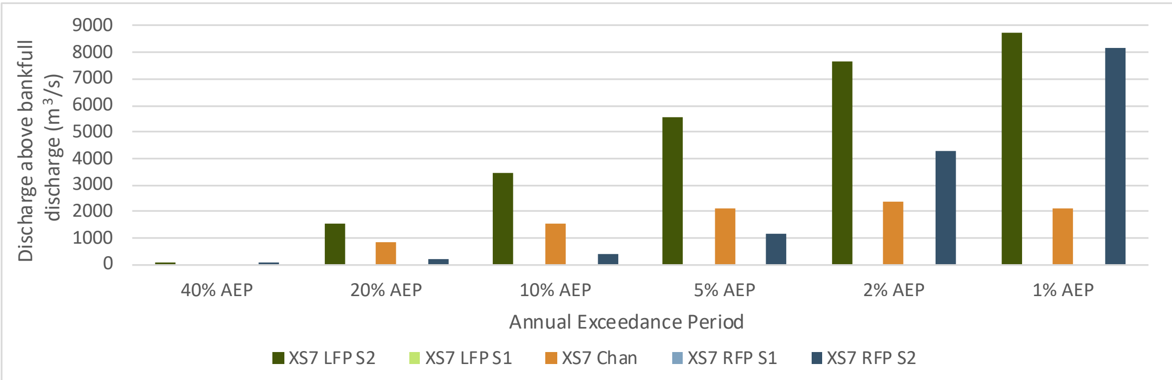

Figure 204. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 7 within the Fitzroy River study area.*

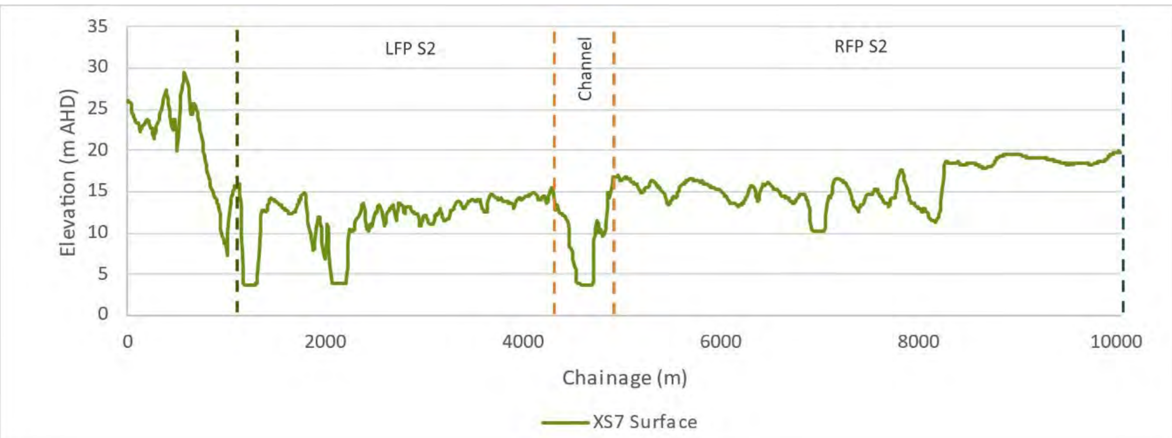

Figure 205. *Cross section 7 within the Fitzroy River study area (cross section location shown in Figure 203).*

Cross section 8

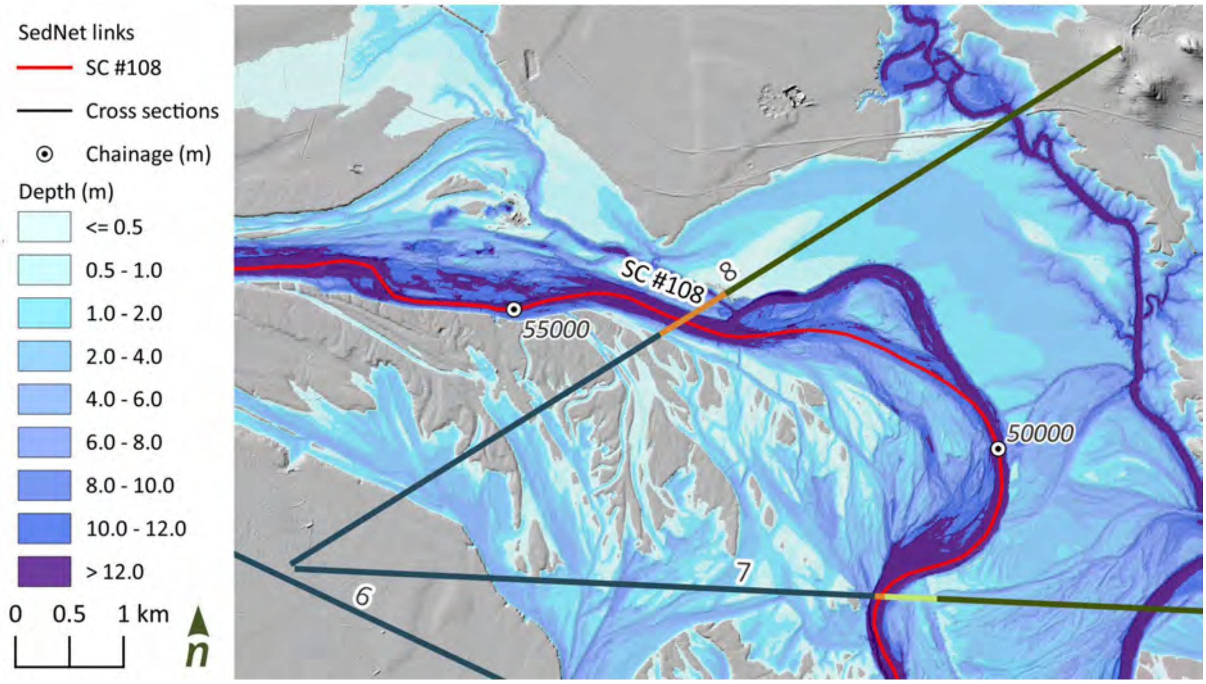

Figure 206. *Location of cross section 8 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

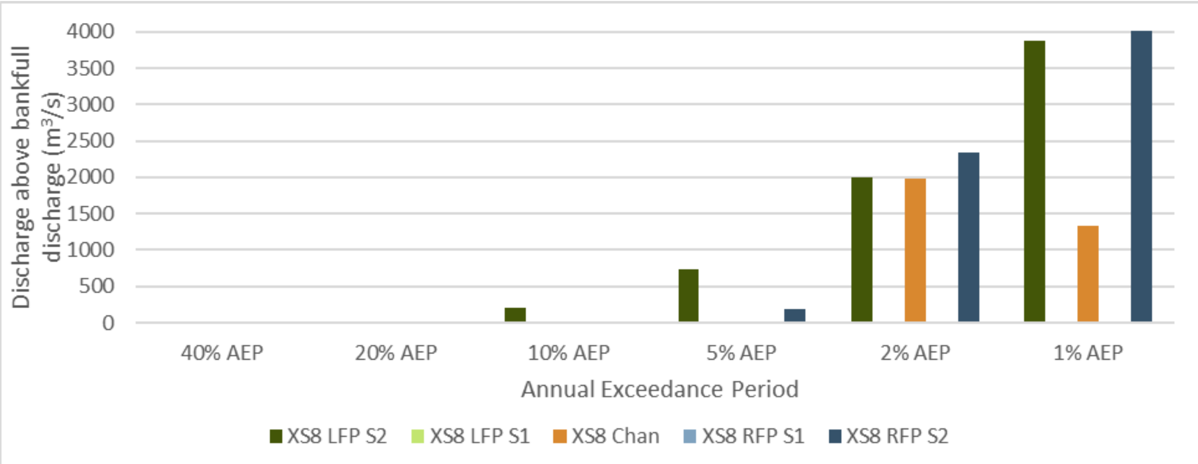

Figure 207. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 8 within the Fitzroy River study area.*

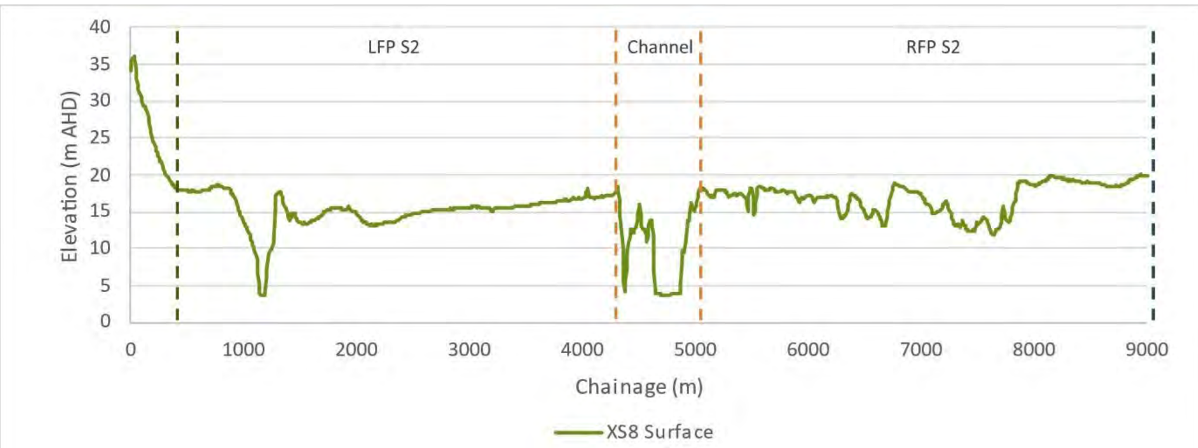

Figure 208. *Cross section 8 within the Fitzroy River study area (cross section location shown in Figure 206).*

Cross section 9

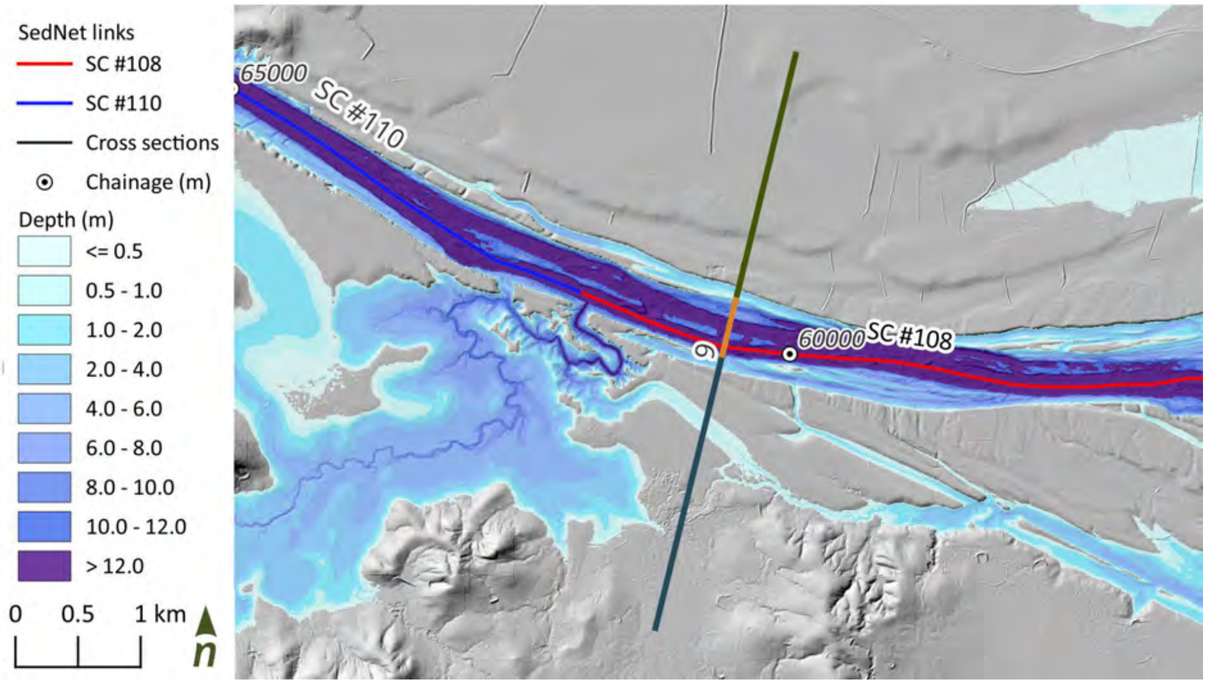

Figure 209. *Location of cross section 9 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

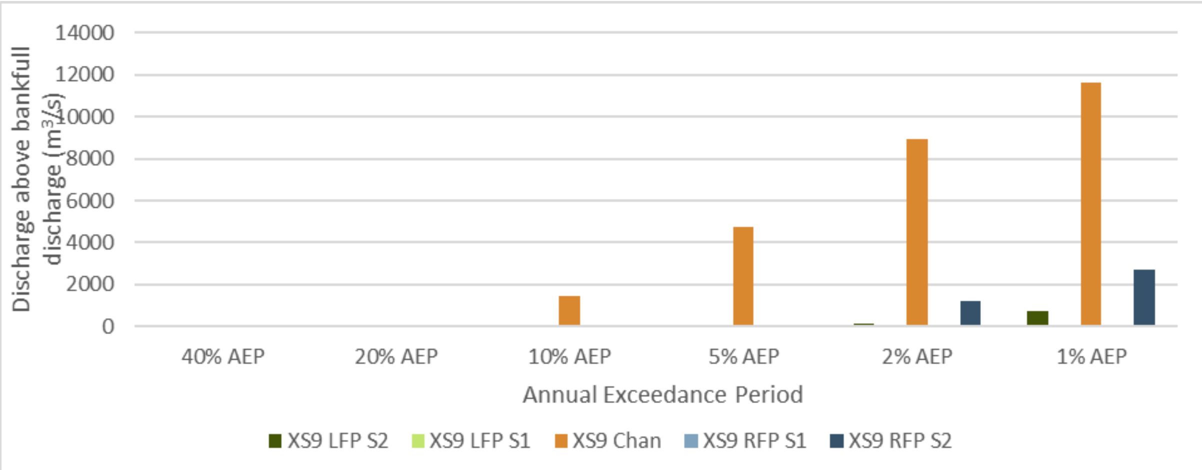

Figure 210. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 9 within the Fitzroy River study area.*

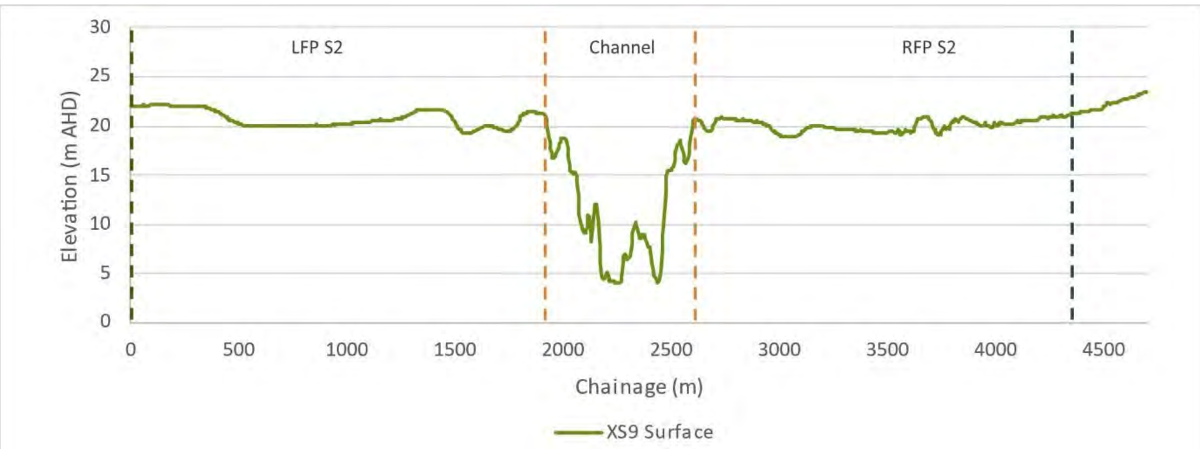

Figure 211. *Cross section 9 within the Fitzroy River study area (cross section location shown in Figure 209).*

Cross section 10

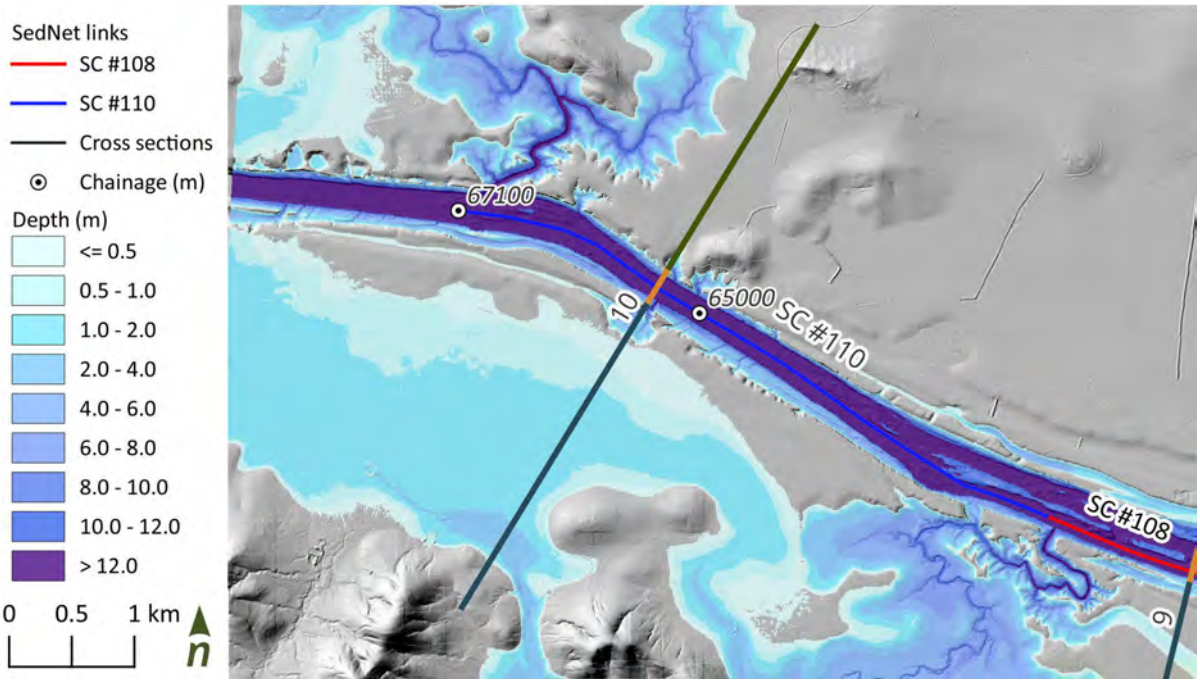

Figure 212. *Location of cross section 10 within the Fitzroy River study area showing model simulation results of the 5% AEP depth.*

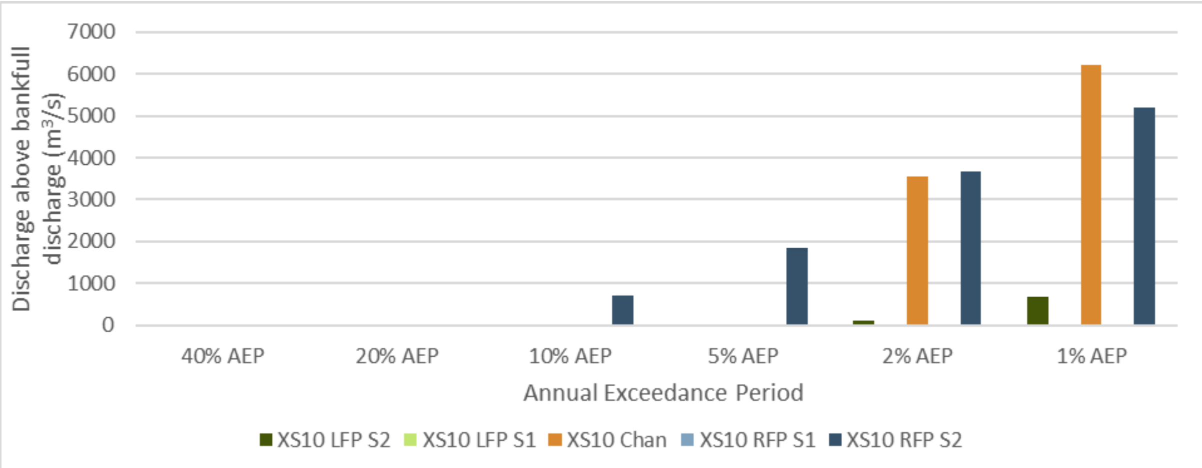

Figure 213. *Bar graph showing the amount of discharge above bankfull discharge within the channel margins and across the floodplain surfaces at cross section 10 within the Fitzroy River study area.*

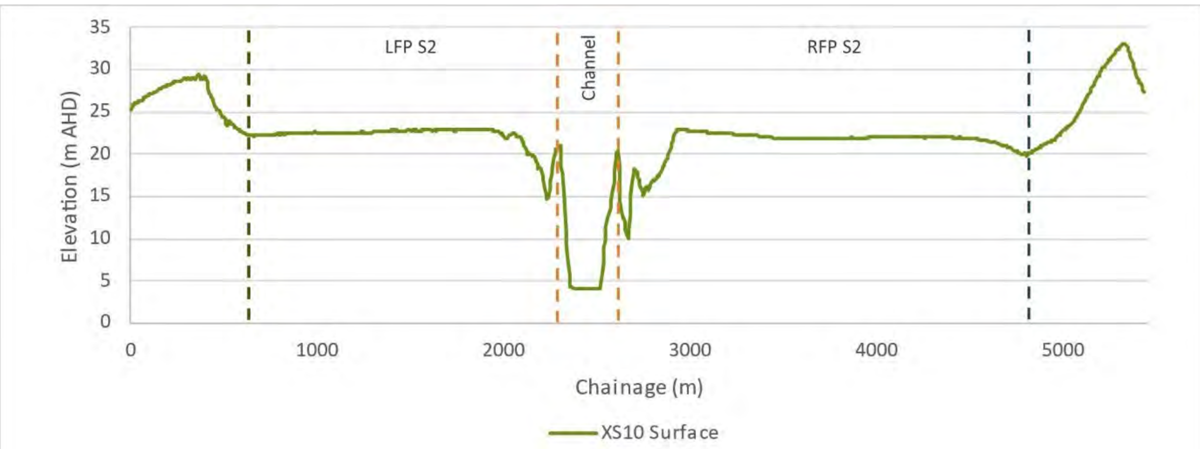

Figure 214. *Cross section 10 within the Fitzroy River study area (cross section location shown in Figure 212).*