Channel morphology and sedimentation in the Rees River

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Foreword

Understanding the channel morphology and sedimentation characteristics of Otago's rivers enables their effective management. Increasing growth throughout the Otago region has implications for management of river systems, primarily the extraction of gravel.

To help maintain the integrity of the region's gravel resources, the Otago Regional Council (ORC) undertakes scheduled cross-section surveys as part of the natural hazards programme. This information is utilised to understand the dynamic fluvial processes of each watercourse and general state of the gravel resource.

This report explores how the morphology and sedimentation of the Rees River has changed over the surveyed periods, while providing a synthesis of the study's results to guide management strategies into the future.

Executive summary

The Rees River is 41 km long and drains a remote alpine catchment of 412 km^2. The majority of the catchment is dominated by foliated semischist deposits derived from undifferentiated volcaniclastic sandstone and siltstone that are highly susceptible to physical weathering. Sediment supplies within the Rees River are primarily derived from the adjacent tributary catchments such as Twelve Mile and Precipice Creeks.

Aerial photography for a number of periods between 1937 and 2006 shows that the Rees River is a dynamic, mobile system. Channel form and development within the Rees River is indicative of a high sediment yield, braided river system. Significant evidence of movement in the location of the channel thalweg and associated lateral migration of secondary channels has been identified in the majority of cross-sections. However, the banks of active channel margins have remained relatively stable over the periods of survey.

Analysis of cross-sections, aerial photographs and anecdotal records indicates that the river has experienced a period of general net aggradation over the respective survey periods. Upper and mid-lower cross-sections are experiencing the largest amounts of net aggradation, while the mid-upper cross-sections have exhibited signs of minor net degradation over the period from 2003 to 2006.

Cross-section analysis indicates that locations adjacent to large tributary catchments experience high variability in bed levels. Additionally, there is some evidence to suggest that large flood events may be the primary transportation mechanism for the redistribution of sediments downstream.

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1. Introduction

This document provides a background into morphological change and sedimentation in the Rees River Catchment. Aerial photography, cross-section analyses and anecdotal information is collated and interpreted to provide a comprehensive review of change over surveyed periods. This information can be used to support assessment of community vulnerability and river management.

2. Rees River Catchment

The Rees River is 41 km long and drains a remote alpine catchment of 412 km^2 (Figure 2.1). The upper catchment is indicative of a steep alpine catchment with a confined channel cutting into schist bedrock. Surrounding tributary catchments create large depositional features on the lateral margins of the valley, while contributing substantial amounts of the sediment to the Rees River channel.

As the valley floor widens in the lower catchment, the river transitions into a braided form with the development of depositional bars and islands in active channel margins. At its outlet, the river deposits into the head of Lake Wakatipu in the form of a delta. The settlement of Glenorchy is located at the margins of Rees River delta.

2.1 Geology

The upper catchment of the Rees River valley is largely dominated by highly erodible schist of the Aspiring lithologic association. Sediments in this region have been identified as finely segregated, quartz-feldspar-mica schist with greenschist bands that cut across Cleft Peak (McSaveney and Glassey, 2002). These deposits are fine-grained and highly susceptible to physical weathering.

The Caples-Rakaia terrane boundary has been mapped down the left and right margins of the valley. Upper slopes on the true right of the catchment are dominated by foliated semischist deposits derived from undifferentiated volcaniclastic sandstone and siltstone. While on the true left, deposits are of a similar composition but exhibit stronger foliation and segregated schists (Turnbull, 2000). Holocene alluvial deposits derived from the highly erodible upper schist catchments, such as floodplains and alluvial fans, dominate the lower slopes and floor of the valley.

Figure 2.1 Rees River Catchment locality map

2.2 Geomorphology

The Rees River basin was carved out by a larger Tyndall Glacier during the Pleistocene (about 12,000 years ago). This basin is typical of a previously glaciated, U-shaped valley with a flat valley floor and gentle lower slopes which lead up to the near vertical peaks of the flanking mountain ranges. On either side of the Rees River Catchment lie the Richardson Mountains to the east and the Forbes mountains to the west, which steeply rise to over 2000m above sea level (Figure 2.2).

The slopes of the northern end of the Richardson Mountains are deeply dissected by a series of narrow gullies leading from minor drainage basins that head Cleft Peak and several unnamed peaks along the ridge to the north (McSaveney and Glassey, 2002). Throughout the catchment, a number of alluvial fans debouch onto the valley floor from adjacent tributaries and contribute significant proportions sediment to the Rees River floodplain.

Figure 2.2 **Oblique view of the lower Rees and Dart valleys and surrounding landscape**

Channel morphology of the lower Rees River is indicative of a braided channel form with an extremely mobile bed load. The lateral migration of channel position, within the active channel margins, occurs frequently, particularly during periods of higher flow.

Figure 2.3 shows the confluence of the Rees River with the head of Lake Wakatipu in 1937, 1977, 1998 and 2006. The dynamic nature of this fluvial system is evident from comparing these images where the secondary channel, on the left of the image, becomes inactive during the period 1937 to 2006.

Figure 2.3 **Aerial images of the Rees River – Lake Wakatipu confluence in 1937, 1977, 1998 and 2006**

The progradation[1] of the Rees River delta into Lake Wakatipu is also evident in these images (Figure 2.3). Aerial photography and anecdotal records indicate that the delta has prograded 90-175m since 1890. Figure 2.4 shows a subsurface longitudinal profile of this feature extending 3km down to the bottom of Lake Wakatipu, surveyed in November 2007.

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[1] Progradation is the process where shorelines advance into the water body that they are depositing into. Sedimentation rates exceed the rate at which sediment is removed, therefore creating depositional features such as deltas.

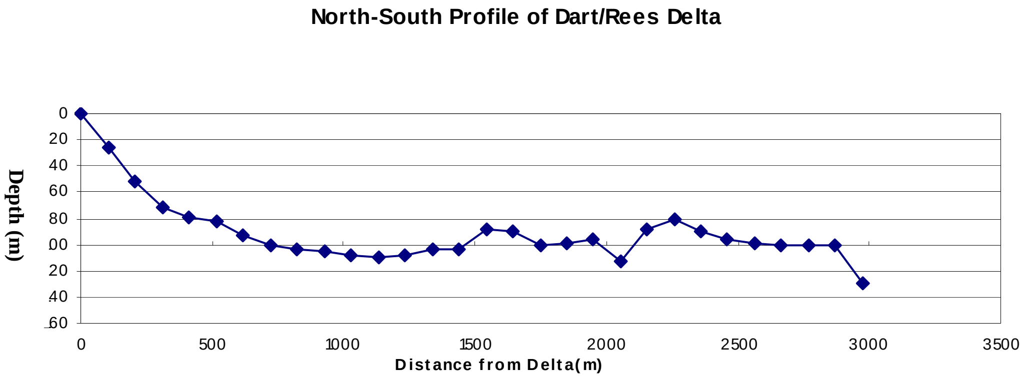

Figure 2.4 Longitudinal profile of the subsurface Rees/Dart delta complex extending into the head of Lake Wakatipu, surveyed November 2007

3. Cross-sections

ORC undertakes scheduled cross-section surveys for selected rivers every year. The cross-section programme enables changes in river morphology to be monitored, and to support assessments and potential effects on communities.

Twelve cross-section locations have been intermittently surveyed on the lower-mid reaches of the Rees River (Figure 3.1). Eight surveys, from August 1978 to December 2006 exist, with comprehensive surveys being undertaken in 2003 and 2006. The shortest survey period, seven years, exists for cross-sections RR3A and RR4A, with the longest being 18 years for cross-sections RR17 and 18A. The May 1999 survey was undertaken before the Clutha Catchment flood event of November 1999.

The mean bed level of the active channel in each cross-section was calculated using the X-Sect cross-section database. The database compiles a list of widths and their associated elevations for each cross-section and survey period. X-Sect calculates all output information (minimum, maximum and mean bed levels) from the respective widths and elevations. Table 3.1 shows each year surveyed and the respective mean bed level calculation for each cross-section. Some historical surveys only include part of the active channel. In this instance, mean bed levels have been calculated over these distances but are not directly comparable to the wider active channel results. Additionally, cross-sections surveyed prior to 1985 generally have few points therefore, the mean bed levels from these surveys are only viewed as indicative.

Table 3.2 shows the net change in mean bed level over the different survey periods. Surveys that did not cover the entire active channel margins are included at the bottom of the table.

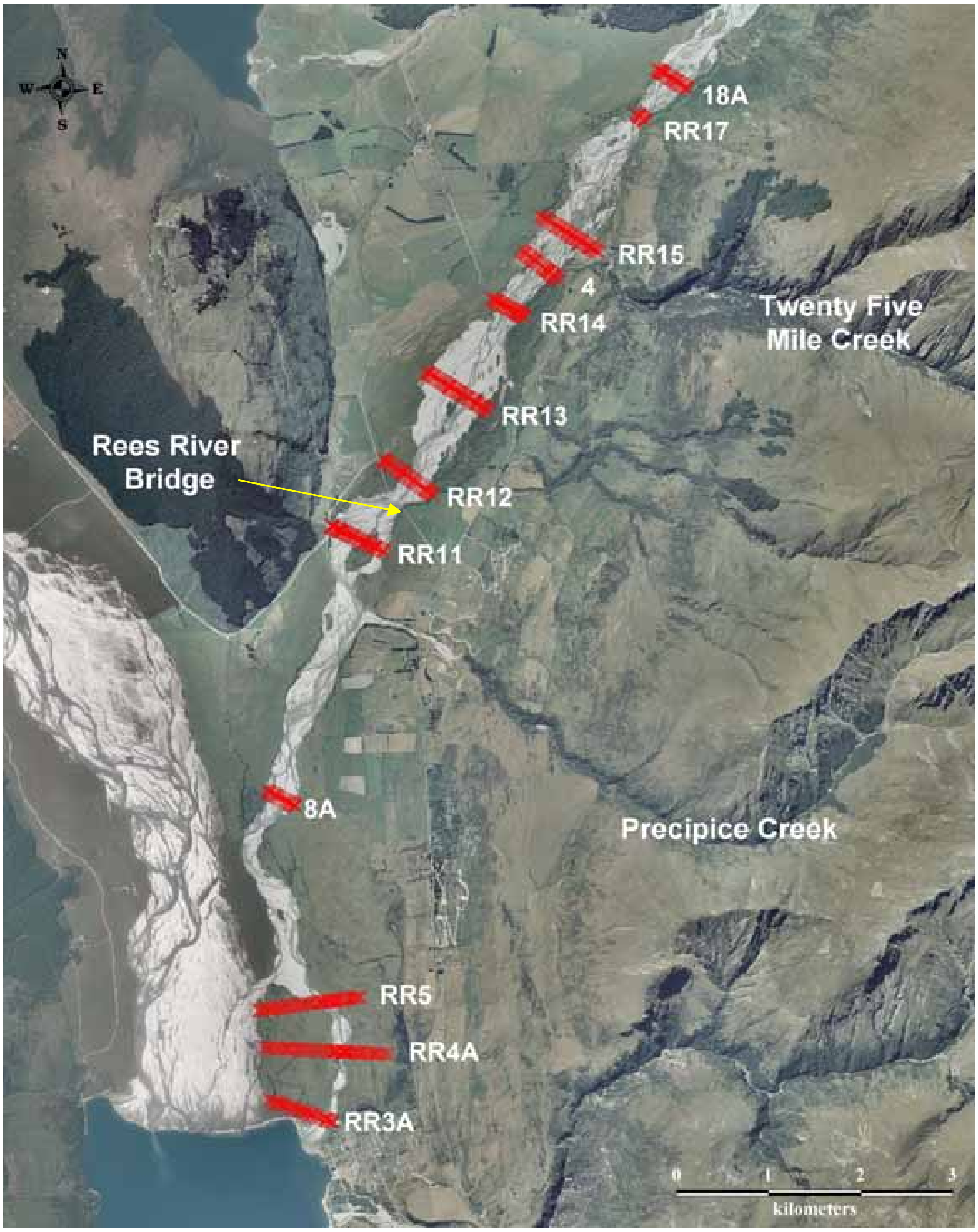

Figure 3.1 Location of surveyed cross-sections for the Rees River superimposed on 2006 aerial photography

Table 3.1 Mean bed level results for surveyed cross-sections of the Rees River. A blank space indicates the cross-section was not surveyed for that year

X-Section	Width (m)	Aug 78	Jun 84	Jul 87	Aug 90	Apr 96	May 99	Jul 03	Dec 06
RR3A	311						411.08	411.16	411.17
RR4A	160						412.57	412.64	412.65
RR5	184				413.96		413.88	414.03	414.06
8A	328		420.32				420.43	420.49	420.54
RR11	400		430.62			430.92	430.97	431.01	430.98
RR11	110							431.47	431.51
RR12	443		434.66			435.09	435.29	435.24	435.23
RR13	706					441.20	441.28	441.40	441.31
RR14	336		447.44			447.49	447.56	447.61	447.53
4	352			451.04		450.93		451.04	451.05
4	462					450.88		451.06	450.95
RR15	328		453.77	453.95		453.70	453.90	453.74	453.70
RR17	74	463.60	463.63			463.65	463.52	463.48	463.86
RR17	129					463.57	463.81	463.76	463.91
18A	321	467.42	467.57					467.81	467.79
18A	401							467.74	467.72

Table 3.2 Net change in mean bed level for each respective survey period

X-Section	Width (m)	1978-1984	1984-1987	1987-1990	1990-1996	1996-1999	1999-2003	2003-2006	Net Change
RR3A	311						+0.08	+0.01	**+0.09**
RR4A	160						+0.07	+0.01	**+0.08**
RR5	184				-0.08		+0.15	+0.03	**+0.10**
8A	328		+0.11				+0.06	+0.05	**+0.22**
RR11	400		+0.30			+0.05	+0.04	-0.03	**+0.36**
RR12	443		+0.43			+0.20	-0.05	-0.01	**+0.57**
RR13	706					+0.08	+0.12	-0.09	**+0.11**
RR14	336		+0.05			+0.07	+0.05	-0.08	**+0.09**
4	462					+0.18		-0.11	**+0.07**
RR15	328		+0.18	-0.25		+0.20	-0.16	-0.04	**-0.07**
RR17	129					+0.24	-0.05	+0.15	**+0.34**
18A	321	+0.15	+0.24					-0.02	**+0.37**
Surveyed cross-sections for channel widths smaller than the active channel margin									
RR11	110							+0.04	+0.04
4	352			-0.11		+0.11		+0.01	+0.01
RR17	74	+0.03	+0.02			-0.13	-0.04	+0.38	+0.26
18A	401							-0.02	-0.02

3.1 Cross-section RR3A

Cross-section RR3A is located near the end of the Rees River delta, which deposits into the head of Lake Wakatipu (Figure 3.1). The construction of the Glenorchy floodbank in 2000 can be seen with the height of the left bank increasing by 1.23m between the 1999 and 2003 surveys. Figure 3.2 shows a plot of cross-section RR3A for the 1999, 2003 and 2006 surveys.

The active Rees River channel is located adjacent to the Glenorchy floodbank, on the true left of the cross-section, and covers a width of 311 m. Mean bed level analysis shows that this location has experienced net aggradation of 0.09 m between 1999 and 2006 (Table 3.1). Most of this aggradation occurred during the period 1999 to 2003, which could be indicative of sedimentation resulting from the November 1999 flood event (the May 1999 survey predated this flood event). Additionally, the thalweg experienced notable aggradation of 0.87 m during this same period, which may be attributed to deposition from the 1999 flood event or channel modification from the construction of the adjacent floodbank.

Figure 2.3 shows the secondary channel on the true right of this cross-section that is no longer active. The 1937 imagery shows an active braided channel at this location, while by 2006 this channel has been succeeded by vegetation (Figure 2.3). This location has been annotated on Figure 3.2 as an ephemeral channel.

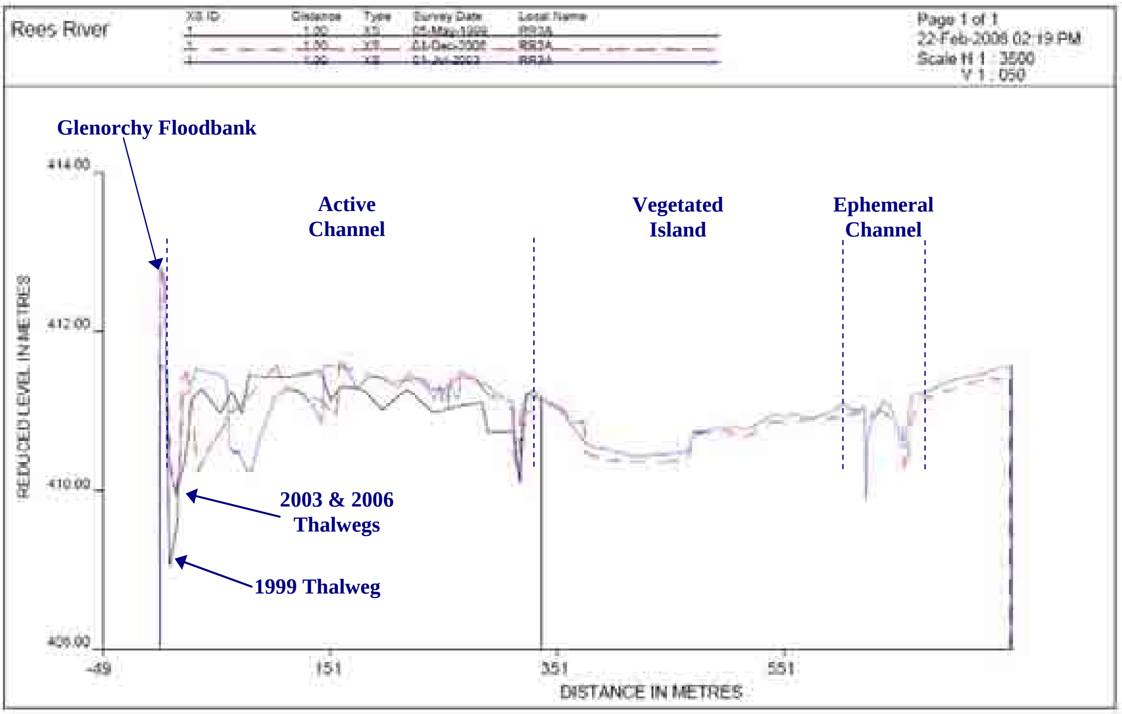

Figure 3.2 Cross-section RR3A, looking downstream

3.2 Cross-section RR4A

Cross-section RR4A is located approximately 0.77 km upstream of cross-section RR3A. Comparative analyses between both of these sections indicate that the geomorphological state and sedimentation characteristics of these cross-sections are similar. Figure 3.3 shows a plot of cross-section RR4A for the 1999, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of only 160m in comparison to the entire 1.425km surveyed in 2006. Mean bed level analysis shows that this location has experienced net aggradation of 0.08m between 1999 and 2006 (Table 3.2). Like cross-section RR3A, most of this aggradation occurred between the 1999 and 2003 surveys, which could be indicative of sedimentation from the November 1999 flood event. The thalweg has experienced significant lateral movement between surveyed periods, reflecting the dynamic braided form of the active channel margins at this location.

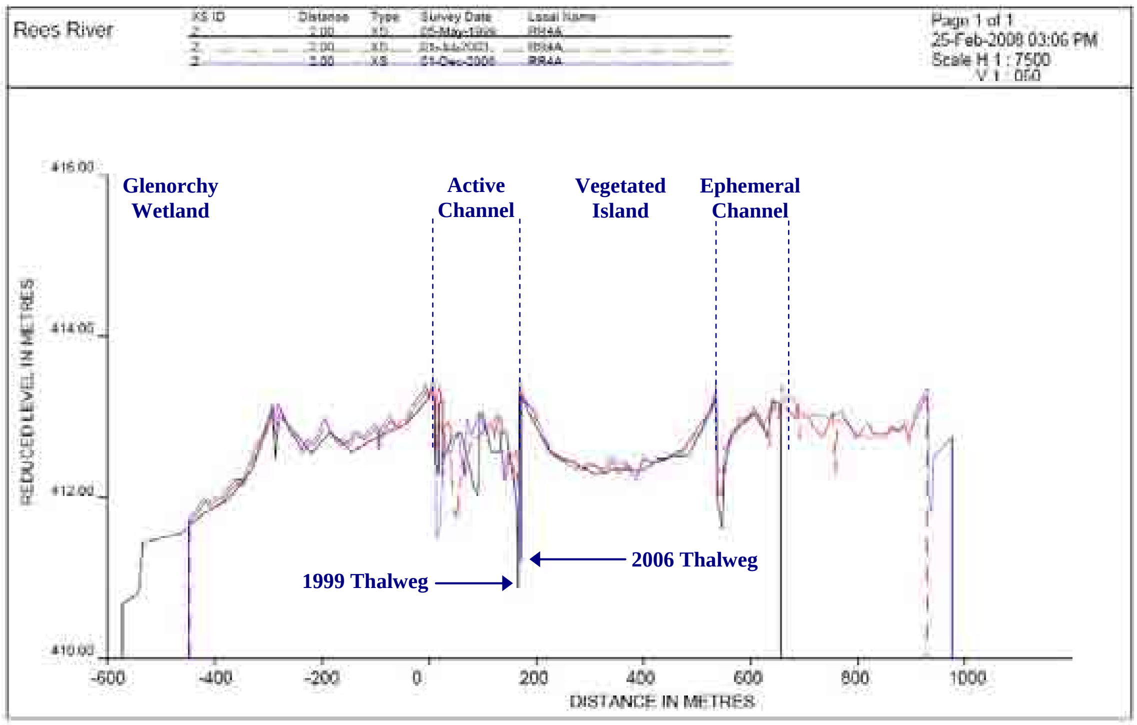

Figure 3.3 Cross-section RR4A, looking downstream.

3.3 Cross-section RR5

Cross-section RR5 is located approximately 1.33km upstream of cross-section RR3A. Like cross-sections RR3A and RR4A, this survey covers the primary active channel and secondary ephemeral channel on the true right (Figure 2.3). Figure 3.4 shows a plot of cross-section RR5 for the 1990, 1999, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of only 184m compared to the entire 1.17km surveyed in 2006. Mean bed level analysis shows that this location has experienced net aggradation of 0.10m between 1990 and 2006 (Table 3.2). Similar to both cross-sections downstream, the most significant period of aggradation occurred during the period 1999 to 2003. Figure 3.4 indicates that the banks of the active channel margin have been relatively stable over the period 1990 to 2006. Additionally, the thalweg during this period has repositioned from the true left to the true right.

The large delineation that extends from approximately 200m to 750m distance in the 1999 survey does not represent the topography at this location. Rather, this section was not surveyed in 1999 as it was not part of the active channel margins.

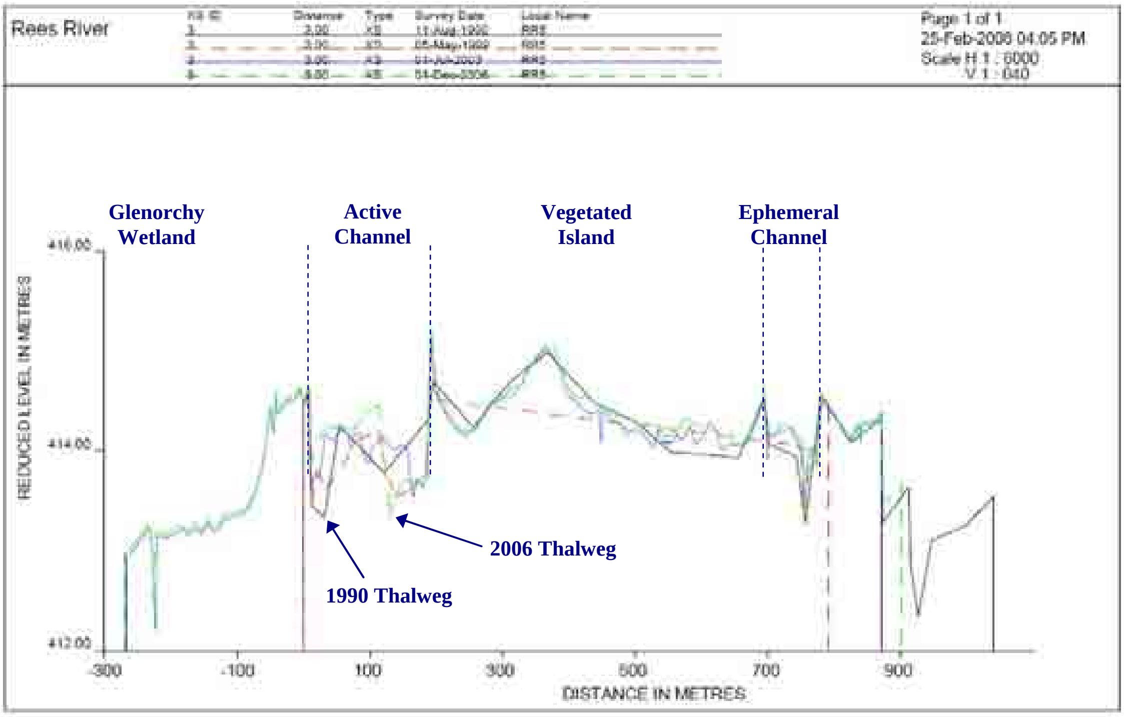

Figure 3.4 Cross-section RR5, looking downstream

3.4 Cross-section 8A

Cross-section 8A is located approximately 3.89km upstream of cross-section RR3A. Surveys were taken in 1984, 1999, 2003 and 2006 with the 1984 survey only consisting of 13 spot heights over 328m. Figure 3.5 shows a plot of cross-section 8A for each of these surveys.

The active channel in this cross-section covers 328m, equal to the 1984 width of survey. Mean bed level analysis shows that this location has experienced net aggradation of 0.22m between 1984 and 2006 (Table 3.2). Visual inspection of Figure 3.5 shows considerable variability in the location of the thalweg and secondary channels between each period surveyed. This variability is symptomatic of the dynamic braided form of the Rees River channel at this location. Additionally, bank erosion of approximately 18.5m occurred on the true left between 1984 and 2003.

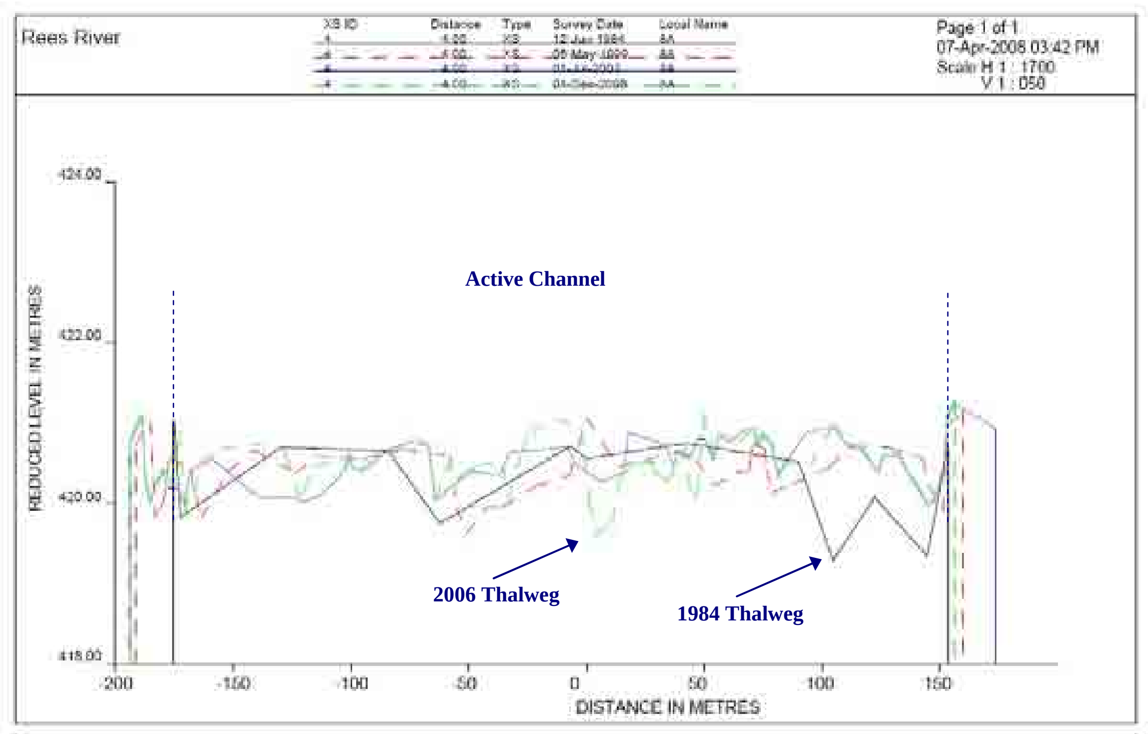

Figure 3.5 Cross-section 8A, looking downstream

3.5 Cross-section RR11

Cross-section RR11 is located approximately 7.09km upstream of cross-section RR3A and 0.65km downstream of the Rees River bridge. A number of surveys were undertaken for this location - 1984, 1996, 1999, 2003 and 2006 - although only two years, 2003 and 2006, extended across the entire channel width. Figure 3.6 shows this location in 1937 and 1998.

Downstream of the bridge, the primary Rees River channel flows to the true left of a large island located in the mid-section of the floodplain. During periods of high flow, the Rees River may migrate across the wider floodplain, although aerial photography indicates it usually resumes its initial course. The Diamond Creek channel flows onto the true right of the Rees River floodplain before confluencing with the main Rees channel downstream of the large island. Figure 3.7 shows a plot of cross-section RR11 for each of the surveyed years.

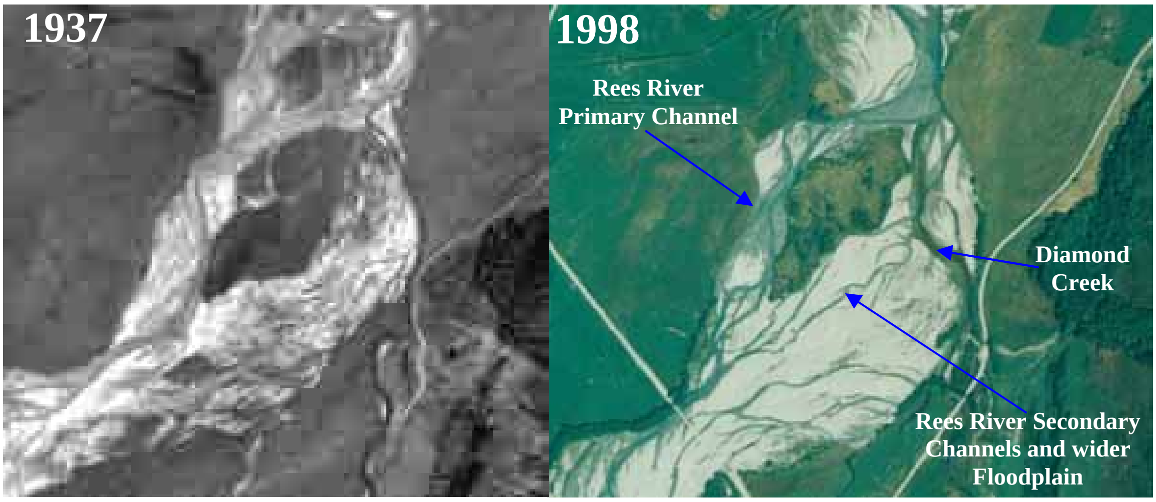

Figure 3.6 Images showing the Rees River, downstream of the bridge for 1937 and 1998. Diamond Creek joins the Rees River floodplain on the right of the images

Located on the true left of the cross-section, the primary channel of the Rees River has only been surveyed in 2003 and 2006. Mean bed level analysis covered a width of 110m for this channel and showed that this location experienced net aggradation of 0.04m during this period.

The rest of the cross-section covers a width of 400 m, equivalent to the width of the 1984 survey. This area extends from the true right of the island to the true right bank, including Diamond Creek (Figure 3.7). Mean bed level analysis showed that net aggradation of 0.36m occurred during the period 1984 to 2006 for this part of the cross-section. A large proportion, 0.30m, of aggradation was measured over the period 1984 to 1996. High channel mobility and lateral migration across the floodplain is evident on this wider part of the cross-section (Figure 3.7).

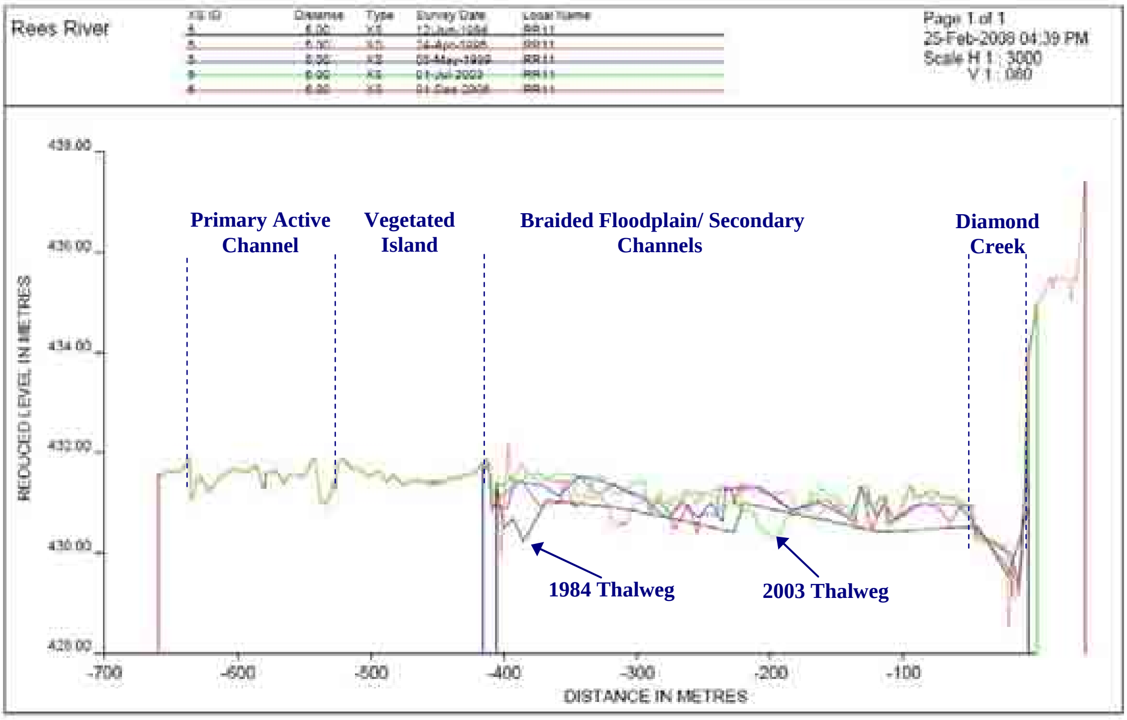

Figure 3.7 Cross-section RR11, looking downstream

3.6 Cross-section RR12

Cross-section RR12 is located approximately 8.01km upstream of cross-section RR3A and 0.36km upstream of the Rees River bridge. Surveys were taken in 1984, 1996, 1999, 2003 and 2006 with the 1984 survey only consisting of 16 spot heights over a distance of 653m. Figure 3.8 shows a plot of cross-section RR12 for each of these surveys.

The active channel in this cross-section covers a width of 443m and excludes the true right of the surveyed cross-section (Figure 3.8). Mean bed level analysis shows that this location has experienced net aggradation of 0.57m between 1984 and 2006. As with cross-section RR11, a large proportion of this aggradation was measured during the period 1984 to 1996. There is no definitive trend in thalweg change at this location due to the high mobility of braided channels.

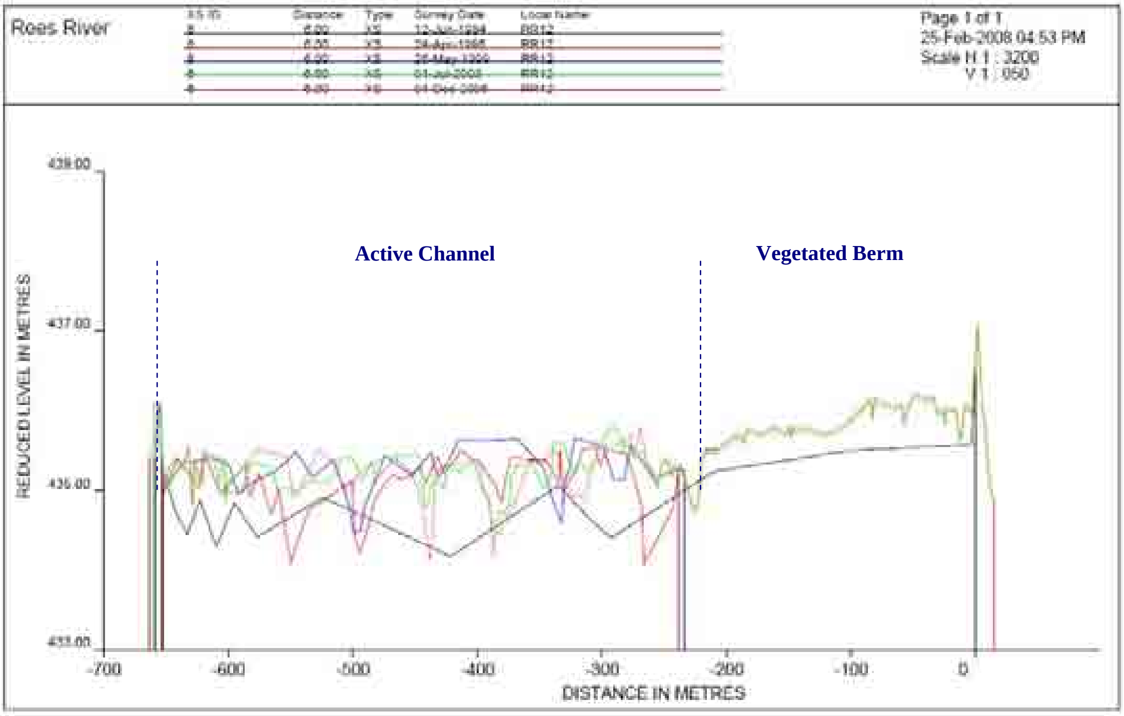

Figure 3.8 Cross-section RR12, looking downstream

Figure 3.9 and Figure 3.10 show photographs of the Rees River bridge taken in February 2008. Anecdotal records note the reduction of freeboard under the Rees River bridge from significant sedimentation during the 20th century. Mean bed level analysis indicates that cross-section RR12 (upstream of the bridge) has experienced minor net degradation of 0.06m between 1999 and 2006 but experienced net aggradation of 0.63m between 1984 and 1999. Downstream of the bridge, cross-section RR11 experienced net aggradation of 0.39m in the period 1984 to 2003 and net degradation of 0.03m between 2003 and 2006.

Figure 3.9 Photograph showing the Rees River bridge on the true right bank looking upstream, February 2008

Figure 3.10 Photograph showing the Rees River bridge on the downstream side looking towards the true left, February 2008

3.7 Cross-section RR13

Cross-section RR13 is located approximately 9.09km upstream of cross-section RR3A and about 1.44km upstream of the Rees River bridge. Figure 3.11 shows a plot of cross-section RR13 for the 1996, 1999, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of 706m, equal to the distance of the 1996 survey. Mean bed level analysis shows that this location has experienced net aggradation of 0.11m during the period 1996 to 2006. However, part of this net change includes net degradation of 0.09 from 2003 to 2006.

There is no definitive trend in thalweg change at this location due to the high mobility of braided channels. While there has been substantial lateral movement of the channel, banks at this location have been relatively stable over the survey periods.

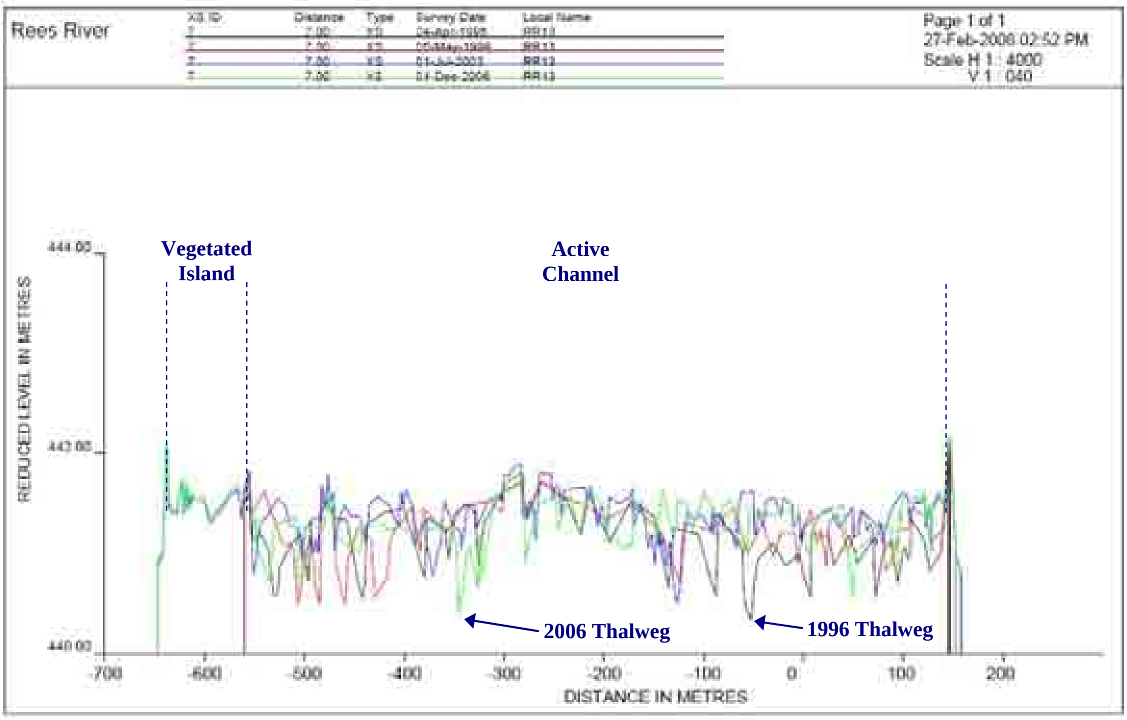

Figure 3.11 Cross-section RR13, looking downstream

3.8 Cross-section RR14

Cross-section RR14 is located approximately 10.17km upstream of cross-section RR3A and 2.52km upstream of the Rees River bridge. Figure 3.12 shows a plot of cross-section RR14 for the 1984, 1996, 1999, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of 336m, with vegetated berms on each side of the channel. Mean bed level analysis shows that this location has experienced net aggradation of 0.09m between 1984 and 2006. Surveys indicate that lateral migration of the channel is common at this location. The thalweg moved about 90m to the left between 1984 and 2006.

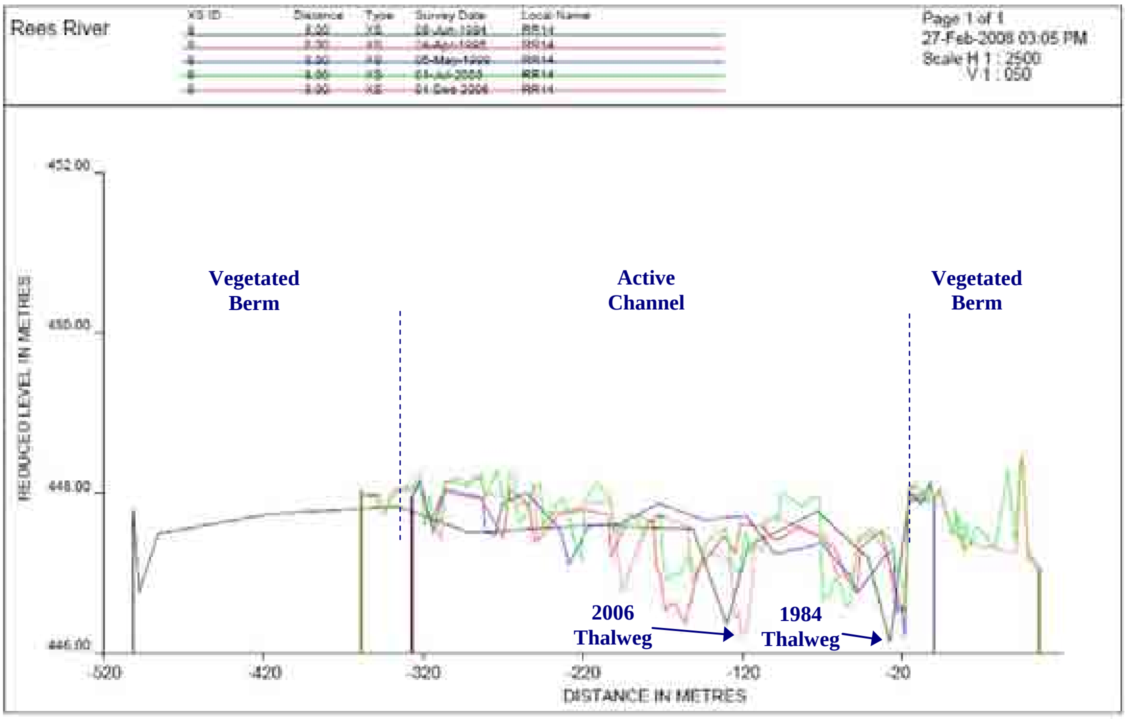

Figure 3.12 **Cross-section RR14, looking downstream**

3.9 Cross-section 4

Cross-section 4 is located approximately 10.75km upstream of cross-section RR3A and about 3.1km upstream of the Rees River bridge. Figure 3.13 shows a plot of cross-section 4 for the 1987, 1996, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of 462m. Comparatively, the 1987 section was only surveyed for a width of 357m. Mean bed level analysis shows net aggradation of 0.07m over the entire channel width between 1996 and 2006 (Table 3.2). The channel on the true left deepened 2.24m between 2003 and 2006.

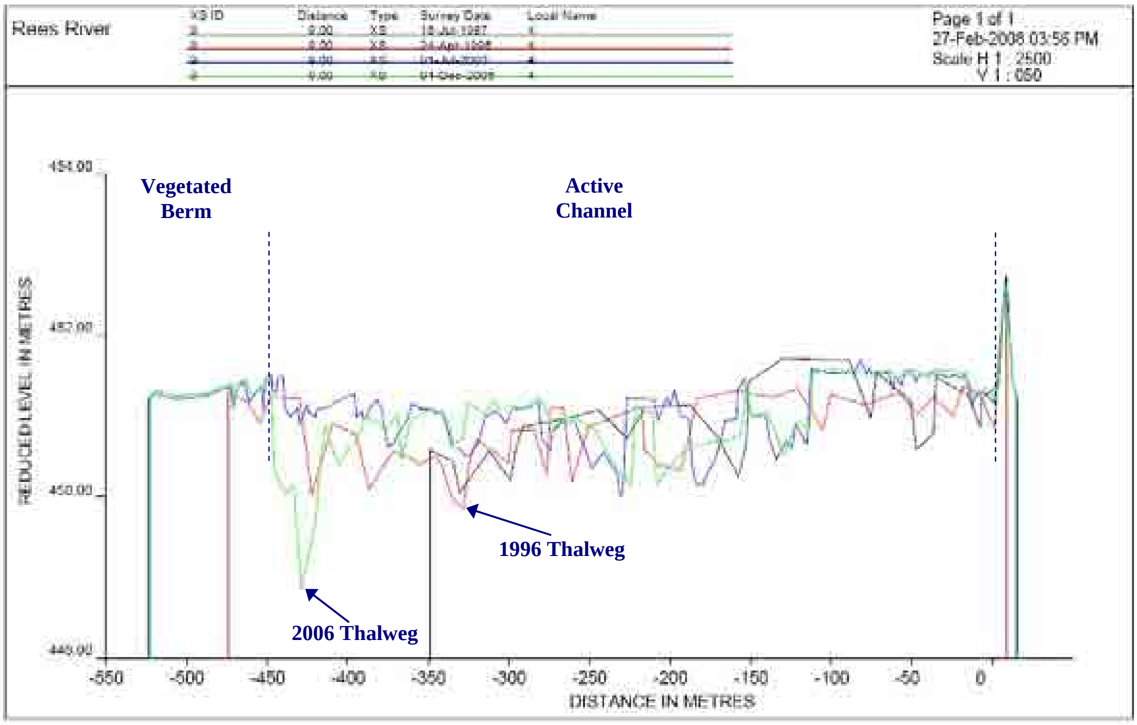

Figure 3.13 Cross-section 4, looking downstream

3.10 Cross-section RR15

Cross-section RR15 is located approximately 11.21km upstream of cross-section RR3A and 3.56km upstream of the Rees River bridge. A large portion on the true left of this cross-section is a longitudinal profile of the Twelve Mile Creek alluvial fan that debouches onto the Rees River floodplain. Figure 3.14 shows a plot of cross-section RR15 for the 1984, 1996, 1999, 2003 and 2006 surveys.

The active Rees River channel lies near the middle of the cross-section, adjacent to the Twelve Mile Creek alluvial fan toe. During periods of high flow, toe-cutting of this alluvial fan by the axial Rees channel may occur. Mean bed level analysis shows that this location has experienced net degradation of 0.07m during the period 1984 to 2006 (Table 3.2). While mean bed level analyses show relatively minor net degradation at this location, variation from aggradational to degradational environments is significant.

Bed levels at this cross-section are interpreted to be significantly affected by the depositional sediment flux of Twelve Mile Creek. Where the active channel margins of the Rees River may be affected by encroachment of the alluvial fan, depositional phases of the Twelve Mile Catchment may contribute intermittent sediment fluxes across the Rees floodplain.

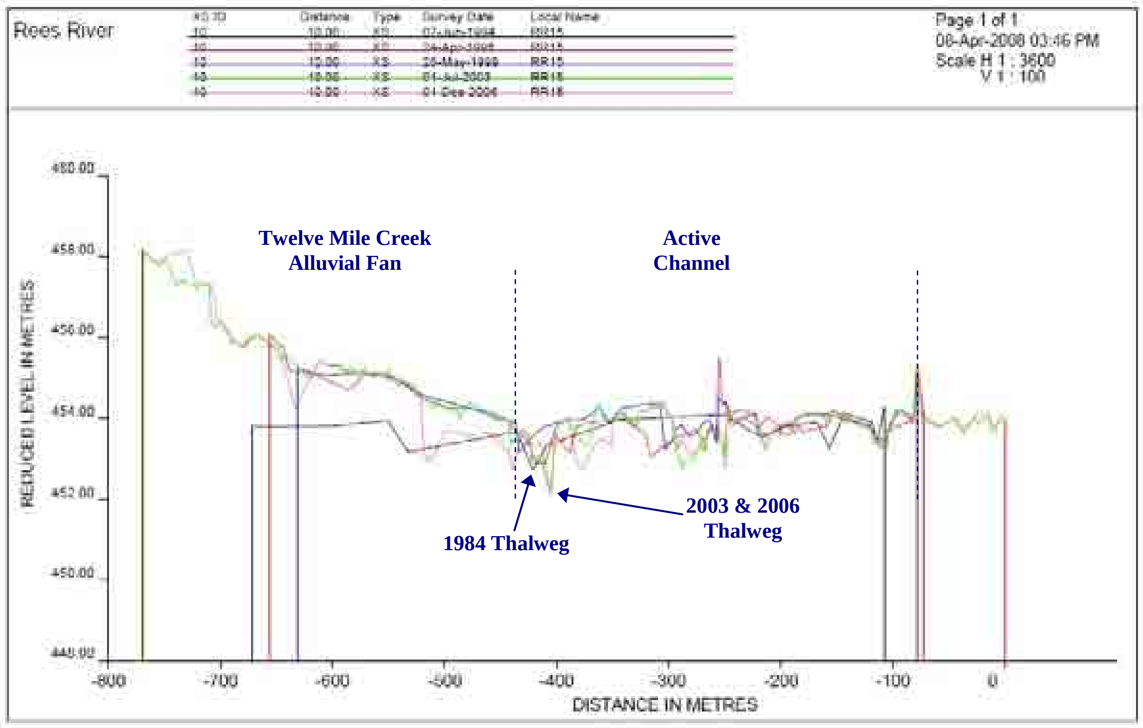

Figure 3.14 Cross-section RR15, looking downstream

3.11 Cross-section RR17

Cross-section RR17 is located approximately 12.7km upstream of cross-section RR3A and about 5.05km upstream of the Rees River bridge. Figure 3.15 shows a plot of cross-section RR17 for the 1978, 1984, 1996, 1999, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of 129m. Comparatively, the 1978 section was only surveyed over 74m. Table 3.2 shows the results of mean bed level analysis for both channel widths. The 1978 survey is not comparable to the rest of the survey periods due to the limited distance. Mean bed level analysis shows that net aggradation over the entire channel width of 0.34m occurred between 1996 and 2006.

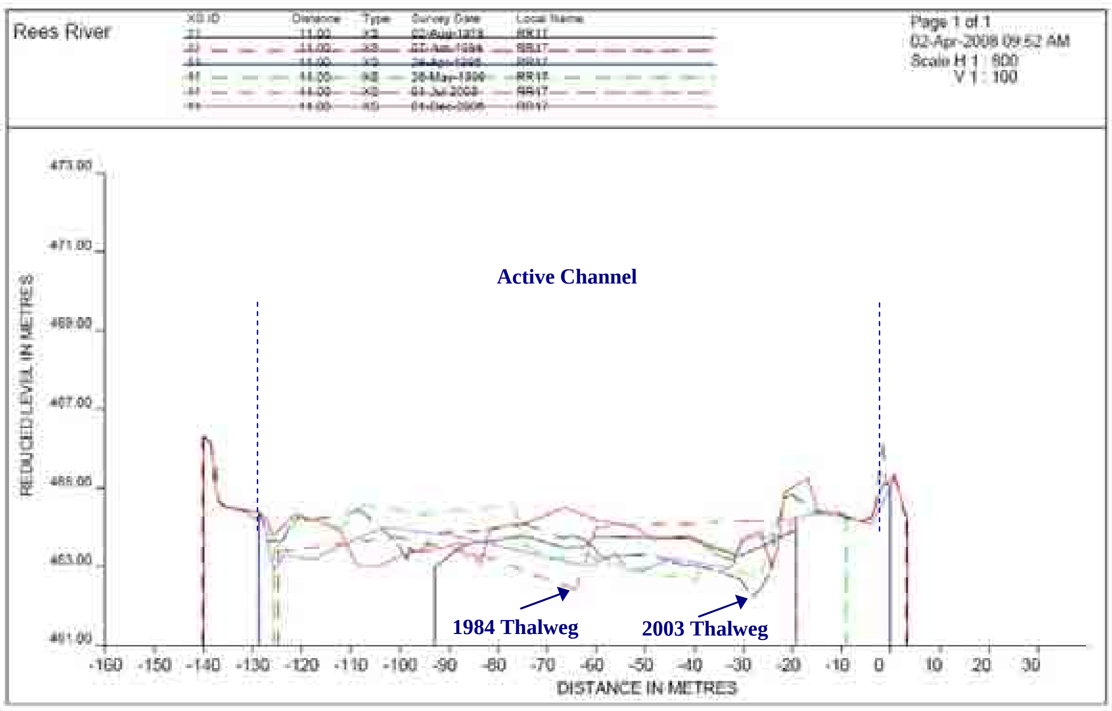

Figure 3.15 **Cross-section RR17, looking downstream**

3.12 Cross-section 18A

Cross-section 18A is located approximately 13.24km upstream of cross-section RR3A and about 5.59km upstream of the Rees River bridge. Figure 3.16 shows a plot of cross-section 18A for the 1978, 1984, 2003 and 2006 surveys.

The active channel in this cross-section covers a width of 401m. Comparatively, the 1978 section was only surveyed over 321m. Table 3.2 shows the results of mean bed level analysis for both channel widths. The 1978 survey is not comparable to the rest of the survey periods due to the limited distance. Mean bed level analysis shows that net aggradation of 0.37m occurred over the 321m width. The thalweg of the channel in the 2006 survey is located on the true right in an area that was not covered in the 1978 and 1984 surveys.

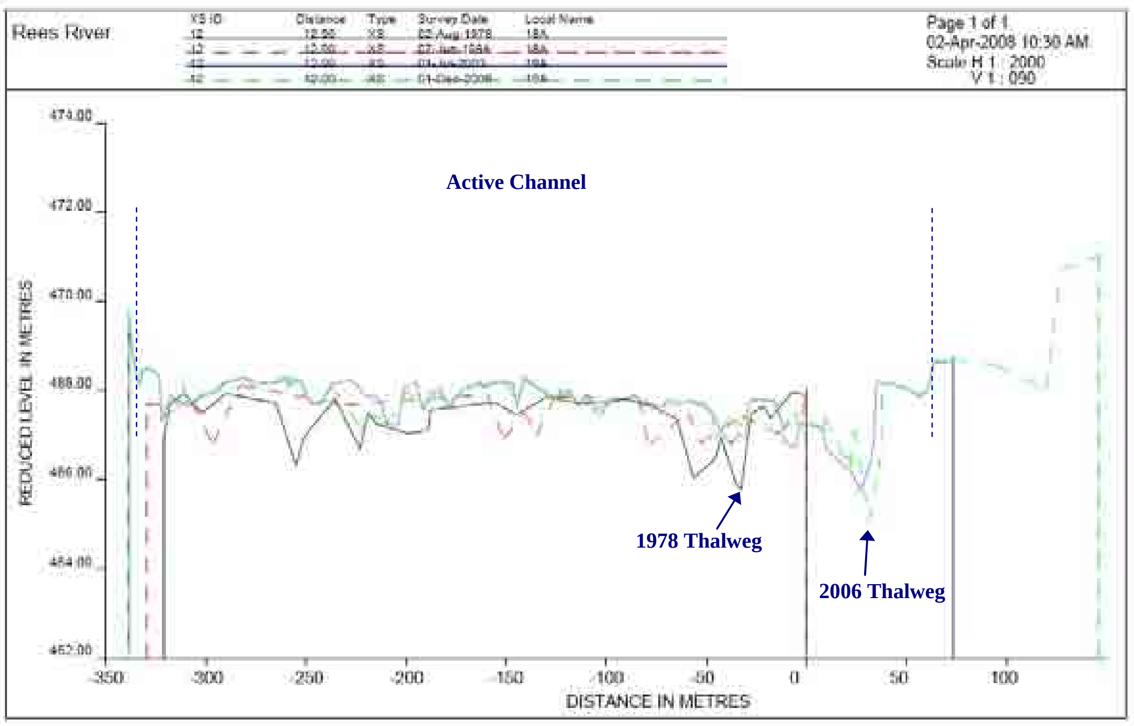

Figure 3.16 Cross-section 18A, looking downstream

3.13 Longitudinal profile

Figure 3.17 shows a longitudinal profile of mean bed level for 1984, 1999 and 2006. These three years were chosen as they covered a suitable temporal range and number of cross-sections surveyed. The longitudinal profile shows that mean bed levels have remained relatively stable over the period 1984 to 2006.

Figure 3.17 indicates that mean bed levels near the upper range of the surveyed catchment have lowered marginally from 1984 to 2006. While in the lower part of the catchment, mean bed levels have risen slightly between 1999 and 2006. Observations derived from the longitudinal profile should be viewed as indicative due to the intermittent number of surveys and survey locations.

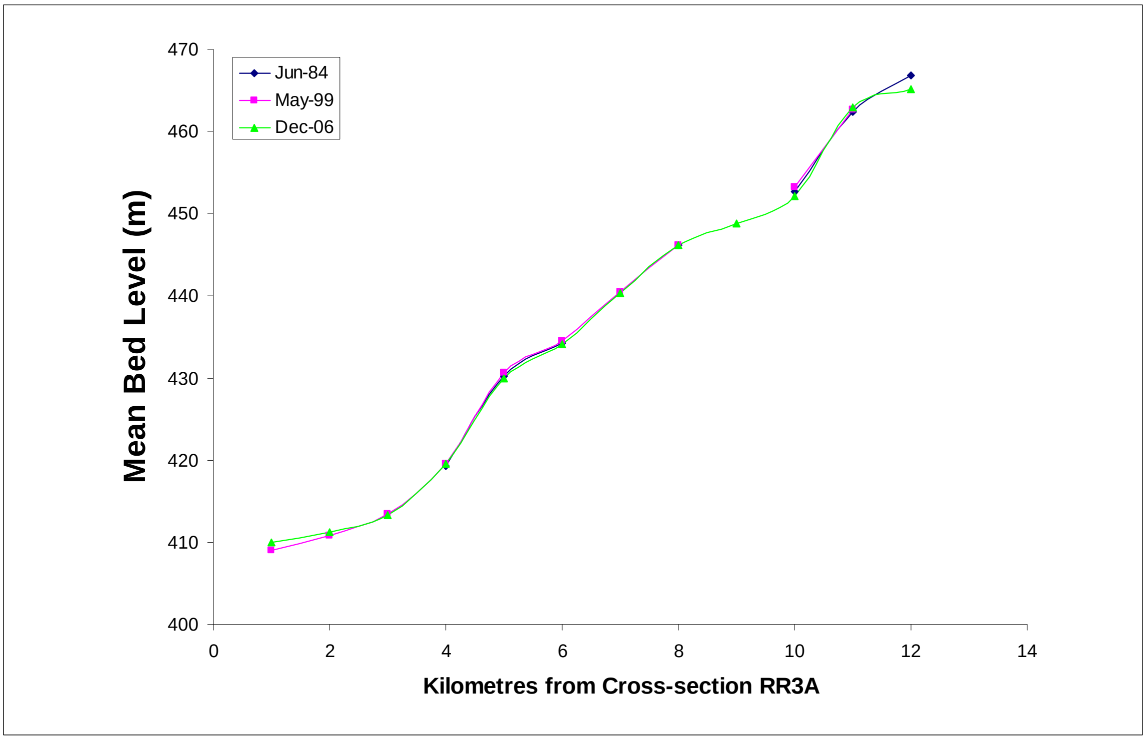

Figure 3.17 Longitudinal profile of the Rees River mean bed levels for 1984, 1999 and 2006

4. Conclusions

A desktop analysis of channel morphology and sedimentation in surveyed reaches of the Rees River has been undertaken using aerial photography, cross-section surveys and relevant documentation. This section provides a synthesis of the study's results to provide an indication of how the river system is changing over time. This will be expressed for the lower, mid and upper cross-sections with a general overview discussing notable variation and trends.

4.1 Upper cross-sections (4, RR15, RR17, 18A)

- Cross-sections 18A and RR17 experienced net aggradation of 0.37m (1978-2006) and 0.34m (1996-2006) respectively.
- Cross-section RR15 exhibits high volatility of switches in aggradation and degradation between survey periods. This is interpreted to a function of the sediment input from the Twelve Mile Creek Catchment. This section experienced net degradation of 0.07m (1984-2006).
- Cross-section 4 experienced net aggradation of 0.07m (1996-2006), while exhibiting fluctuation similar to cross-section RR15.

4.2 Mid cross-sections (RR11, RR12, RR13, RR14)

- Between 1984 and 1999, cross-sections RR12 and RR11 experienced net aggradation of 0.63m and 0.35m aggradation respectively.
- All cross-sections in this part of river experienced minor net degradation during the survey period 2003 to 2006.
- Cross-sections RR13 and RR14 experienced 0.11m (1996-2006) and 0.09m (1984-2006) net aggradation respectively.

4.3 Lower cross-sections (RR3A, RR4A, RR5, 8A)

- Cross-sections RR3A and RR4A have a relatively short period of survey from 1999 to 2006 and show minor net aggradation over this period.
- Cross-sections RR5 and 8A have longer survey periods and show net aggradation of 0.10m (1990-2006) and 0.22m (1984-2006) respectively.

Aerial photography obtained for a number of periods between 1937 and 2006, shows that the Rees River is a dynamic, mobile system. Channel form and development within the Rees River is indicative of a high sediment yield, braided river system. Significant evidence of movement in the location of the channel thalweg and associated lateral migration of secondary channels has been identified in the majority of cross-sections. While dynamism in channel morphology has been identified from cross-sectional analysis, the Rees River banks have remained relatively stable at surveyed locations.

Figure 4.1 shows a graphical representation of the net change in mean bed levels quantified for each cross-section over each respective period of survey. An holistic interpretation of mean bed level results indicates that the upper (RR17, 18A) and mid (8A, RR11, RR12) cross-sections are experiencing net aggradation while other surveyed locations are experiencing minor fluctuations in net mean bed levels.

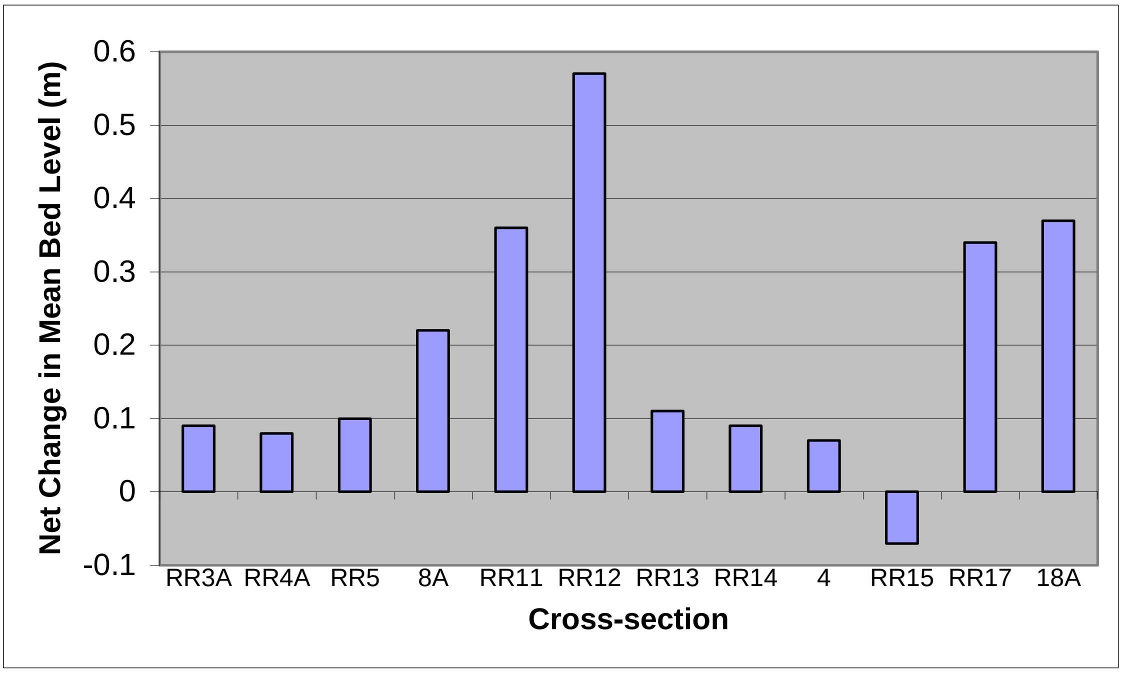

Figure 4.1 **Graph showing net change in mean bed level across all survey periods for each cross-section location**

Local variability in the bed levels of some cross-sections, such as RR15, over surveyed periods indicates that bed levels are significantly affected by sediment inputs from adjacent catchments. Additionally, the redistribution of these sediments from upper to lower catchments may be primarily activated by large flood flow events, such as in November 1999.

5. References

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