NEILLY GROUP
ENGINEERING

# IRVINEBANK WATERSHED RESTORATION PROJECT

## INVESTIGATION AND PRELIMINARY REHABILITATION PROGRAM

15 AUGUST 2022

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# Document Control

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| A | 30 June 2022 | Reece Fraser<br>Jim Tait | Initial Draft | Brent Hennekam<br>Brett Twycross | Adam Neilly |
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# List of Abbreviations

| | |
|---|---|
| **AEP** | Annual Exceedance Probability |
| **AR&R** | Australian Rainfall & Runoff |
| **BOM** | Bureau of Meteorology |
| **BSS** | Bed Shear Stress |
| **DA** | Development Application |
| **DTMR** | Department of Transport and Main Roads |
| **ERA** | Environmentally Relevant Activity |
| **GSNRM** | Gulf Savannah NRM |
| **IFD** | Intensity Frequency Duration |
| **LiDAR** | LIght Detection And Ranging |
| **NGE** | Neilly Group Engineering |
| **NRIP** | Natural Resources Investment Program |
| **NRM** | Natural Resource Management |
| **RPEQ** | Registered Professional Engineer of Queensland |
| **SARA** | State Assessment and Referral Agency |
| **SRTM** | Shuttle Radar Topography Mission |
| **UAV** | Unmanned Aerial Vehicle |
| **WBNM** | Waterhed Bounded Network Model |

# 1 Introduction

## 1.1 Background

The aesthetic and recreational values of McDonald Creek are central to the Irvinebank township. The creek is flanked on either side by a recreational reserve which accommodates picnics, camping and local events upstream of the town dam. Town locals recollect a time when the creek was a much deeper channel through the town centre with many pools present for swimming.

According to locals the current day McDonald Creek is infilled with sediment which has been sourced upstream from historical mining activities. This has reduced the capacity of the local waterway to convey flow events, causing increased flooding and erosion (GSNRM, 2021). Comparison of modern day photos (Figure 1) to historical photos (Figure 2) made available from community consultation (undertaken as part of this study) shows the magnitude of the impact, which is not readily apparent when inspecting the area today.

**Figure 1 McDonald Creek Bridge Crossing in 2021, from downstream looking upstream**


**Figure 2 McDonald Creek Bridge Crossing in 1914, from downstream looking upstream**

Gulf Savanah NRM (GSNRM) have a grant application from the Natural Resources Investment Program (NRIP) to restore the environmental function, flow, health, aesthetic and recreational values of McDonald Creek and therefore Irvinebank township. The project involves:

- **Stage 1** (this report) - an investigation to determine the geomorphology of the creek, source of sediment and a rehabilitation program and costing.
- **Stage 2** - an environmental education program alongside operational works for recovery that have been scoped and costed in this report. This may involve placement of leaky weirs, dredging of sediment, upstream sediment detention works, and placement of rocks.
- **Stage 3** – revegetation.

## 1.2 Scope of Work

GSNRM have requested that Neilly Group, in consultation with Jim Tait (Econcern) prepare a plan to rehabilitate McDonald Creek to return community-sought amenity and recreational values to the town centre. The scope of works of the rehabilitation plan is to:

- Undertake Catchment Delineation and Mapping
- Review Historical Aerial Imagery and Reports
- Undertake a Site Inspection and Community Consultation
- Undertake Hydrological Modelling
- Undertake a Geomorphic Review
- Prepare Costed Rehabilitation Options for the area

The aim of the above scope of works is to identify / confirm the processes leading towards the siltation of McDonald Creek, and then to determine the steps required for rehabilitation.

## 1.3 Available Data

The outcomes achievable within this study are limited to the quality of available data, which includes:

- Topography:
  - 2011 LiDAR information available from Geoscience Australia at 1m gridded resolution and in point-cloud format
  - 30m gridded topography from the Shuttle Radar Topography Mission (SRTM) available from Geoscience Australia
- Land Use
  - Historical Aerial Images available from QImagery dating back to 1960
  - Historical Mining Points available from the Queensland Government
- Stream Flow:
  - No stream flow records for the local area for a period >10 years
- Rainfall
  - Rainfall records from 1889 to present day from BOM Daily Rainfall Gauge Irvinebank (#031032).

## 1.4 Methods

### 1.4.1 Site Inspection

A site inspection was undertaken by Reece Fraser (Neilly Group - Principal Land and Water Scientist), Jim Tait (Econcern - Senior Environmental Scientist) and John Drysdale (Neilly Group – Project Implementation Coordinator) on 25 May 2022 to:

- Collect topographic data around the area of interest
- Inspect the geomorphology of the creek
- Inspect publicly accessible areas of the catchment upstream of the town to find point-sources of high sediment loads to the receiving environment

### 1.4.2 Community Consultation

Community Consultation was undertaken by Jim Tait in association with GSNRM on 26 May 2022 following the site inspection. The purpose of the community consultation was to seek historical information from the community on the function and behaviour of McDonald Creek, and to determine the aspirations of any rehabilitation actions throughout the area.

### 1.4.3 Historical Aerial Photo Interpretation

Historical aerial photographs were acquired from the following sources, and geo-referenced. These images were analysed for historical channel changes and changes in the catchment upstream. Dates examined included:

- QImagery

- 1960
- 1970
- 1974
- 1978
- 1981
- 1986
- 1992
- 1994
- 2004

- Google Earth Imagery
    - 2017

### 1.4.4 Hydraulic Modelling

Hydraulic modelling was undertaken. A detailed methodology is provided in Appendix A.

# 2 Site Overview

Thea area under investigation is McDonald Creek, approximately 700m upstream of the bridge and the area downstream of the bridge adjacent to the camping area (Figure 3). McDonald Creek, the main creek flowing through Irvinebank, exists in the area of investigation as a series of shallow (<1m deep) pools connected in a pool-riffle sequence (Figure 3e). The overbank area is colonised by relatively thick vegetation. The southern/left hand over bank has a recreational park colonised with prominent fig trees and several other species (Figure 3a).

The bridge is located approximately three-quarters of the way along the study area. Immediately downstream there is evidence of sedimentation as well as an informally installed permeable rock wall (Figure 3d and h).

Immediately downstream of the area of investigation is Loudoun Dam. This dam was installed in 1885[1] and serves as the town water supply. The dam is heritage listed with a concrete stepped spillway which was installed in 2006 (Figure 3g). Tailings were deposited into the dam until the 1980's when they were placed in the Target Gully tailings storage facility to the immediate south of the dam (Figure 3).

McDonald Creek upstream of the town also exists as a cobble-bed stream in a series of pool-riffle sequences, albeit more spaced apart (Figure 3b). Riparian vegetation occurs along the banks of the creek for one or both sides. Gibbs Creek also flows into Loudoun Dam and is a comparable stream to McDonald Creek. However there is no excess sediment supply so, for the purposes of this study, it forms a 'reference reach' to indicate what McDonald Creek could/would have appeared like without an artificially increased sediment load from historic mining operations (Figure 3c). Upstream of the township McDonald Creek and Gibbs Creek share many of the same features and are relatively comparable (Figure 3b, Figure 3c).

[1] https://en.wikipedia.org/wiki/Irvinebank_Dam Date accessed: 28/06/2022

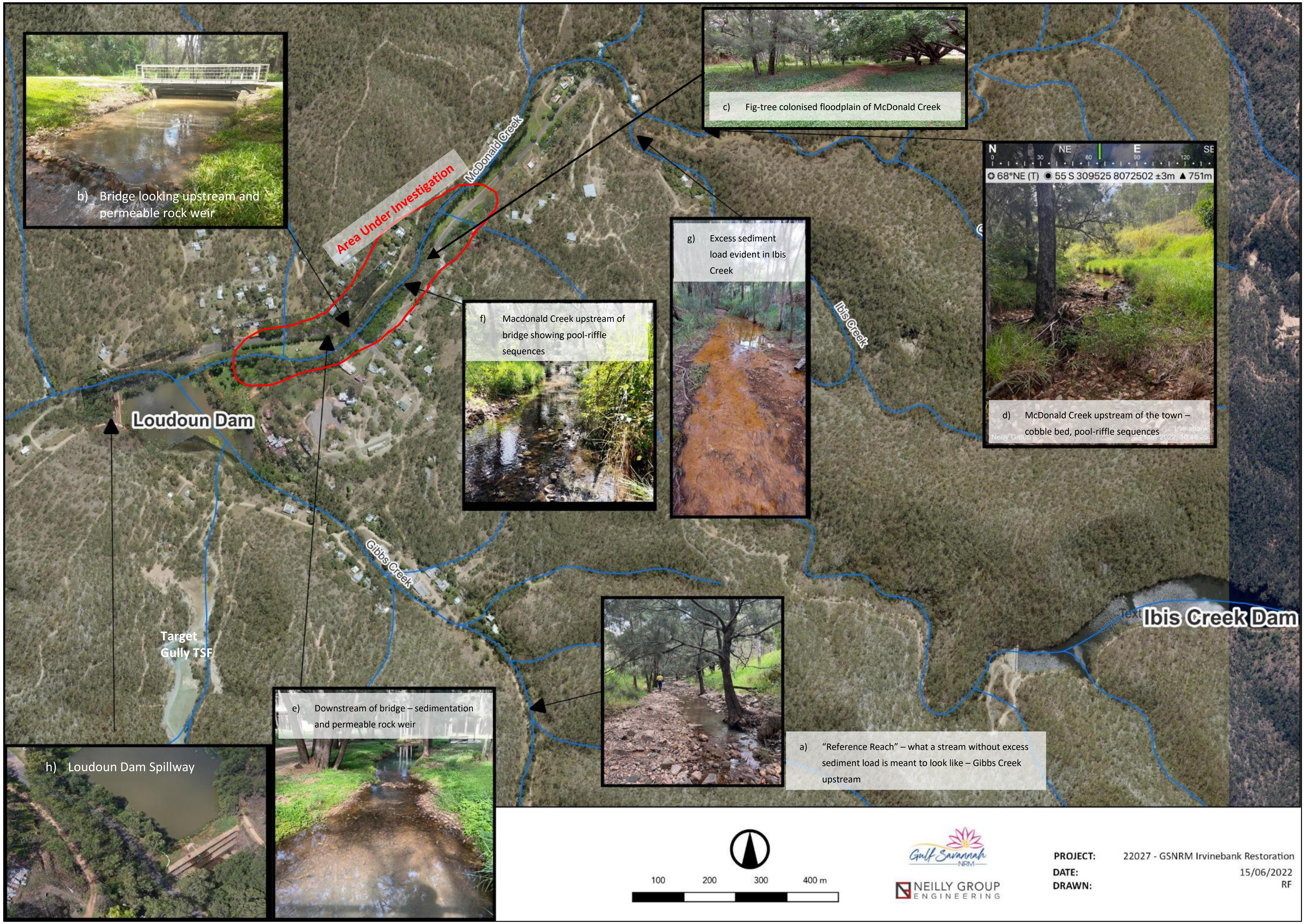


**Figure 3 Overview map of key features in the study area**

# 3 Site Geomorphology

There is a balance between the volume and size of sediment available and the power available to transport it. The resultant balance (or lack thereof) dictates the shape and behaviour of stream channels (Figure 4). If there is a perfect balance between the available sediment (volume and size) and the flow and velocity available to transport it, there is no erosion (degradation) or sedimentation (aggradation). An excess of flow and velocity compared to the sediment available for transport can result in erosion, while an excess of sediment (compared to the flow and velocity available) can result in sedimentation (aggradation). The flow and velocity available is dictated by the longitudinal slope of the river system, confinement of the valley, climate and rainfall-runoff processes (Figure 4).

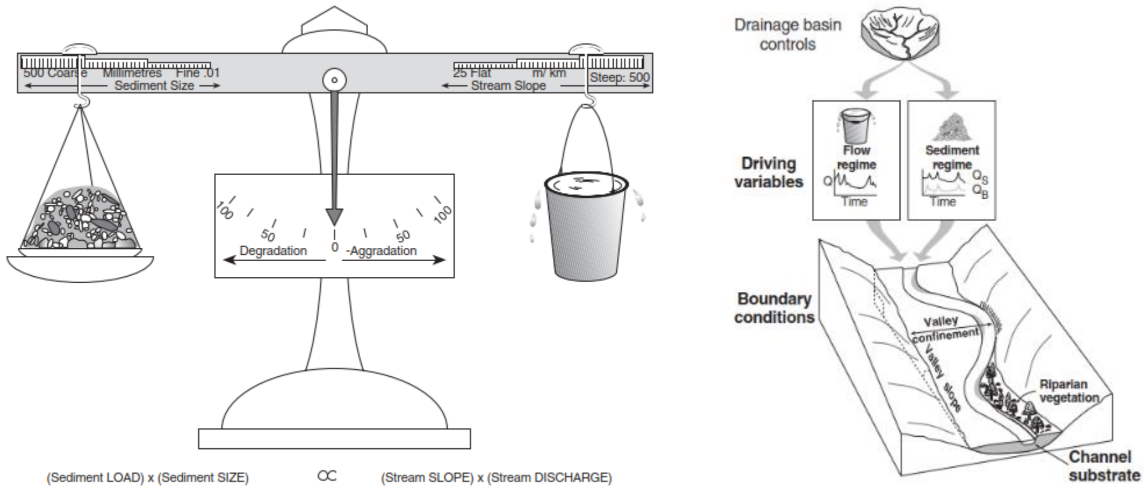


**Figure 4 Processes governing overall channel form and function (Charlton, 2008)**

This section examines:

- The available sediment supply to McDonald Creek and the area under investigation
- Landscape characteristics that will dictate flow and deposition
- Channel form and function of the area.

## 3.1 Upstream Catchment Area

Historically, the catchment area upstream of Irvinebank has been subjected to high intensity open-cut and underground mining and quarrying. Evidence of several operations still exist today as remnant features in the landscape. Historical aerial imagery was acquired from QImagery and geo-referenced in QGIS to determine the level of disturbance in the upstream catchment area. All areas of major disturbance were digitised into the one overlay which is pictured below in Figure 5 to show the scale of historical upstream disturbance.

Much of the upstream catchment area has been rehabilitated and large-scale disturbance is not evident in current aerial photographs. There are several areas where vegetation has not re-grown which may liberate excess sediment into the receiving environment. These areas were inspected on-ground and via UAV during the site inspection. With reference to Figure 5 it was found

- The area north and west of Lady Norman has large, significant disturbance still to the present day. However, examination of the drainage lines downstream (near Herberton

Petford Rd) does not show any large build-up of sediment consistent with the upstream disturbance
- The remainder of the disturbance in the Lady Norman area has self-contained drainage (i.e. any runoff would accumulate in the depression created by the open-cut mine operation)
- Disturbance around the Jack in the Box area is limited to that surrounding an underground adit and is not expected to liberate large volumes of sediment.
- Disturbance around Lizzie is similar to Jack in the Box with minimal disturbance evident around an underground adit
- The only area with visible sediment accumulation is upstream of the road culvert near the Waste Transfer Station. This sediment is probably sourced from the area "north" of Lady Norman (Figure 5) and accumulates behind the road culvert. Community consultation identified that this culvert is buried in sediment which is excavated annually.

Inspection of many of these areas shows an exposed land surface that will liberate sediment into the local receiving environment. However further investigation of the catchment area upstream of the township, but downstream of these areas, shows that there is little to no evidence of contemporary sediment accumulation in the drainage lines immediately downstream, let alone McDonald Creek. The only area of note is around the Waste Transfer Station. However the volume of sediment evident in and around this location does not align with the volume of sediment that has accumulated in McDonald Creek in the township.

Community consultation revealed that there is a heavy sediment load (Figure 3f) entering McDonald Creek immediately upstream of the study area, from Ibis Creek, likely sourced from the Peterson Mining area. The Mount Peterson mining area consists of a vertical adit above the creek which spills sediment straight into Ibis Creek. The excess sediment load entering McDonald Creek is clearly evident in this drainage line compared to others (Figure 3).

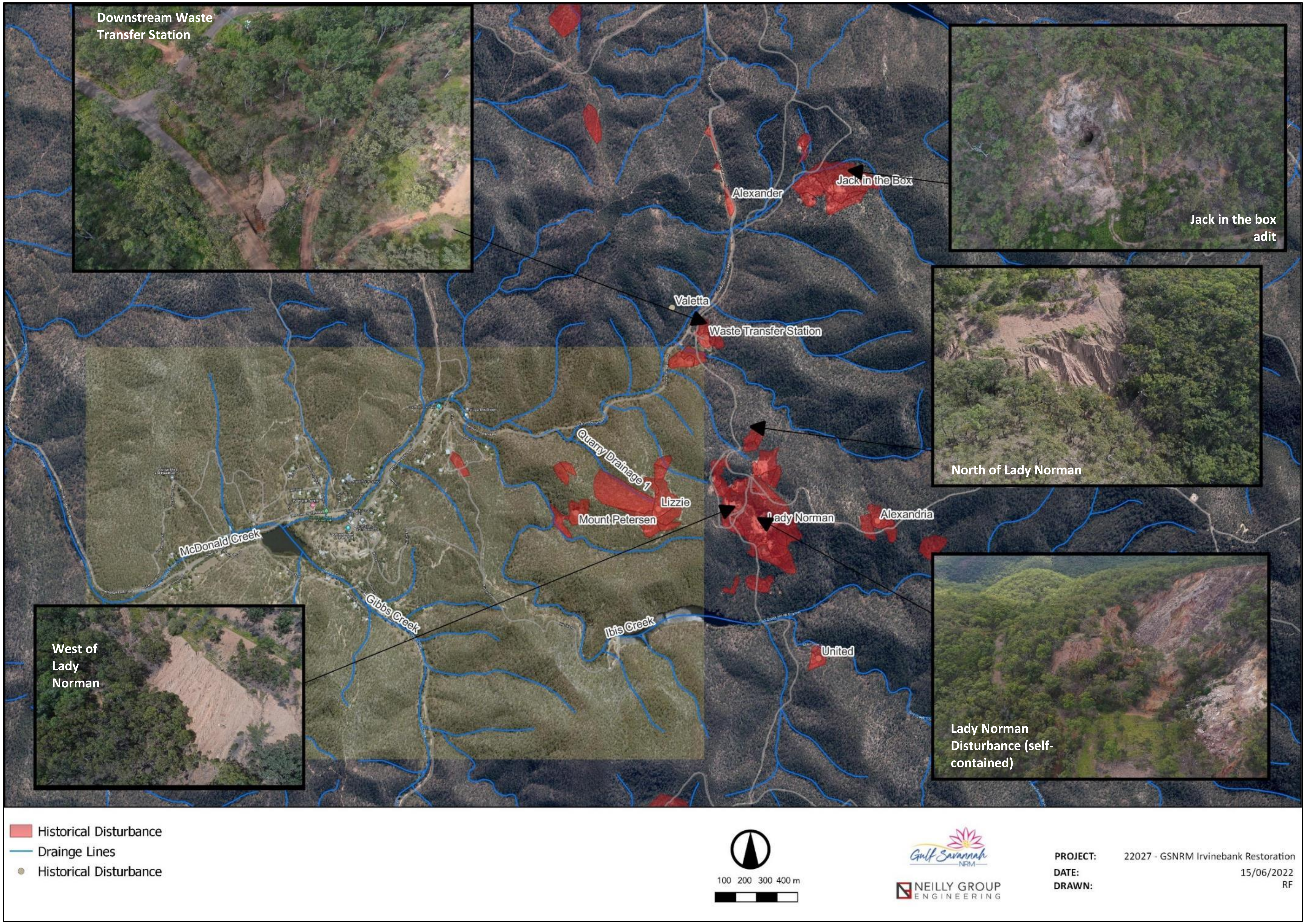


**Figure 5 Major historical disturbance with images overlaid**

## 3.2 Channel Shape and Behaviour

### 3.2.1 Catchment Scale

The behaviour and shape of a stream channel is highly dependent on the grade along the stream channel. The steeper the grade, the higher the velocity and therefore the more potential for sediment transport. With respect to sediment transport, stream systems can be either:

- **Supply limited**: where the sediment transport ability of the stream out-weighs the sediment available for transport
- **Transport limited**: where the supply of sediment exceeds the ability of the stream to transport it through the system.

Longitudinal profiles of the major drainage lines (Figure 6) show that the overall gradient of the area is approximately 1:100 (1m fall per 100m along the direction of flow). The relatively steep gradients found throughout the area will ensure that flow velocities are relatively high, and the probability of the streams being 'transport limited' will be low (i.e. there should be sufficient velocity in any flows to transport whatever sediment is supplied to major flow paths).

However, the Loudoun Dam decreases the longitudinal gradient along McDonald Creek and Gibbs Creek, for a distance of approximately 800m upstream of the spillway. This decrease in longitudinal gradient will reduce stream velocities throughout the area, resulting in a decreased capacity for sediment transport, increasing the probability that that particular area may be 'transport limited'. Therefore, as with all dams, it is expected that there will be some degree of increased sediment deposition at and above the headwaters of the full supply level of the dam, as velocities are reduced because of the decreased longitudinal slope of the stream system.

The modelling results for the 50% AEP (roughly the 1 in 1.5-year storm) provide good agreement with this observation. Velocities (Figure 8) and shear stresses (Figure 9) in reaches immediately upstream of the town are consistently above 2m/s and 60N/m$^2$ respectively. Shear stress represents the force applied to the bed of the river channel. A value of 60N/m$^2$ is sufficient to begin to transport 50-90mm sized particles as well as strip out and erode short grasses. Once flows in McDonald Creek reach roughly the position of the house marked, velocities decrease to approximately the 1.0m/s range and shear stresses are not as pronounced. This is because of the combination of the reduced longitudinal profile because of the Loudoun Dam and the resultant sediment accumulation in the valley of McDonald Creek.

Simplified bed shear stress (BSS) results more clearly show the decrease in sediment transport ability. The results for the 50% AEP event (Figure 10) show the average BSS for each approximately 100m section of McDonald Creek and Ibis Creek. Upstream of their confluence, in the relatively steep area of the town (approximately 1:50 longitudinal gradient) the average BSS is above 80N/m$^2$ for significant sections (especially in Ibis Creek compared to McDonald Creek) and other sections are above 60N/m$^2$. In other words, the BSS is sufficient to mobilise particles in the order of 60-128mm diameter. Conversely downstream of the confluence of McDonald Creek and Ibis Creek the BSS decreases with some sections then showing an average BSS of 40-60N/m$^2$ (capable of transporting 32-60mm diameter particles). It would be expected that significant deposition of particles between ~60mm to 128mm would occur in this area. Average BSS further decreases with proximity to the study area, with a large section of McDonald Creek showing a BSS in of approximately ~35N/m$^2$, sufficient to transport particles with a 30mm diameter in the 50% AEP event.

As supported by site photographs the bed sediment within this area shows some signs of local deposition (Appendix C). Bed deposition is not clearly evident further upstream where the shear stresses are sufficient to ensure smaller sediment is mobilised and not deposited in these areas.

The longitudinal profiles in Figure 6 and Figure 7 show that, at the bridge, there is approximately 2m thickness of sediment accumulation in the main channel of McDonald Creek compared to what would have existed prior to the installation of Loudoun Dam.   Community consultation identified that the Loudoun Dam was installed in the 1880s, and is therefore a long-term feature.

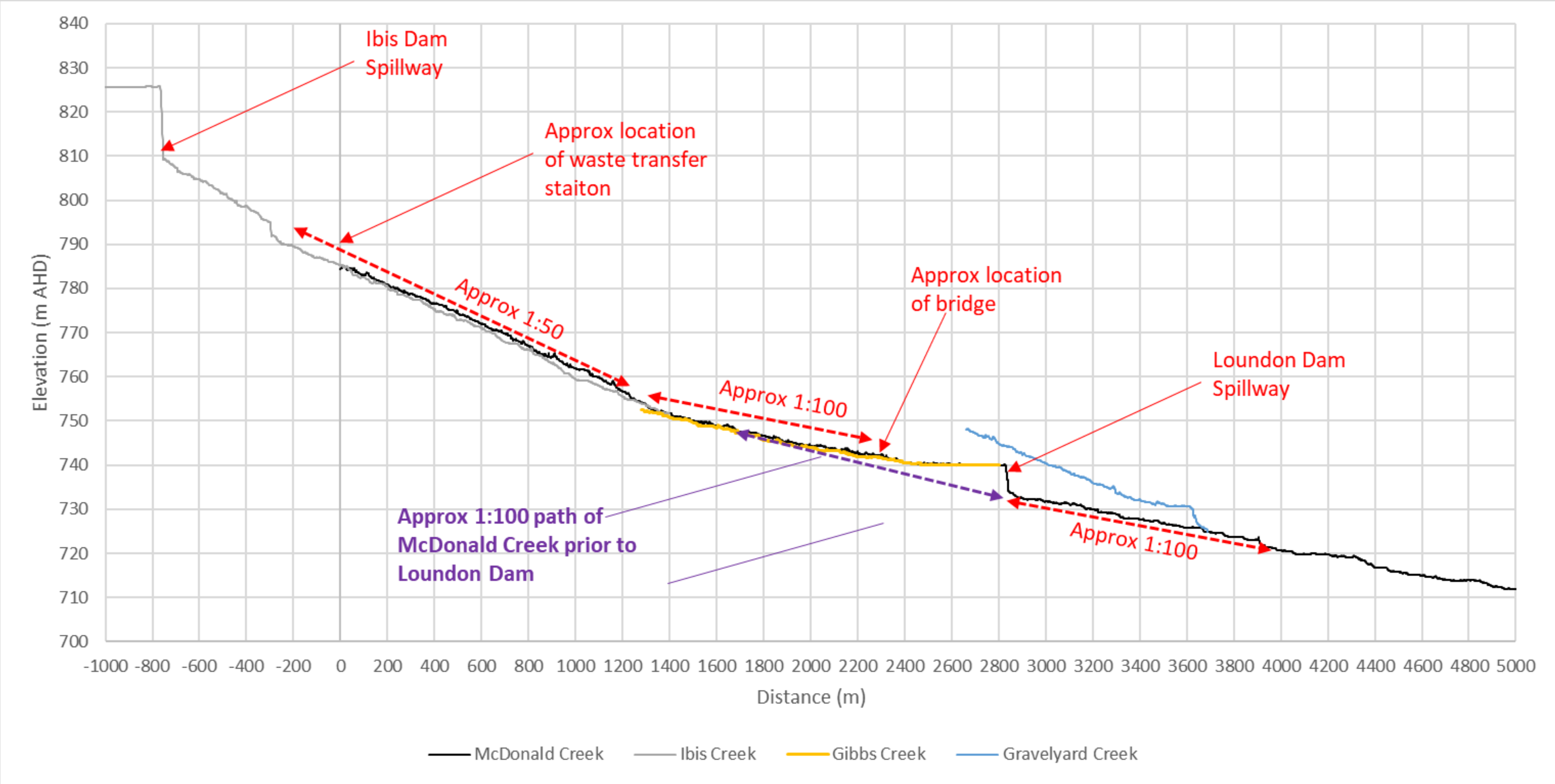


**Figure 6 Longitudinal profile of all major drainage pathways through the area. Purple annotation shows the potential historic gradient of McDonald Creek prior to installation of the Loudon Dam**

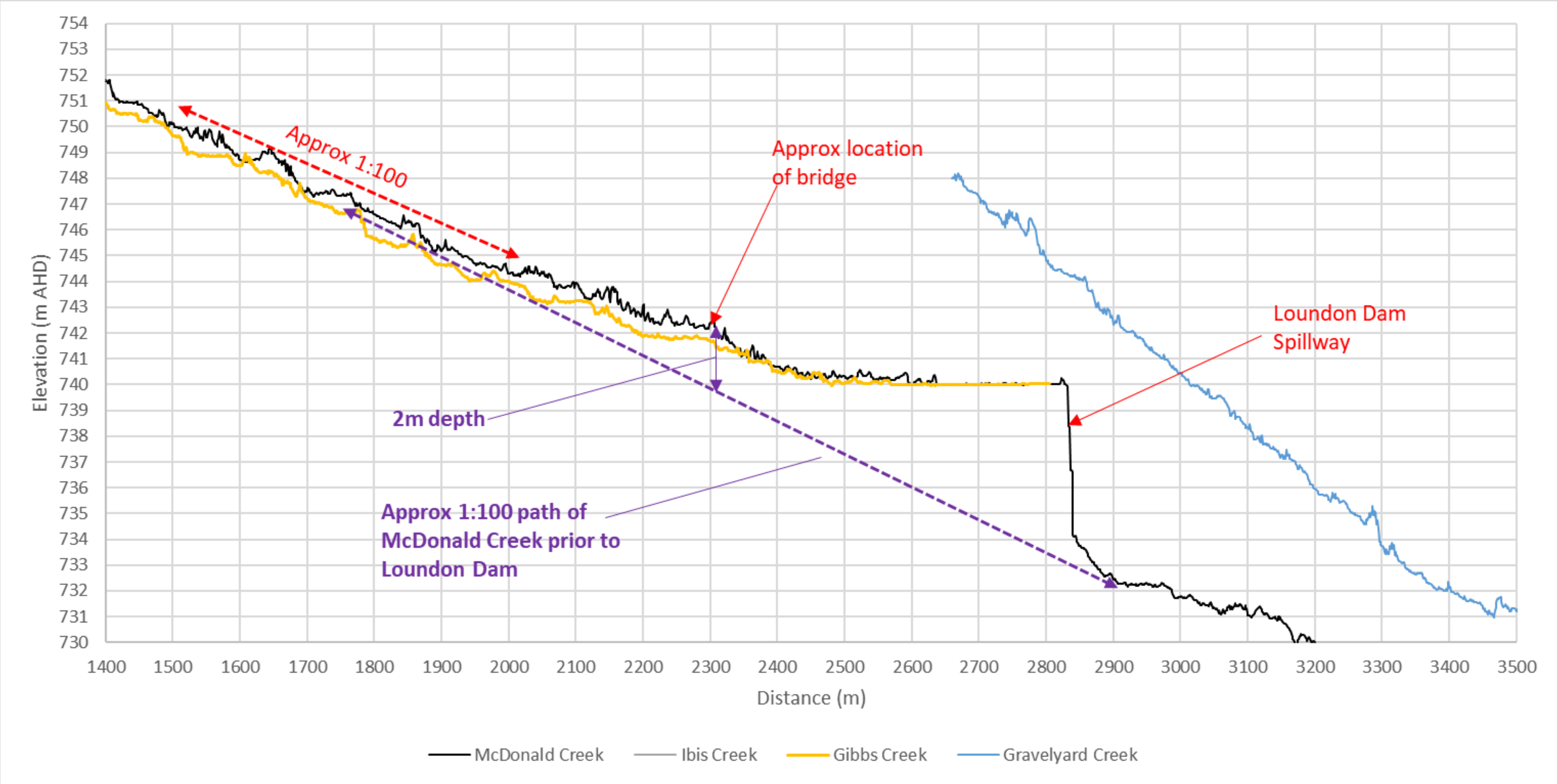


**Figure 7 Longitudinal profile of all major drainage pathways through the area, immediately around Loudon Dam. Purple annotation shows the potential historic gradient of McDonald Creek prior to installation of Loudon Dam**

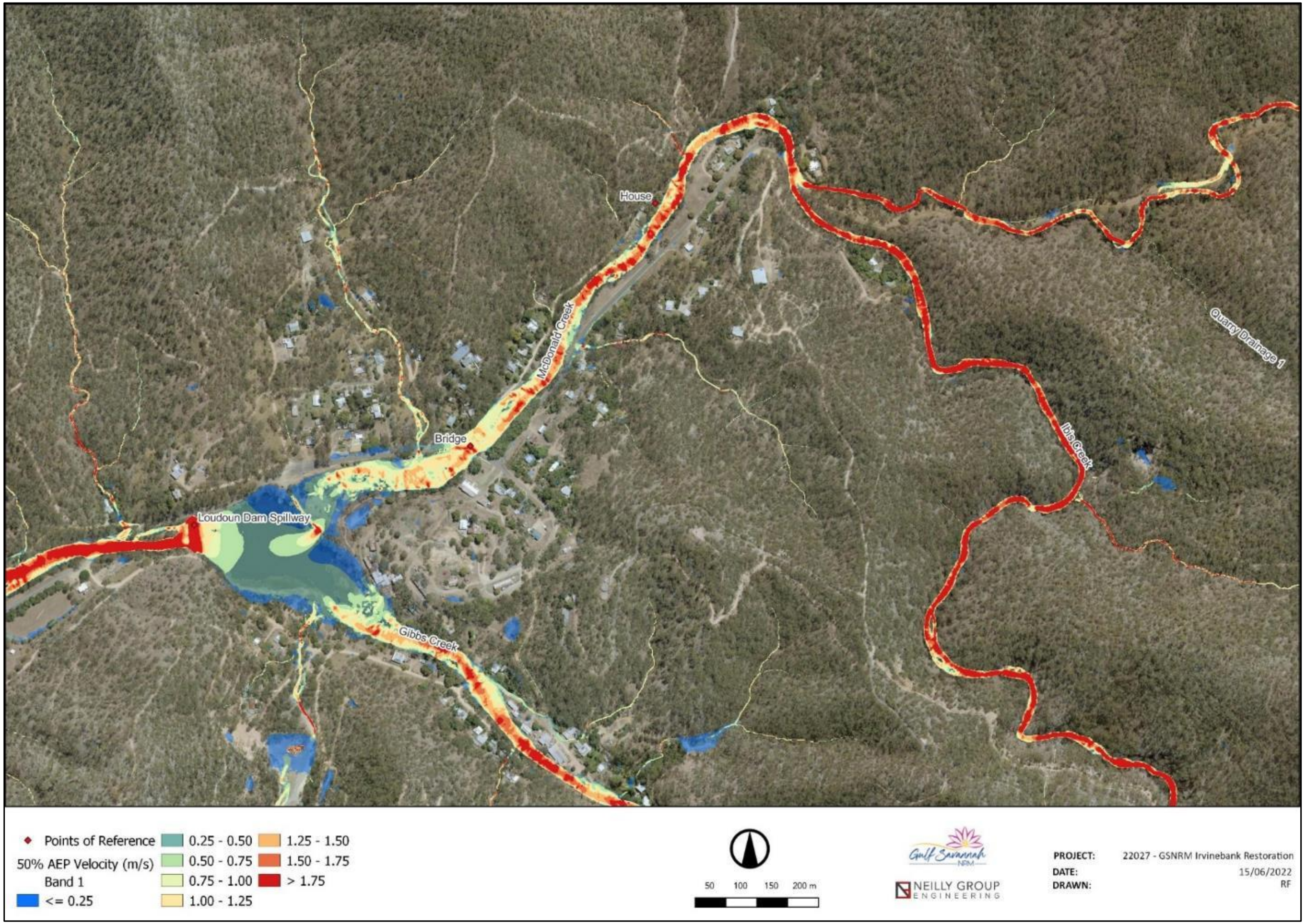


**Figure 8 50% AEP modelled velocity**

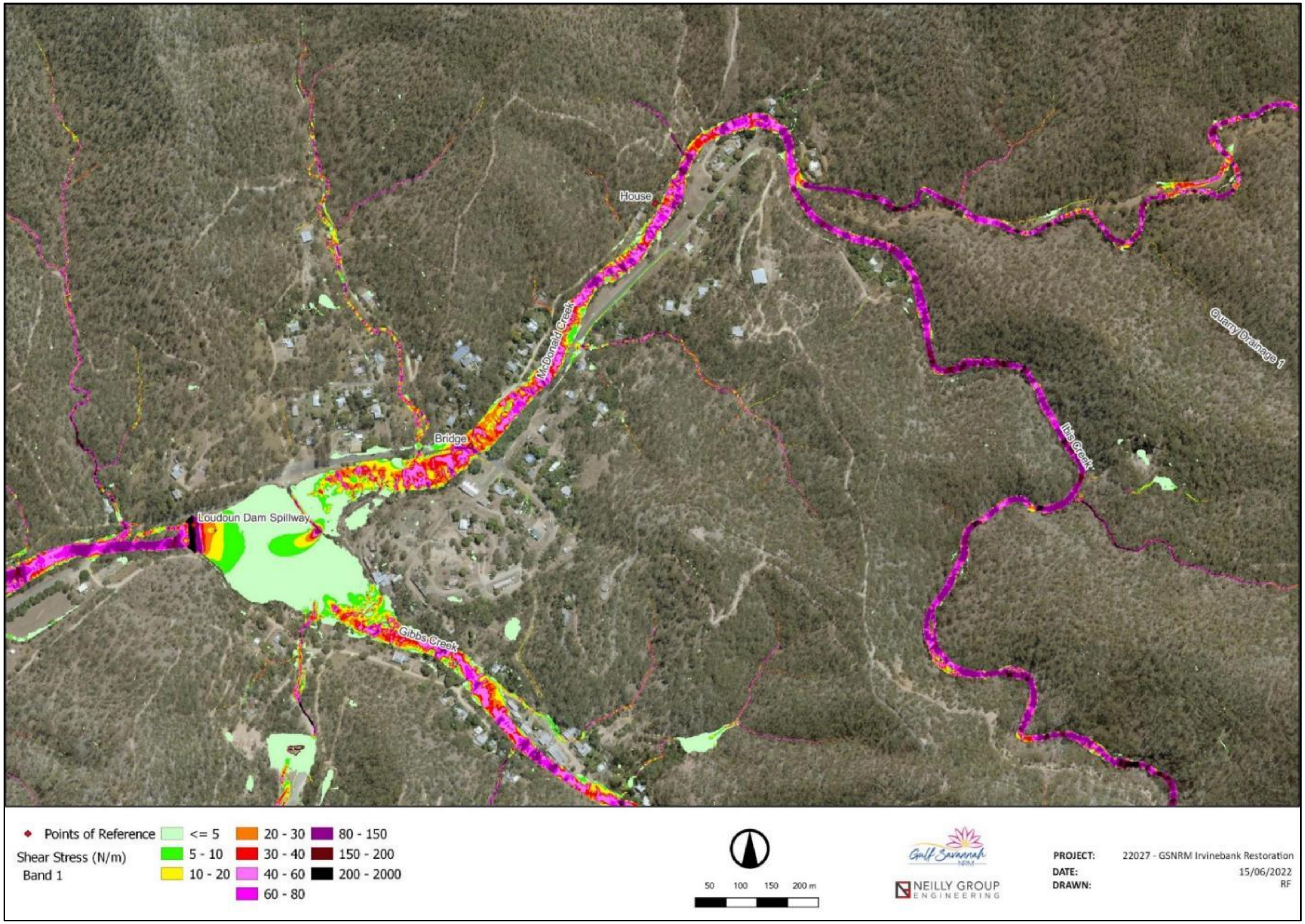


**Figure 9 50% AEP modelled BSS**

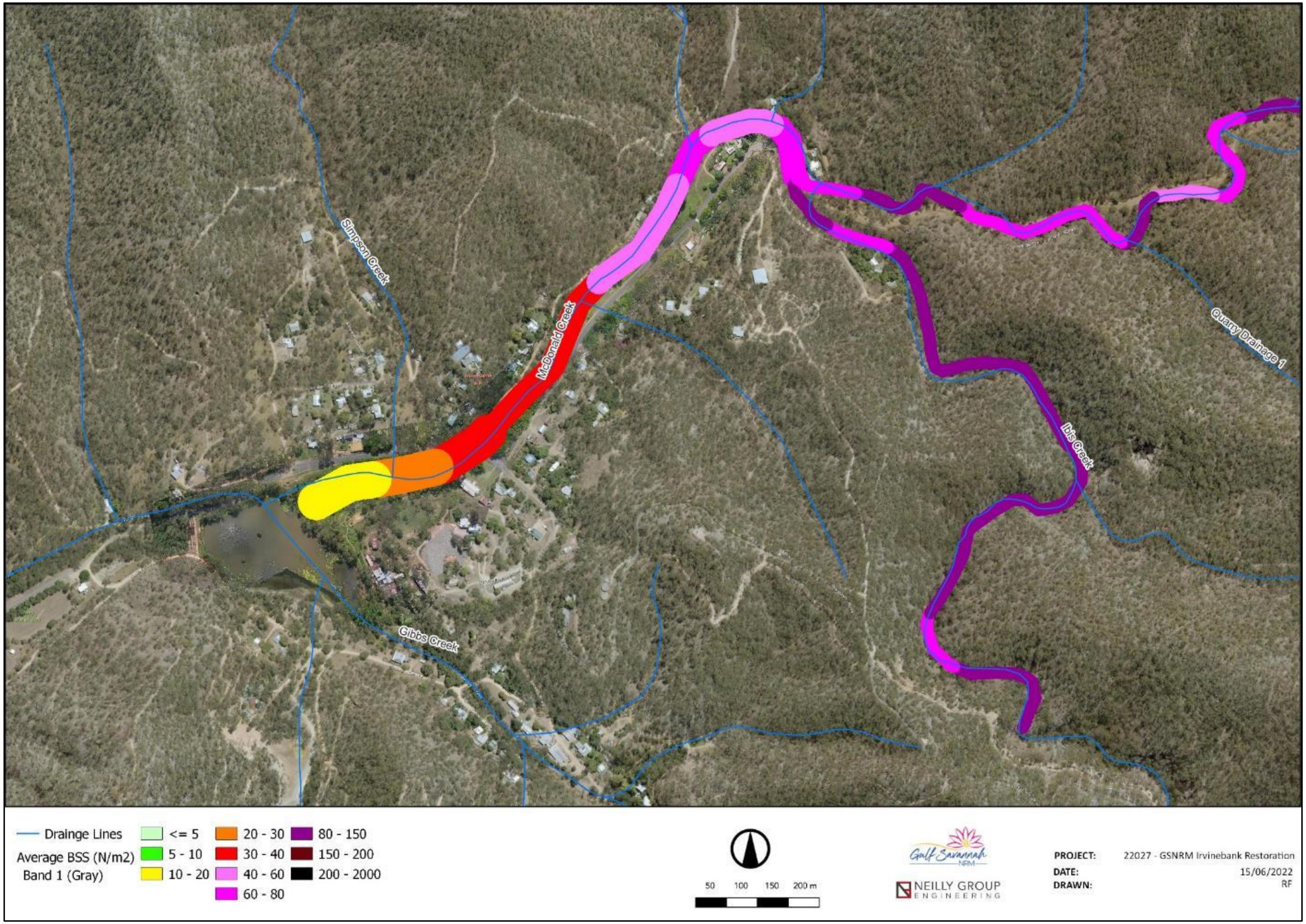


**Figure 10 Average bed shear stress results for each ~100m long section of McDonald Creek and Ibis Creek during the 50% AEP**

### 3.2.2 Reach Scale

The channel running directly through the centre of town exists as a series of pool-riffle sequences through a cobble substrate (Figure 11). Inspection of the reach shows that bed sediment has accumulated throughout the reach (Figure 11). The overbank area has been colonised by thick vegetation which, in areas, consists of weedy vegetation. Throughout a section in the centre of town, the overbank consists of parkland with mature fig trees present (Figure 3, page 11).

Although there is evidence of bed sediment accumulation throughout the area under investigation, the stream has a relatively 'healthy' form as evidenced by the series of pools and riffles, slightly meandering channel pattern and established riparian vegetation. It is not until the channel cross section is compared between what is present today (Figure 1, page 6) and the photo available from 1914 (Figure 2, page 7), that the level of impact and sedimentation is clear. The bridge abutments used to stick out of the surrounding floodplain by 1-2 metres, but are now relatively level with the surrounding landscape. It is then evident that the entire 'valley' of McDonald Creek has been infilled with sediment, parkland built over the top and in other areas, it has been colonised by vegetation which has had sufficient time to establish so the entire area appears natural. The historic aerial photograph sequence shows that colonisation of riparian vegetation has occurred since the 1960's (Figure 12).


**Figure 11 Example of existing pool-riffle feature upstream of bridge (left) and bed sediment accumulation (right) – photos courtesy of Jim Tait**


**Figure 12 Historical aerial photographs of the reach under investigation**

Based on the longitudinal profile analysis in the section above, approximately 2m of sediment has accumulated. A representative cross section from south-east to north-west through the area around the bridge shows the likely magnitude of sediment infilling (Figure 13).

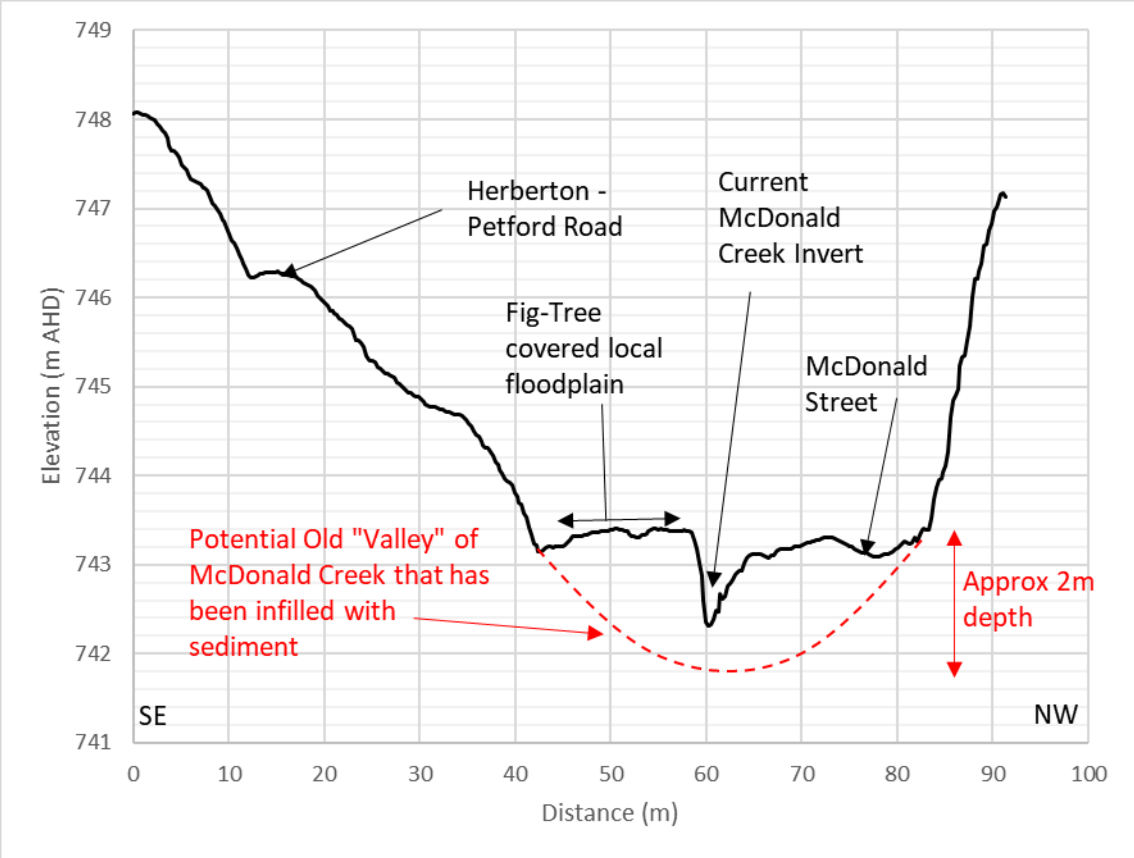


**Figure 13 Representative cross section through McDonald Creek from SE to NW immediately upstream of the bridge**

## 3.3 Climate

Climate is analysed in terms of the water year (October to September the following year). This is undertaken to ensure that the entire wet period from November through to April-May is counted as the one unit, rather than split between a Calendar Year. For the purposes of this report the water year 1901 – 1902 corresponds to October 1901 – September 1902.

The climate of Irvinebank is dominated by a distinct wet season and a distinct dry season. Approximately 80% of the years' rainfall occurs in the period between December to March (Figure 14) with a chance of considerable rainfall experienced in November or April. This period is associated with the monsoon trough each year. Within these months most of the rainfall occurs as short, intense rainfall events associated with tropical cyclones or remnant low pressure systems crossing the east coast or the western coast of the Gulf of Carpentaria. These events can result in the majority of the months' (or in some cases, years') rainfall being delivered in a few days and have a high potential for sediment transport throughout the catchment. Of the past 133 years, approximately 85% of years have experienced between 70% or more of the annual water year rainfall in the December to March period (Figure 15).

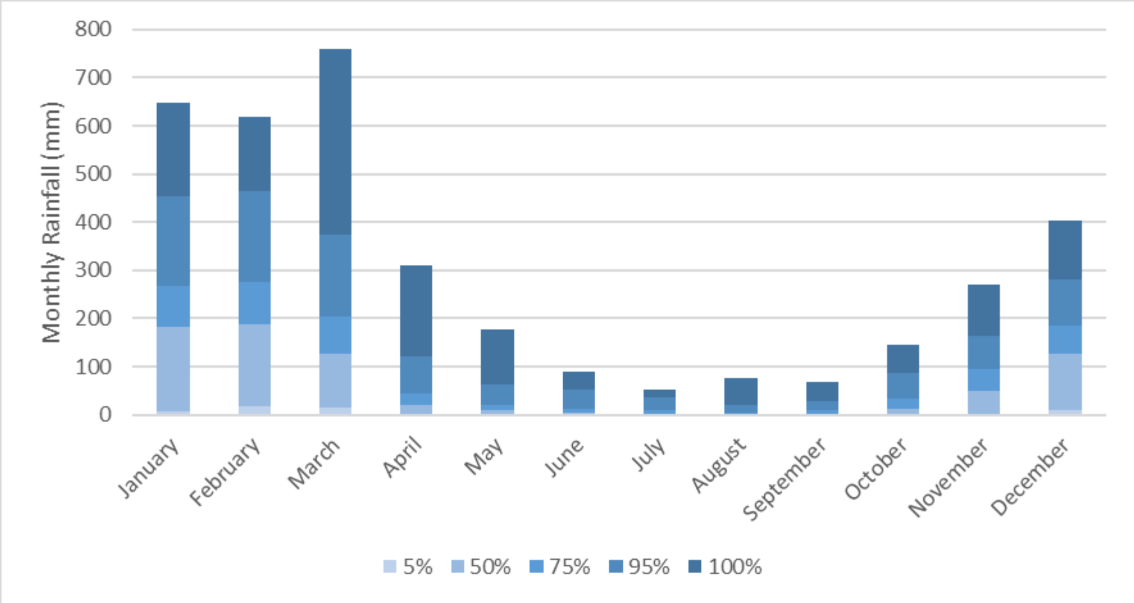


**Figure 14 Monthly rainfall statistics for the Irvinebank township**

The average yearly rainfall is approximately 853mm per water year (from October the previous year to September). However, the 90th percentile water year rainfall is approximately 1255 mm, approximately 150% of the average, highlighting the highly variable rainfall throughout the area (Figure 15). Not only is rainfall highly variable throughout the year, but rainfall over successive years is also highly variable.

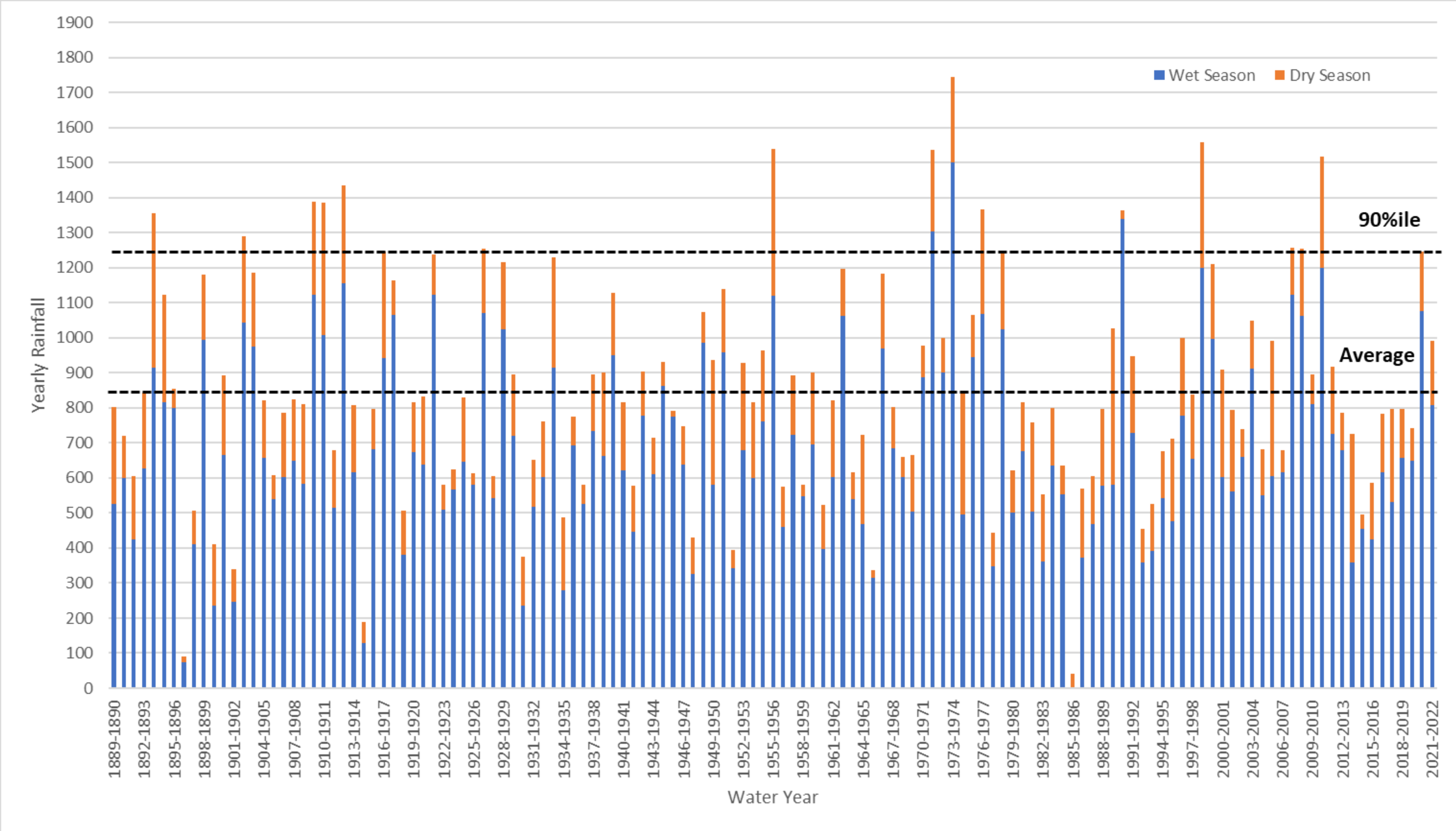


**Figure 15 Yearly totals (per water year) from 1889 to present**

The recent decade from 2011-2020 has been relatively dry compared to historical periods. Figure 16 shows that within this 2011-2020 period there were only 2 years with an annual water year rainfall above the average of 823mm per water year, however in the period before (2001-2010) there were 7 out of 10 years with an average annual rainfall greater than the average. Of those, 1 year was between the 90% and 100% annual rainfall total (i.e. between 1255mm and 1744mm), 1 year was between the 75% (1074mm and 1255mm) and 5 years were between the average (823mm) and 75% (1074mm). It wasn't since the 1980's that there were so few years with above average rainfall in any given decade.

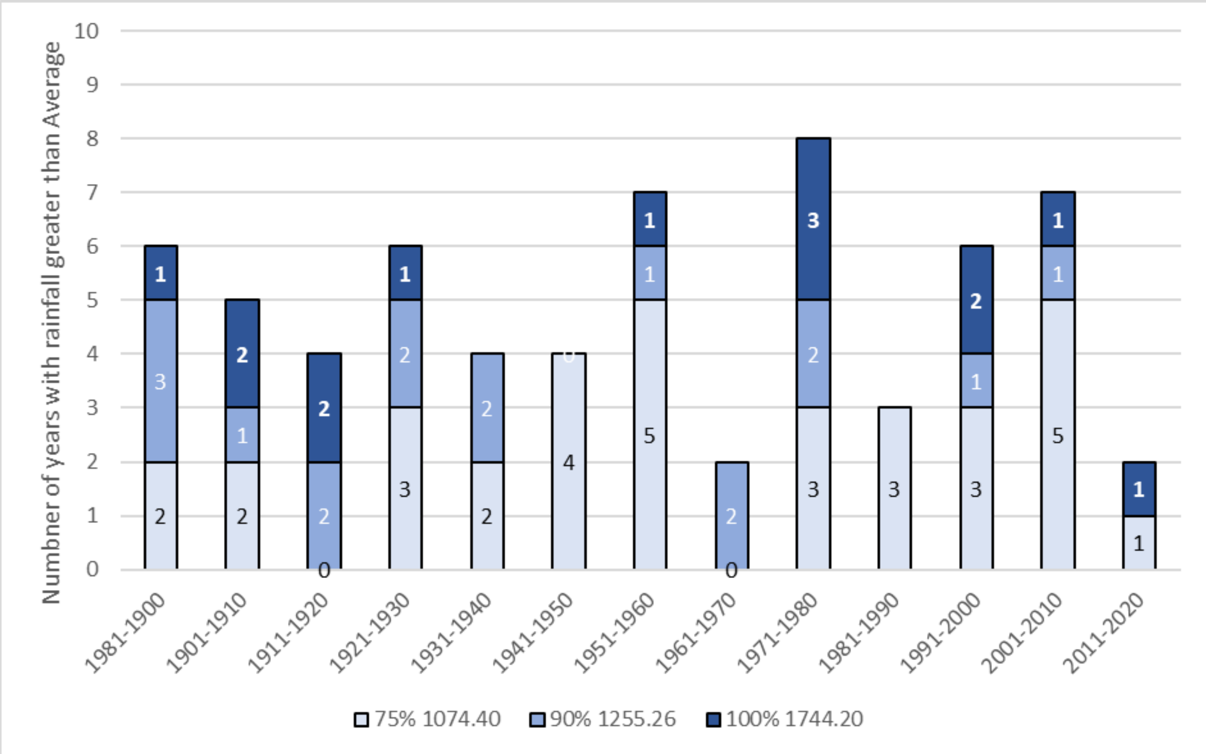


**Figure 16 Number of years with rainfall totals above the average (823mm) in any given decade**

### 3.3.1 Rainfall Intensities

Rainfall intensity data is available from the Bureau of Meteorology (BOM) as Intensity Frequency Duration (IFD) data. IFD data for Irvinebank is presented below in Table 1. The IFD data represents the total millimetres rainfall depth for a rainfall event of a given duration and Annual Exceedance Probability (AEP). For example, 1 in 100-year (1% AEP) storm of 60 minutes duration will deliver a total rainfall depth of 77.4mm. However, a 1 in 100 year (1% AEP) storm of 24 hours duration will deliver a total of 258mm over that 24 hours.

The data is presented to compare against daily rainfall totals available for Irvinebank from the BOM. Since only daily information is available for the historical record at Irvinebank, historical rainfall intensities for durations less than the 24-hour storm cannot be compared and are subsequently greyed-out in Table 1 below.

**Table 1. Rainfall IFD data for Irvinebank in total millimetres for the design storm event**

| Duration | ARI >> 0.5 year | 1 year | 1.44 year | 2 year | 4.48 year | 5 year | 10 year | 20 year | 50 year | 100 year | 200 year | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AEP>> 2EY | 63.20% | 50% | 0.5EY | 20% | 0.2EY | 10% | 5% | 2% | 1% | 1 in 200 | 1 in 1000 |
| **10 min** | 9.86 | 12.6 | 14.2 | 15.8 | 19 | 19.4 | 22.1 | 24.9 | 28.6 | 31.4 | 36.8 | 49.7 |
| **20 min** | 15.2 | 19.5 | 21.9 | 24.3 | 29.2 | 29.8 | 33.9 | 38.4 | 44 | 48.2 | 56.5 | 76.3 |
| **30 min** | 18.7 | 24.1 | 27 | 30 | 35.9 | 36.6 | 41.6 | 47 | 53.8 | 58.8 | 68.9 | 93.2 |
| **45 min** | 22.5 | 28.9 | 32.4 | 35.9 | 42.8 | 43.6 | 49.5 | 55.8 | 63.8 | 69.6 | 81.5 | 110 |
| **1 hour** | 25.1 | 32.3 | 36.2 | 40.1 | 47.7 | 48.6 | 55.1 | 62.2 | 70.9 | 77.4 | 90.6 | 123 |
| **1.5 hour** | 28.8 | 37.2 | 41.5 | 46.1 | 54.7 | 55.8 | 63.2 | 71.3 | 81.3 | 88.7 | 104 | 141 |
| **2 hour** | 31.4 | 40.6 | 45.4 | 50.4 | 59.8 | 61 | 69.1 | 78 | 89.1 | 97.3 | 114 | 154 |
| **3 hour** | 34.9 | 45.5 | 50.9 | 56.5 | 67.3 | 68.6 | 78 | 88.3 | 101 | 111 | 130 | 176 |
| **4.5 hour** | 38.5 | 50.6 | 56.7 | 63 | 75.6 | 77.1 | 88.1 | 100 | 116 | 128 | 150 | 202 |
| **6 hour** | 41.2 | 54.5 | 61.2 | 68 | 82.2 | 83.8 | 96.2 | 110 | 128 | 142 | 167 | 225 |
| **9 hour** | 45.5 | 60.6 | 68.4 | 75.9 | 92.9 | 94.7 | 110 | 126 | 149 | 167 | 196 | 264 |
| **12 hour** | 48.9 | 65.7 | 74.2 | 82.4 | 102 | 104 | 121 | 140 | 167 | 188 | 221 | 298 |
| **18 hour** | 54.8 | 73.9 | 83.9 | 93.1 | 116 | 119 | 140 | 164 | 198 | 226 | 265 | 358 |
| **24 hour** | 59.8 | 80.9 | 91.9 | 102 | 129 | 131 | 156 | 184 | 224 | 258 | 302 | 408 |
| **30 hour** | 64.3 | 86.9 | 98.9 | 110 | 139 | 142 | 169 | 201 | 247 | 286 | 329 | 446 |
| **36 hour** | 68.4 | 92.4 | 105 | 117 | 149 | 152 | 182 | 216 | 268 | 310 | 355 | 482 |
| **48 hour** | 75.6 | 102 | 116 | 129 | 165 | 168 | 202 | 243 | 302 | 352 | 402 | 548 |
| **72 hour** | 87 | 117 | 133 | 148 | 190 | 194 | 234 | 282 | 352 | 411 | 474 | 649 |
| **96 hour** | 95.3 | 129 | 147 | 163 | 209 | 213 | 258 | 310 | 386 | 450 | 521 | 714 |
| **120 hour** | 101 | 138 | 157 | 174 | 224 | 229 | 275 | 330 | 409 | 475 | 550 | 751 |
| **144 hour** | 106 | 145 | 165 | 184 | 236 | 241 | 289 | 345 | 424 | 491 | 564 | 769 |
| **168 hour** | 108 | 150 | 172 | 191 | 245 | 250 | 299 | 355 | 434 | 499 | 568 | 771 |

### 3.3.2 Historical Events

The 10 largest rainfall intensities for the 1 to 7-day duration storms were extracted from the historical data and ranked 1-10 (Table 2). The three largest / most commonly occurring dates were colour-coded into the table. By far the largest event occurred in March 1967 based on the rainfall intensities for the 2-day (48hr) to 7-day (168hr) rainfall intensities. The next commonly occurring date was an event in 1999, and another significant event in 1911 (Table 2). The maximum rainfall intensity for each duration of these events are plotted against the IFDs below in Figure 17. The 1967 event stands out beyond all other significant rainfall events in the record. The 1967, 1999 and 1911 events are described further in the sections below.

Of note, none of the top 10 rainfall intensities for the 24hr to 168hr events (Table 2) occurred in the 2000's. This indicates that there have not been intense rainfall events occurring relatively recently.

**Table 2. Top 10 dates for a given rainfall intensity for a given duration storm event**

| | | Duration | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 24hr | 48hr | 72hr | 96hr | 120hr | 144hr | 168hr |
| Rank | 1 | 27/01/1906 | 13/03/1967 | 14/03/1967 | 14/03/1967 | 14/03/1967 | 15/03/1967 | 14/03/1967 |
| | 2 | 31/01/1913 | 1/02/1913 | 13/03/1967 | 15/03/1967 | 15/03/1967 | 13/03/1967 | 13/03/1967 |
| | 3 | 12/02/1999 | 13/02/1999 | 2/04/1911 | 13/03/1967 | 16/03/1967 | 14/03/1967 | 15/03/1967 |
| | 4 | 12/03/1967 | 14/03/1967 | 1/02/1913 | 15/02/1999 | 13/03/1967 | 16/03/1967 | 16/03/1967 |
| | 5 | 23/03/1997 | 24/03/1997 | 14/02/1999 | 3/04/1911 | 12/03/1967 | 17/03/1967 | 17/03/1967 |
| | 6 | 10/02/1927 | 28/01/1906 | 2/02/1913 | 2/04/1911 | 15/02/1999 | 12/03/1967 | 18/03/1967 |
| | 7 | 11/03/1918 | 27/01/1906 | 13/02/1999 | 2/02/1913 | 25/03/1974 | 9/03/3799 | 12/03/1967 |
| | 8 | 1/02/1973 | 12/03/1967 | 15/03/1967 | 1/02/1913 | 16/02/1999 | 16/02/1999 | 10/03/3799 |
| | 9 | 13/03/1967 | 1/04/1911 | 12/03/1967 | 14/02/1999 | 4/04/1911 | 10/03/3799 | 9/03/3799 |
| | 10 | 2/03/1979 | 31/01/1913 | 24/03/1997 | 3/02/1913 | 3/04/1911 | 15/02/1999 | 17/02/1999 |

**Legend**

| | | |
|---|---|---|
| 1967 Event | 1999 Event | 1911 Event |

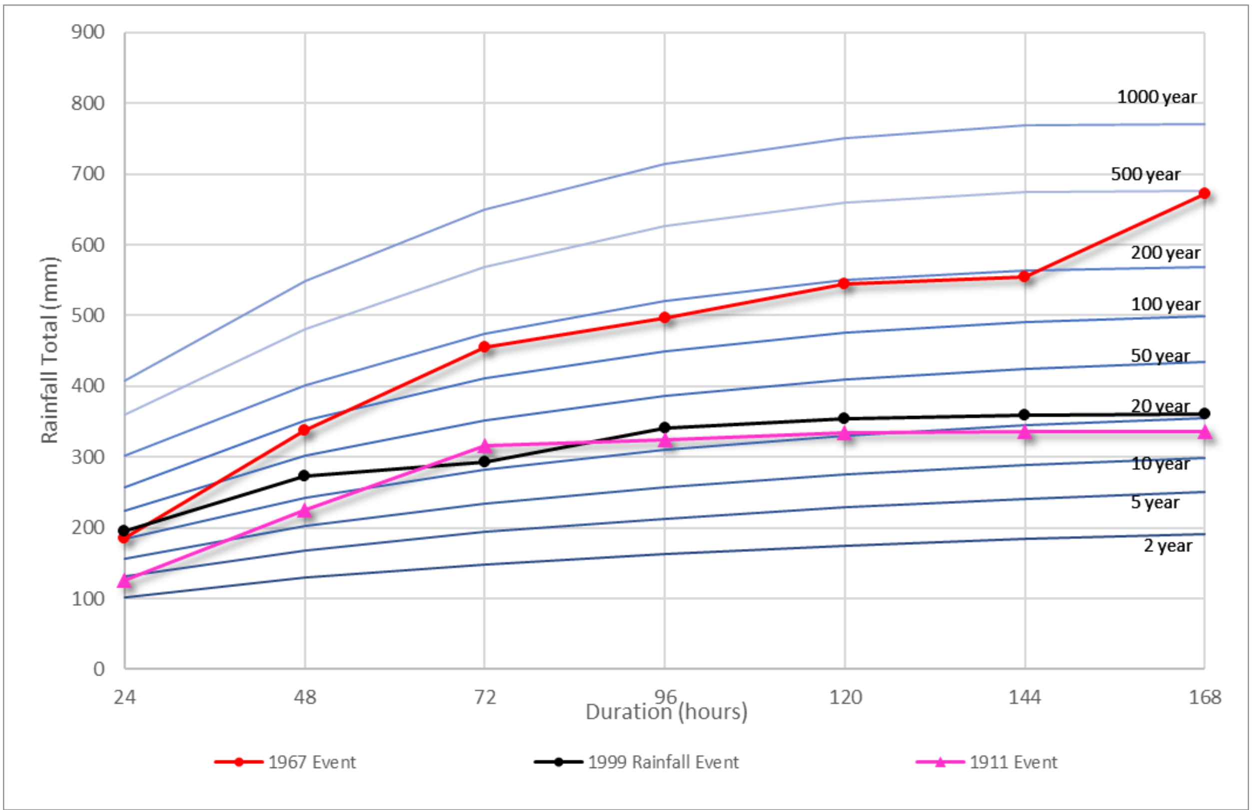


**Figure 17 Historical rainfall intensities for the 1967 rainfall event**

### 1967 Event

The largest event on record saw 671mm rainfall in the 7 days between 8th March and 15th March 1967. The cumulative rainfall total at daily rainfall durations over the event are compared to the IFDs for the site in Figure 17 and show that:

- For a 7-day total rainfall (168hr) the event was close to a 500-year rainfall event
- For rainfall durations between 72hr and 144hr (3-day to 6-day), the event was close to a 200-year rainfall event
- The event was near a 100-year event for the 2-day rainfall total
- The event was near a 20-year event for the maximum rainfall intensity falling over a 24hr period

The potential for significant amounts of sediment movement during this event was high.

### 1911 Event

The maximum rainfall intensity occurring in the 1911 event was somewhere between a 1 in 20-year and 1 in 50-year, 3-day (72hr) duration. However, the event as a whole had a total rainfall intensity over 7-days (168hr) somewhere between a 10-year and 20-year event. The potential for significant sediment movement during this event is lower than the 1999 event as the 24-hour rainfall intensity is less, therefore indicating less potential for high intensity rainfall that causes large flows.

### 1999 Event

The 1999 event was a 20-year, 7-day event seeing 360mm fall between 11 Feb and 17 Feb. The rainfall intensity for the majority of durations was somewhere between a 20-year and 50-year event (Figure 17).

# 4 Summary of Historical and Current Sediment Processes

A summary of the critical factors in the geomorphic analysis, climate analysis and from the Community Consultation are:

**Historic Processes**

- The Loudoun Dam, present since the 1880's, has reduced the hydraulic gradient along McDonald Creek for a distance of at least 800m upstream. This has an impact in reducing flow velocities and increasing sediment deposition upstream of the dam.
- There has been historical land disturbance upstream of the township across relatively large areas of the catchment. Historical aerial photography is only available from the 1960's, but this is enough to indicate a high level of disturbance (highlighted areas on Figure 5).
- A very large flood event occurred in 1967, approximately a 1 in 500-year, 7-day event. Community consultation verifies that this is when most of the sediment accumulated in McDonald Creek. There has not been an event like it since records began in 1889. The next-largest event (in terms of rainfall intensity of 24hr duration or more) was in 1999 which was a 1 in 20-year event.
- There are only four events in the Top 10 rainfall intensities experienced in the record since 1967, including the 1999 event (plus events in 1973, 1979 and 1997).
- Out of the top 10 rainfall intensities for the 24-hour duration event, the 48-hour duration event, through to the 168-hour duration event, none occur in the 2000's, indicating that rainfall intensity (as indicated by daily rainfall) has decreased in recent times
- The 2000's have been relatively dry at Irvinebank with only 2 years with above average rainfall in 2011-2020.

Based on the above it is evident that the 1967 flood event disturbed a large volume of sediment from the catchment upstream of Irvinebank. The reduced hydraulic gradient in McDonald Creek in the area under investigation, a result of Loudoun Dam, caused a large amount of this sediment to be deposited in the area from the one event, filling the 'valley' of the creek. Following 1967 there has been no sufficiently sized flow event to re-mobilise the sediment and transport it further downstream before vegetation was able to colonise, further locking it in place. This has resulted in the shape and form of the township as evidenced today. It is estimated that approximately 2m of sediment lies in the 'valley' of McDonald Creek based on the likely longitudinal profile of the drainage system prior to the installation of the Loudoun Dam.

**Contemporary Processes**

- Disturbance in the upstream catchment in the current day is far less than what has occurred historically. Nevertheless, there are some features remaining in the landscape that appear to liberate additional sediment loads into the receiving environment upstream of the township. This is particularly evident in the northern areas of the Lady Norman complex (Figure 5). However, these sediment sources do not appear to be contributing significant loads to the receiving environment. The largest impact is that the culvert on the Herberton Petford Rd downstream of the Waste Transfer Station needs to be re-instated each year.
- The major source of sediment to McDonald Creek appears to come from the Mount Petersen mining area via Ibis Creek. Sedimentation of the waterway is evident to a much larger degree than other major drainage lines inspected upstream of Irvinebank.

- Sedimentation impacts at the Waste Transfer Station appear to be localised with excess sediment sourced from the northern areas of the Lady Norman historical mining complex.

Regardless of whether upstream land uses are completely rehabilitated and are no longer a source of sediment to the receiving environment, the reach under investigation will continue to be a deposition zone for sediment due to several factors:

- The reduced hydraulic gradient because of the presence of Loudoun Dam
- The bridge and associated abutments will act to retard flows in some events, enhancing deposition on the floodplain

# 5 Rehabilitation Strategy

## 5.1 Constraints Review

Legislative and on-ground constraints will guide the scope of the activities achievable within the study area. Constraints identified include:

- Approval constraints
  - McDonald Creek is mapped a “Red / High” under waterway barrier works approval requirements
  - Any works in the immediate vicinity of the bridge will likely trigger DTMR referral and must be designed to ensure no worsening of flood levels or velocities around the bridge
- Infrastructure constraints
  - Downstream of Bridge
    - Powerlines close to the road and location of proposed pool – these will reduce the size available for a pool
    - Underground services are present in various locations. These include Telstra lines and others.
    - Large fig tree on the eastern bank immediately downstream of the pool
  - Free-camp area
    - Powerlines and power poles present
    - Telstra services and other underground services present

## 5.2 Aims

The aims of the rehabilitation strategy are based on the outcomes sought by the community. These include:

- Increases in amenity of McDonald Creek by
  - Increasing swimming holes (particularly downstream of the bridge)
  - Restoring the existing pool and riffle sequences to deeper variations that occurred historically
  - Decreasing the frequency of flood break-outs
  - Removal of weeds
- Minimising flooding of the ‘camping area’ resulting from drainage from Simpson Creek.

To address the above aims, the following tasks have been derived for the rehabilitation strategy:

1. Pool-riffle sequence reinstatement upstream of the bridge
2. Creation of a large swimming hole immediately downstream of the bridge
3. Weed Removal and Vegetation Management
4. Simpson Creek drainage
5. Removal of excess sediment in the Loudoun Dam Forebay

Additional activities recommended include:

6. Investigation of the Mount Petersen sediment source and rehabilitation options

## 5.3 Costing

The main objective of this report is to determine the activities and costs required to rehabilitate McDonald Creek. The activities are listed as 1-5 above. However, available data is insufficient to undertake the design, and estimate quantities for construction of the above tasks. In addition, there will be significant approvals costs required under the current Queensland Planning laws, as most works consist of waterway barrier works.

Therefore, costs to undertake the above works are broken down into:

7. Data acquisition, design and approvals
8. Construction and maintenance costs
9. Other costs associated with construction

### 5.3.1 Data Acquisition and Design

**Topographic and Feature Survey**

Updated topographic information will be require for the area outlined below in Figure 18. This is an area of approximately 6.6ha which will require topographic and feature survey. Estimated cost for this area is approx. $15,000 for a licenced surveyor to undertake these works based on previous NGE projects.


**Figure 18 Area required for survey acquisition for Detailed Design**

**Detailed Design**

Detailed design will use the topographic and feature survey and will involve:

- Hydraulic modelling

- Earthworks modelling
- Preparation of design report, quantities, specifications.

The Detailed Design costs will increase or decrease with the scope of works.  An assumed scope of works is provided in this section.

Estimated Detailed Design costs are approximately $35,000 excluding GST.

Given the proximity to services for several of the proposed works, a service locator will need to be commissioned during the Detailed Design phase to identify further constraints to the design. Estimated cost is $4,000 based on costs of similar works in remote locations.

<u>Mount Peterson Sediment Scoping</u>

An additional investigation is required to determine the volume of sediment that is likely entering the system from Mount Peterson, and to contrast with the surface area and voids present within McDonald Creek.  The purpose of this study would be to determine whether the volume of sediment delivered to Ibis Creek, and therefore McDonald Creek, is a significant volume compared to the volume of pools existing, and proposed to be created, from proposed works in this document.

If the volume of sediment entering the system from Mount Petersen and Lady Norman is significant compared to the void volume, there is no benefit in undertaking the works outlined within this document as the pools and voids will be quickly infilled.  However, if the volume of sediment coming from Mount Petersen and Lady Norman is not significant compared to the total volume of pools existing and proposed within McDonald Creek, then the works can occur with low risk of sediment infilling.  There will always be the risk of an exceptionally large flood event liberating sufficient sediment from the upstream catchment to fill the works created.

In addition, the reduced hydraulic gradient through the area under investigation because of the Loudoun Dam will ensure that sediment deposition is increased throughout the area compared to natural conditions.  Albeit in this instance, natural conditions are used to refer to a time prior to 1885 when the Loudoun Dam was installed.

Therefore, it is recommended that this investigation is undertaken during the Detailed Design phase.

Landscape and Catchment modelling approaches (such as eWater Source, MUSIC, RUSLE) make a large number of assumptions regarding the sediment load delivered to waterways based on catchment land uses and will not be able to account for the apparent high degree of sediment delivery to the stream system from Mount Peterson. Although these modelling methods are relatively complex and have a high precision, they do not have a high degree of accuracy with relation to the real world unless there is thorough calibration and verification. Therefore, reliance on a modelling methodology to attempt to determine the volume of sediment to ‘capture’ or retain upstream of the township, in order to safeguard the works proposed, is fraught with error.

Subsequently the Detailed Design phase should include on-ground investigation and inspection of the Mount Petersen area as a first priority.  The investigation may identify that there is sufficient sediment being liberated from Mount Petersen to warrant further progress with works downstream impractical, and that monies would be better to be diverted to remediating Mount Petersen.

**Approvals**

Approvals costs are generally significant if any state interests are triggered.  As the area is mapped as a “High” significance for waterway barrier works, this will trigger approval by the relevant state agencies.  An aquatic ecologist specialist will be required to prepare a waterway barrier works report.  Estimated costs are $7,000 excluding GST.

Hydraulic modelling will need to occur during the Detailed Design phase to demonstrate no worsening of flow conditions on the Herberton Petford Rd bridge as the road is a state controlled road. Hydraulic modelling will be required to be signed off and approved by a RPEQ. Costs are likely to be in the order of $10,000 in addition to Detailed Design works.

Excavation of approximately 300m$^3$ of material from the stream bed will likely trigger an ERA and require a Quarry Material Allocation Notice (QMAN). In the budget we have allowed for approximately $5,000 to prepare an "Operational Plan" typically required for these kinds of applications and to address concerns from the administering authority.

Estimated approval lodgement costs are approximately $25,000 (estimate only) and subject to SARA development application fee assessment at the time of application.

## 5.4 Construction Cost Estimates

### 5.4.1 Pool-Riffle Sequence Reinstatement Upstream of Bridge

**Sacrifical Reach – Sediment Extraction**

Pool-riffle sequences are proposed to be accentuated throughout the area immediately upstream of the bridge and within the town. However, given the potential for additional sediment to be transported into the reach from Ibis Creek, a sacrificial zone of approximately 100m further upstream is proposed. This zone is labelled as 'sacrificial' as sediment will be excavated from the reach to ensure sufficient void space is created to accept additional sediment, minimising the probability of the pool-riffle sequences downstream being infilled.

**Pool-Riffle Sequences**

This reach is proposed as the site for the establishment of riffle pool sequences with pool dipping and wading amenity (Figure 19).

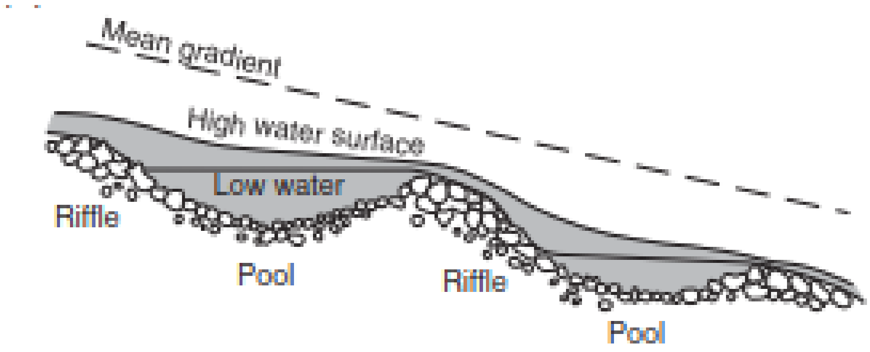


**Figure 19 Riffle pool sequence (left) vs a step-pool sequence (right) (Charlton, 2008)**

The existing riparian overstory includes a dense woodland of all the key tree species associated with the representative regional ecosystems except for paperbarks. It also includes a range of exotic tree species including Orange Jasmin *Murraya paniculate, Common Mango Mangifera indica, Java Plum* Syzygium cumini, Cocos palm Syagrus romanzoffiana, Oleander Nerium oleander, African Tulip Spathodea campanulata and Rattle Pod Crotalaria sp. There is an equally diverse mix of herbaceous understory weed bushes, vines and grasses including Singapore Daisy Sphagneticola trilobata, Japanese Honeysuckle Lonicera japonica, Centro Centrosema platycarpum, Jamaican Snakeweed Stachytarpheta jamaicensis, Devils Fig Solanum torvum, Tobacco Bush Solanum mauritianum, and Guinea Grass Megathrysus maximus.

Local residents expressed some concern how this reach has become closed by overstorey shading. They felt that the canopy should be more open as the reach was historically but did not want to impact its habitat values. All agreed that the exotic component of the overstory vegetation should be cleared and controlled and that this would serve to open the site back to a more open woodland riparian community representative of its natural condition. Canopy opening will also serve to help establish grassy groundcovers.

The intention for this reach is that it become an area of streamside amenity for people picnicking and recreating within the vicinity of the established fig tree canopy. The intervening bank between the established fig trees and the water course is currently dominated by herbaceous and vine weeds that make it unsuitable for bank side recreation. Works will likely involve sediment excavation from this reach and some (initial spraying, brush cutting) scrape clearing and reforming of the bank slope to the watercourse channel. Some of the overstory vegetation may be destroyed as part of these works. Following earthworks revegetation should include the seeding of suitable grass ground cover and planting of emergent macrophyte species such as Lomandra and Fimbristylis around placed rock and formed bank slopes to help stabilise placed materials and the formed channel and add steam habitat values. The site should initially attract a higher level of maintenance to ensure the suite of weeds do not become re-established until a suitable, managed ground cover is established. Subject to how much of the native overstory vegetation is destroyed during works there may be some requirement for some infill revegetation of the dominant native canopy species.

**Scope**

Works are likely to include

Upstream Sacrificial Zone

- channel sediment excavation (approx. 330$m^3$ assuming 6m width, 110m length and 0.5m depth) and cobble movement to deepen the stream channel
- Disposal of excavated material off-site (location for disposal is unknown at this time).

Pool-Riffle Enhancement Zone

- Work with a small excavator to shift cobbles and place boulders for pool-riffle enhancement
- Large rock placement for scour pool formation and protection.
- Establishment of ground cover, potential turfing of disturbed areas to restore amenity.

All Areas

- Extensive weed management
- Revegetation and infill planting of riparian vegetation where weed species have been removed
- Extensive maintenance.

Data is insufficient to be able to determine preliminary designs of enhancing the pool-riffle sequence. The 2011 LiDAR data does not provide sufficient penetration of the vegetation canopy, and, bathymetry of beneath the water surface (expected to be approximately 1m) is required. Similar can be said for the sediment excavation required in the Loudoun Dam forebay. Therefore a number of assumptions are used to estimate quantities required for costing purposes. Assumptions include:

- Main stream length of 110m
- Main stream top width of 6m
- Deepening stream by 0.5m
- Quantity of sediment excavated.

Based on the above assumed existing channel dimensions, the following quantities have been allowed for restoration works:

- 330m$^3$ of sediment excavation across the entire reach.
- There is likely no re-use options for 330m$^3$ of a mixture of sands, gravel and cobbles with minor silt and clay present, so the material must be disposed off-site.
- Hybrid step/riffle-pool sequences to be installed at 6 locations within the upstream reach, working to exacerbate existing pool-riffle sequences. The 'steps' are to include provision for a low flow channel to flow through the weir. The 'riffle' zone is to be created from large rock/boulders (sourced from off-site) with the largest rock to be placed on either side of the bank to force a narrow constriction near the centre of the channel. This will act like a spillway/fish ladder (Figure 20).

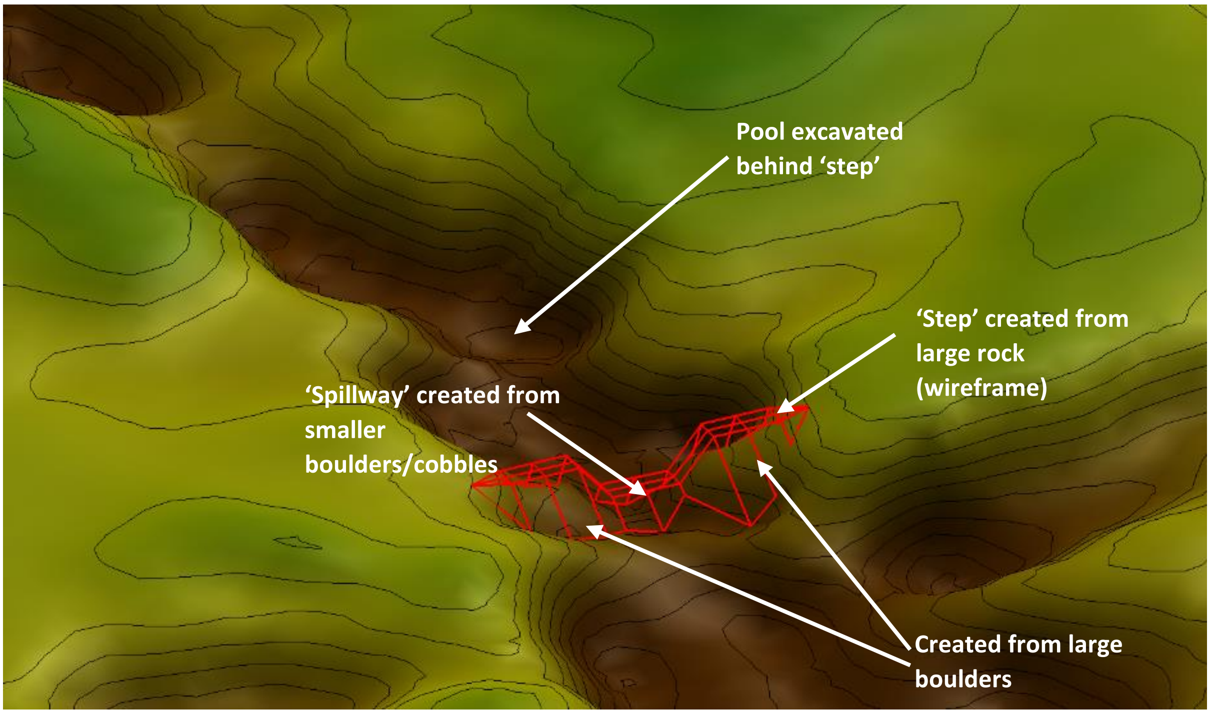


**Figure 20 3d perspective view of schematic riffle/step-pool sequence**

Initial weed removal has been assumed to be significant with a budget of $15,000 allowed for.

**Vegetation Management and Revegetation**

The stream restoration site has a history of high disturbance associated with mining and elevated sediment loads in its catchment and vegetation clearing during Irvinebank's pioneering settlement and industrial tin smelting past. Most of the site including the original stream channel was buried in a deltaic like deposit of coarse material during an exceptional extreme rainfall event in 1967. This event mobilised unconsolidated mine overburden down the catchment and deposited it in the terminal stream reach at its backed-up confluence with the Irvinebank Dam. The project site is located within this terminal stream reach.

Since that time much of the stream channel has been recolonised by native riparian vegetation and a contemporary channel cut into the aggraded bed material left from the 1967 flood. Two allied Regional Ecosystems are mapped by the Qld Herbarium for remnant riparian vegetation at the site.

**RE9.3.13** – Paperbark Melaleuca spp., River Red Gum Eucalyptus camaldulensis and River She Oak *Casuarina cunninghamiana* fringing open forest on streams and channels

**RE9.3.12a** - Sandy riverbeds sometimes with patches of ephemeral grassland, herbland or sedgeland, which can include Black Speargrass Heteropogon contortus, Bothriochloa spp., and Ammannia multiflora. There can be clumps of shrubs (or isolated emergents), which can include Swamp Box Lophostemon grandiflorus, Paperbarks Melaleuca spp., River Red Gum Eucalyptus camaldulensis and River She Oak (*Casuarina cunninghamiana*)

Representative species of both these regional ecosystems were identified across the proposed restoration site. It is recommended that local providence seed be collected from nominated species of these regional ecosystems and tube stock be produced for revegetation needs prior to any scheduled site works. As a minimum it is recommended that the following key species be utilised:

- River Red Gum (*Eucalyptus camaldulensis*)
- River She Oak (*Casuarina cunninghamiana*)
- Swamp Box (*Lophostemon grandifloras)*
- Mat Rush (*Lomandra longifolia*)
- Sedge *Fimbristylis sp* (local species)

The following allowances have been made for revegetation of the area:

- Planting of
    - 600x Mat Rush
    - 600x sedges
    - 100x River She Oak
    - 100x River Red Gum
- Establishing ground cover across disturbed areas (1000m$^2$ assumed)
- Approximately 400m$^2$ of turfing and establishment for amenity restoration.

### 5.4.2 Large Swimming Feature – Downstream of the Bridge

The intention of these works is to provide a larger pool for recreational swimming, an amenity historically enjoyed by older residents in the bedrock-controlled stream channel that characterised this reach prior to the 1967 sediment burial. In keeping with the historical recollections of the openness of the stream channel along this reach, the community communicated that they wished for this pool feature to not be heavily revegetated. The idea arrived at was that riparian trees could be established on one side (town side) of the pool feature to provide aesthetics and some riparian habitat continuity with the upstream reach, but that the park side be kept as an 'open sky' access and recreation area. Interstitial areas around rockworks used to stabilise pool margins will however provide planting sites for stream bank macrophytes such as Lomandra and Fimbristylis to stabilise placed materials and provide habitat value. These species could also be incorporated into the design of access ways to the pool feature to secure pool margins during inundating high flow events.

The shape and configuration of the pool is constrained by:

- Powerlines / power poles to the west and south-west
- The bridge abutments immediately upstream
- The base of a large fig tree on the eastern bank.

Therefore, the dimensions of any pool feature that can be installed are relatively small. A concept of the pool (in context of the 2011 available LiDAR data) is provided below Figure 21 with a representative cross section in Figure 22.

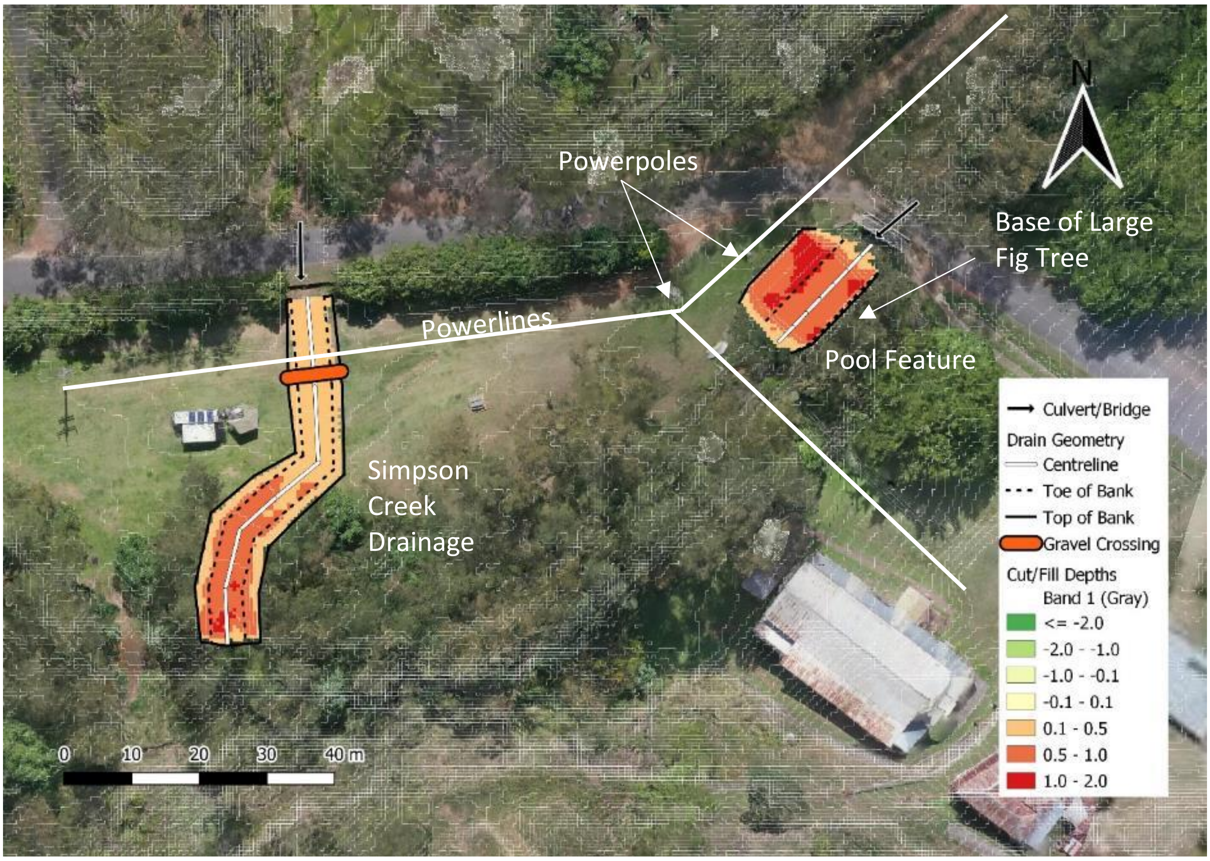


**Figure 21 Approximate cut depths for Simpson Creek drain and pool downstream of the bridge**

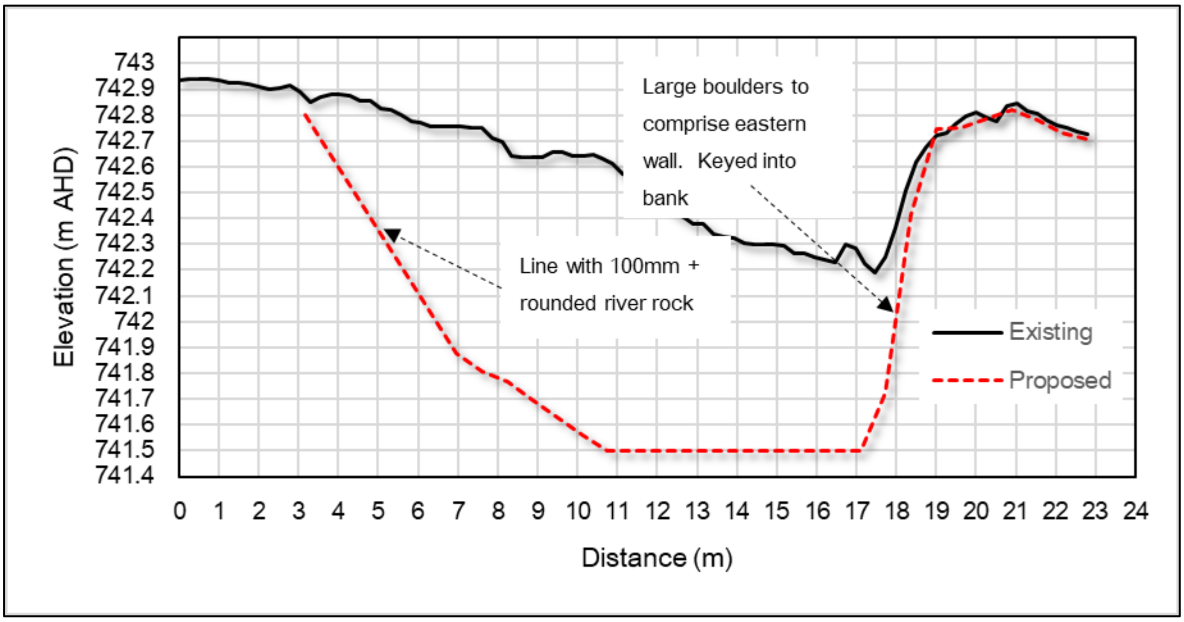


**Figure 22 Representative cross section of proposed pool**

Works proposed include:

- Clear and grub, topsoil stripping
- Excavate material and place in spoil pile (no disposal cost included)
- Line pool with rounded river rock

- Placement of large boulders along eastern bank of excavated pool. Line with granular filter/geotextile
- Line perimeter of pool with vegetation (Lomandra, Sedge) at 3 plants per linear meter
- Reinstate turf to disturbed areas (assumed to be 10m width around perimeter of pool).

### 5.4.3 Simpson Creek Drainage

Simpson Creek drains a relatively small catchment and outlets via a culvert into the camping area. Hydraulic modelling for the area shows that peak flows in Simpson Creek occur concurrently with McDonald Creek for the 50% AEP event. It is obvious from the community consultation that it is not large flow events, rather very regular frequent events that are causing the nuisance flows through the park. Therefore, for the purposes of this assessment, it will be assumed that flows are limited to Simpson Creek only and there are no larger flows occurring along McDonald Creek.

The intention of these works is to contain the flow discharges of the Simpson Creek sub catchment within a formed channel /preferential flow path across the public camping ground and to a confluence with Gibbs Creek, rather than generate nuisance flooding for campers. To demarcate the channel and to help maintain its form under high flow conditions and add habitat value, it is recommended that this channel be revegetated with a single line of native riparian trees along each side of the channel margin. Given the camping use of the grounds, large branch shedding Eucalypts are a less suitable choice for this channel and it is recommended that smaller more open structured species be used including River She Oak Casuarina cunninghamiana and Swamp Box Lophostemon grandifloras. Planting of emergent macrophyte species such as Lomandra and Fimbristylis around channel margins would also add habitat value and additional channel erosion protection

There is approximately 1.7m of vertical fall from the outlet of the main culvert transmitting flows underneath Herberton Petford Road from Simpson Creek to the invert of McDonald Creek on the southern side of the park. Even with a very wide, open drain (4m base width, 7m top width, maximum of 1.7m deep) this will create scouring velocities (approx. 1.7m/s) during the 50% AEP flow event. Therefore, additional structure is required to ensure velocities are limited to minimise scour. A step-pool sequence will be installed along the drainage line to act as armouring in the drain while the invert has a relatively steep drop to minimise the hydraulic gradient. The drainage footprint is provided in Figure 21 above.

Vehicle access will need to be provided through the drain in the form of a compacted crossing (Figure 21). This can double as the ‘step’ for the drain and will consist of a 3m wide compacted flat pad in the base of the drain made of a mixture of gravels and river cobbles.

Therefore the works will comprise:

- Clear and grub the footprint (500m$^2$)
- Topsoil stripping and stockpiling
- Relocation of services (Telstra lines run through the area)
- Cut to drain design levels (approx. 235m$^3$)
- Supply, placement and compaction of gravel and river cobbles to form the vehicle access track (assumed 26m$^2$ at 600mm deep) and act as a ‘drop structure’ for the drainage line
- Replace topsoil across the drain footprint
- Turfing of the created drain, including soil preparation, soil ameliorants and turfing (455m$^2$)
- Supply and install plants as riparian vegetation along both sides of the drain, plants to be installed at 3 plants per linear meter.

### 5.4.4 Excavation of accumulated sediment in Loudoun Dam

The Loudoun Dam had a sediment forebay installed for a mining company to dredge and re-process sediment within the dam. A wall was constructed across the McDonald Creek inlet of the Loudoun Dam which is evident in Figure 23. Finer sediment has accumulated in this area in the past several years and has been colonised by thick ground cover vegetation (Figure 24).

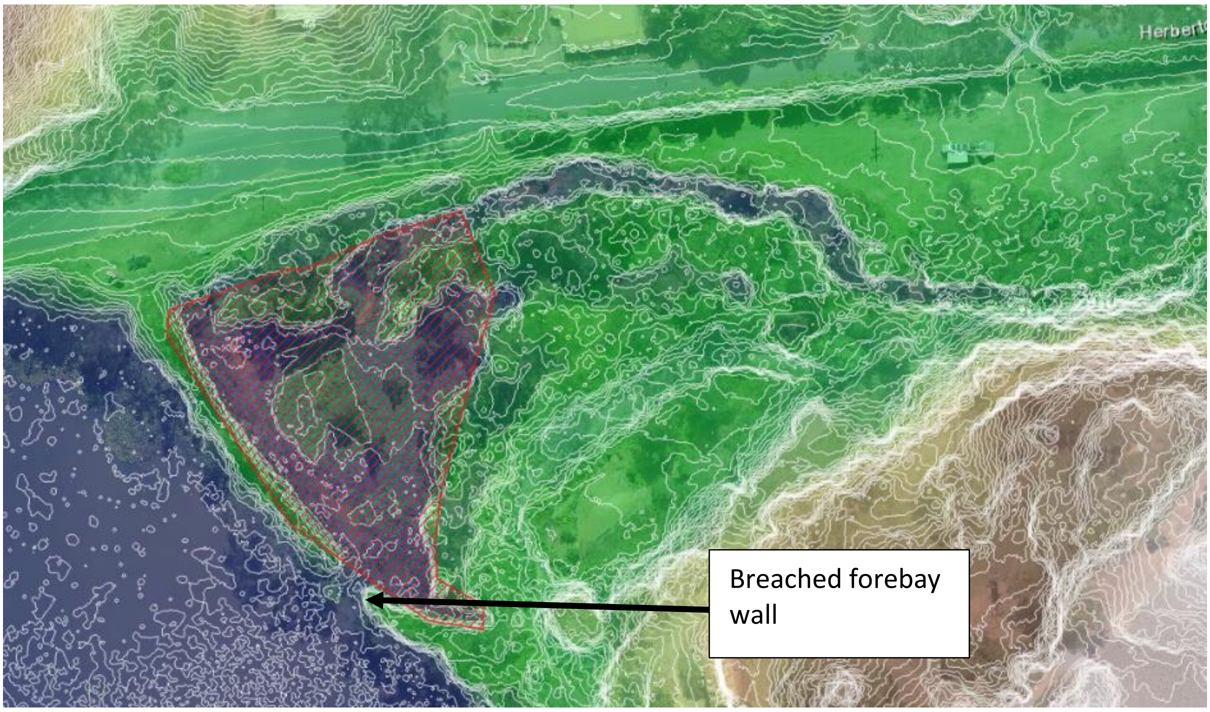


**Figure 23 Shaded relief of LiDAR DEM with Loudoun Dam sediment forebay highlighted**

The accumulation of sediment within this area will exacerbate sediment deposition further upstream, within the area of investigation, as there is less volume for sediment deposition downstream. Removal of accumulated sediment in this area will allow more 'flow through' of finer sediment through the stream system upstream, minimising deposition. However, over time, additional sediment will accumulate in the forebay and will need removal.

The current configuration of the breached forebay wall allows 'dead zones' to form within the sediment forebay, promoting fine sediment deposition. Further breaching the dam in the northern corner would remove this 'dead zone' and minimise the deposition of finer sediment within the forebay. However, this would transmit the fines into Loudoun Dam rather than holding them back in the forebay.

Therefore, to achieve dual aims of protecting water quality / amenity in Loudoun Dam and removal of sediment in the forebay to minimise deposition further upstream, direct removal of sediment within the forebay will be required.

Placement of spoil outside the floodplain will be required, or disposal off-site. It is unclear what level of contaminants are present within the sediment, given the dam's historic containment of ore-rich material. Therefore, sampling and analysis is recommended prior to re-use, otherwise disposal of the sediment in a suitable facility is required. Disposal of sediment off-site is recommended.

**Figure 24 Sediment accumulation and colonisation in the sediment forebay of the Loudoun Dam**

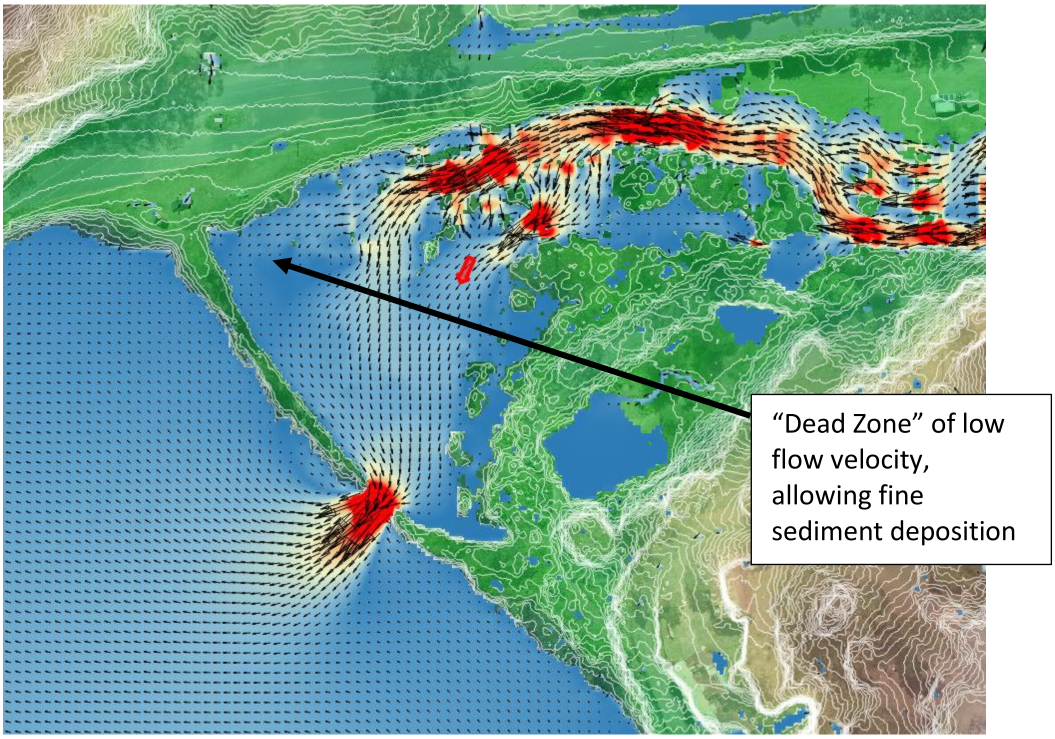


**Figure 25 Velocity results of the 50% AEP flood event of the Loudoun Dam forebay just prior to overtopping**

The cost estimate for this component is based on the following assumptions:

- Approximate excavation area as outlined in Figure 23 (4000m$^2$)
- Approximately 1 week of a small excavator to remove as much material as possible.
- Relatively dear disposal costs of excavated material. No disposal location nominated.
- Excavation of accumulated material will be undertaken around larger existing trees using relatively small-scale equipment for manoeuvrability. Aquatic weeds and ground cover to be removed.

### 5.4.5 Other Costs

Other costs for the above works are anticipated to include:

- Erosion and Sediment Control Plan and infrastructure ($7,500)
- Further community engagement and consultation (20 hours of staff time) ($3,000)
- As-Constructed drawings/survey ($5,000)
- Mobilisation / Demobilisation of machinery and equipment ($10,000)
- 12 months of maintenance, including irrigation and weed control across all areas – labour and material costs ($70,000)
- Contingency (~10% of total) ($40,000)
- Project management – 1x project manager at 40 hours per week for 4 weeks - ($26,000).

The above additional costs add approximately $200,000 to the total.

### 5.4.6 Summary of Costs

A summary of the costs outlined in the Section above is provided in Table 3. These cost estimates are based on:

- Specific quote from earthmoving operator based in the Tablelands for the step-pool sequences, Simpson's Creek drainage line and downstream pool creation
- Costs and unit rates for gully and stream bank repair projects undertaken by Neilly Group in the Tablelands and surrounding region (i.e. Daintree/Mossman)
- Recent costs incurred from construction of other environmental restoration projects undertaken by Neilly Group (i.e. approval costs and estimates) around North Queensland.

Costs to dispose excavated material (from all aspects) of these works are unknown and therefore cost assumptions assume disposal of material off-site (i.e. no material re-use). If, during Detailed Design, material re-use is identified and highlighted, this will greatly affect price.

A full breakdown of cost estimates is provided in Appendix D.

**Table 3. Cost estimate summaries for major components of work scoped**

| Item | Description | Cost Estimate |
|---|---|---|
| **1.1 Detailed Design** | • Topographic Survey<br>• Service Locator<br>• Detailed Design<br>• Further Investigation of Mount Petersen sediment source | $54,000 |
| **1.2 Approvals** | • Hydraulic modelling report | $74,000 |

| Item | Description | Cost Estimate |
|---|---|---|
| | • Fishway report<br>• Sediment extraction operational plan<br>• SARA lodgement fees<br>• Contingency for unforeseen issues arising form the DA process<br>• Fishway expert present during construction | |
| **2 Upstream Pool-Riffle Sequence Reinstatement** | • Weed removal<br>• Excavation of 600m$^3$ of material<br>• Formation of bunds using the excavated material<br>• Creation / enhancement of 6x pool-riffle sequences<br>• Revegetation with 200 trees, 1,200 lomandra/sedge<br>• Turfing of 400m$^2$<br>• Ground cover establishment of 1,000m$^2$ | $59,420 |
| **3 Simpson's Creek Drainage** | • Topsoil stripping and grubbing<br>• Creation of a new drainage line across the camping area to convey flows including hydraulic 'step' and hard-stand vehicle crossing<br>• Relocation of services intercepted by the drain<br>• Turfing the drainage line<br>• Revegetation of the banks of the drainage line<br>**Subject to Detailed Design** | $49,638 |
| **4. Downstream Pool Creation** | • Clear and grub and topsoil strip<br>• Creation of a pool area immediately downstream of the bridge<br>• Selective placement of large boulders and cobbles<br>• Turfing of disturbed areas<br>• Revegetation | $17,845 |
| **5. Excavation of Sediment from the Loudoun Dam Forebay** | • Sediment excavation<br>• Disposal of excavated sediment off-site<br>**Subject to Detailed Topographic Survey** | $26,500 |
| **6. Maintenance (12 months)** | • Watering<br>• Weed control<br>• Minor earthworks | $90,000 |
| **7 Miscellaneous Construction Costs** | • Fishway superintendent inspection during construction<br>• Erosion and Sediment Control Plan<br>• As-Constructed Drawings and Survey<br>• Project Management<br>• Further Community Engagement<br>• Mobilisation and Demobilisation<br>• Contingency (10%) | $90,500 |
| **TOTAL** | | $441,903 |

# 6 Assumptions

- The level of works required to implement the activities proposed in this document are derived having not undertaken Detailed Design and are based on inaccurate topographic information (2011 LiDAR). Cost estimates may change once Detailed Design is undertaken. Cost estimates err on the high side in case further funding is sought based on the contents of this report to prevent funding shortfall to achieve the desired works.
- Approval triggers and processes are based on available mapping from Queensland Spatial and are based on experience in other similar projects throughout North Queensland. No SARA pre-lodgement meeting has been undertaken to verify referral agencies or requirements to gain approval.
- Hydraulic modelling outlined in this document is preliminary only and is not to be relied upon for flooding assessment or any other purpose than what is discussed within this report.
- No ranking or preference is given to the works considered in this report as this can be undertaken by Gulf Savannah NRM. Priorities may/will change depending on community attitudes, funding sources available, funding priorities and various constraints.
- No prices within this report constitute a quote to undertake further works and are indicative only.

# 7 Summary and Conclusions

- Enhanced point-source sediment load historically and currently delivered to Irvinebank via McDonald Creek and Ibis Creek.
- 1967 event unlike anything in the record from 1890 to present. Mobilised a large volume of sediment from upstream.
- Loudoun Dam has reduced the hydraulic capacity of approx. 800m or more upstream. Therefore, sediment moving down the stream system is deposited in and above the headwaters. This probably caused the mass-deposition of sediment in the area of interest in the 1967 event.
- No sufficient events since to re-mobilise sediment. Has been colonised by vegetation.
- Contemporary enhanced sediment load appears to come from Mount Peterson in Ibis Creek catchment, downstream of the Ibis Dam.
- The reduced hydraulic capacity of the channel as a result of Loudoun Dam and infilled valley ensure that the area of investigation will be a sediment deposition zone no matter what happens, even if upstream sources of sediment are abated.
- Therefore there is a major risk of sediment drowning any restoration works proposed in the area of interest.
- Works proposed to enhance the habitat and aesthetics of the area, generally in-line with community expectations are:

  (1) Creation/enhancement of 6 pool-riffle sequences in the 200m upstream from the Herberton Petford Road Bridge. This task also includes significant excavation (300m$^3$) for a sacrificial reach upstream to accept additional sediment, significant weed removal, turfing and ground cover establishment and riparian planting with native species.
  (2) Creation of an in-stream pool for swimming and recreation immediately downstream of the bridge
  (3) Excavation of a shallow drain through the free-camp area to transmit flows from Simpson Creek culverts to McDonald Creek to minimise nuisance flooding
  (4) Excavation of fine sediment accumulating in the forebay of Loudoun Dam

  Cost of on-ground works are approximately $153,000 + $90,500 miscellaneous construction costs totalling $243,500

- Significant ancillary works are required to achieve the above tasks, including:

  (5) Detailed design, topographic survey and further investigation of the source and quantity of sediment coming from Mount Peterson mining complex
  (6) Significant approvals due to waterway barrier works and the volume of sediment excavated from the waterway
  (7) Maintenance requirements (at least 12 months)

  The cost of ancillary works are approximately $198,000 ($128,000 design and approval costs, $70,000 maintenance).

# 8 References

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Fischenich, C. (2001). *Stream Stability Thresholds for Stream Restoration Materials.*

GSNRM. (2021). *Irvinebank Applied Watershed Management Project.* Georgetown, QLD: GSNRM.

USGS. (2008). *Simulation of Flow, Sediment Transport and Sediment Mobility of the Lower Coeur d'Alene River, Idaho.* US Geological Survey.

# Attachment A: Hydraulic Model Setup

## Introduction

A TUFLOW 2d hydraulic model was setup for the Irvinebank township based on the 2011 LiDAR. The model extent covered the area available from 2011 LiDAR and continued downstream past Loudon Dam. TUFLOW calculates the flow depth, elevation, velocity and shear stresses on a cell-by-cell basis using elevation data and input flow values. These calculations were used to guide the analysis of geomorphic behaviour of the system and evaluate options for remediation.

## Rainfall-Runoff

The conversion of rainfall to runoff was undertaken in accordance with Australian Rainfall & Runoff 2019 (AR&R). Rainfall was applied directly to the model where there was available LiDAR in a 'direct rainfall' configuration (Figure A below). Outside the extents of available LiDAR, the Watershed Bounded Network Model (WBNM) was used to calculate flow of drainage lines upstream and the calculated flow hydrograph input into the model at or near its boundary.

Both rainfall-runoff calculation options were consistent with Australian Rainfall & Runoff (AR&R) 2019. However, as there are no flow gauges in the immediate vicinity with sufficient data (>30 years length of continuous flow data), no calibration or verification of the model was undertaken and the losses adopted were standard as provided by the AR&R Data Hub.

Irvinebank lies on the boundaries of the Monsoonal North and Wet Tropics regions for temporal patterns. The Monsoonal North series of temporal patterns were used to determine how rainfall of a given intensity, frequency and duration occurred.

## Structures

No structure (i.e. culvert) data was available for the purposes of this study. Therefore roadways present in the LiDAR data were breached in the locations of major culverts, as evidenced in the site inspection and/or in LiDAR data. The result is that the TUFLOW model will likely over-estimate flows at key locations as there is no retardation of flows as a result of culverts in the model. This is expected to have only a minor impact on the values examined from the modelling and will not have an impact on the overall rehabilitation strategy or outcomes presented.

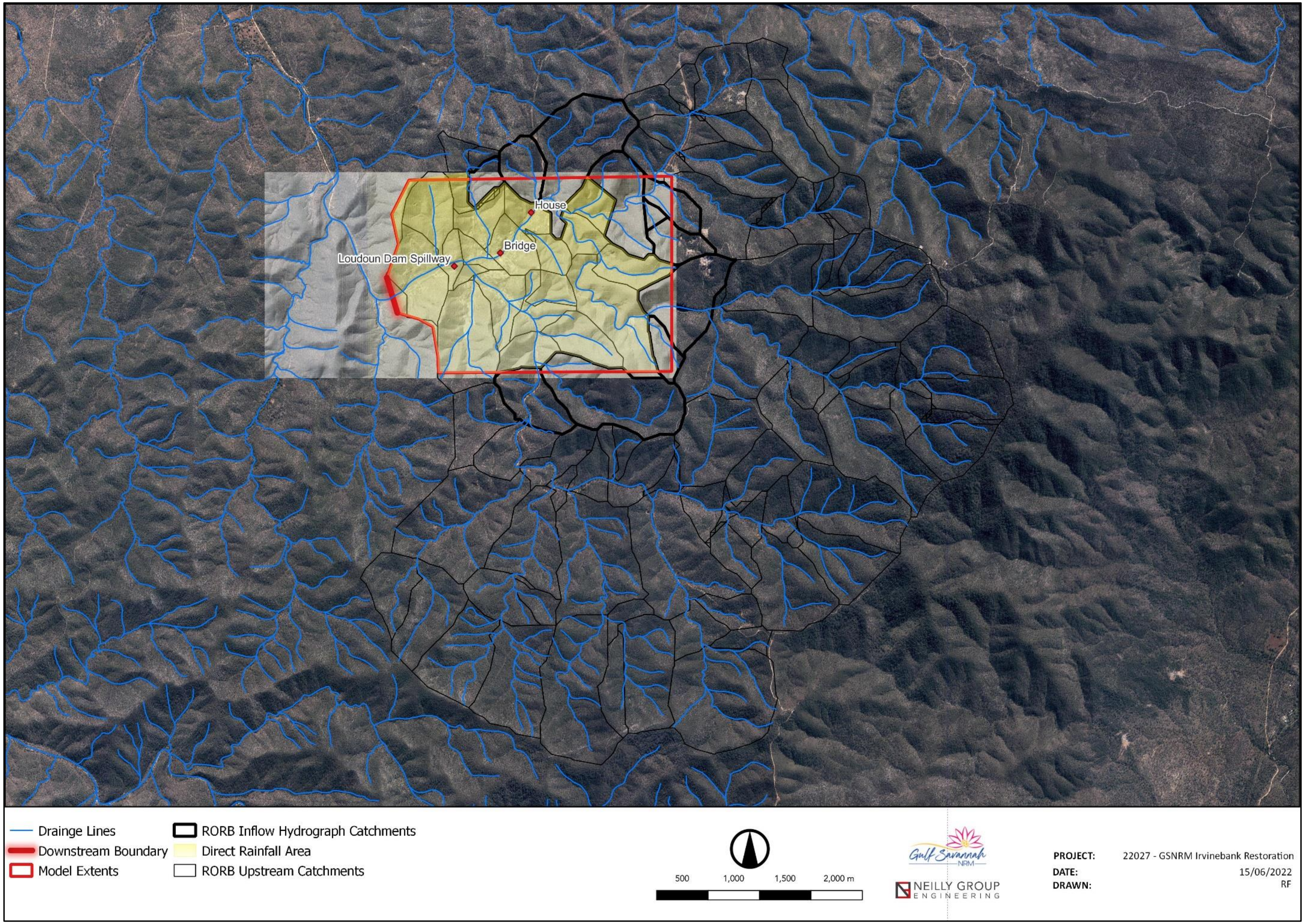


**Figure A: Hydraulic model setup**

## Critical Duration

The critical duration is the duration storm event for a given AEP that provides the highest water levels at a location, based on the interplay between rainfall intensity, duration event, time taken for runoff to travel from the furthest location in the catchment and the rate of runoff accumulation at a particular location. In accordance with AR&R 2019 methods, 10 temporal patterns of rainfall distribution were examined for each duration rainfall event for each AEP and the peak discharge for the temporal pattern closest to (but higher than) the median was adopted. The critical duration is then the highest peak discharge from the adopted median for each AEP.

The peak discharge for McDonald Creek, as well as Simpson Creek, for each adopted critical duration and temporal pattern is provided below in Table 4. Box plots of the range of peak discharges from all temporal patterns, for the adopted critical duration, for the 50%, 20% and 10% AEPs are provided below in Figure 26 and Figure 27.

**Table 4. Adopted critical duration for this study**

| Location | Event | Critical Duration | Adopted Temporal Pattern | Peak Discharge ($m^3/s$) |
|---|---|---|---|---|
| McDonald Creek Upstream of Bridge | 50% AEP | 9 hour | TP04 | 24.70 |
| | 20% AEP | 6 hour | TP05 | 48.24 |
| | 10% AEP | 6 hour | TP08 | 52.73 |
| Simpson Creek Outlet into Park | 50% AEP | 9 hour | TP02 | 1.85 |
| | 20% AEP | 6 hour | TP04 | 2.88 |
| | 10% AEP | 4.5 hour | TP02 | 3.31 |

For the purposes of modelling expedience, the critical duration storm for Simpson Creek was adopted as the same critical duration for McDonald Creek, as the only difference is the temporal pattern chosen between the two. This ensures that the same TUFLOW model run can be examined for McDonald Creek and Simpson Creek, rather than a separate run. This results in an adoption of a peak discharge of $1.5m^3/s$ for Simpson Creek (TP04) instead of a peak discharge of $1.85m^3/s$ (TP02) for the 50% AEP.

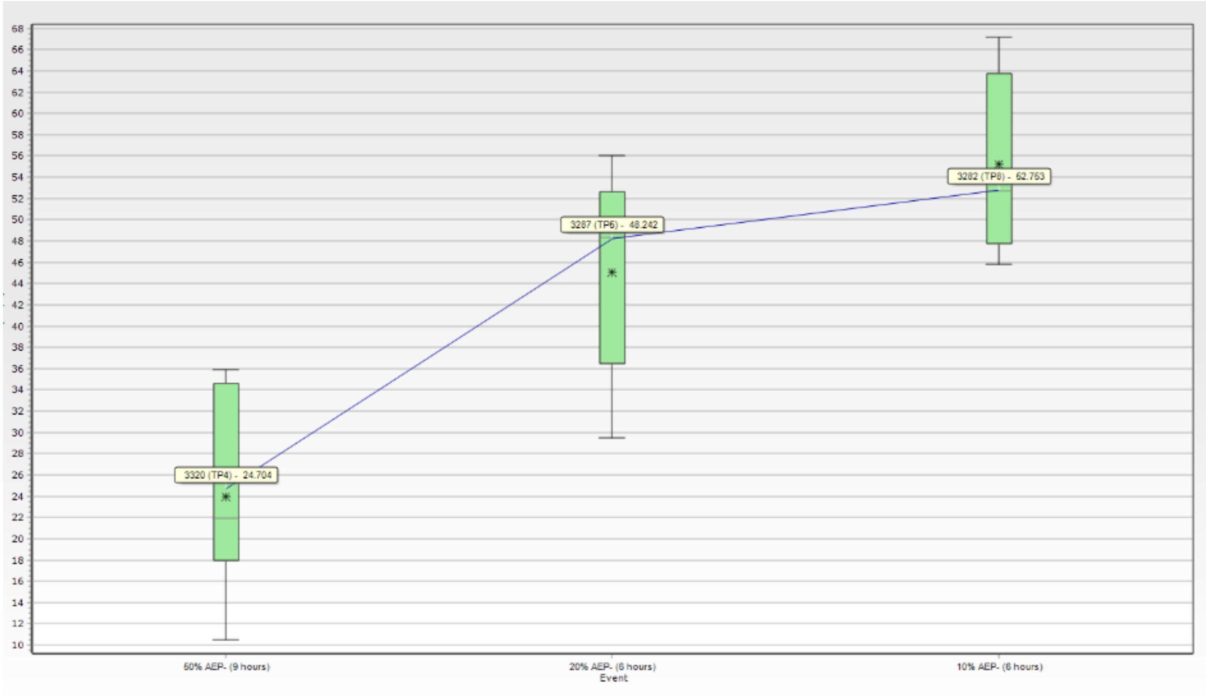


**Figure 26 Adopted peak flow rates for McDonald Creek immediately upstream of the bridge**

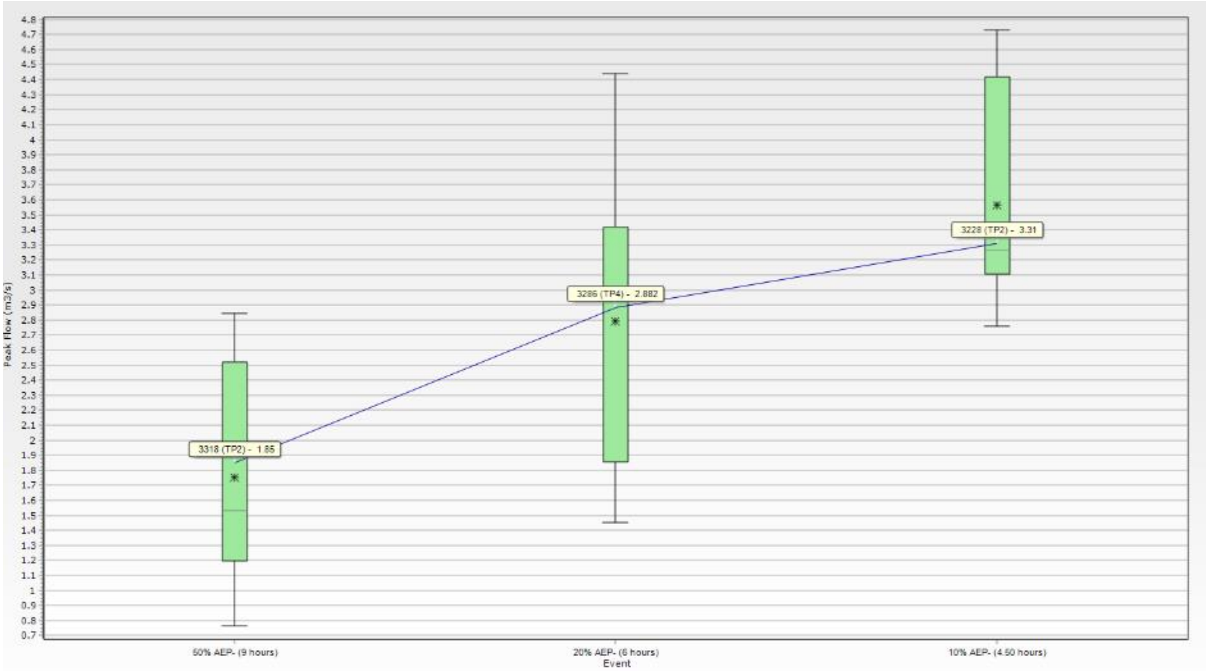


**Figure 27 Adopted peak flow rates for the Simpson Creek Outlet**

## Model Outputs – Bed Shear Stress

Bed shear stress is a measure of the force placed on the bed and banks of the creek system. It is an output of the 2d hydraulic model used. Numerous studies have determined the critical shear stress for various materials – i.e. the shear stress required to mobilise the material. Shear Stress thresholds are outlined below in Table 5

**Table 5. Common shear stress thresholds**

| Classification (US) | | Diameter (mm) | Shear Stress ($N/m^2$) |
|---|---|---|---|
| Boulder | Very Large | 2032 | 1790 |
| | Large | 1016 | 895 |
| | Medium | 508 | 445 |
| | Small | 254 | 225 |
| Cobble | Large | 127 | 110 |
| | Small | 63.5 | 52 |
| Gravel | Very Coarse | 33.02 | 25.8 |
| | Coarse | 15.24 | 11.97 |
| | Medium | 7.62 | 5.74 |
| | Fine | 4.064 | 2.87 |
| | Very Fine | 2.032 | 1.43 |
| Short Native Bunch Grasses | | | 45 |
| Long Native Grasses | | | 85 |
| Structurally Diverse Vegetation | | | 120 |
| Floodplain Stripping | | | 100 |
| Clayey Sands | | | 4.5 |
| Inorganic Clays | | | 6.6 |

# Attachment B: Summary of Community Consultation

Main outcomes of community consultation were:

- The creek used to have an open riparian vegetation condition with few trees lining the creek (possibly because they were historically cut down and fed to boilers and wood stoves)
- Creek used to be bedrock controlled with swimmable and fishable pools formed by rock bars present
- Trees colonised the bed after the 1967 flood event
- In the absence of trees, it would all be a sediment delta without a channel and there would still be flood issues – it is the trees that are channelising flow through the large 'dump' of sediment since the 1967 flood and forming and keeping the channel there
- Any improvement to channel capacity as a result of the project would be greatly appreciated due to flooding of adjoining road frontages that is experienced under the current condition

**Sediment Supply**

- Concurrence that sub-catchment from the Waste Transfer Station is a key supplier. This requires that Council dig-out the road culvert annually. However, the material may not make its way all the way into the town unless there is an exceptionally large event.
- Catchment below the water supply dam is also a major contributor. "The Boogie Hole" (a rock pool historically used byteh town community for swimming) is on this drainage line, has been buried in sediment, and never recovered. The Mount Peterson mine supplies sediment to this catchment and is a large tunnel dump site.

**Outcomes Sought**

- Main desire is for amenity increases in terms of swimming holes, and increased channel capacity to reduce flood break-outs upstream of the bridge.
- Clear-out weeds but try to avoid damage to established native trees.

<u>Upstream of the bridge</u>

- Sediment excavation to reinstate pool depth
- Accentuation of the pool-riffle sequence and creation of pool maintaining scour by placement of large rocks to create flow concentration points and/or drop structures that scour out receiving pools (similar to the form that existed historically when it was a bed rock controlled reach)
- Weed management including removal of exotic trees (Java Plum, common Mango) and management of understory weeds, ground cover to create greater amenity adjoining swimming /dipping pools

<u>Downstream of Bridge</u>

- Sediment excavation to reinstate pool depth
- Creation of a large feature 'swimming pool' with broadened (2x –3x existing channel), deepened and rock stabilised margins where need be, and an open aesthetic (i.e. not tree

canopy covered at least not all of it) – was proposed that the most appropriate site for that would be immediately downstream and adjoining the bridge as that is the area that already has that type of recreational use associated with it

- Accentuation of lower pool (upstream of old cement bund /crossing) depth via in channel rock bar, this idea was canvassed and supported, but issues around barrier permitting were noted and the impression was given that provision of the large pool feature superseded its need (perhaps can be included as an option)
- Construction of a flow channel for Simpson Creek, from the culvert coming through the main road to its confluence with the main creek - currently storm events down this catchment catch campers unaware and create tent flooding and vehicle bogging and the idea was that a dedicated flow path channel would reduce these risks
- Excavating bund outlets (the merits of this were explained - in terms of preventing fine sedimentation in upstream backwaters), there was some concern that would result in all accumulated sediment being mobilised into the dam, it was explained that would not be the case or intention, there was no clear direction, thoughts are that this would still improve the aesthetic and water quality of the lowermost stream reach and should get a guernsey as a costed option at least

# Attachment C: Photos and Descriptions from Site Inspection (Jim Tait)

Constricted scour pool beneath existing MacDonalds Ck bridge – currently used for swimming recreation. Emulation of flow constriction – scouring pool formation proposed for upstream reach

Example of existing wading pool within riffle – scour pool sequence reach upstream of bridge.

Accumulated coarse material within stream channel upstream of bridge, Size fraction of this material means only likely to mobilise on extra large events

Bed accumulated sediment at top of riffle- scour pool reach above bridge, a potential source of sediment bed load during large events

Example of existing pool feature in riffle -scour pool sequence reach upstream of bridge. The intention is to emulate and accentuate this channel form with proposed works

Accumulated bed sediment in reach above bridge, a target for extraction and channel capacity reinstatement . Road frontage in background currently experiences flooding when the stream breaks our of the sediment filled channel.

Accumulated bed sediment in reach above bridge, a target for extraction and channel capacity reinstatement – bank forming and weed clearing proposed for left bank

Accumulated bed sediment in reach above bridge, a target for extraction and channel capacity reinstatement – bank forming and weed clearing proposed for left bank

Prograding bed sediment load at top of pool formed around bridge constriction, target for extraction, or possibly suitable extraction point for a sediment trap – right bank proposed for weed management

Accumulated bed sediment downstream of the bridge constriction scour – maintaining a straight flow path conduit downstream and some channel proposed pool feature separation (rock wall?) on right bank of existing channel could protect proposed expansive pool feature (right) from sediment inflows

Fig tree canopy reach upstream of bridge is proposed for sediment extraction channel reinstatment and wading dipping pool amenity formed by accentuation of in channel scour pool and riffle sequence by large rock flow constrictions in-stream channel – NB need in channel controls to limit change in slope between works reach and upstream sediment stores to prevent bed coarse material stores being stabilised

Proposed swimming pool feature would lie to left in front of upstream bridge crossing. Protection and stabilisation of bridge infrastructure under high flow events needs to inform pool design.

Proposed preferential flow path for Simpson Ck catchment inflows may have confluence with main stream channel in foreground left

# Attachment D: Cost Estimate Breakdown

| | Description | Cost ($) |
|---|---|---|
| 1.1 | **Design and Approvals** | |
| 1.1.1 | Topographic Survey | $15,000 |
| 1.1.2 | Detailed Design | $35,000 |
| 1.1.3 | Service Locator | $4,000 |
| 1.2 | Approvals | |
| 1.2.1 | - Lodgement Fees | $25,000 |
| 1.2.2 | - Hydraulic modelling report | $10,000 |
| 1.2.3 | - Fishway report | $7,000 |
| 1.2.4 | - Sediment Extraction Operational Plan | $5,000 |
| 1.2.5 | - Contingency | $15,000 |
| 1.2.6 | - Fishway Superintendent inspection during construction | $12,000 |
| | **SUB TOTAL** | **$128,000** |
| 2 | **Upstream Pool-Riffle Sequence Reinstatement** | |
| 2.1 | **Weed Removal** | |
| 2.1.1 | Removal of weeds within the subject area and disposal of cuttings | $15,000 |
| 2.2 | **In-Stream Excavation and Pool-Riffle Sequence Creation** | |
| 2.2.1 | Sacrificial reach - In-stream excavation and cart to spoil | $6,600 |
| 2.2.2 | Sacrificial reach - Disposal of excavated material | $13,200 |
| 2.2.3 | Supply of large boulders rock for in-stream pool-riffle sequences | $1,620 |
| 2.2.4 | Placement of rock for in-stream pool-riffle sequences using small excavator | $4,800 |
| 2.3 | **Revegetation of disturbed areas** | |
| 2.3.1 | Plant supply - 600x Mat Rush + 600x Sedge + 100 River She Oak + 100 River Red Gum | $4,000 |
| 2.3.2 | Plant installation | $4,200 |
| 2.3.3 | Seeding of temporary disturbed areas | $2,000 |
| 2.3.4 | Turfing of disturbed areas near the creek line for amenity restoration | $8,000 |
| | **SUB TOTAL** | **$59,420** |
| 3 | **Simpson's Creek Drainage** | |
| 3.1.1 | Clear and grub and topsoil strip (nominal 150mm) bund footprints (if applicable) | $918 |
| 3.1.2 | Strip and stockpile topsoil (nominal 150mm thickness) | $6,885 |
| 3.1.3 | Cut to spoil | $4,700 |
| 3.1.5 | Supply of and compaction of rock and gravel for roadway access across drain | $780 |
| 3.1.7 | Replace topsoil across created drain | $7,215 |
| 3.1.8 | Turfing including cultivation, soil ameliorants, imported topsoil, fertilisers, turf cover | $9,100 |
| 3.1.9 | Supply and install plants as riparian vegetation along the drainage line at 3 plants per linear meter | $5,040 |
| 3.1.10 | Relocation of services | $15,000 |
| | **SUB TOTAL** | **$49,638** |
| 4 | **Downstream Pool** | |
| 4.1.1 | Clear and grub and topsoil strip (nominal 150mm) bund footprints (if applicable) | $500 |

| | Description | Cost ($) |
|---|---|---|
| 4.1.2 | Strip and stockpile topsoil (nominal 150mm thickness) | $3,750 |
| 4.1.3 | Cut to spoil | $4,700 |
| 4.1.4 | Line pool with rounded river rock sourced from the site | $1,200 |
| 4.1.5 | Supply and placement of large boulders along eastern side of pool | $1,800 |
| 4.1.6 | Line perimeter of pool with vegetation at 3 plants per linear m, including installation | $1,275 |
| 4.1.7 | Turfing including cultivation, soil ameliorants, imported topsoil, fertilisers, turf cover | $4,620 |
| | **SUB TOTAL** | **$17,845** |
| **5** | **Loudoun Dam Forebay** | |
| 5.1.1 | Clear and grub footprint where possible | $8,000 |
| 5.1.2 | Excavation of removed sediment and disposal off-site | $18,500 |
| | **SUB TOTAL** | **$26,500** |
| **6** | **Maintenance** | |
| | 12 Month Maintenance including irrigation and weed control | **$70,000** |
| **7** | **Miscellaneous Construction Costs** | |
| | Erosion and Sediment Control Plan | $1,500 |
| | Erosion and Sediment Control Devices | $5,000 |
| | Project Management | $26,000 |
| | Community Engagement and Consultation | $3,000 |
| | As-Constructed Drawings / Survey | $5,000 |
| | Contingency | $40,000 |
| | Mobilisation / Demobilisation | $10,000 |
| | **SUB TOTAL** | **$90,500** |
| **TOTAL** | | **$441,903** |