Assessment of Erosion Processes in the South Pine River in Close Proximity to Energex Infrastructure.
Final Report August 2010

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Collaborative Research in South East Queensland

This study was a collaboration between Energex Ltd and Griffith University. Considerable information was also supplied by Moreton Bay Regional Council to assist in improving our knowledge of streambank erosion processes in the lower reaches of the South Pine River. Griffith University have given inkind support through additional staff hours to develop tools that may be of use to the broader SEQ region in relation to stream revegetation activities. Energex Ltd contracted this research in order to use the data to inform the decision making process regarding the placement of new infrastructure and access points.
Executive Summary

Channel Migration Findings:

- Channel migration rates have been determined for seven sections of the South Pine River (SPR) study reach using two separate methods that gave comparable results.
- Migration rates have increased over the past 118 yrs and the most likely causes are the change in catchment and riparian condition as a result of clearing, gravel extraction, removal of bank vegetation and the increased frequency of bankfull discharge events.
- Lateral migration rates have increased significantly since 2002 in sections downstream of the old meander loop with a potential maximum shift in orthogonal length of 10-30 m over the next 50 yrs.
- Channel planform upstream of the cut-off has been stable over the past 118 yrs and the significant lateral migration of this section of the study reach is unlikely over the next 50 yrs under current conditions.
- It is probable the meander cut-off bend will migrate in an off-axis trajectory and unlikely to migrate north towards the apex of the old meander loop.

Flow Velocity and the Affect of Vegetation Distribution:

- Water depth and flow velocities for the 1, 2, 5 and 20 yr recurrence interval discharges were modelled using the one dimensional HEC RAS and HEC geoRAS software.
- Water depth inundation layers were comparable to previous flooding reports undertaken for Moreton Bay Regional Council.
- Flow velocity maps illustrate the areas of potential fluvial erosion within the channel and across adjacent sections of the floodplain.
- Revegetation of the channel banks affects flow velocity patterns within the channel and across the adjacent floodplain.

Likely Impacts on Infrastructure:

- Lateral migration of the channel is likely to continue downstream of the meander cut-off. The probable migration direction is on an off-axis trajectory, which is not considered a significant risk to existing and proposed infrastructure over the next 60 yrs.

Recommendations:

- Planned revegetation of channel banks within the SPR study reach should include appropriate revegetation of the adjacent floodplain to prevent erosion in unvegetated areas that are shown to be at risk from high flow velocities.
- HEC geoRAS modelling of several flood events shows the cut-off section of the study reach is at risk from high flow velocities.
- Temporary access points if located within the cut-off area during the dry season should be revegetated with appropriate mangrove species along the toe of the bank and across the floodplain with deep rooted terrestrial species after access activities are completed.
- Permanent access points for infrastructure maintenance are recommended to be located within the upstream arm of the old meander loop, preferably at an existing disturbed site that has manageable bank slope angles that can be revegetated and stabilised.
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1 Glossary

Bankfull Discharge: The formative flow of water that characterises the morphology of a fluvial channel

Bedload Transport: The movement of material along the riverbed generally through rolling or pushing of material

Channel Planform: The shape of the channel as seen from above in plan view

Geomorphic Assessment: The assessment of landforms and the processes that have shaped them

Lateral Migration: The movement of a channel in a direction from side to side of the valley

Orthogonal Shift: Shift in the direction of a point having a set of mutually perpendicular axes or coordinates that meet at right angles

Simple Scarp Form: A sharp break in profile, also described as a knickpoint or headcut
2 Introduction

Main Aims of the Study:

This report details an assessment of a specified reach of the South Pine River (SPR) adjacent to an existing electricity supply network owned and operated by Energex Ltd. The reach in question has undergone channel planform changes in response to several significant flooding events over the past 18-24 months. The reach is located approximately 4km upstream of the confluence of the North and South Pine Rivers and encompasses a large meander loop with cleared paddocks used for grazing purposes on the majority of adjacent land, (Figure 2.1)

Energex have an existing electricity supply line traversing the meander loop in a north to south axis and it is proposed that this supply is duplicated within the current easement approx 20m east of the existing line. The meander loop has been cut off from the main flow of the river and now only flushes through tidal movement of water with minimal inflow from the upstream catchment. The existing supply line and associated towers are currently inaccessible as a consequence of the meander loop cut off and advice is sought on a preferred access point for the maintenance of existing and proposed electricity supply infrastructure. An interim report using field assessments and the analysis of historical aerial photographs was presented in June 2010 (Appendix 1) and the findings of this earlier work are discussed in the main body of this report.

In addition to the assessment of appropriate access, this report was commissioned by Energex Ltd to investigate the rates of channel migration along specific reaches of the lower SPR and whether lateral migration of the channel will affect adjacent infrastructure.

Two approaches have been adopted:

- The use of historical data to determine past migration rates for the study reach of the SPR, and
- Hydraulic modelling of the channel to identify sites of high erosion potential.

The results of these investigations are provided to assist in the decision making process regarding the placement of new infrastructure and access points. They also illustrate the potential benefits of bank revegetation.

The South Pine River Catchment:

The South Pine River has a catchment area of ~240 km$^2$, with its headwaters at the foot of Mount Glorious, and its confluence with the North Pine River near Lawnton. Dominant land uses within the catchment include native bush, grazing, rural residential and urban. Gravel extraction has occurred throughout the alluvial reach. The SPR is one of the few rivers in Southeast Queensland (SEQ) that is not impounded and still has remnant stands of rainforest in its upper reaches.

Catchment clearing and landuse intensification, including extensive gravel extraction, since European settlement has resulted in observed changes in rivers and streams of SEQ. Significant degradation of ecosystem function has been observed (Abal et al, 2005), often related to removal of riparian vegetation, increased rates of bank erosion and bed lowering following bed disturbance. These changes are very evident in the SPR, especially in the alluvial reaches.
Bank erosion is a natural process in meandering streams, being more or less offset by bank construction over the medium term. In unstable river channels, bank erosion outstrips bank construction increasing the channel cross-sectional area. Accelerated bank retreat due to channel expansion or simply because of an increased meander migration rate can threaten built infrastructure such as roads, buildings or powerlines situated within the riparian zone or on the floodplains. The management of such areas is dependent on a clear understanding of river processes.
3 Desktop and Field Analysis of the Study Reach

The following datasets were sourced through several collaborating organisations to assist in the desktop analysis of the SPR study reach:

- LiDAR derived DEM 2009 (Moreton Bay Regional Council - MBRC),
- Lower Pine River Flood Study: 2009 (MBRC),
- Amended Hydraulic Assessment Report: 2010 (MBRC),
- HEC RAS model: Aurecon contract, 2010 (MBRC),
- Field survey cross sections: South Pine River, 2010 (MBRC),
- Field survey cross sections: South Pine River, 2010 (Energex)
- Parish Maps: 1892 (DERM), and
- Daily discharge data for Draper’s Crossing: 1966-present (DERM).

Additional field surveys were conducted by Griffith University staff between February and June 2010 to undertake geomorphic assessments of the reach, perform instream flow measurements, confirm the extent and condition of vegetation and collect bank sediment samples. These data were used to assist in the determination of historical erosion rates and the development of channel hydraulic models.

3.1 Geomorphic Assessment

The study area is the ~2.5km alluvial reach extending downstream from a point approximately 400m north of Gympie Road and includes as its focus the recently developing meander cut-off (Figure 2.1). In this reach the SPR is tidal with an average tidal range of 1-1.2 m. Mangrove colonised benches extending a few metres from the bank toe and built to the high tide level are present, though highly dissected. Where these remain intact (the locations are shown in Figure 2.1) they provide important bank protection functions. In contrast bare banks can be observed to have a simple scarp form, reflecting active retreat.
Figure 2.1: Study reach of the South Pine River divided into seven sequential sections (A-G) for the assessment of channel migration rates. The inset map shows the location of the meander loop on the lower reaches of the South Pine River.
3.2 Determination of Historical Channel Migration Rates

Methods:

The study reach has been divided into seven sequential sections (A-G, Figure 2.1) with a channel migration rate determined for each section (Figures 2.5 & 2.7). The sequential sections were delineated as areas of active channel migration over time whereas subsequent analysis of hydraulic modelling used cross-sections of the channel that were chosen to describe instream features or channel forms.

Channel migration rates have been measured using the methods of Micheli et al (2004). First, sequential centrelines are defined in ArcGIS from each of the aerial photographs (Figure 2.2) with the change in position of these centrelines through-time quantified using an ‘eroded-area polygon’. The 1892 Centreline is mapped to the remnant channel outline visible in the light detection and ranging (LiDAR) data. The channel representation on the Parish map is assumed to be offset due to a mapping / rectification error. The fact that no topographic expression of a channel remnant exists where the 1892 channel is shown on the parish map provides support for this interpretation (Figure 2.3).

An eroded-area polygon is created by intersecting two channel centrelines (Figure 2.4). The area and perimeter of the eroded polygon is calculated, from which the average migration distance perpendicular to the channel centreline is determined. The lateral migration distance is equal to the polygon area divided by the average stream length for the polygon (with average stream length equal to one-half of the polygon perimeter). Note this gives average migration rate of the channel length, and is therefore less than the maximum channel displacement along the line of the longest orthogonal (see Hickin, 1975; Hickin and Nanson, 1984), the traditional measure of channel migration. For comparison the migration rate using the longest orthogonal method is also reported (Figure 2.6).
Figure 2.2: Centrelines determined from each of the aerial photographs for 1892, 1955, 2002 and 2009.
Figure 2.3: The 1892 Centreline is mapped to the remnant channel outline visible in the hillshaded DEM derived from the LiDAR data.

Figure 2.4: Measurement of channel migration rate using the eroded area polygon method Micheli et al (2004). The purple polygon bounded by the 1892 centreline (light blue) and the 1955 centreline (red) represents the area eroded in the period 1892-1955. Likewise the light green polygon bordered by the 2002 centreline (green) represents the area eroded in the period 1955-2002.
Figure 2.5: Average centreline migration rates as measured using the eroded-area polygon method (Micheli et al, 2004) for the seven reaches identified in Figure 2.1. Note that the three 'steps' represent the periods encompassed by the four time slices examined, i.e. 1892-1955, 1955-2002, 2002-2009.

Channel Migration Rate Results:

These data show differing migrations rates for each section of the study reach over the four time periods that were examined. In section A, at the apex of the meander loop, the highest rate of migration occurred between 1982 and 1955 with an average rate of approximately 0.75m/yr. This rate of migration has subsequently fallen to a negligible level over the past seven years. It is possible the rate of extension of the meander loop had stabilised due to the achievement of a stable bed slope for current hydrologic conditions. Now that this section of the meander loop is cut-off from the main channel, it is unlikely to be re-instated. Sections D and E show similar patterns of migration rate over the four time periods. The maximum rate of approximately 1.1m/yr has occurred for both sections since 2002. These
sections of the study reach clearly illustrate that the meandering channel is actively migrating downstream across the alluvial floodplain. This process is also illustrated in the migration rate patterns in sections F and G. These sections of the study reach show a maximum migration rate of approximately 1.4m/yr since 2002. The migration of meandering channels is affected by the erodibility of boundary surfaces, riparian vegetation and relic valley dimensions and the rate of channel migration is affected by changes in catchment and riparian condition.

Figure 2.6: Longest orthogonals (dark blue) identified for shifts between channel centrelines dating to 1892 (light blue), 1955 (red), 2002 (green) and 2009 (purple).
Figure 2.7: Average centreline migration rates as measured using the longest orthogonal method (Hickin, 1975; Hickin and Nanson, 1984) for the seven reaches identified in Figure 2.1. Note that the three 'steps' represent the periods encompassed by the four time slices examined, i.e. 1892-1955, 1955-2002, 2002-2009.
Figure 2.8: Shift in channel centreline along longest orthogonal since 1892 for seven reaches identified in Figure 2.1.

Data derived from the analyses of the longest orthogonal in sections A-G of the study reach are representative of the maximum channel displacement rates that have occurred over the four time periods. Figure 2.7 shows that the highest migration rates have occurred since 2002 and sections D-G again are the most active sections of the study reach. These results are similar to the migration rates derived from the erodible polygon method and Figure 2.9 illustrates a linear relationship between the two methods, indicative of comparable results from two methods. Rates of migration derived from the erodible polygon method are lower than those derived from the longest orthogonal method as the latter method derives a maximum rate while the former method derives an averaged migration rate.
Future Channel Migration Pathways:

Assessment of the study reach has been undertaken using historical data, which can inform assumptions for future migration rates given the current hydrologic conditions and adjacent landuse and riparian vegetation condition. These data would suggest migration rates for sections of the study reach downstream of section C could see an orthogonal shift of 10-30 m over the next 50yrs if we consider the rates achieved between 1955 to 2002 (Figure 2.8). Changes to channel length and bed slope as a consequence of the meander cut-off could affect these migration rates and further lateral movement of the channel may be observed over and above 10-30 m in the next 50 yrs. Revegetation of the channel banks would assist in slowing these rates but may not prevent the changes initiated by the meander cut-off event.

It is unlikely the recently cut-off meander bend will migrate through the island area shown in Figure 2.10. The upstream arm of the cut-off has shown a stable configuration since at least 1892. Assuming stability at this point, then the next 50-60 yrs will see continued delivery of flow energy to the outside bank downstream of the bend axis and more likely an off-axis delivery of the meander is expected. The flow velocity pathways are discussed in section 3 to further illustrate this point. The more likely evolutionary trajectory for the old meander loop landform is the formation of a disconnected billabong to a backswamp then clay plug to finally a meander scar; although the tidal flow influence in this section of the river may prevent this sequence of events or influence the time period taken for this to occur.
Channel Bank Erosion Processes in the South Pine River-August 2010

Channel Migration Processes in the SPR:

Channel migration rates show a clearly increasing trend since 1892, coincident with and likely caused by changes in catchment and riparian conditions, including clearing, gravel extraction and removal of bank vegetation. At the scale permitted by the imagery, no significant channel widening is observed, suggesting that the observed increase in channel migration rate is unlikely to be due to channel deepening followed by bank collapse and widening leading to increased flow energies. Rather it appears that the extra flow energy implied by the greater migration rates is independent of any increase in channel cross section.

Alternative explanations are an increase in slope, a decrease in roughness, decrease in sediment transport and an increase in the frequency of bankfull discharge events. Of these, slope increases are an unlikely cause, given the absence of tectonic tilting or significant channel shortening. This leaves a decreased supply of sediment, decreases in channel roughness and increased run-off as a consequence of landuse change as the most likely explanations for the increased channel migration rates observed. As bedload transport is a significant consumer of stream energy, the effect of reducing sediment supply (due most likely to gravel extraction from the bed) can be understood in general terms as increasing the amount of stream energy available to the channel to erode the channel boundary (i.e. to migrate).

Likewise, the removal of roughness elements (eg vegetation) from the banks and floodplain significantly increases flow velocities and therefore available stream energy. The SPR catchment has experienced extensive clearing within the catchment as a consequence of changed landuse and urban development. Studies by Zhang et al (2001) have shown changes in catchment vegetation from forest to grass communities can significantly increase run-off as a consequence of the reduction in annual evapo-transpiration and interception of run-off from trees (Figure 2.11). The annual rainfall for the SPR is approximately 1500 mm/yr. This would result in an increase in excess run-off from 400 to 800 mm/yr in cleared areas of the catchment. A doubling of potential run-off from the catchment would result in an increased frequency of bankfull discharge events and an increased occurrence of fluvial erosion of channel banks.
Figure 2.11: Differences between evapo-transpiration of forested and grass-land with mean annual precipitation (Zhang et al., 2001).
4 Development of Hydraulic Models

A literature review was undertaken to assess the applicability of several hydraulic models for this project. Previous studies have shown the use of geographic information systems (GIS) techniques are becoming more widely used to map changes to channel planform over time and bank erosion potential within the channel (Winterbottom and Gilvear, 2000; Reinfields et al, 2004; Aggett and Wilson, 2009). Indeed, MBRC have undertaken HEC RAS modelling of the lower reaches of the SPR to assist in the design of bank stabilisation works downstream of the old meander loop. The introduction of high resolution terrain imaging techniques such as light detection and ranging (LiDAR) have allowed the development of digital elevation models (DEM) with a 0.1m vertical resolution and grid size of 1m x 1m. This grid size is sufficient to model fine-scale landscape features for geomorphic analysis. This approach addresses past criticisms, (Finlayson and Montgomery, 2004) that GIS-based geomorphic analyses to undertake hydrologic modelling of a catchment were poor due to coarse grid sizes that could not effectively define landscape features at a relevant scale.

One dimensional hydraulic models can be used in conjunction with high resolution spatial data to compute water inundation levels and mean water velocities in order to determine areas of high erosion potential within stream channels. The HEC RAS (version 4.1 Beta) 1-D model was chosen as a suitable hydraulic model for this project and was used in conjunction with HEC geo-RAS (version 4) to export geometric data from the DEM to HEC RAS. The development and interpretation of 2-D and 3-D models, although more realistic in terms of representation of complex flow (Bates et al, 2003), require expensive parameterisation to work effectively. Hence the 1-D HEC RAS model was chosen as the preferred option

The HEC RAS framework allows modification of the modelled channel through manipulation of cross section data and the assignment of horizontal roughness coefficient values (Manning’s n coefficient). ArcGIS (version 9.3) was used to display the outputs from HEC RAS for the models depicting the current situation and those depicting changed vegetation scenarios.

4.1 Development of HEC RAS Models for the SPR Study Reach

Methods:

LiDAR derived maps of the bare ground DEM were developed from 2009 data for the study reach supplied by MBRC. Figure 3.1 shows the meander cut-off model that was developed for the reach with the stream line (in blue) and cross sections (in green) that were used in the HEC RAS model. Cross sections surveyed in the field by Energex contractors and interpolated cross sections are also represented in Figure 3.1. It should be noted that field cross sections were not available for the cut-off section of the channel and an interpolated cross section was used at the apex of the bend in this area.

The underlying DEM layer shows the channel with an intact meander loop as the data were captured before the meander loop cut-off process was triggered. The use of this DEM layer is not ideal as data interpolated by HEC geo-RAS for floodplain inundation levels does not strictly match the current cut-off channel topography. However, the objectives of this project can still be met with the available DEM data. If further investigations are undertaken to detail revegetation activities, it is advised that a current DEM is used.
The HEC RAS model was developed to investigate in-channel mean water velocities following a meander cut off event. Data extracted from the DEM for cross section geometry, spatial location and streamline pathway were exported from HEC geoRAS into HEC RAS for manual manipulation. LiDAR detection of bare ground is significantly inhibited by water and channel bed geometry cannot be derived from this data if water is lying within the channel. Manipulation of channel bed geometry to reflect field surveyed data was achieved using the HEC RAS geometry editor.

Flow velocity is a function of slope, depth and frictional energy loss (expressed as roughness of the channel/floodplain). The higher the Manning’s n value—the lower the flow velocity value as energy is lost through drag, frictional resistance etc. In this exercise, Manning’s n values were determined by solving for n the Manning’s equation: \( V = \frac{R^{2/3}S^{1/2}}{n} \) where \( V, R \) and \( S \) are obtained from field measurements and represent mean velocity, hydraulic radius and energy slope, respectively. As field measurements were conducted over a restricted discharge range, n selection was also guided by comparison with n values computed for streams of similar characteristics (Chow, 1959). The value thus determined was \( n=0.036 \) for channel bed areas within the cross sections.

Manning’s n values for landuse areas across the floodplain and associated with the bank slopes were determined through the review of previous studies undertaken for this area (Lower Pine River Flood Study 2009, MBRC). Assignment of appropriate n values for mangrove communities required a literature review to determine the most appropriate value. Previous studies undertaken on behalf of Redlands Council (Redlands Flood Study, 2003) used an n value of 0.18 for mature stands of mangrove. A landuse map was developed in ArcGIS and Manning’s n values associated with cross sections were extracted from this map using HEC geo-RAS. Figure 3.2 shows the delineation of landuse areas, which are assigned specific n values.
Steady Flow and Recurrence Interval Discharge Scenarios:

Steady flow computations for the meander cut-off model were run for discharges representing the 1, 2, 5 and 20 yr recurrence interval events. The daily discharge data was obtained from the Dept of Environment and Resource Management (DERM) for the gauging station at Draper’s crossing. This station is on the South Pine River upstream of the project reach and flow data has been adjusted on a linear scale to take into account the additional catchment area. Initial flow runs indicated the 1yr recurrence interval discharge ($Q=107 \text{ m}^3/\text{s}$) is a bankfull event. This has been confirmed as valid from previous flood studies (MBRC, 2009), HEC RAS modelling (MBRC, 2010) and personal communication (T.Weber, BMT WBM). An example of the output from HEC geo-RAS is shown in Figure 3.3, where water surface elevation is related to the underlying DEM to calculate the distribution of water depths for each corresponding recurrence interval discharge.
Figure 3.3: Spatial representation of water depth (m) for the 1, 2, 5 and 20 yr recurrence interval events.

Figure 3.3 shows the 1 yr recurrence interval event to be a bankfull discharge with increasing discharge events inundating more of the floodplain as delineated by the boundary polygon (extent of the cross sections). The 5 and 20 yr discharges are very similar in their inundation pattern. However, the inundation layer is computed only as far as the extent of the cross sections in HEC RAS. The water depth layers show the expected inundation...
patterns for these discharge events given previous studies (Lower Pine River Flood Study, MBRC 2009).

**Flow Velocity Pathways under Existing Vegetation Conditions:**

HEC geo-RAS was used to compute the depth averaged velocities within the main channel in reference to the water surface elevation data derived from a steady flow computation undertaken in HEC RAS, which used designated Manning’s n values and an upstream boundary condition (normal depth=0.0003). It should be noted that the scenarios were run assuming an outgoing tide, higher tidal ranges as a consequence of flooding events were not modelled in this project. Figure 3.4 shows the depth averaged water velocities for the meander cut-off model under current vegetation distribution patterns.

![Figure 3.4: Spatial representation of depth averaged velocities (m/s) for the 1, 2, 5 and 20 yr recurrence interval events.](image)
The modelled depth averaged velocity maps show values that are similar within the channel for the 1 and 2yr events. Above the 1yr recurrence interval discharge, the maps show increased velocities across the channel and adjacent floodplain immediately downstream of the cut-off on a straight section of the reach. This is a shallow part of the reach and increased flow velocities would be expected at this point.

Velocity maps can be used to visualise areas of high flow during flood events and these data show increased velocity associated with the cut-off area, indicating this is a highly dynamic part of the reach even during frequent flooding events. Given that bank vegetation in this area is sporadic in its distribution, it would seem a likely area for increased bank erosion activity. The velocities within the channel downstream of the cut-off decrease in the 5 and 20 yr recurrence interval events as energy is dissipated over a larger inundation area as the water flows out of the channel and over the banks onto the floodplain.

### 4.2 Assessment of HEC RAS Model with Changed Vegetation Cover

Factors affecting channel migration rates include the strength of boundary material, presence of vegetation, depth of flow and velocity of water. As described above, other factors include slope and width of the channel. The data in Figure 3.4 shows the effects of water depth and velocity within the study reach under current vegetation distribution but does not investigate the effect of revegetation scenarios on these parameters. Following a project meeting with Energex Ltd, it was decided to model the effects of revegetation of the riparian zone along the reach on flow velocity patterns.

**Modelling Inclusion of Vegetation Cover along the Left and Right Banks of the SPR Study Reach:**

Floodplain and in-channel roughness values were determined and assigned as previously described in section 3.1. The current distribution of vegetation was determined using the first return point data from the LiDAR survey undertaken in late 2009 on behalf of MBRC. The proposed revegetation of both banks of the study reach was modelled by manually assigning appropriate Manning’s n values along each cross section using the HEC RAS geometry editor. Mangrove distribution was increased within the channel and the existing vegetation cover across the floodplain remained unchanged for this scenario. HEC RAS has limitations when modelling flow and inundation depths out of the channel and across the floodplain. There are more suitable models for this purpose and it is recommended any further research should investigate the use of such models to determine any significant changes to water depth inundation as a consequence of increasing the amount of vegetation within the channel.

Depth averaged velocity maps in Figure 3.5 compare velocities associated with the 2, 5 and 20 yr recurrence interval events for the current vegetation cover and revegetated study reach scenarios. The range of velocity values is comparable across the current and revegetated scenario but the distribution of high velocity values differ depending on the placement of riparian vegetation.
Figure 3.5: Spatial representation of depth averaged velocities (m/s) using a model of current vegetation distribution and a proposed revegetation of the SPR study reach.
High flow velocity values are evident within the channel for all of the flooding events and increased velocities are seen immediately downstream of the cut-off on the adjacent floodplain, similar to the data in Figure 3.4. There is deflection of the flow and increased velocities along the inner bank of the meander during the more frequent 2 yr recurrence interval event as a consequence of modelled revegetation along both banks of the bend. This is in contrast to the current vegetation scenario, where flow velocities are contained within the centre of the channel for these flood events.

The most striking difference between the current vegetation cover and revegetation of the study reach is the changed pattern of flow associated with the left hand bend within the study reach during the 5 and 20 yr flood events. The addition of roughness values equivalent to mature mangroves along the left and right hand banks in this area has resulted in a decrease of depth averaged velocity within the channel and increase of flow velocity on both the left hand and inner right hand floodplains (Figure 3.6). Increasing the vegetation on the channel bank slows the flow, spreads the water over the floodplain, and decreases the flow velocity, lowering the erosion potential on the outer curve of the bend. Analysis of the two vegetation scenarios suggests the introduction of vegetation into the channel did not significantly affect the water surface elevations. However, the elevations are modelled to the extent of the cross sections and may not have picked up differences in water depth further away from the channel.

![Figure 3.6: Spatial representation of depth averaged velocities (m/s) for the proposed revegetation of the left bank only scenario during a 20 yr recurrence interval event. The velocity layer has 50% transparency to aid visualisation against the underlying Hillshade DEM.](image-url)
These results illustrate the importance of vegetation on flow velocities and revegetation activities should consider the issues associated with revegetation along the river channel and floodplain. High erosion potential areas of the banks can be addressed with increasing the roughness element through bank revegetation but the problem should not be deflected to other areas, which may not have adequate vegetation cover to withstand increased flow velocities. If revegetation of the channel banks is planned to address bank retreat, it is also prudent to consider appropriate revegetation of associated floodplains.

**Impacts on Infrastructure based on Modelled Scenarios:**

In terms of using the depth averaged velocity maps to inform decisions for the maintenance of existing infrastructure and the installation of new infrastructure the data is relatively clear. Under current vegetation cover the higher velocity values are concentrated within the channel during all of the modelled flow events upstream and immediately associated with the cut-off area. Changes to flow velocities are minimal in this area with proposed revegetation activities throughout the study reach. The current Energex tower is a significant distance away from this area of dynamic activity and the probable migration trajectory of the channel is in a north-west direction, away from the current infrastructure. Higher flow velocity values are associated with the right bank immediately downstream of the cut-off, as the new channel planform is directing flow against this bank. This area has a mature stand of mangroves, which will no doubt contribute to bank shear strength. However, non-continuous riparian vegetation can produce localised scouring and increased flow turbulence, which can diminish some of the positive functions of riparian vegetation in regards to bank stabilisation (Trimble, 2004). It is recommended that revegetation of the channel from the toe to the top of the bank with mangrove species will assist in reducing the effects of fluvial erosion processes in this area. It is also recommended that Energex work collaboratively with MBRC and local landowners across multiple properties to revegetate the adjacent floodplain in order to prevent localised erosion.

**4.3 Temporary Access for Construction of New Infrastructure**

Areas of high erosion potential have been assessed in relation to the selection of access sites for maintenance activities through field investigations. The proposed temporary causeway is located north of the cut-off area within the upstream arm of the meander loop. This area was not recommended in the interim report (Appendix 1) as a permanent access site as flow velocity mapping shows it is too close to the dynamic section of the cut-off channel and further monitoring of this area would be required before confirming the stability of this area over time. However, this site is acceptable as a temporary access with the recommendation that the area is reinstated once construction activities are complete and preferably before the next wet season.

There is evidence of previous causeway structures within the cut-off section of the channel and flow velocity mapping suggests it is probable this material will be removed on the outer curve of the cut-off bend. Energex staff have already liaised with the relevant State agencies to discuss the removal of this material, which does not form part of the original bank profile. Consideration must be given to how this is achieved as currently the remnant causeway material is of a larger diameter than the underlying bank material and hence more resistant to flow velocities. Removal of this material will require consideration of bank re-profiling to achieve stable bank slopes and the revegetation of this section of the channel with mangrove communities and deep rooted terrestrial species at the top of the bank to improve bank stability over time. The effects of vegetation on bank stability have been investigated for a small number of Australian terrestrial species (Abernethy et al, 2000) but more work is required on south east Queensland species to improve our knowledge of stream rehabilitation techniques. At this stage it is recommended that species are chosen from the remnant vegetation categories described by the Regional Ecosystem mapping work in SEQ (Queensland Herbarium) relevant to the lower reaches of the SPR. Appropriate vegetation will need to be considered for overhead infrastructure and Energex Ltd have guidelines on suitable tree species for overhead powerlines.
5 Long Term Projection of Channel Migration

Channel migration observed over the past 118 yrs (Figure 4.1) gives an indication of the extent of movement of the channel within the current floodplain and is an indication of future migration of the channel over the next 100 yrs. The most likely causes of increased migration rates are changes to catchment and riparian condition as a result of clearing, gravel extraction, removal of bank vegetation and increased run off due to catchment landuse change. The determination of historical channel migration rates for seven sections of the study reach show increased migration occurring downstream of the cut-off with a potential maximum shift in orthogonal length of 10-30 m over the next 50 yrs. Upstream reaches of the SPR within 1 km of the study reach do not show significant lateral migration of the channel and it is unlikely a meander will approach the cut-off area within the next 50 yrs. Given two major road bridges and a rail crossing traverse the SPR upstream of this area any lateral migration of the channel will no doubt be addressed as meanders can significantly undermine bridge piers.

![Figure 4.1: Extent of channel migration since 1892 to 2009.](image)

However, as previously mentioned, if a geomorphic threshold has been reached as a consequence of changes to catchment condition over time and the removal of vegetation from riparian zones, it would seem prudent to reduce any risks associated with locating infrastructure in close proximity to dynamic systems such as waterways. Depth averaged velocity mapping with different vegetation cover scenarios show that increasing the vegetation on the channel bank slows the flow, spreads the water over the floodplain, and decreases the flow velocity, lowering the erosion potential on the channel boundary surfaces. Therefore, it is recommended that revegetation is undertaken in the cut-off area to
reduce any risks associated with lateral migration of the channel towards existing and proposed infrastructure.

6 Summary

This report has used two approaches to assess channel migration in the South Pine River and the results of these methods illustrate how the study reach has changed over time as a consequence of changes to the floodplain and upstream catchment. The assessment of channel migration rates using historical information is important for current and future predictions of channel migration patterns as it gives us an understanding of the underlying processes that have driven the observed increases in migration rates over recent time periods. The assumptions regarding processes will still be valid for future predictions of changes to channel planform and can be used in conjunction with modelling outputs to determine areas of high erosion potential. Both of these approaches will assist in determining the appropriate management intervention activities needed to manage future migration changes in the study reach and will assist in decision making processes for several interested stakeholders. It is important to note that vegetation has proven effective in slowing channel migration rates in previous studies but will not prevent this process from occurring entirely if a geomorphic threshold has been reached through changes to catchment condition (Schumm, 1973).

The one dimensional hydraulic model, HEC RAS was used in conjunction with high resolution spatial data and HEC geo-RAS to compute water inundation levels and mean water velocities in order to determine areas of high erosion potential within the stream channel and across the floodplain.

Depth averaged velocities for several modelled flood discharges under current vegetation conditions show similar distribution patterns with the higher values concentrated within the channel. The section of the study reach immediately downstream of the cut-off experiences high velocity flows during flooding events, particularly along the right bank as a consequence of the changed flow-path following the meander cut-off event. The channel banks and floodplain at this point should be considered a high priority for revegetation activities.

Flow velocity distribution patterns in the SPR study reach are strongly influenced by vegetation distribution. The method of revegetation should be carefully considered to include appropriate revegetation of the floodplain given the depth averaged velocity mapping results for the revegetation scenario show deflection of flow at frequent flooding events towards the inner bank of a meander bend and increased flow velocities across the floodplain as a consequence of increased roughness elements within the channel.

Revegetation of the banks and floodplain is important for areas selected as temporary access points as HEC geoRAS modelling shows the cut-off section of the study reach is at risk from high flow velocities.
7 Proposed Further Investigations

There were several assumptions made for the HEC RAS modelling component of this project, which could benefit from further data collection. Areas of interest for further investigation include:

- Field surveying of the channel around the cut-off section of the reach to define the shape of the current channel following flow events since late 2009;
- Use of updated LiDAR derived bare ground elevation data if available;
- Assessment of bank shear strength with and without different vegetation communities to assess the erosion potential of modelled flow velocities;
- Characterisation of SEQ tree species within riparian zones, including root density and maximum root depth;
- Investigation of flow models coupled to erosion processes and bank stability predictions;
- Assessment of tidal inflows on water depth elevations during flooding events;
- Investigation into the effect of reduced sediment inputs through extraction activities on flow velocities;
- Sediment dating of channel forms and key areas of the floodplain to improve our understanding of channel migration over time given anthropogenic influences;
- The effect of changes in bank vegetation distribution over time and channel migration rates; and
- Efficacy of management interventions, such as revegetation of the channel and floodplain on sediment budgets.

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8 References


9 Appendices

9.1 Appendix 1: Interim Report 2nd June 2010

1. Interim Report

2. Assessment of Erosion Processes in the South Pine River in Close Proximity to Energex Infrastructure

N Saxton, Australian Rivers Institute, Griffith University

This report details an assessment of a specified reach of the South Pine River adjacent to an existing electricity supply network owned and operated by Energex Ltd. The reach in question has undergone channel planform changes in response to several significant flooding events over the past 18-24 months. The reach is located approximately 4km upstream of the confluence of the North and South Pine Rivers and encompasses a large meander loop with cleared paddocks used for grazing purposes on the majority of adjacent land, (Figure 1).

1. Figure 1 Specified reach of the South Pine River

Energex have an existing electricity supply line traversing the meander loop in a north to south axis and it is proposed that this supply is duplicated within the current easement approx 20m east of the existing line. The meander loop has recently been cut off from the main flow of the river and now only flushes through tidal movement of water with minimal inflow from the upstream catchment. The existing supply line and associated towers are currently inaccessible as a consequence of the meander loop cut off and advice is sought on a preferred access point for the maintenance of existing and proposed electricity supply infrastructure.

Field assessments of the site were conducted in February and May 2010 by Griffith University staff. Significant changes to the bed and banks of the river within the immediate area of the meander cut off were noted within this 3 month period and are the basis for the following recommendations:
1. *The preferred access point for maintenance activities is located on the northern end of the upstream arm of the meander loop, (Figure 2).*

![Figure 2 Location of preferred access point for maintenance purposes](image)

This site was chosen for several reasons:

- Modest bed slope with predominantly cobble bed material (Figure 3);
- Existing access track that will limit further disturbance to riparian vegetation;
- Manageable bank slope angles that can be revegetated to increase stability on either side of the access track (Figure 4a and b);
- Changes in water levels driven by tidal exchanges and not from dominant upstream flows (will only experience significant inundation following large flood events);
- The banks of the meander loop will further stabilise over time due to the colonisation of the area with mangrove communities and altered flow patterns within the channel from the upper catchment;
- Historical changes to the channel planform from cut off events have shown further migration of the channel associated with the downstream arm of the meander loop and not the upstream arm (these events may have taken thousands of years to eventuate-optical dating of sediments in the remnant meander scrolls would allow further determination of this time period); and
- Other potential sites along the upstream arm are unsuitable due to acute bank angles or existing vegetation that, if cleared for an access track, would compromise the stability of the bank.
2. **Figure 3 River bed across existing access track**

![Figure 3 River bed across existing access track](image)

**Figure 4a Access point on the left hand bank**  
**Figure 4b Eroding right hand bank adjacent to existing access track**

2. **Access to the site is not recommended adjacent to the immediate cut off area**

An alternative access site was proposed by Energex that would utilise the existing easement adjoining St Paul’s School. This site is situated at the upstream end of the meander loop and directly adjacent to the meander cut off. This suggestion is not recommended for several reasons:

- The cut off area of the channel is still significantly unstable and dynamic (Figures 5 and 6- a significant amount of material has been removed and is being deposited as bars downstream of the cut off);

- The main channel is likely to continue its realignment until a more stable radius of curvature is achieved for the new meander section of the reach-this may continue for several wet seasons depending on the magnitude and frequency of flooding events;

However, once the main channel has achieved a more stable configuration-it is possible this site could be used for maintenance access purposes. It is advised this area is monitored.
and resurveyed in several years to establish any further likely changes to the channel planform.

Figure 5 Cut off section of the South Pine River February 2010

Figure 6 Cut off section of the South Pine River June 2010

3. **Access overland is not recommended for installation of new infrastructure**

The physical duplication of an existing electricity supply line by Energex is proposed either through overland or aerial transport of infrastructure. It is recommended that aerial transport of heavy equipment is used where possible. If overland access is required it is proposed the access site in Figure 2 is considered as the preferred site. This section of the cut off meander loop is far more stable and easily revegetated to re-instate the river banks after modifications are made for the access of large transport vehicles. It may also serve as a community engagement tool with the current landholder, in conjunction with revegetation activities on the outer bank of the new meander curve, which is currently at
risk of further erosion due to the altered instream flow patterns from the upper catchment.

9.2 Appendix 2: HEC RAS Outputs

All HEC RAS generated files will be included on the final report CD