Goulburn River Environmental Flow Hydraulics Study

Topographic data review

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PROJECT DETAILS

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Client	GBCMA
Client project manager	Geoff Earl
Water Technology project manager	SHM
Report authors	SHM, BIH
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15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 9558 9366
Fax (03) 9558 9365
ABN No. 60 093 377 283
ACN No. 093 377 283

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1 INTRODUCTION

This report documents the topographic data review undertaken for the Goulburn River Environmental Flow Hydraulics Study. The report reviews available topographic data, identifies key topographic data gaps, assesses the suitability of available topographic data for use in the hydraulics analysis, and discusses the likely impact on the hydraulic analysis due to the topographic data gaps.

Goulburn Broken Catchment Management Authority (Goulburn Broken CMA) has commissioned the Goulburn River Environmental Flow Hydraulics Study. This project is required to undertake hydraulic and hydrologic modelling of the Goulburn River from Lake Eildon to the River Murray.

The study brief outlines the following project tasks:

1. Data collation and review – Collation and review of the available topographic and streamflow data information.
2. Topographic data gap identification – Identify the gaps in the available topographic data, and suggest potential mediation options.
3. Asset mapping – Locate and map known public and private assets along the Goulburn River and adjacent surrounds.
4. Hydrologic analysis – Investigate relative contribution from downstream tributaries, and assess design flood hydrographs for the Goulburn River catchment.
5. Hydraulic analysis and flow behaviour – Assess flow behaviour of the Goulburn River over a range of potential environmental flows.
6. Socioeconomic assessment – Evaluate the social and economic costs of potential Goulburn River environmental flows.
7. Real time flow management – Review and scope real time flow management framework.
8. Management option assessment – Scope feasibility of management options for environmental flow releases.

This report addresses the first and second project tasks.

Reliable and suitable topographic data is the backbone of this project. The accuracy of the project outcomes are inherited from the topographic data utilised in the hydraulic analysis. To this end, the topographic data review is a key component in the delivery of this project.

The structure of this report is as follows:

- Section 2: outlines available topographic data collated
- Section 3: reviews and compares topographic data from various sources
- Section 4: assess the suitability of the available topographic data for use in the hydraulic model
- Section 5: recommends potential topographic data capture to assist hydraulic analysis

2 AVAILABLE TOPOGRAPHIC DATA COLLATION

2.1 Overview

This section identifies relevant topographic available data and information collated. Sources of topographic data collated include:

- Remote sensed topographic data
- Field surveyed topographic data

2.2 Available remote sensed topographic data

The base topographic data for the study area is sourced from Airborne Laser Scanning (ALS) undertaken by the Goulburn Broken CMA. This ALS data has a vertical accuracy of +/- 0.10 m at 1 standard deviation along the Goulburn River floodplain. The data was captured in March 2007 . The ALS data is available as a 2 m and 10 m grid. Figure 2-1 shows the extent of the available ALS data.

The available ALS data set for the lower Goulburn River floodplain was captured in 2001, and extents the above coverage to the Murray River confluence.

2.3 Available field surveyed topographic data

In addition to the ALS data, field surveyed waterway cross sections and bathymetry data are available from the following sources and at the following locations:

- State Rivers and Water Supply Commission
    - Seymour (15 Cross-sections from Chainage 306.9 km to 316.8 km)
    - Shepparton (58 Cross-sections from Chainage 136.8 km to 182.8 km)
    - Lower Goulburn (54 Cross-sections from Murray-Goulburn confluence (Chainage 0 km) to Chainage 135.5 km)
- Goulburn River Environmental Flow Study (Cottingham et al 2003)
    - Waterway cross sections were taken for 5 reaches. For three of the five reaches, the cross sections were geo-referenced to AMG. These sets consist of 16-18 cross sections at a separation of 200 m. The geo-referenced cross section sets are located at the following chainages:
        - 276.27 km to 273.26 km (Site 1)
        - 222.11 km to 219.11 km (Site 2)
        - 165.19 km to 162.17 km (Site 3)
- Melbourne Water - North-South Pipeline Project investigations
    - Bathymetric survey of the Goulburn River at Killingworth
- Goulburn Murray Water – Lake Nagambie
    - Bathymetric survey of Lake Nagambie.
- Goulburn Broken CMA – Goulburn Weir to Murray confluence
    - Bathymetric survey of Goulburn River: Goulburn Weir to Murray confluence.

Figure 2-2 displays the field survey locations.

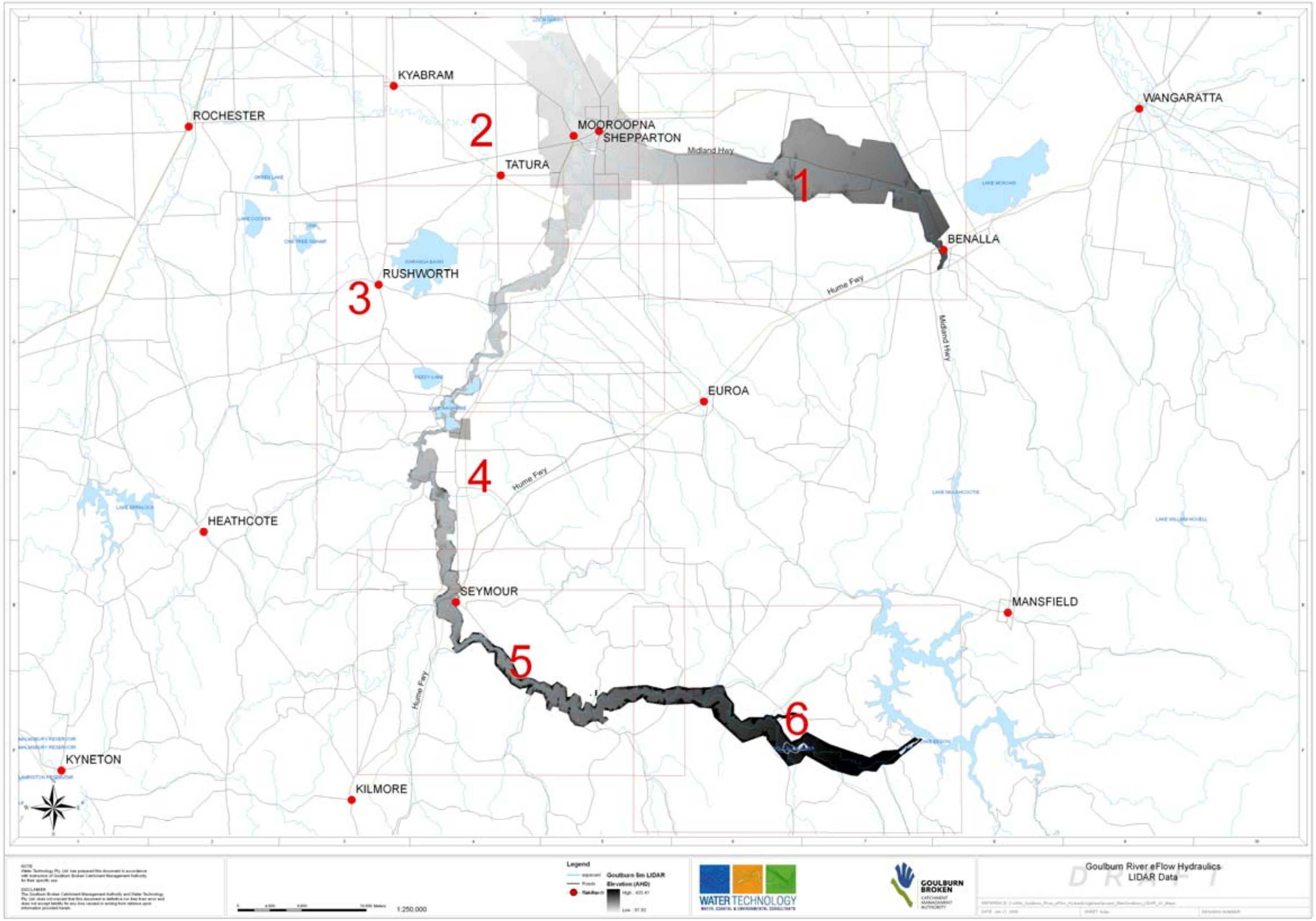


Figure 2-1 ALS extent from Lake Eildon to Shepparton

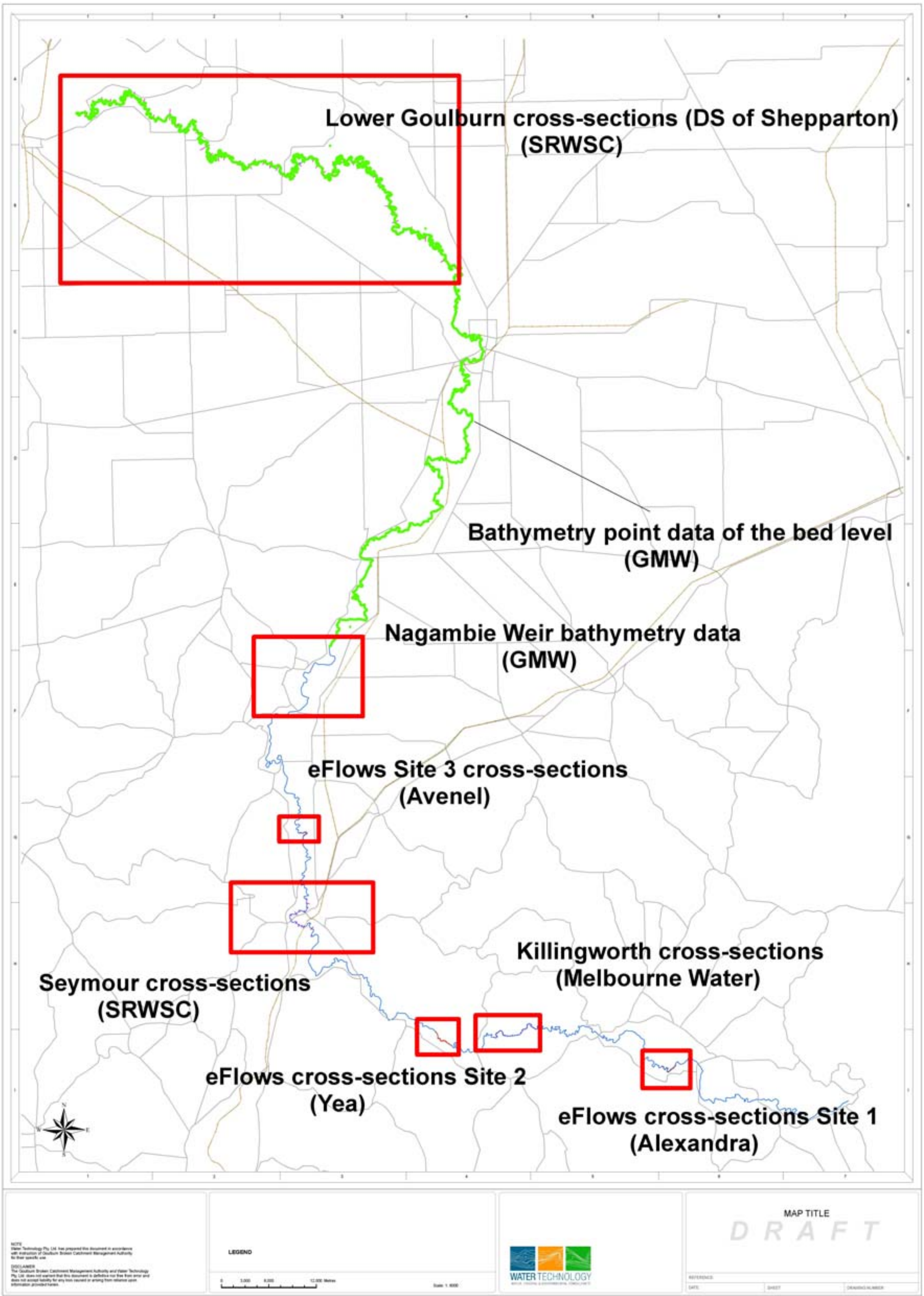


Figure 2-2 Field survey locations

3 TOPOGRAPHIC DATA REVIEW

3.1 Overview

This section reviews the topographic data from the ALS and field survey sources, and compares waterway geometry from the available topographic data sources.

Simple comparisons of bed profiles and cross section shapes have been undertaken where field surveyed and remote sensed topographic data are both available. The comparisons have been broken into the following groups, depending on the sources of the field survey cross sections:

- SR&WSC cross sections (Section 3.2)
- Melbourne Water bathymetry data near Killingworth (Section 3.3)
- Goulburn-Murray Water bathymetry data at Lake Nagambie (Section 3.4))
- Environmental Flows Study cross section (Section 3.5)

The bathymetric data below Lake Nagambie has only become available in early July. Due to time constraints, no formal assessment of this data set has been included in this report. The later study report will discuss this data set in detail.

A discussion on the findings of the comparisons is provided in Section 3.6.

The comparisons in this section have extracted cross section/bed profile from the ALS 2 m grid data.

3.2 SR&WSC cross sections

A total of 127 cross sections have been surveyed by the State Rivers and Water Supply Commission, as outlined in Section 2.3. At each cross section, a comparison was undertaken for the field surveyed and ALS extracted data. The cross sections have been surveyed in two locations, downstream of Shepparton (Lower Goulburn) and adjacent to Seymour.

For all of the analysed cross sections, the ALS cross sections displayed a flat/or inclined straight line segments across the invert of the channel. These line segments results from the absence of ALS data and suggests the presence of water in the channel. Figure 3-1 display a typical comparison of waterway cross sections.

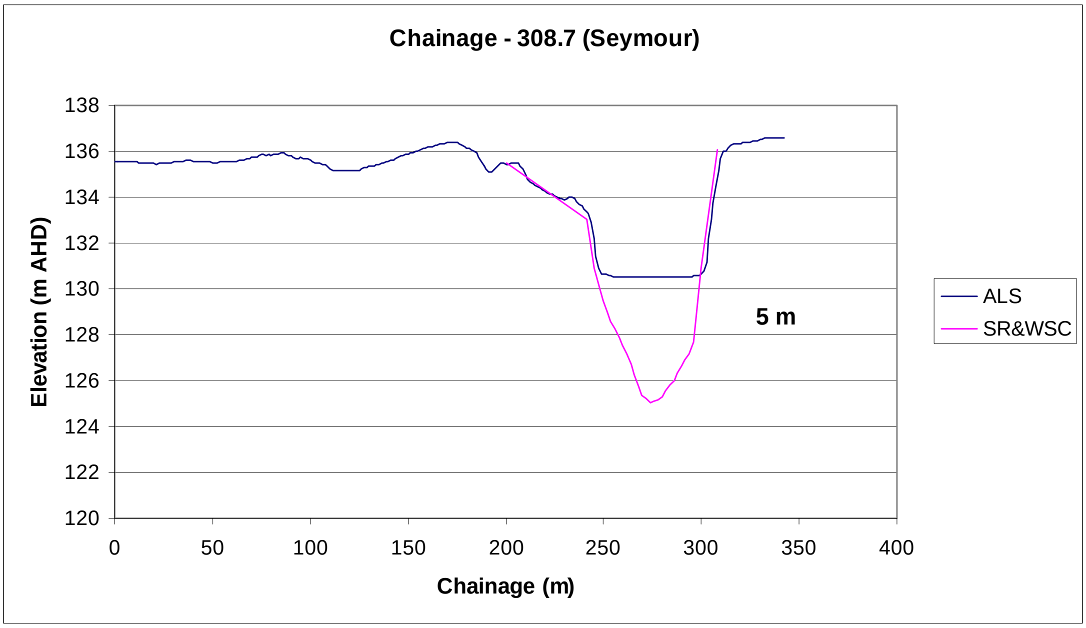


Figure 3-1 Waterway cross section comparison (Goulburn River near Seymour)

Comparison plots of all field surveyed and ALS extracted cross sections are provided in Appendix A.

Generally, the ALS extracted cross sections compared favourably with the field survey above the water level. This favourable comparison provides confidence that the ALS topographic data set will provide reliable cross sections for hydraulic modelling above the water surface.

The influence of water in the channel at the time of the ALS capture is illustrated through the comparison of long sections, refer to Figure 3-2, Figure 3-3 and Figure 3-4.

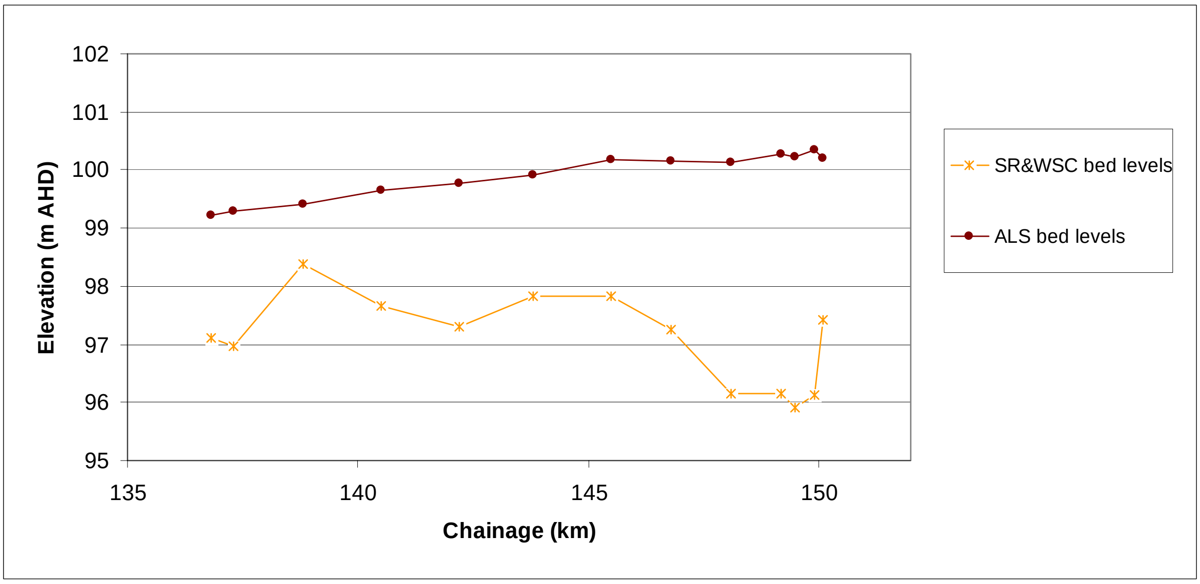


Figure 3-2 Bed level profile comparison (Lower Goulburn River Chainage 136 to 151 km)

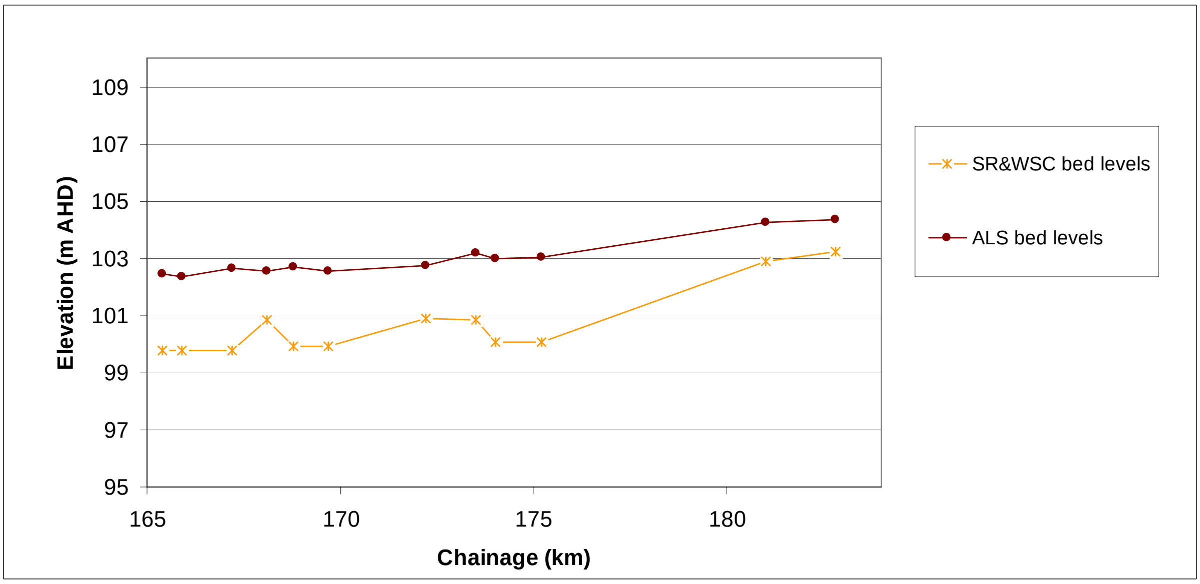


Figure 3-3 Bed level profile comparison (Lower Goulburn River Chainage 165 to 183 km)

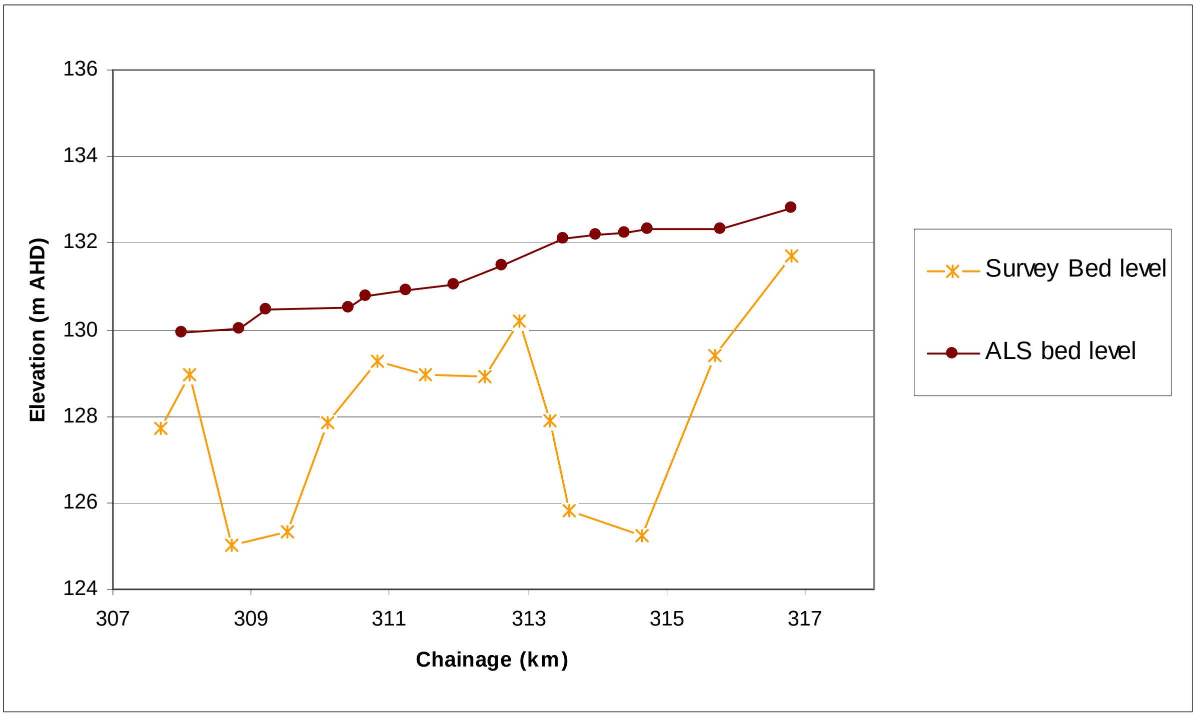


Figure 3-4 Bed level profile comparison (Goulburn River at Seymour Chainage 307 to 317 km)

The comparisons of the surveyed and ALS bed levels reveal the water depth at the time of the ALS capture. The variation in depth of water along the river reflects pools and riffles. The water depths in the Lower Goulburn cross sections ranges from 0.6 – 4.2 m with an average value of 2.7 m, and for Seymour the depth varies from 1 – 5 m with an average value of 3 m.

3.3 Goulburn River Bathymetry at Killingworth

The waterway cross sections at Killingworth have been developed using bathymetry survey provided by Melbourne Water (via SKM). This bathymetric survey is part of the North South pipeline investigations undertaken on behalf of Melbourne Water. This bathymetric survey extends for approximately 9 km of the Goulburn River. For the analysis of this section of the Goulburn River cross sections have been extracted approximately every 300 m. Figure 3-5 displays a typical waterway section comparison.

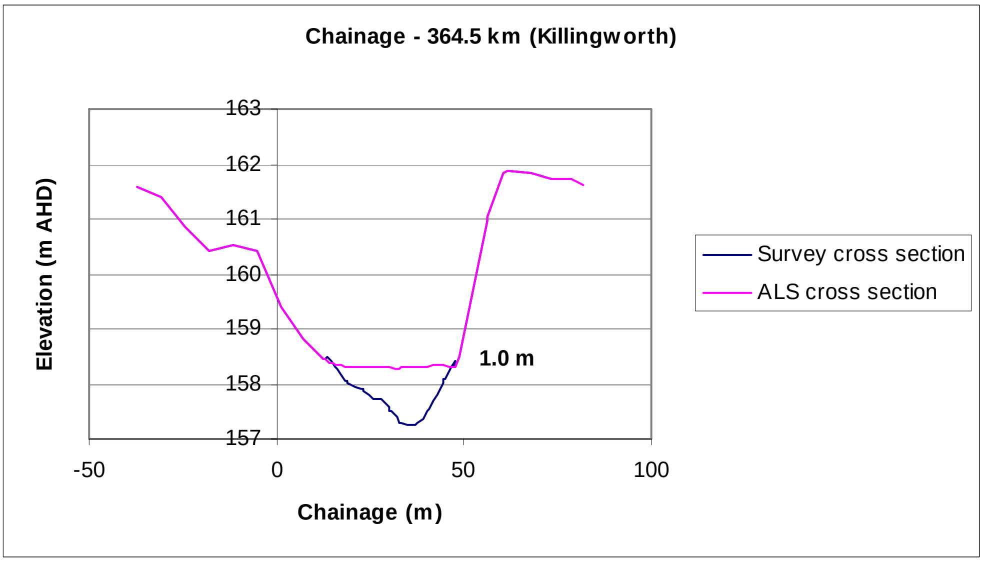


Figure 3-5 Waterway cross section comparison (Goulburn River near Killingworth)

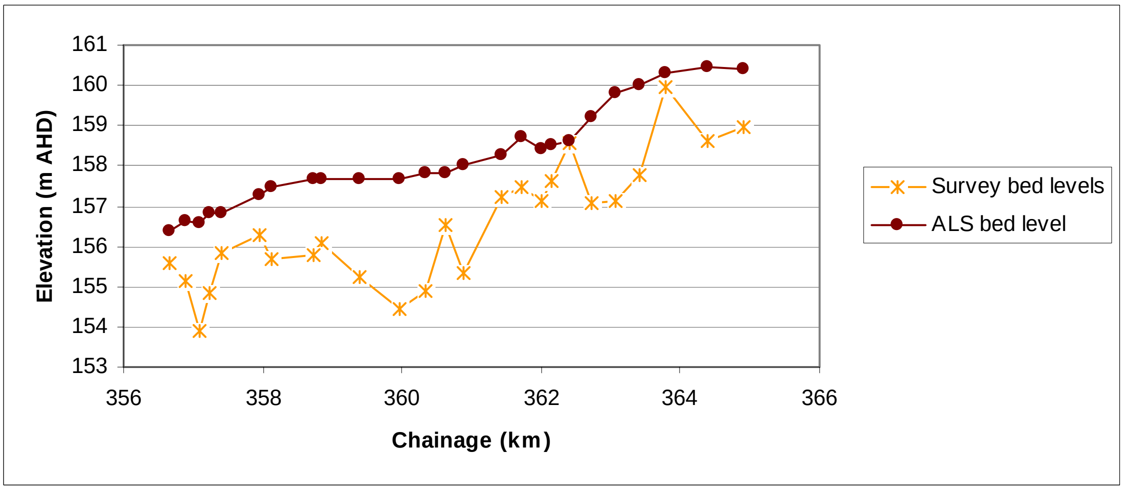


Figure 3-6 Bed level profile comparison (Goulburn River at Killingworth Chainage 356 to 365 km)

The range of difference in the bed levels from the ALS survey at the Killingworth 0.3 – 3.3 m with an average difference of 1.7 m. There is more detail in this section of the river because of the small distance in between cross sections. The pools and riffles are quite clear in the bathymetric survey.

3.4 Goulburn River Bathymetry at Lake Nagambie

Goulburn Murray Water recently undertook bathymetric survey of Lake Nagambie, as outlined in Section 2.3. The study team has requested this data and is awaiting supply of the data set. Once received, the similar comparison to those outlined in Section 3.3 will be undertaken.

3.5 Environmental Flows Study Cross sections

There are five sets of cross sections surveyed for the Goulburn River Environmental Flows study (Cottingham et al 2003). Of these five sets, there has been assessment of three sets in this report. For two sites, the exact location of the cross sections could not be properly verified. Figure 3-7, Figure 3-8 and Figure 3-9 display bed level comparisons.

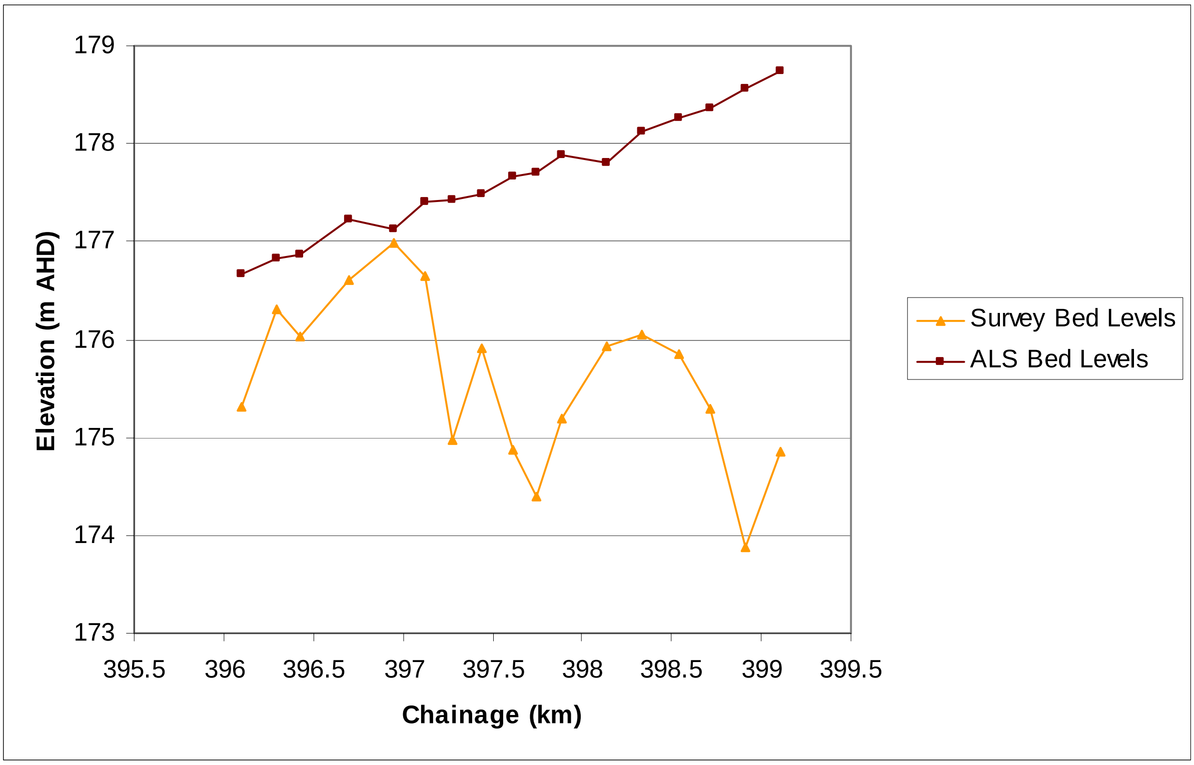


Figure 3-7 Bed level profile comparison (Site 1 Chainage 273 to 276.3)

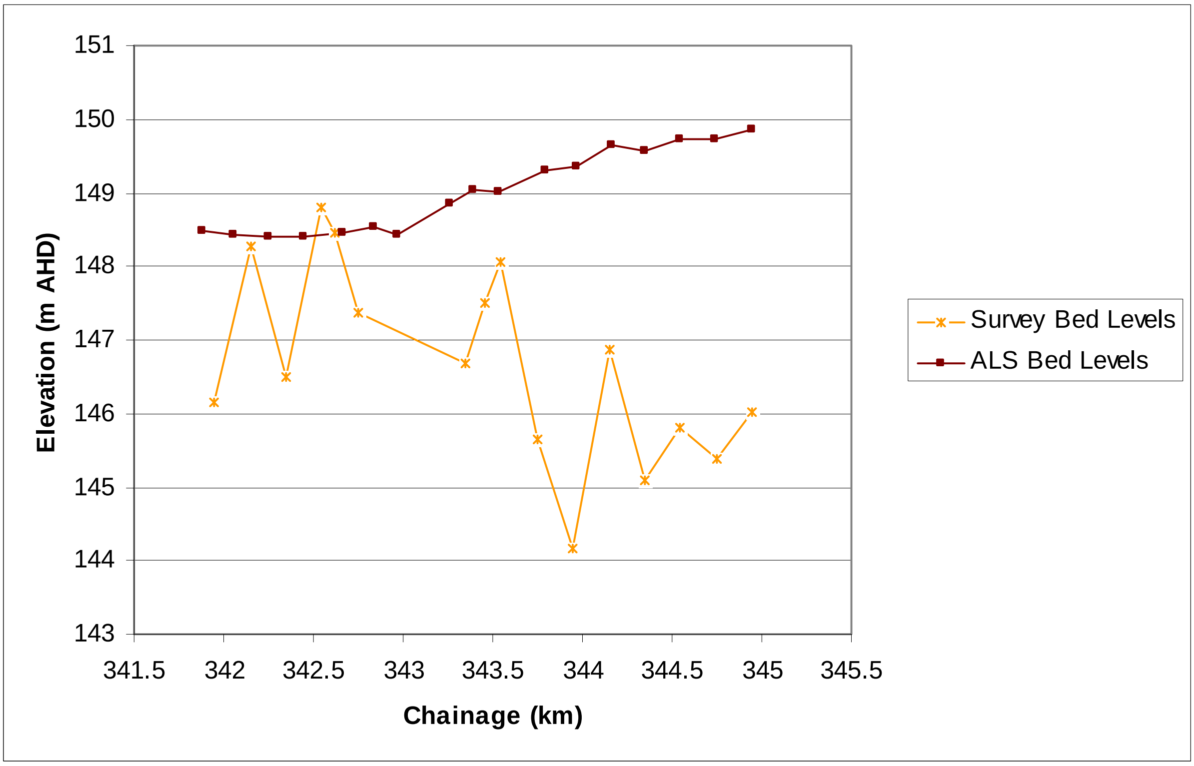


Figure 3-8 Bed level profile comparison (Site 2 Chainage 218.5 to 222.3)

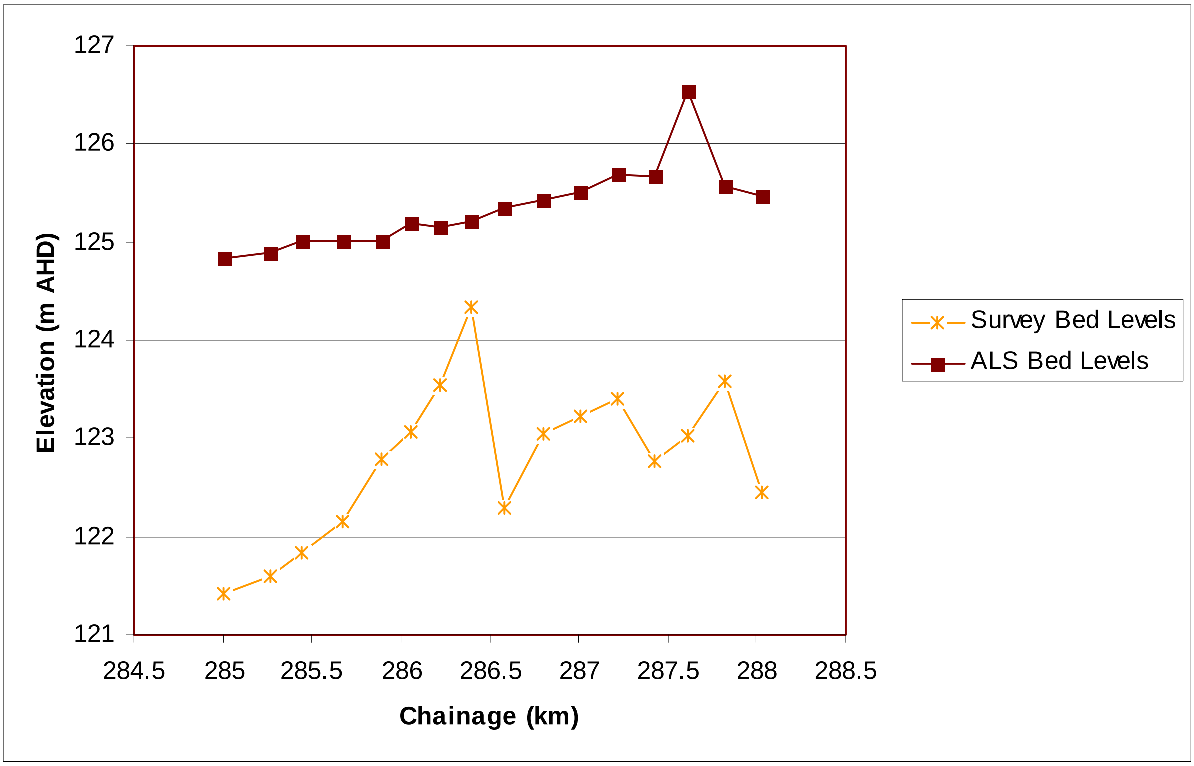


Figure 3-9 Bed level profile comparison (Site 3 Chainage 162 to 165.4)

The ranges and average of differences for the three sites are as follows:

- Site 1
  - Range: 0.2 – 4.7 m
  - Average: 2.1 m
- Site 2
  - Range: -0.4 – 5.2 m
  - Average: 2.38 m
- Site 3
  - Range: 0.9 – 3.5 m
  - Average: 2.6 m

3.6 Discussion

Direct comparison of field surveyed cross sections with cross sections extracted from the ALS data set, reveals that the ALS data provides good representation of the geometry above the water level at the time of ALS data capture.

The field surveyed cross sections shows significant variations in bed levels for the surveyed reaches. This variation reflects the presence of pools and riffles. Such variation in bed levels limits the application of uniform alternations in the ALS bed levels to approximate field surveyed bed levels.

The influence of the ALS cross section on the flow behaviour is explored through the the application of one dimensional hydraulic models, as discussed in Section 4.

It is noted that there are 4 new cross-sections being surveyed, under VEFMAP, the following 4 sites (Geoff Earl pers. comms.):

- Moss Road Murchison
- Darcy Track Toolamba
- Loch Garry Gauge
- McCoys Bridge

Each of the 4 sites, it is proposed to survey 15 cross-sections per site to cover one meander wavelength.

A bathymetric survey has been recently completed for the Goulburn River below Goulburn Weir. This bathymetric survey consists a continuous long section along the nominal river centreline, with additional bathymetric data was captured at large pools. The water level at the time of the survey was also captured.

4 TOPOGRAPHIC DATA SUITABILITY ASSESSMENT

4.1 Overview

This section assesses the suitability of the topographic data for use in the hydraulic modelling.

This assessment utilised a number of one dimensional (1D) hydraulic models. The hydraulic models were constructed for reaches corresponding to the field based survey discussed in Section 3. The reaches assessed were Seymour, Killingworth, two reaches in the Lower Goulburn below Shepparton, and three sites from the Environmental Flow requirements study (Cottingham et al 2003). For these reaches, the 1D hydraulic models used the available waterway cross sections from the field based and ALS data sets. Modelled flow profiles over a range of flow magnitudes, 25 m^3/s to 500 m^3/s (2,160 – 43,200 ML/d), were assessed for the Seymour, lower Goulburn and Killingworth reaches. Modelled rating curves (stage –discharge curves) were determined at the upstream limit for all of the above reaches.

To assess the influence of the ALS on flow behaviour, the following four cross section scenarios were considered at the modelled reaches:

- Field based survey (SR&WSC/bathymetric survey/environmental flow study sources)
- ALS extracted without modifications
- ALS extracted with the channel invert lower 1 m
- ALS extracted with the channel invert lower 2 m

Figure 4-1 shows an example of the field based cross section with ALS extracted section with and without modifications.

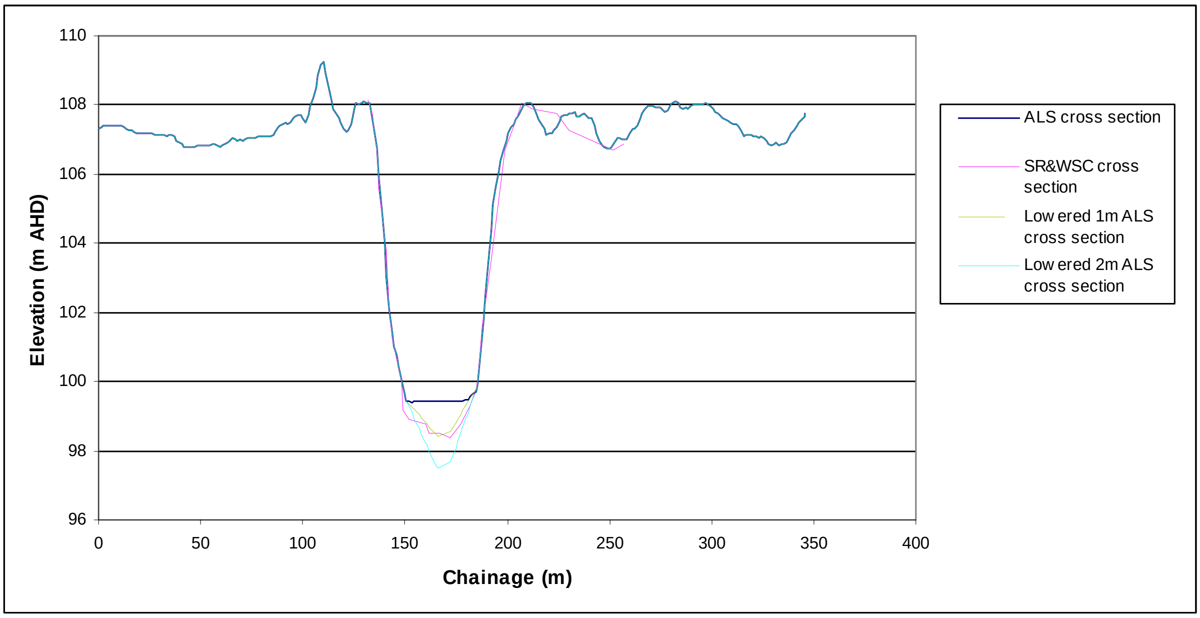


Figure 4-1 Sample alterations to ALS cross sections (Unchanged, lowered by 1 and 2m) at chainage 138.8 km

Section 4.2 to 4.5 details the above comparisons for the Goulburn River at Seymour, below Shepparton, Killingworth and the environmental flow study sites.

Also, hydraulic models were constructed using the ALS data adjacent to the key streamflow gauges along the Goulburn River, including Trawool, Seymour, Murchison and Shepparton. For these reaches, modelled and gauged rating curves were compared, refer to Section 4.6 for details.

The above assessments were focused at the site and reach scale. To assess the influence of the ALS data set on the routing of flows along the study area, a 1D hydraulic model was constructed from downstream of Eildon to just upstream of Goulburn Weir. This 1D model utilised cross section extracted from the ALS data without alternation. The period March 2005-May 2005 were selected as a representative streamflow sequence, where there were limited contributions from tributaries downstream of Eildon. Comparison of gauge and modelled flows and water levels at key gauges, Trawool and Seymour, provides insight into the model's ability to simulate travel times along the river.

As discussed in Section 3.6, the ALS data is limited to the waterway and floodplain terrain above the water level, at the time of data capture. The hydraulic modelling, discussed in this section, provides insight into the influence on modelled flow behaviour due to the use of the ALS data set. From these insights, recommendations regarding the additional topographic data collection are presented in Section 5.

The 1D hydraulic model, MIKE11, was applied. Each model has been setup with the roughness (Manning's n) set at a constant 0.03. The downstream end of each model has been set at a stage – flow relationship. This relationship is used to provide an appropriate downstream boundary.

4.2 Goulburn River at Seymour

The set of SR&WSC cross sections at Seymour show considerable variation in bed levels over the reach. At chainages, 309 and 314 km there are cross sections that are substantially higher with deep pools at approximately 310 and 316 km.

Modelled flow profiles were assessed across a flow range of 25 to 500 m^3/s. For each flow, four profiles were assessed using the four cross section scenarios, outlined in Section 4.1.

Figure 4-2 and Figure 4-3 display the modelled flow profiles at 100 m^3/s and 250 m^3/s respectively.

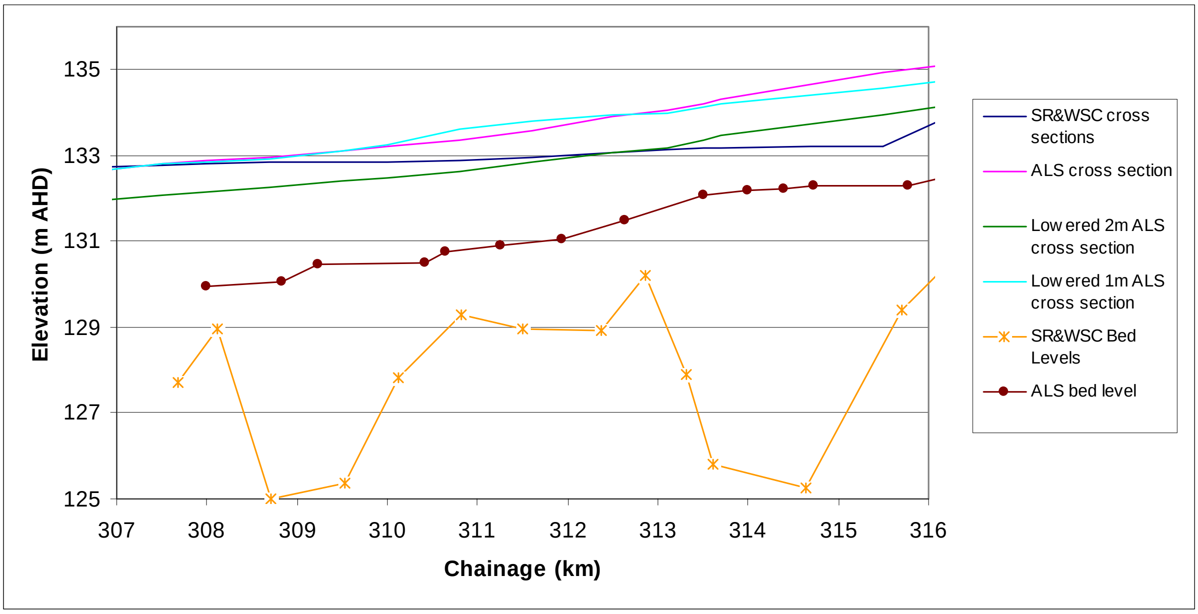


Figure 4-2 Goulburn River at Seymour – Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

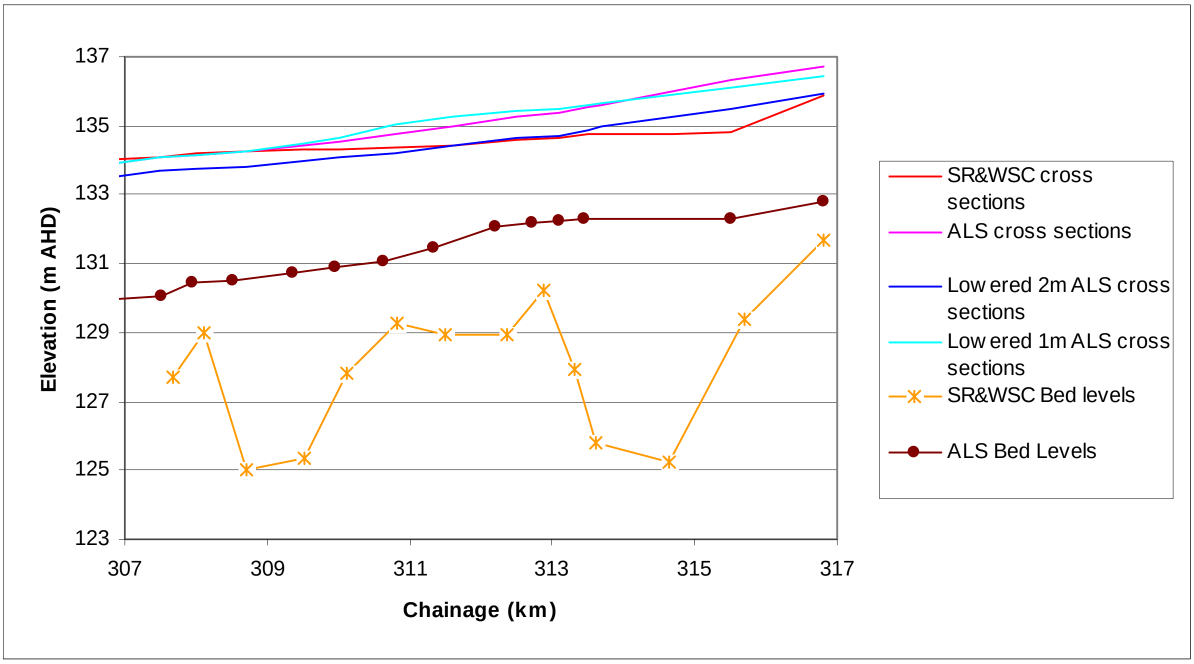


Figure 4-3 Goulburn River at Seymour – Modelled flow profile comparison at 250 m^3/s (21,600 ML/d)

From Figure 4-2 and Figure 4-3, the use of ALS data without modifications results in the higher water levels than the SR&WSC (field based) sections. This result is in line with expectations. At the lower flow of 100 m^3/s, the difference in the flow profile is greater than at the higher flow of 250 m^3/s. Lowering the middle point in the ALS by 1m has made little impact on the modelled flow profile.

Figure 4-4 displays the modelled rating curves extracted at the upstream limit (Chainage 317 km).

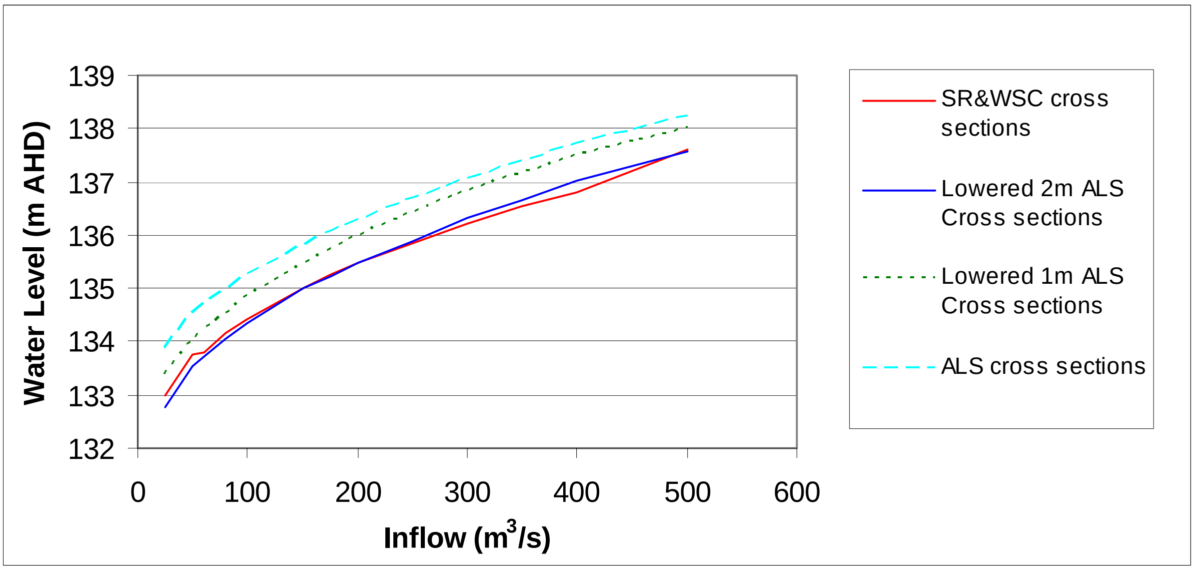


Figure 4-4 Goulburn River at Seymour – Modelled rating curve comparison (Chainage 317 km)

The results show the un-altered ALS having approximately a 0.5 m higher water level over the flow range considered. For the ALS cross section lowered by 2 m, the modelled rating curve is in line with the SR&WSC cross section results.

4.3 Lower Goulburn River below Shepparton

The two 1D models have been developed for the Lower Goulburn downstream of Shepparton based on the location of the SR&WSC cross sections, chainages 137 to 150, and 165 to 182 km.

Figure 4-5 and Figure 4-6 display the flow profiles for the lower Goulburn Chainage 165- 182 km for the 100 m^3/s and 250 m^3/s respectively.

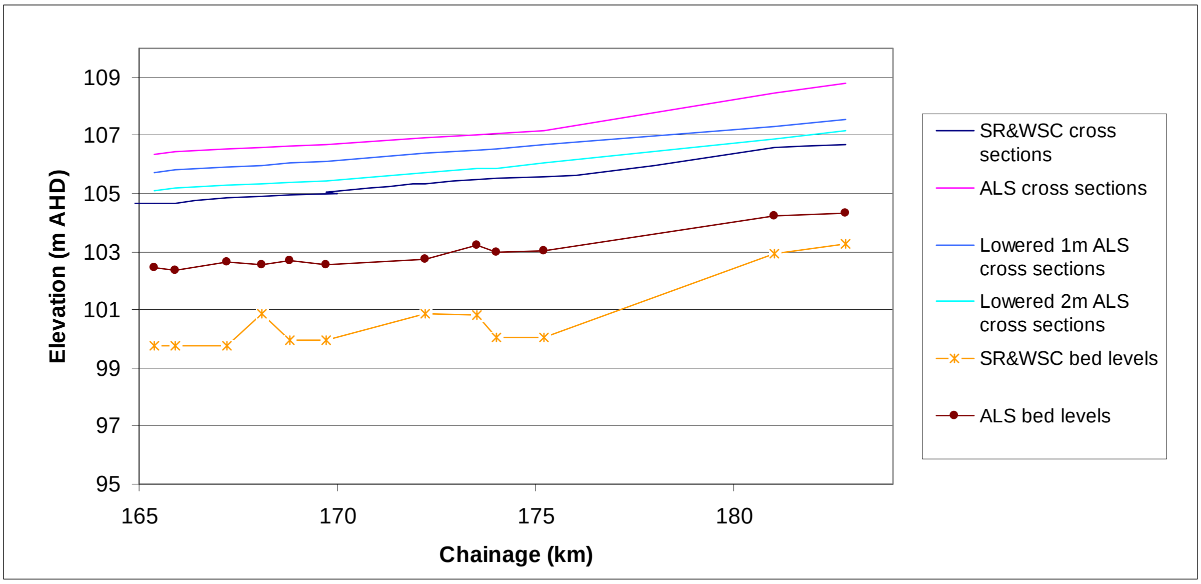


Figure 4-5 Goulburn River below Shepparton (Ch. 165 – 182) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

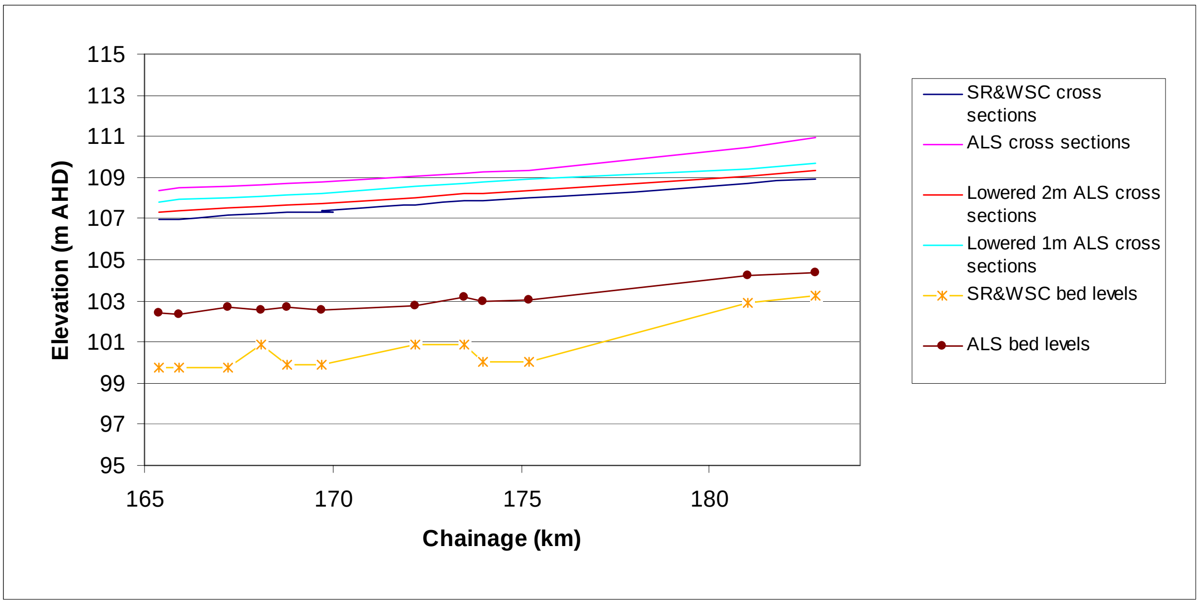


Figure 4-6 Goulburn River below Shepparton (Ch. 165 – 182) - Modelled flow profile comparison at 250 m^3/s (21,600 ML/d)

Figure 4-7 and Figure 4-8 display the flow profiles for the lower Goulburn Chainage 136- 150 km for the 100 m^3/s and 250 m^3/s respectively.

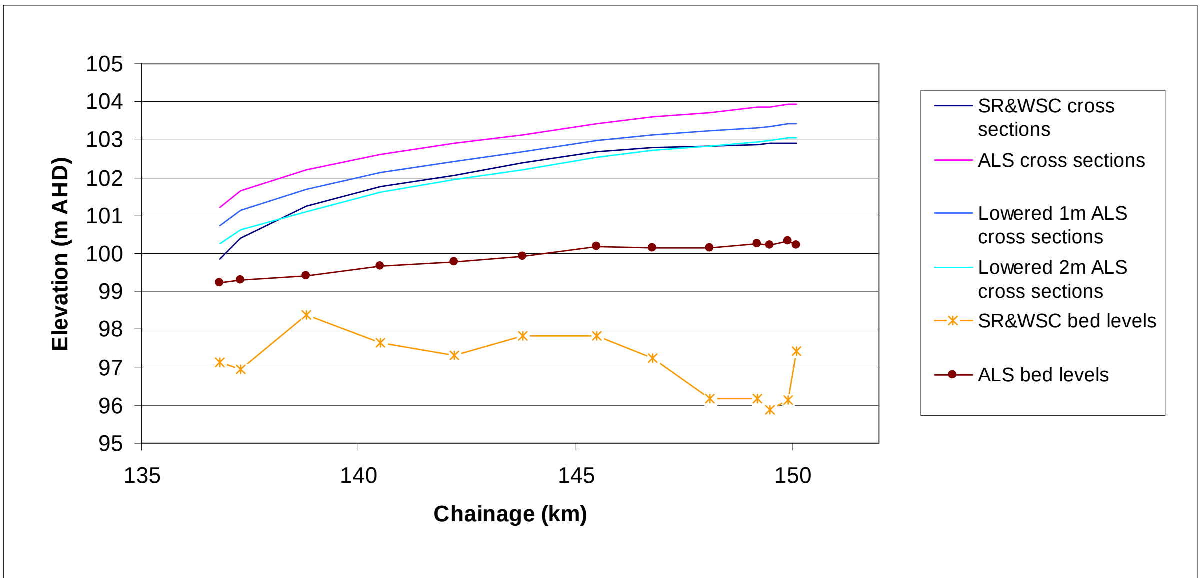


Figure 4-7 Goulburn River below Shepparton (Ch. 136 – 150) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

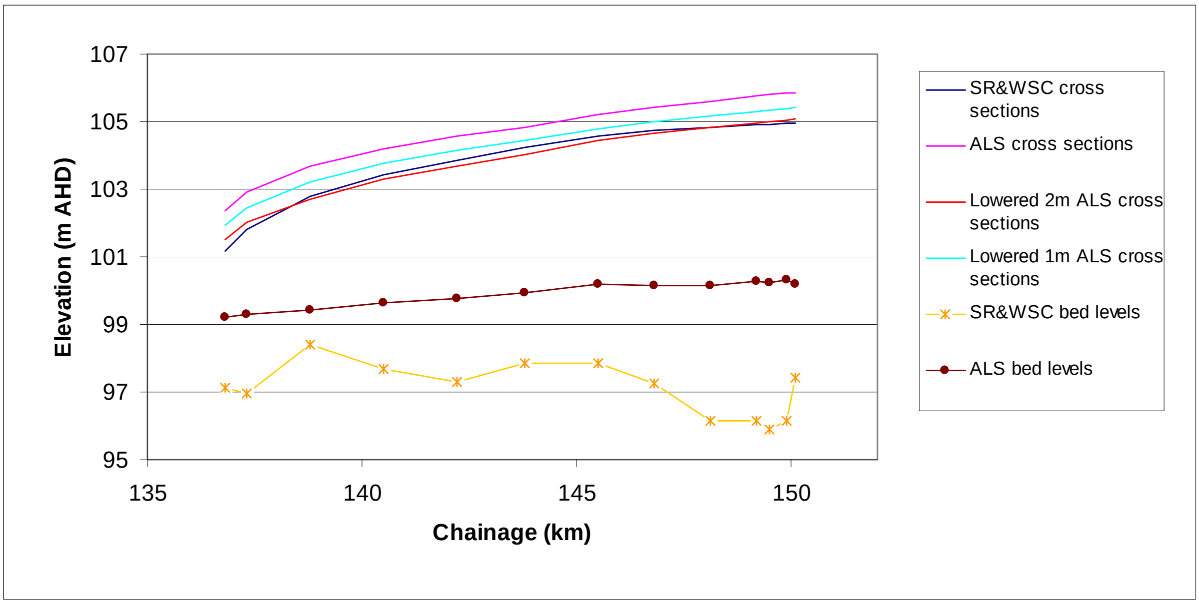


Figure 4-8 Goulburn River below Shepparton (Ch. 136 – 150) - Modelled flow profile comparison at 250 m^3/s (21,600 ML/d)

The flow profiles for the two Lower Goulburn locations show the ALS cross sections lowered by 2m fits the SR&WSC flow profile fairly well. For the reach Ch. 165 - 182 km, the profile is being slightly over estimated, and for the reach, Ch. 136-150 km the ALS lowered by 2m is line with the SR&WSC flow profile. Once again, the difference in each set of cross sections is more readily seen in the lower flow scenario of 100 m^3/s.

Figure 4-9 and Figure 4-10 displays the modelled rating curves for the lower Goulburn reaches at Chainages 150 km and 182 km respectively.

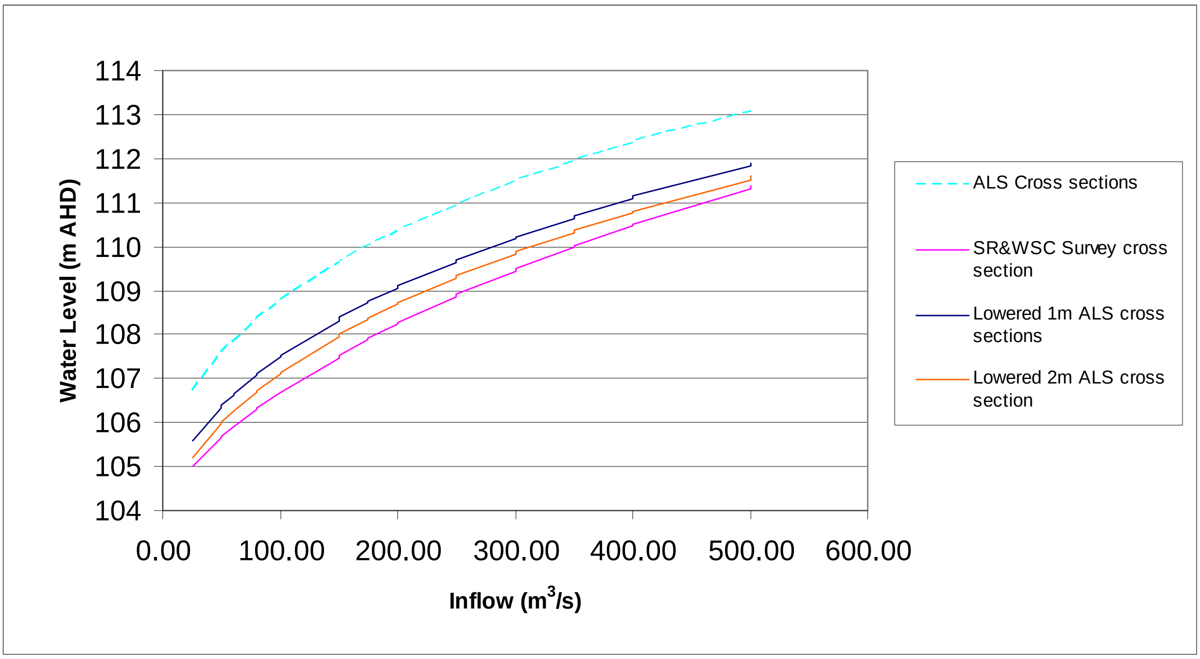


Figure 4-9 Goulburn River below Shepparton (Chainage 150 km) – Modelled rating curve comparison

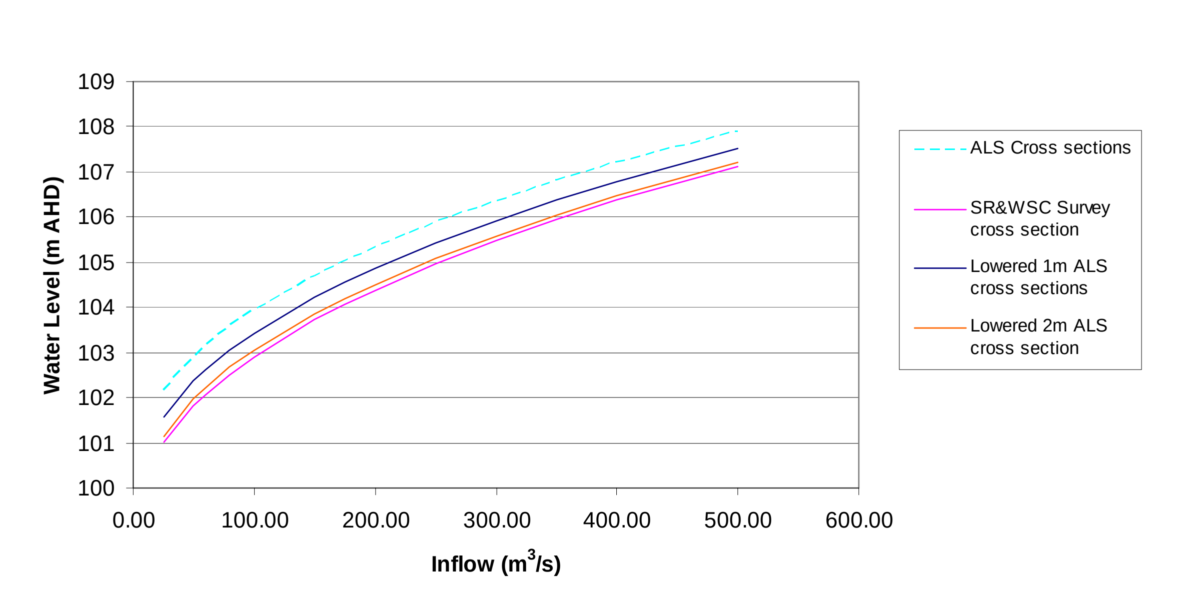


Figure 4-10 Goulburn River below Shepparton (Chainage 182 km) – Modelled rating curve comparison

Similar to the Seymour reach, the results show the un-altered ALS having approximately a 0.5 m higher water level over the flow range considered. For the ALS cross section lowered by 2m, the modelled rating curve is in line with the SR&WSC cross section results.

4.4 Goulburn River at Killingworth

The availability of continuous bathymetric data, adjacent to Killingworth, enables cross sections to be obtained at a relatively close spacing (~ 200 m).
Figure 4-11 and Figure 4-12 display the flow profiles for the Killingworth reach Chainage 356- 365 km for the 100 m^3/s and 250 m^3/s respectively.

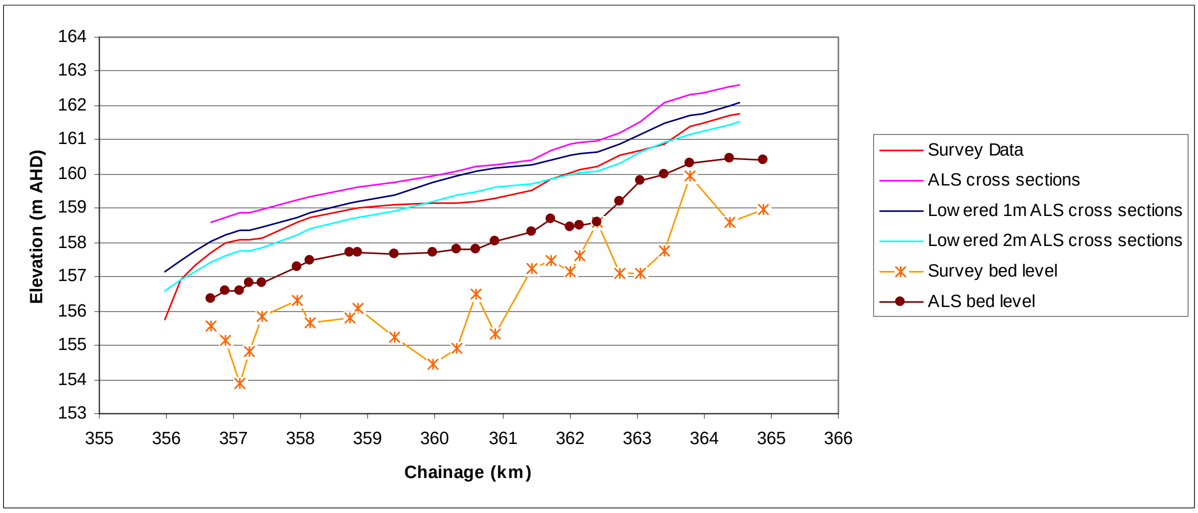


Figure 4-11 Goulburn River at Killingworth (Ch. 356 – 365) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

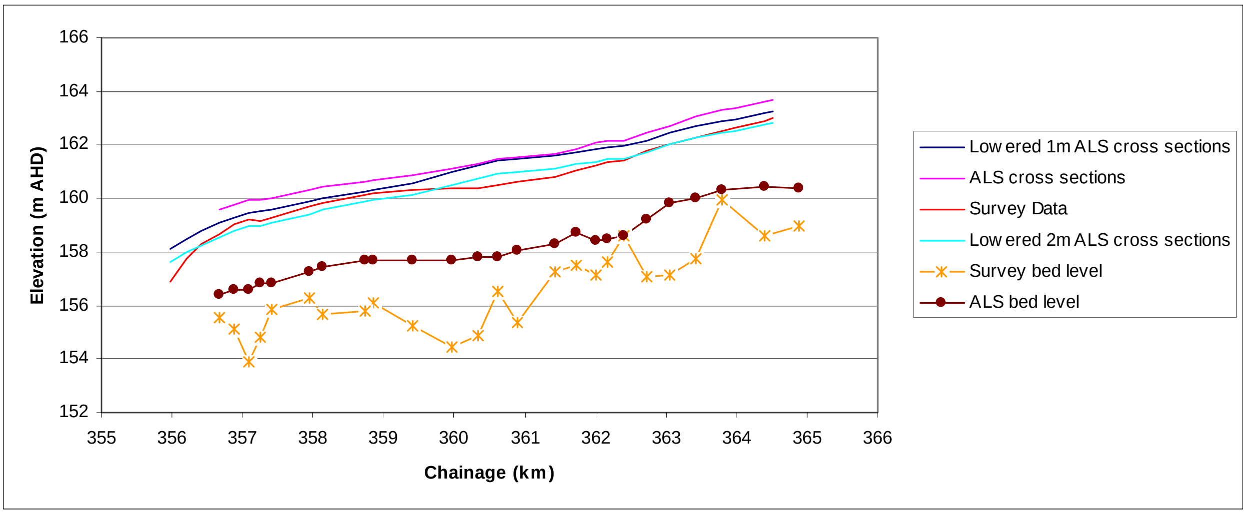


Figure 4-12 Goulburn River at Killingworth (Ch. 356 – 365) - Modelled flow profile comparison at 250 m^3/s (21,600 ML/d)

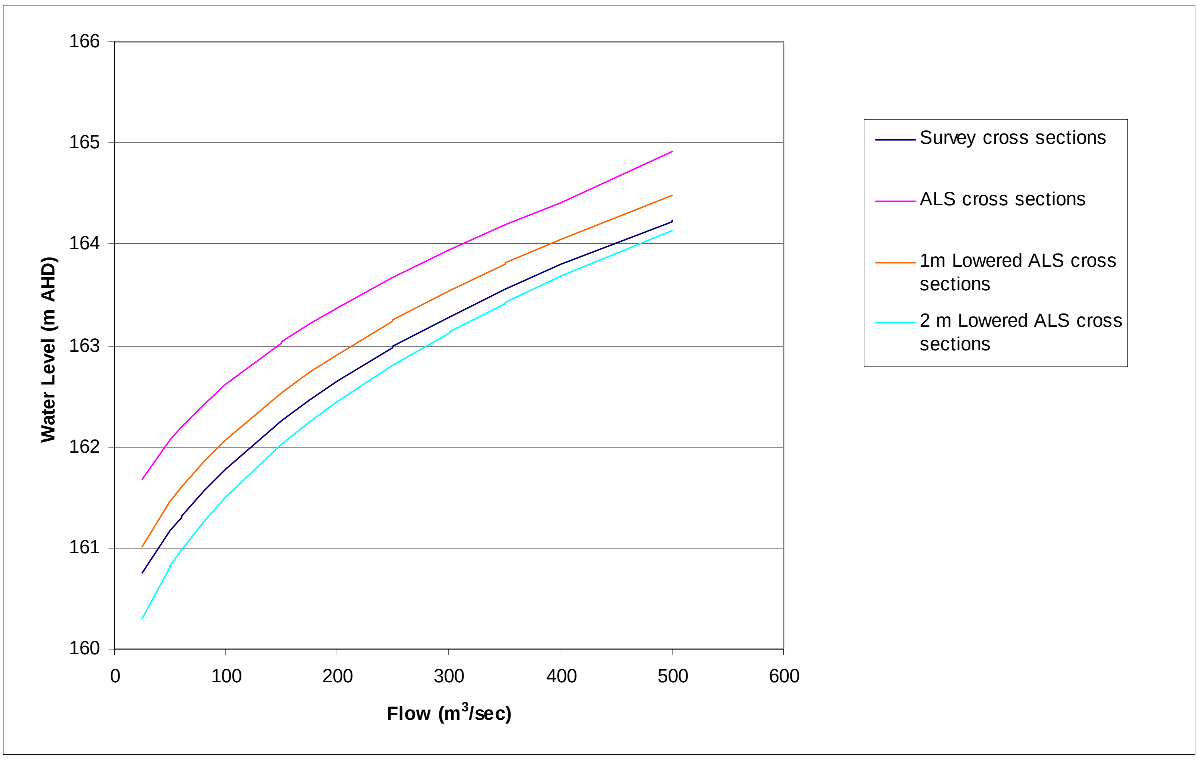


Figure 4-13 Goulburn River at Killingworth (Chainage 365 km) – Modelled rating curve comparison

4.5 Environmental Flows Requirements Study Sites

The analysis for the three sites from the Environmental Flow Requirements Study (Cottingham et al 2003) was limited to the comparison of the field surveyed and unaltered ALS cross sections.

4.5.1 Site 1 - Avenel

The modelled flow profiles for a 100 m^3/s flow are displayed in Figure 4-14.

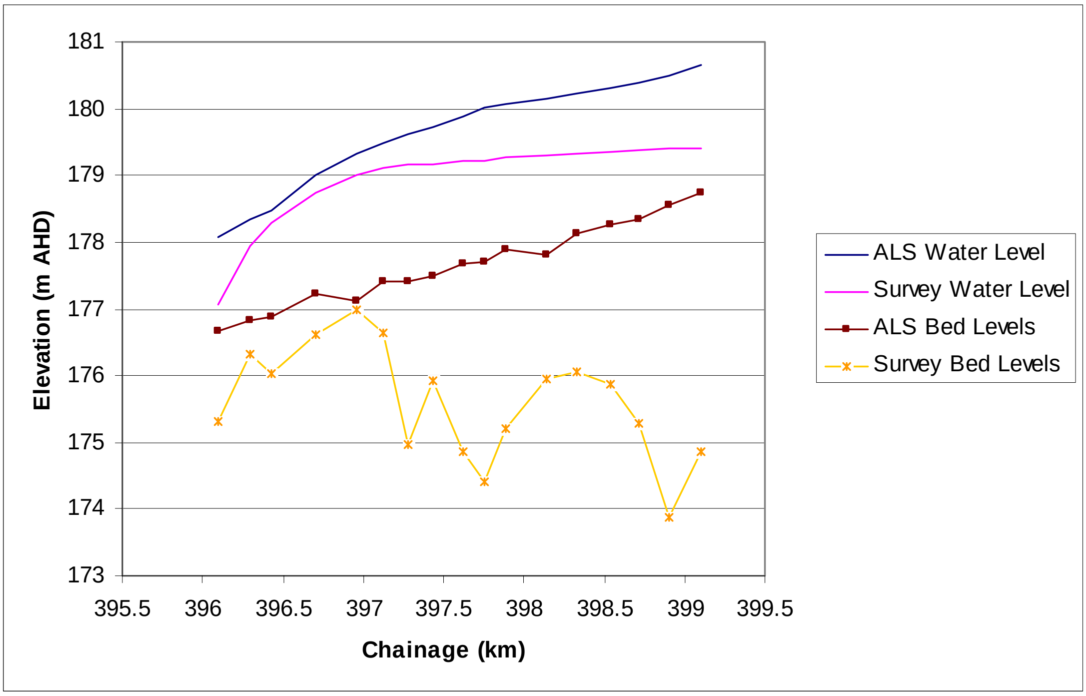


Figure 4-14 Goulburn River at Site 1 (Ch. 396 – 399) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

Considerable differences in water levels are seen along the reach. The differences arise from the differences in the bed levels yielded from the field based survey and the ALS data set.

Figure 4-15 shows the modelled rating curves, with a constant difference in water level as the inflow increases. This is consistent with the previous model results from earlier analysis. At the very high end flows the difference between model results does come down slightly to approximately 0.8 m from 1.1 m at the lower end of the flow range.

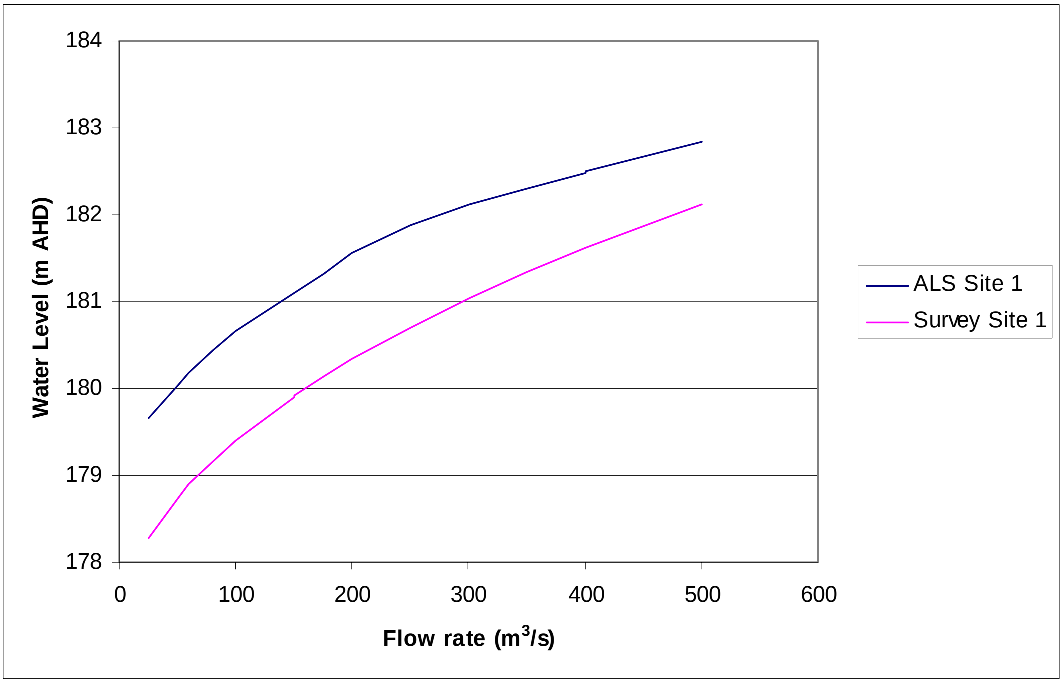


Figure 4-15 Goulburn River at Site 1 (Chainage 399 km) - Modelled rating curve comparison

4.5.2 Site 2 Yea River confluence

Figure 4-16 displays the modelled flow profiles for Site 2 (Ch. 342 – 345 km) for a rate of 100 m^3/s. The Site 2 results show a similar result to the Site 1 results with the ALS grossly over estimating the water level when there is a deeper section of river present but the difference narrows down when there is a shallower section of river where the difference between the ALS and field surveyed bed levels is minimal.

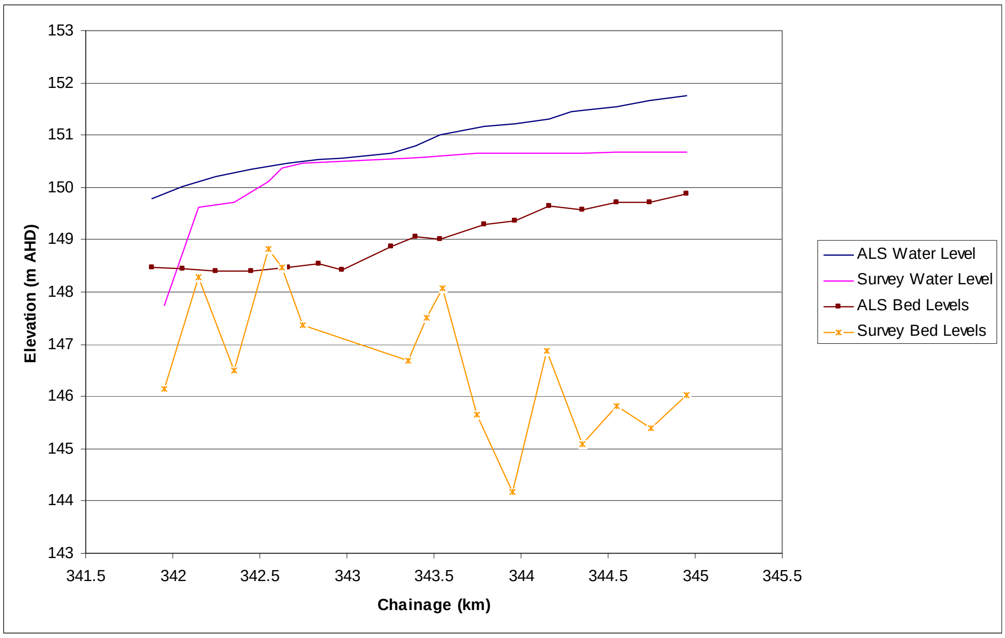


Figure 4-16 Goulburn River at Site 2 (Ch. 342 – 345) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

As for Site 1, Figure 4-17 displays the water level difference in the modelled rating curve of up to 1 m.

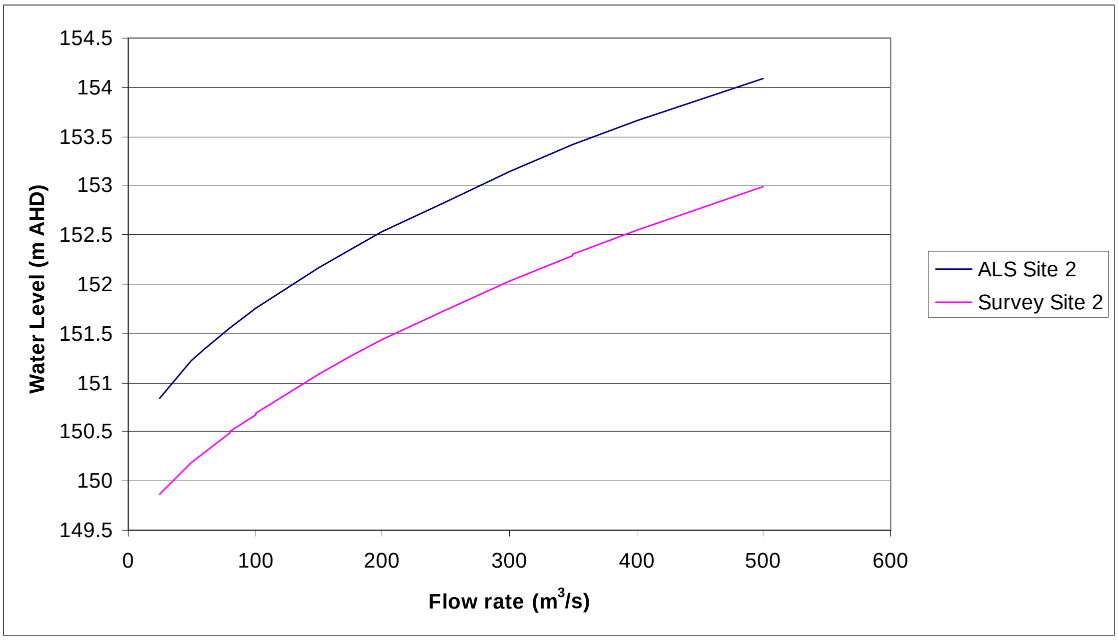


Figure 4-17 Goulburn River at Site 2 (Chainage 345 km) - Modelled rating curve comparison

4.5.3 Site 3 Alexandra

The field surveyed cross sections for Site 3 show a relatively flat section of the Goulburn River. This flat section produces a more consistent difference in the water levels from the ALS and surveyed cross sections, as seen in the flow profile for a 100 m^3/s flow shown in Figure 4-18.

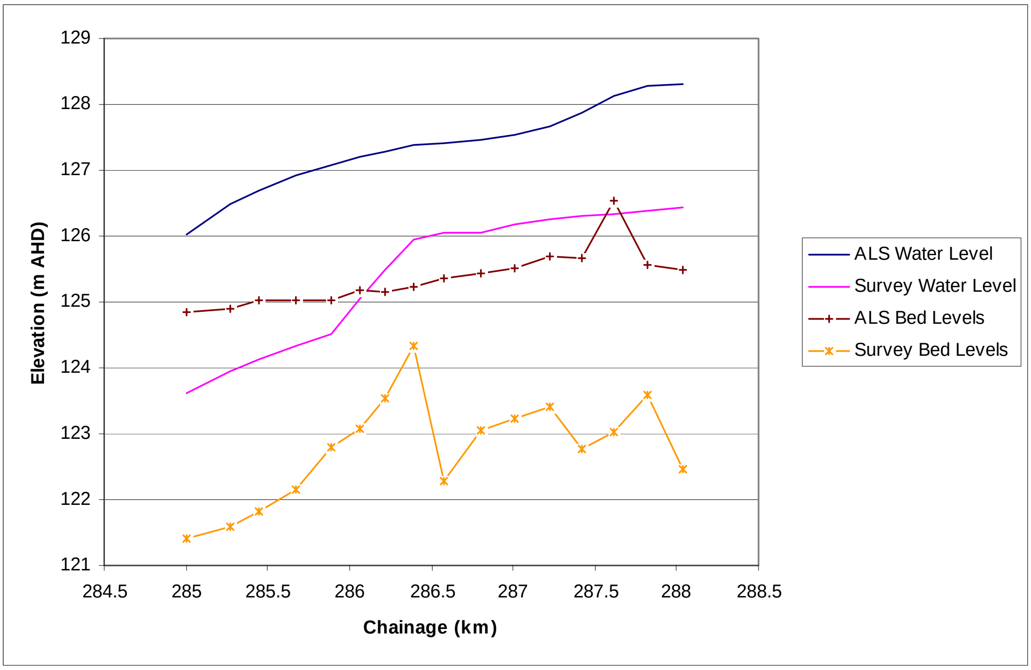


Figure 4-18 Goulburn River at Site 3 (Ch. 285 – 288) - Modelled flow profile comparison at 100 m^3/s (8,640 ML/d)

Figure 4-19 displays the modelled rating curves from both the ALS and the surveyed cross sections. A consistent difference in water level is approximately 1.5 m for the whole range of inflows.

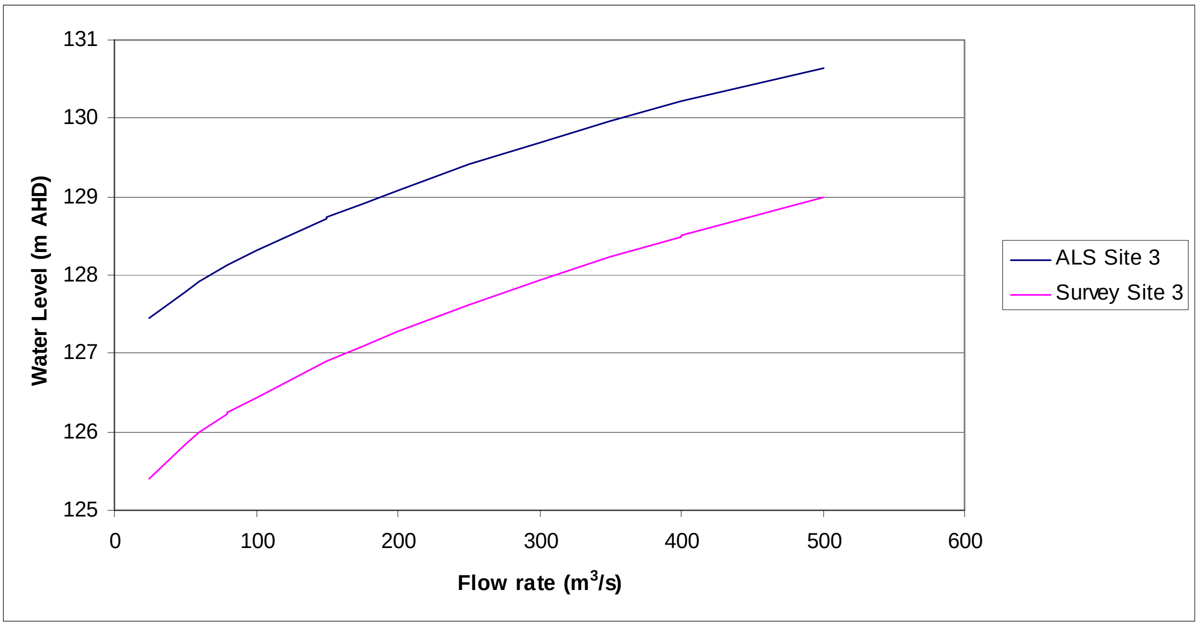


Figure 4-19 Goulburn River at Site 3 (Chainage 288 km) - Modelled rating curve comparison

4.6 Streamflow gauge rating curve comparison

The comparisons discussed in Sections 4.2 to 4.5 are between sets of hydraulic model results. This section discusses the comparison of modelled rating curves to gauged rating curves at key streamflow gauge locations. The key gauge locations include:

- Gauge 405200A - Goulburn River at Murchison
- Gauge 405201B – Goulburn River at Trawool
- Gauge 405202B – Goulburn River at Seymour
- Gauge 405203C – Goulburn River at Eildon (Downstream)
- Gauge 405204C – Goulburn River at Shepparton

The most recent rating curve for the five above gauges were sourced from Thiess – Hydrographic Services.

Figure 4-20 to Figure 4-24 display the comparison of modelled (with un-alternated ALS data) and gauged rating curve at the above streamflow gauge locations.

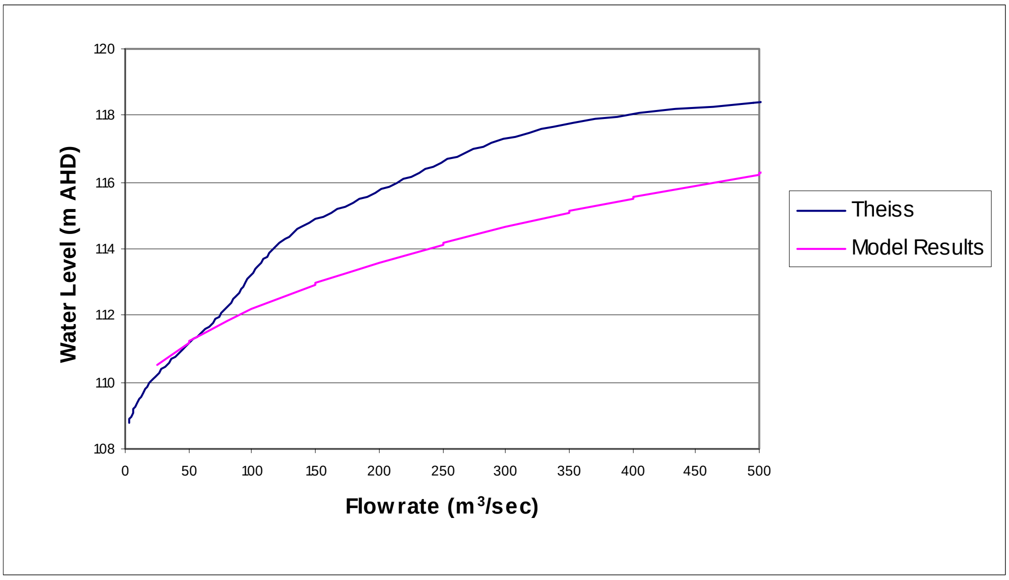


Figure 4-20 Goulburn River at Murchison (405200A) - Modelled and gauged rating curve comparison

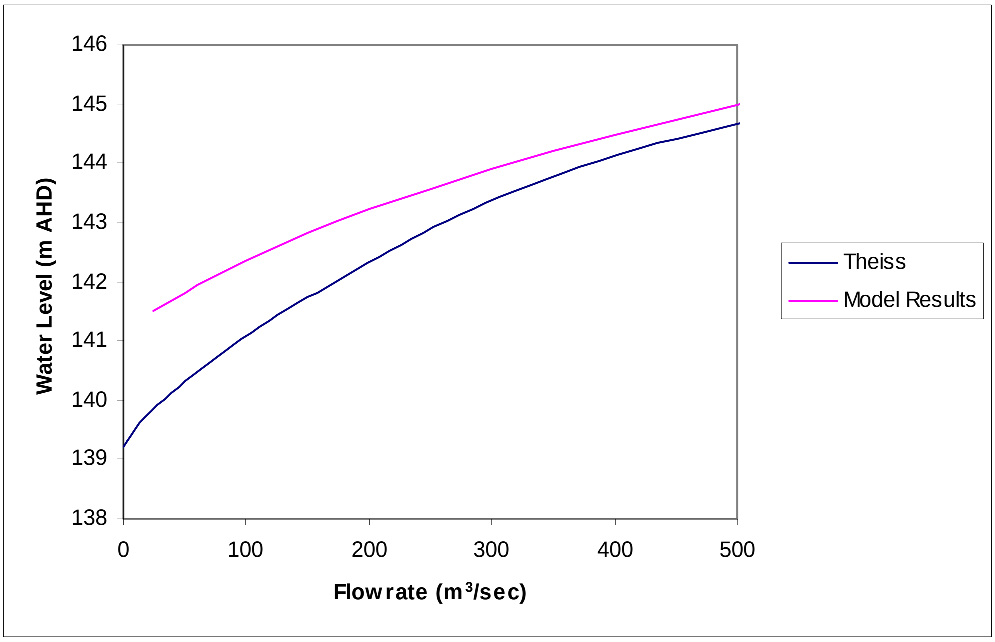


Figure 4-21 Goulburn River at Trawool (405201B) - Modelled and gauged rating curve comparison

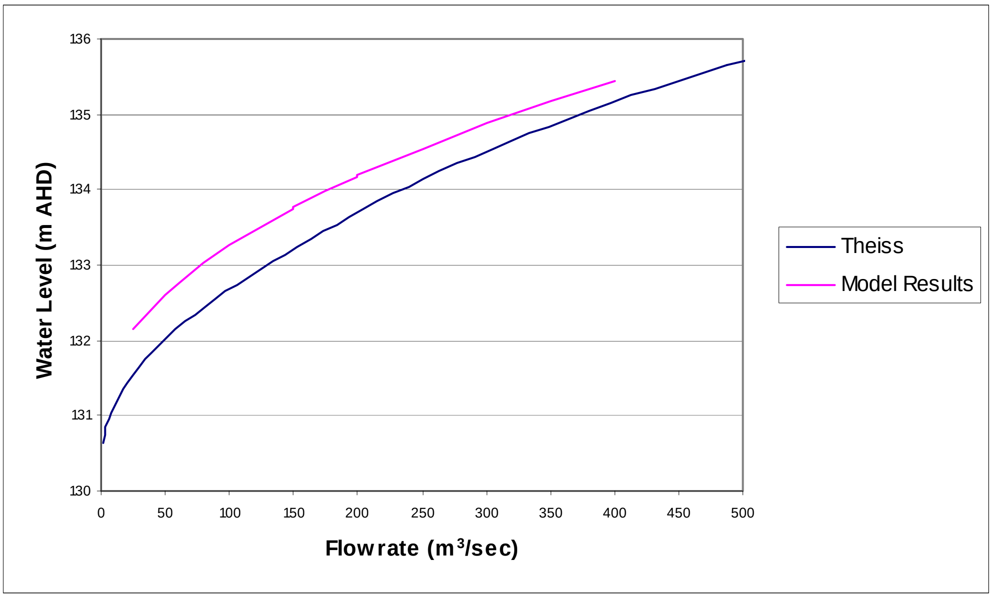


Figure 4-22 Goulburn River at Seymour (405202B) - Modelled and gauged rating curve comparison

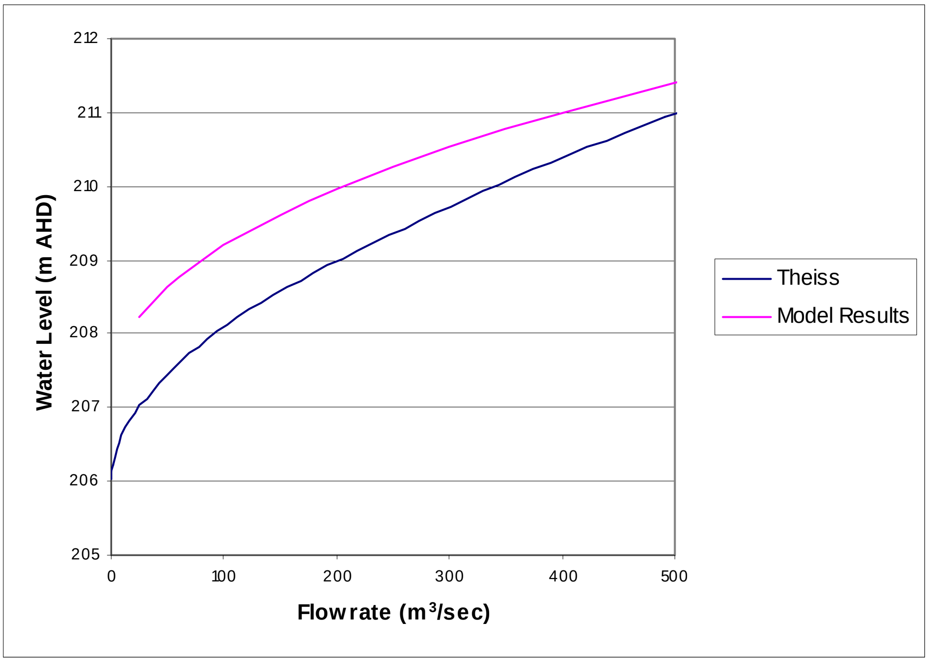


Figure 4-23 Goulburn River at Eildon (downstream) (405203C) - Modelled and gauged rating curve comparison

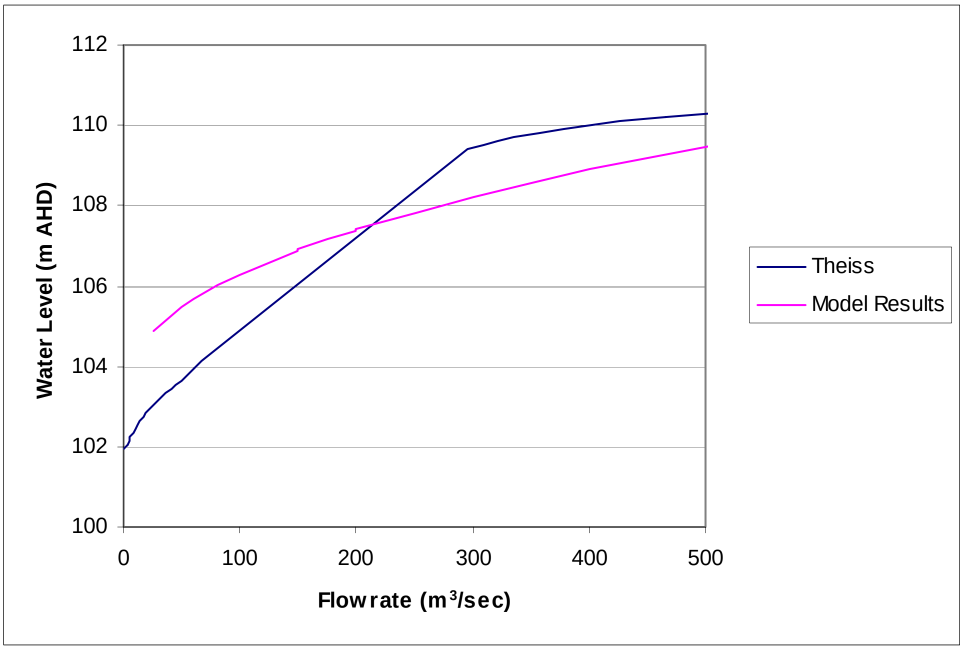


Figure 4-24 Goulburn River at Shepparton (405204B) - Modelled and gauged rating curve comparison

In line with the modelled rating curve comparisons, the comparisons to gauged rating show the higher modelled water levels for a given flow at Eildon, Trawool and Seymour. At Shepparton (Figure 4-24), modelled rating curve provides higher water levels for flows up to 200 m^3/s. However, for higher flows, the modelled rating curve yields lower water levels. This behaviour is due to the gauged rating curve reflecting floodplain flows above 200 m^3/s. The 1D hydraulic model for the Shepparton reach does not consider the floodplain flows. The differences in the modelled and gauged rating at Murchison appear to be inconsistent with the other sites. The reasons for the inconstancy are being investigated.

4.7 Goulburn River – Eildon to Goulburn Weir

As outlined in Section 4.1, 1D hydraulic model was constructed from downstream of Eildon to upstream of Goulburn Weir. The 1D hydraulic model was limited to upstream of Goulburn Weir due to absence of bathymetric data for Lake Nagambie (Goulburn Weir pondage). The cross sections for this 1D model were extracted from the ALS data set without any alternation. The extracted cross sections were nominally at a spacing of 400-500 m, and only included the main Goulburn River channel i.e. no floodplain areas considered. Given the use of the main Goulburn River channel cross sections, the 1D model is suitable for routing flows up to bankfull.

To remove uncertainty associated with ungauged tributary contributions downstream of Eildon, the 1D model were applied to a streamflow sequences dominant by releases from Eildon. The period March 2005-May 2005 were selected as a suitable historical streamflow sequence.

The 1D model were run over the selected period with the only model inflows downstream of Eildon.

Figure 4-25 to Figure 4-28 provide comparison of observed and modelled water levels and flows, at Trawool and Seymour for the period March–May 2005.

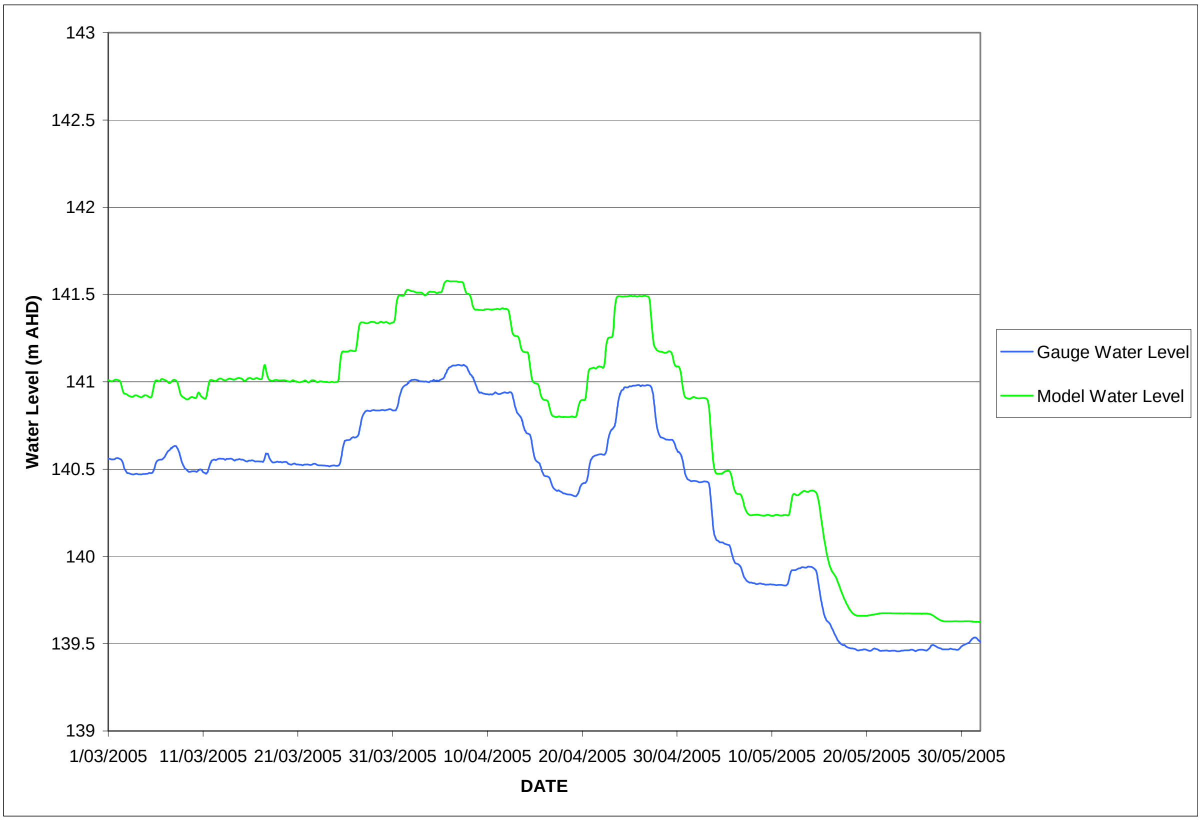


Figure 4-25 Goulburn River at Trawool – March-May 2005 – Water levels

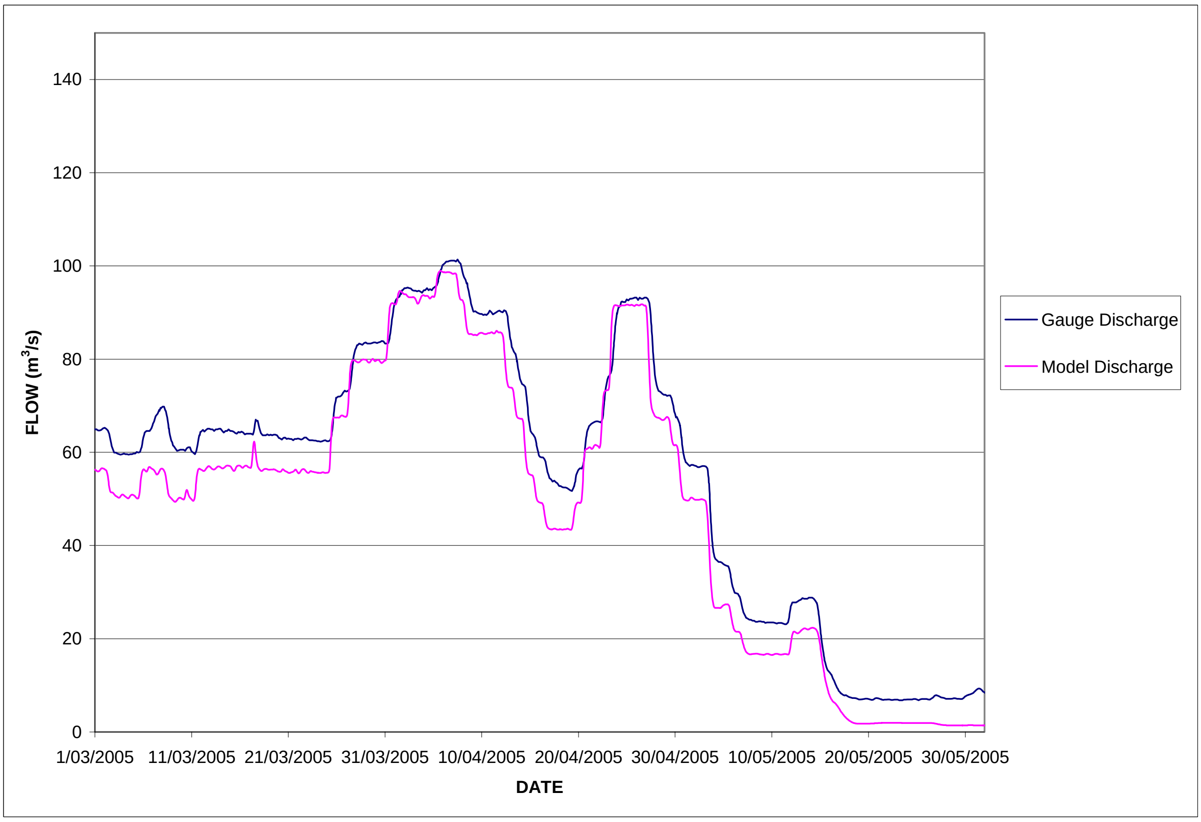


Figure 4-26 Goulburn River at Trawool – March-May 2005 – Flows

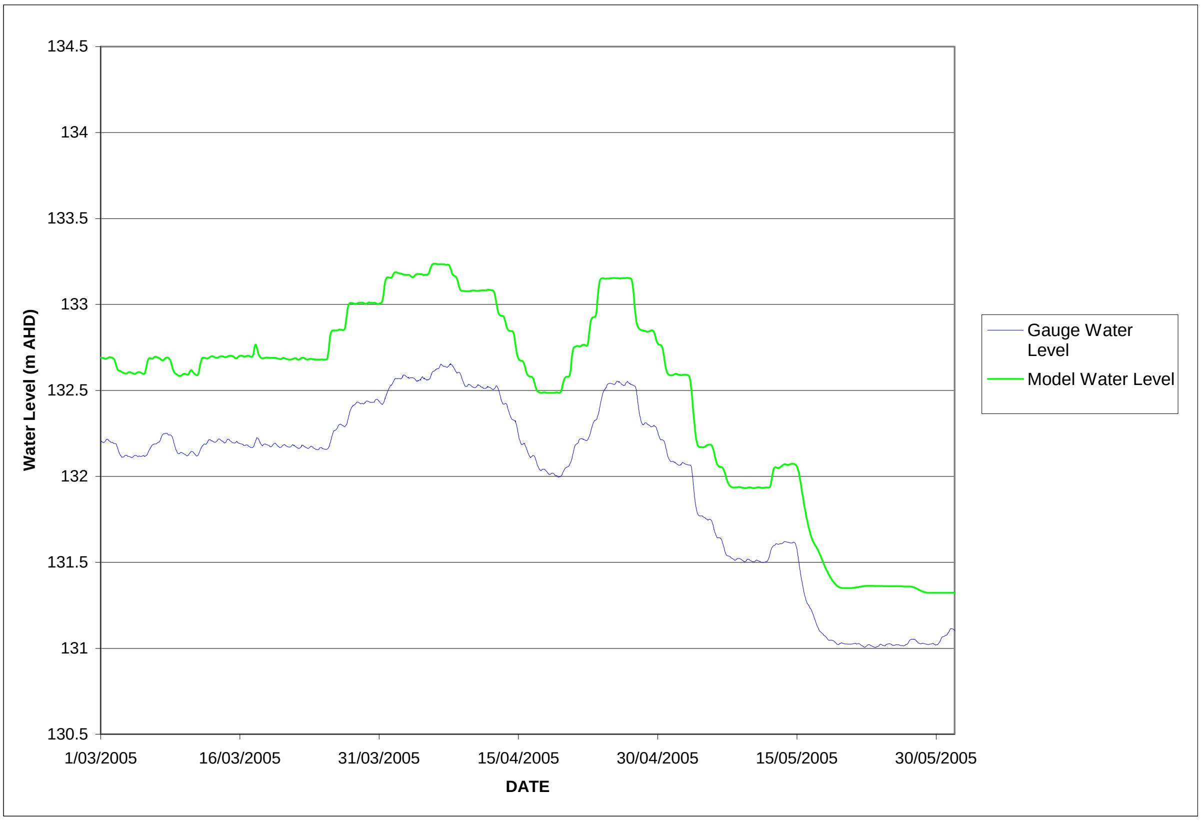


Figure 4-27 Goulburn River at Seymour – March-May 2005 – Water levels

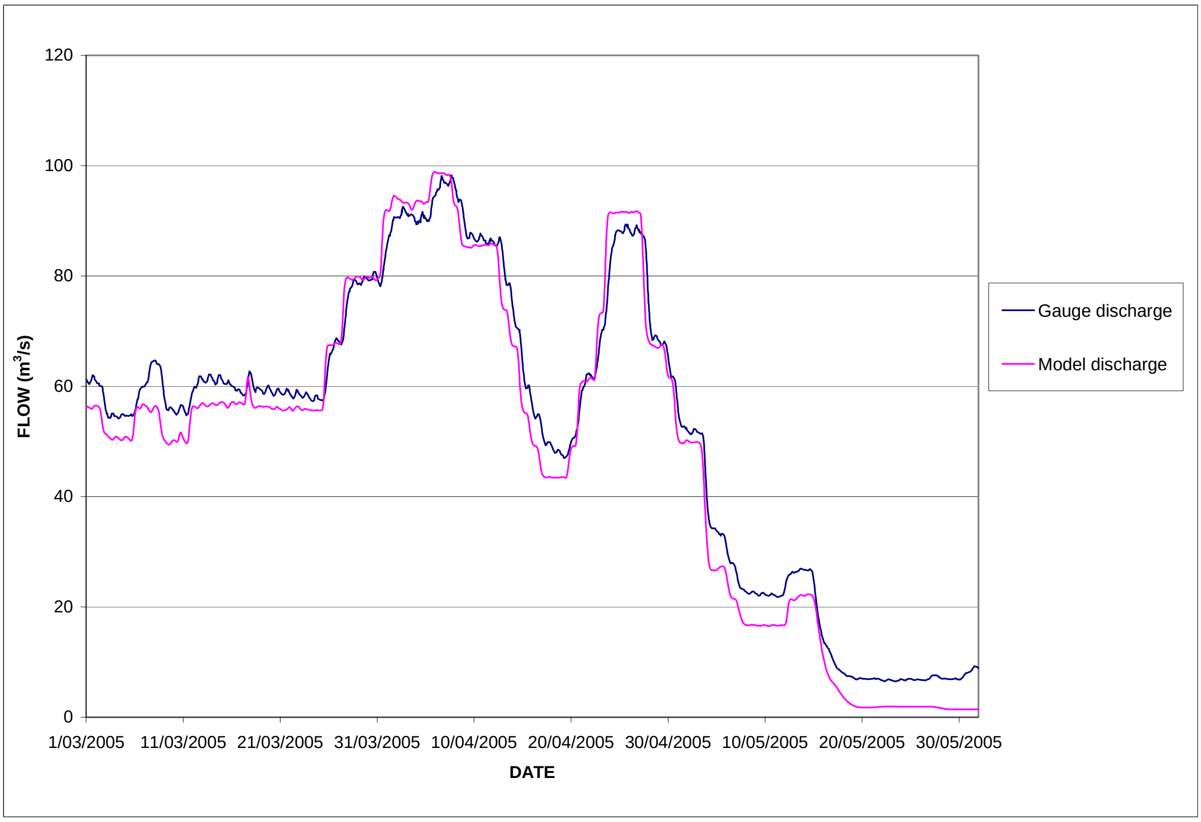


Figure 4-28 Goulburn River at Seymour – March-May 2005 – Flows

The above water level comparisons show a consistent difference in modelled and observed of about 0.5 m. This difference is in line with the difference discussed in previous sections. The difference reflects the cross section area and conveyance not captured in the ALS data set.

The flow comparisons show a good agreement in the flow magnitude and timing at both Seymour and Trawool. These comparisons provide confidence in the 1D model's ability to simulate in channel flow behaviour.

4.8 Discussion

The comparison of modelled flow profiles and, rating based field survey and ALS extracted cross sections generally suggest the use of the ALS data (without alternations) yields higher water levels for a given flow. The higher water levels, generally range to up 2 m, with a median value of around 0.5 m.

The comparison of the observed and modelled time-series of flows and stages at Seymour and Trawool (Figure 4-25, Figure 4-26, Figure 4-27 and Figure 4-28), for the period March 2005- May 2005, shows the following:

- Good reproduction of flow magnitudes and timing.
- A relative uniform overestimation of observed water levels by about 0.5 m.

The differences in water levels, due to the ALS data, generally remain relative constant over the flow range considered (nominally up to bankfull). This constant difference reflects the pattern in the cross section conveyance (function of flow area and hydraulic radius) between the field surveyed and ALS cross section. Figure 4-29 show a typical conveyance curve for the Goulburn River at Killingworth.

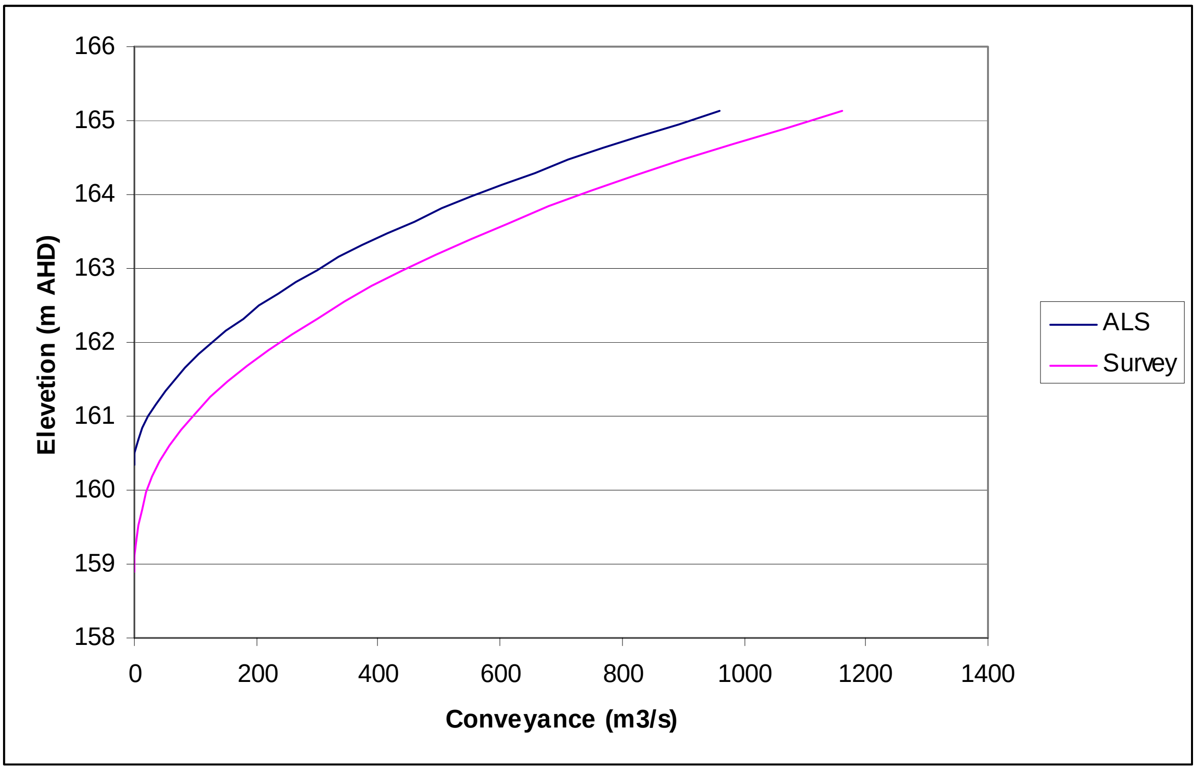


Figure 4-29 Goulburn river at Killingworth – Cross section conveyance

This overestimation in modelled water levels stage could be resolved by the conveyance employed in the hydraulic modelling. The conveyance can be reduced by decreasing the hydraulic roughness (Manning's n), increasing waterway area by lowering the channel invert, or a combination of both elements.

The decreased Manning's value will introduce unrealistic values. The use of unrealistic Manning's n is considered undesirable as the effort to compensate for the unaccounted waterway area is lumped into roughness values. Further, the lower Manning's n will increase the flood wave speed and affect the flood travel time along the river.

Downstream of Lake Nagambie, the recent bathymetric survey will be incorporated into the hydraulic modelling. Hence, no other alternation to the ALS data is necessary to enable use in the hydraulic modelling.

Upstream of Lake Nagambie, lowering the channel invert can be achieved by either obtaining bathymetric survey or an assumed alternation to the ALS data.

The capture of bathymetric data, below the water level at the time of the ALS capture, will provide data on the waterway geometry, and in turn enable revision of the waterway area and conveyance. The inclusion of the additional bathymetric data in the hydraulic modelling will enable model calibration, for the 1D (in-bank) model, to the rating curves and measured stages at key streamflow gauges. The predictive capability of the 1D hydraulic model, in between the gauges, is unable to be formally evaluated, due to the absence of observed stages at immediate locations.

GBCMA (Geoff Earl pers.comms) provided the scope of the bathymetric survey recently undertaken for the reach Goulburn Weir to Shepparton. This recent survey proposed a single bathymetric survey along the centreline of the "current" low level waterway, with a nominal sampling interval of 550 mm.

This proposed survey approach provides an indication of the bed profile. However, the capturing a single bathymetric string along the waterway centreline may not provide the deepest point in the waterway cross section. The undertaking of "circles", as noted, will further refine the waterway geometry at pools. From a hydraulic modelling perspective, the capture of riffle sections are of primary importance. These riffle sections control the low flow regime when focusing on reach scale hydraulics behaviour. However, the capture of the riffle sections has a lessening influence on hydraulic behaviour as the flow approaches bank full.

The incorporation of the single bathymetric string into the hydraulic modelling will aid to improve the hydraulic model predictive capability at or near bankfull flows. This improvement at this flow range then provides for improved modelling of the flow required to engage floodplain wetlands. However, this proposed survey approach at lower flows may provide reduced improvements, due to the entire waterway cross section geometry not being captured at a location.

Hence, the value of this proposed approach depends on the focus of the hydraulic modelling. Such a proposed approach is sufficient if the primary focus is on understanding the engagement of floodplain wetlands. On the other hand, if the primary focus, is understanding the flow regime required to inundate in-channel features, then additional lateral survey points across the waterway cross section are required. Given this study focus on wetland engagement, this recent bathymetric survey data is likely to be of great value in resolving an element of uncertainty.

The comparison of the cross section extracted from the ALS with surveyed cross sections, reveal that the ALS data reflects the cross section geometry above the water level. As such, the capture of additional cross sections is considered unwarranted.

Preliminary hydraulic analysis, outlined in Sections 4.2 to 4.5, indicate that uniform alternations to the ALS cross sections, by lowering the bed levels by 1 m and 2 m, yielded modelled flow profiles and rating curves approaching the field surveyed results.

Given these results from the preliminary analyses is considered likely that alternations to the ALS bed levels, are likely to yield a reasonable comparison of observed and modelled water levels at the gauges over longer flow time-series

As the available cross sections and bathymetry is relatively spatially spread, the variation of an alternation would be difficulty to assess and assign. A single uniform alternation is simple, and removes the need for further assumptions regarding the spatial variation.

Such a uniform alternation, while providing good comparison at the gauges, is not easily evaluated at immediate locations. Some insight could be gained for higher flows as part of the model calibration to flood events, where observed flood levels were available. As discussed, the use of a uniform alternation, like the inclusion of additional bathymetry, is difficult to assess at immediate locations (between the gauges). However, the additional bathymetry does remove an element of uncertainty regarding the bed geometry.

5 CONCLUSIONS AND RECOMMENDATIONS

This report has reviewed and assessed the available topographic data for use in the hydraulic modelling of the Goulburn River below Lake Eildon.

The following conclusions are provided:

- ALS data set provides a good representation of the waterway geometry above the water level at the time of the data capture, when compared to the available field surveyed cross sections.
- Field surveyed cross sections/ bathymetry is limited to several short reaches of the Goulburn River upstream of Lake Nagambie.
- Available field survey indicates significant variation in the bed level of the Goulburn River, over the available surveyed reaches.
- The use of ALS data set, without alternations, will overestimate water levels for a given flow. This overestimation ranges up to 2 m, with a median value of around 0.5 m for the available surveyed reaches. This is variable within short reaches and between reaches.
- The capture of additional bathymetric data, upstream of Lake Nagambie, removes an element of uncertainty regarding the waterway bed geometry and underpins a consistent bathymetric data source along the entire study area.
- The use of a uniform alternation in ALS data bed levels, upstream of Lake Nagambie, is likely to yield a good comparison of modelled and observed flow and water levels at gauges.
- The predictive capability of the 1D hydraulic model, in between the gauges, is unable to be formally evaluated, due to the absence of observed stages at immediate locations.

Given these above conclusions, the study team recommends the capture of bathymetric data for the Goulburn River upstream of Lake Nagambie. The study team considers the scope of the recent bathymetric data survey to be appropriate for the remaining reach above Goulburn Weir.

However, the study team recognises the considerable cost and time involved in any further bathymetric survey capture. To progress the study, the 1D hydraulic modelling will employ a uniform alternation to the ALS bed level.

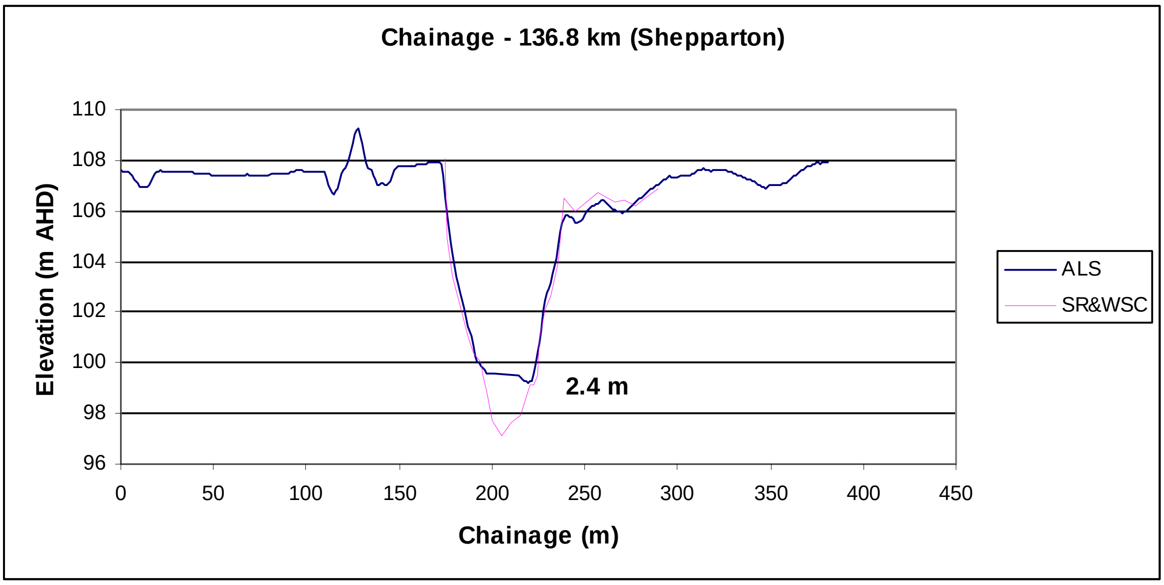
In summary, the additional bathymetry data capture is desirable to remove a source of uncertainty. However, the use of a uniform alternation provides a reasonable approach to the assessment of floodplain wetland engagement, with limitations on in-channel flow behaviour at a specific location. The 1D modelling could be revised as bathymetry becomes available.

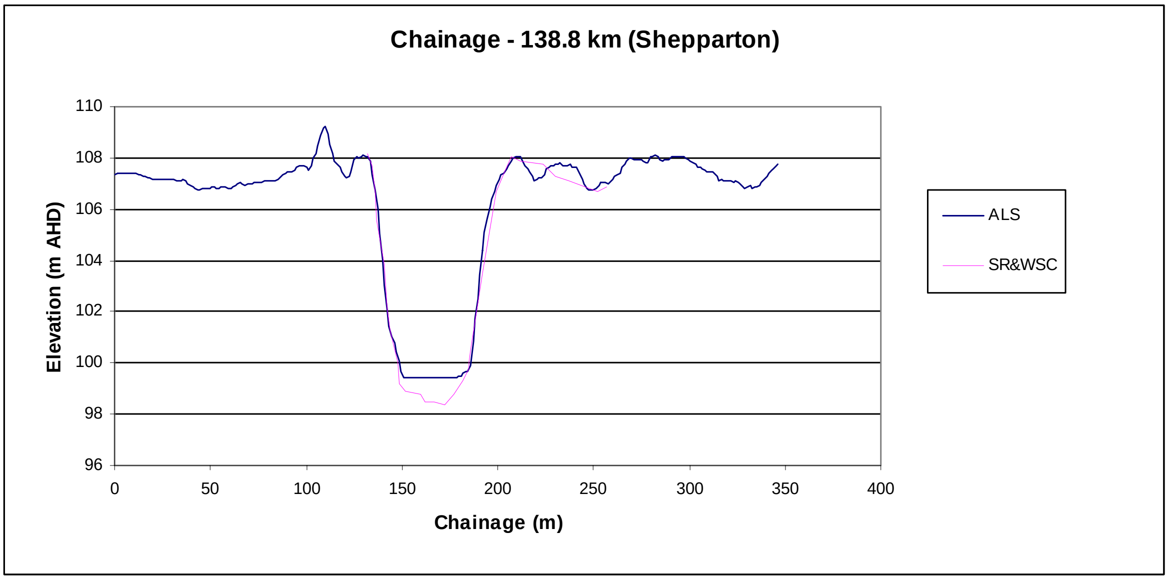
REFERENCES

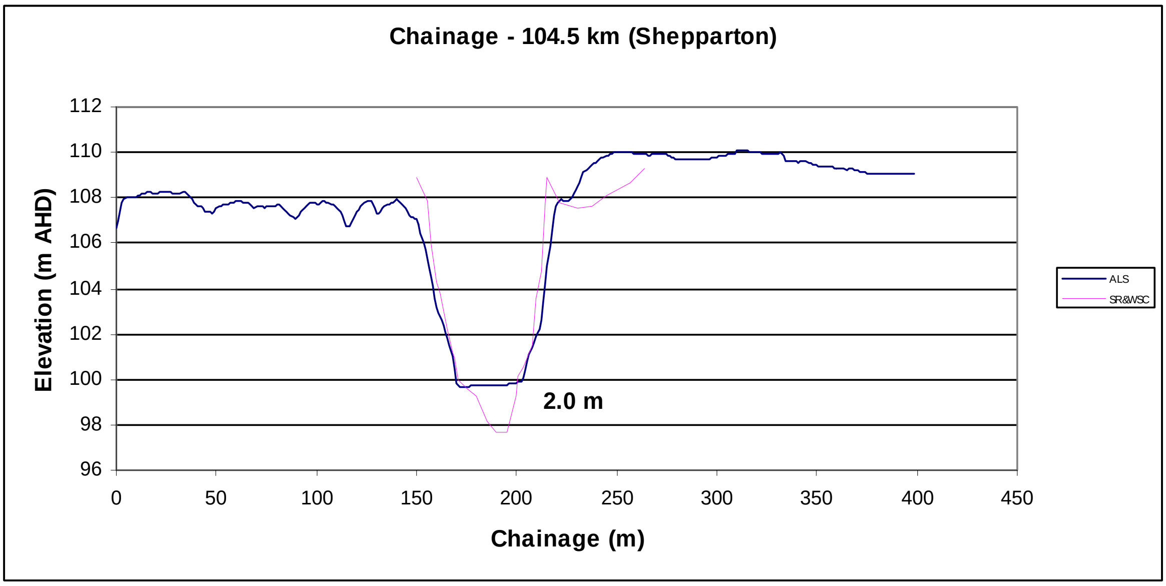
Cottingham P, Stewardson M, Crook D, Hillman T, Roberts J, and Rutherfurd I 2003. *Environmental flow recommendations for the Goulburn River below Lake Eildon.* University of Canberra, ACT 2601 Technical Report 01/2003. November 2003.

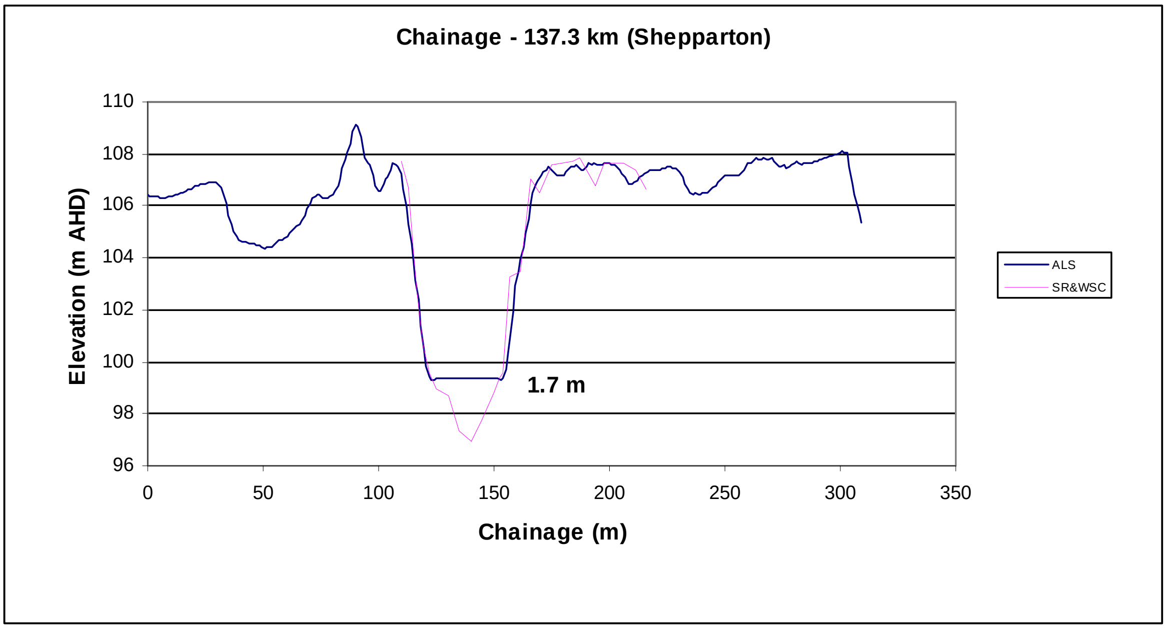
APPENDIX A WATERWAY CROSS SECTION COMPARISON

Lower Goulburn below Shepparton
Cross section comparison








Chainage - 137.3 km (Shepparton)
Elevation (m AHD)
110
108
106
104
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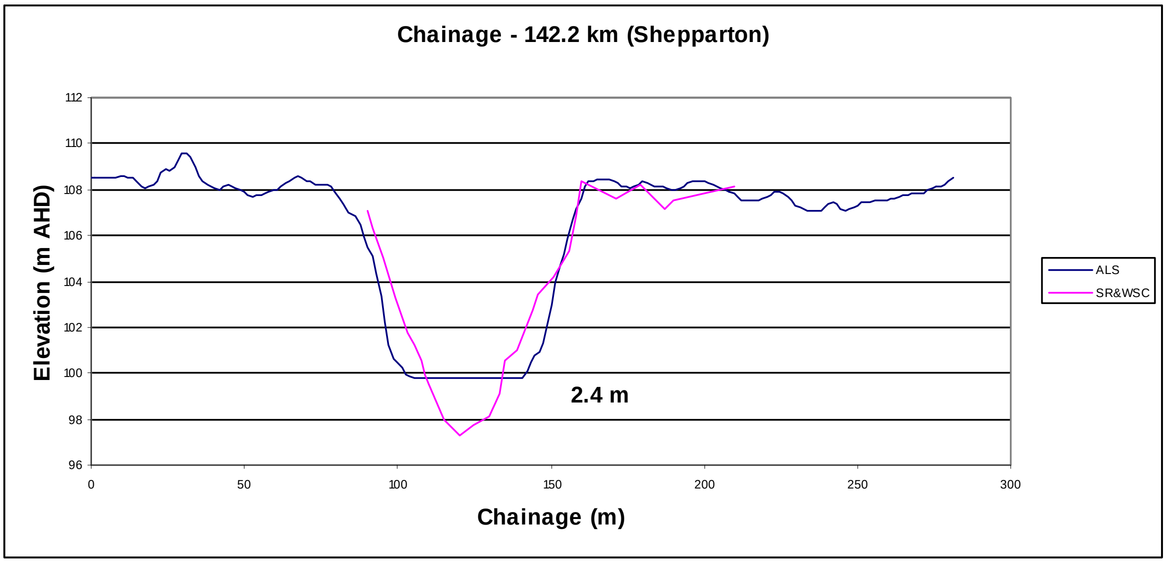
98
96
0
50
100
150
200
250
300
350
Chainage (m)
1.7 m
ALS
SR&WSC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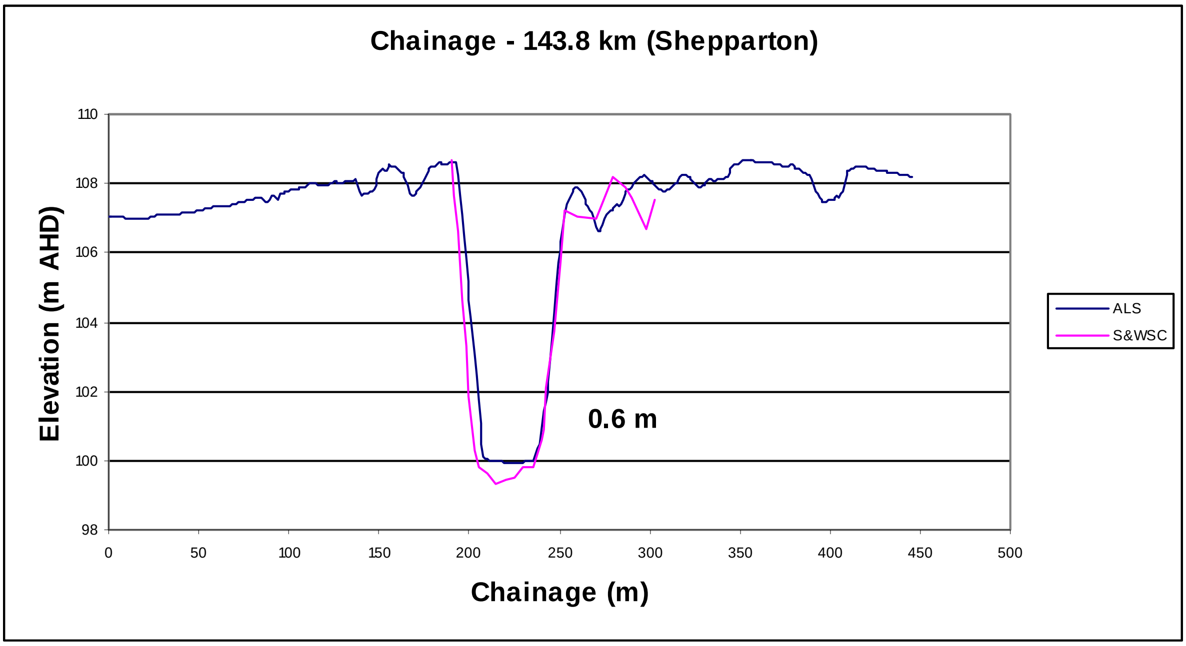
Elevation (m AHD)
112
110
108
106
104
102
100
98
96
0
50
100
150
200
250
300
Chainage (m)
2.4 m
ALS
SR&WSC


Chainage - 143.8 km (Shepparton)
Elevation (m AHD)
110
108
106
104
102
100
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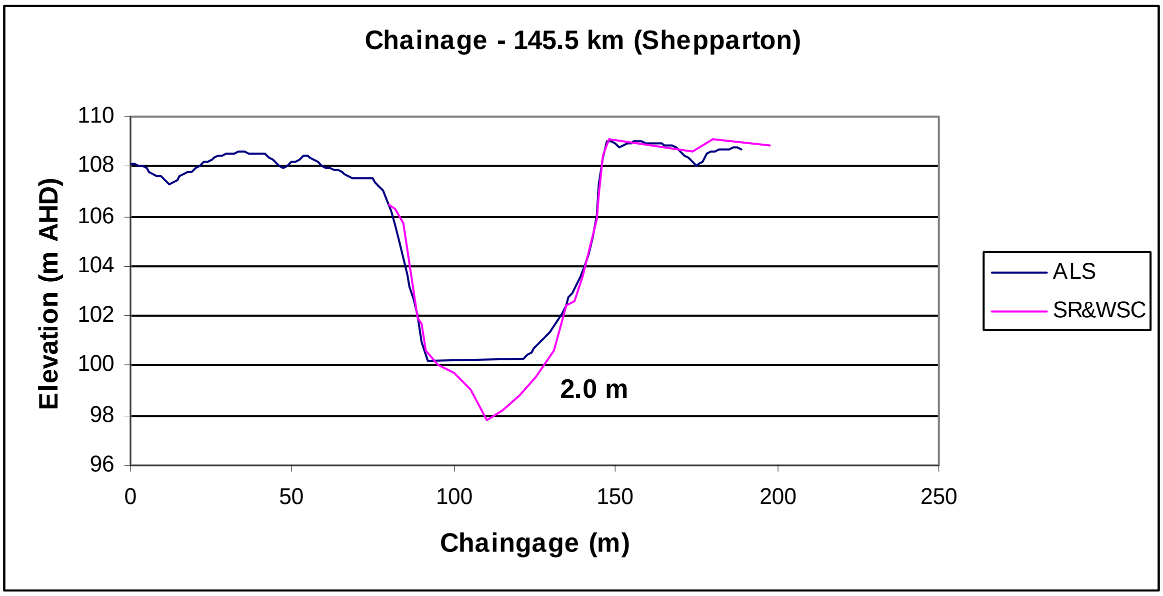
0
50
100
150
200
250
300
350
400
450
500
Chainage (m)
0.6 m
ALS
S&WSC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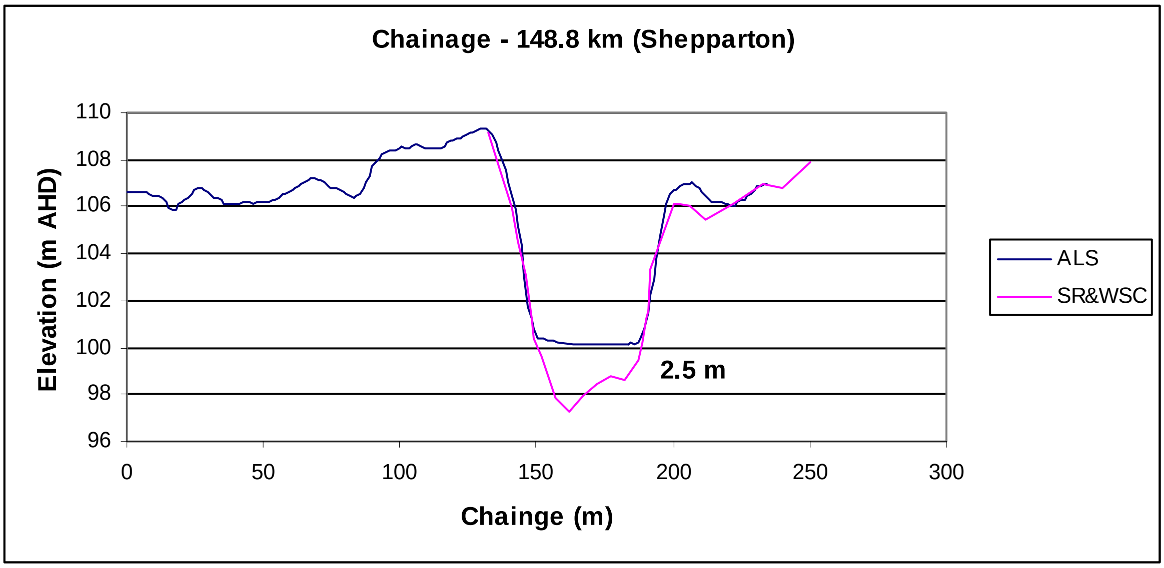
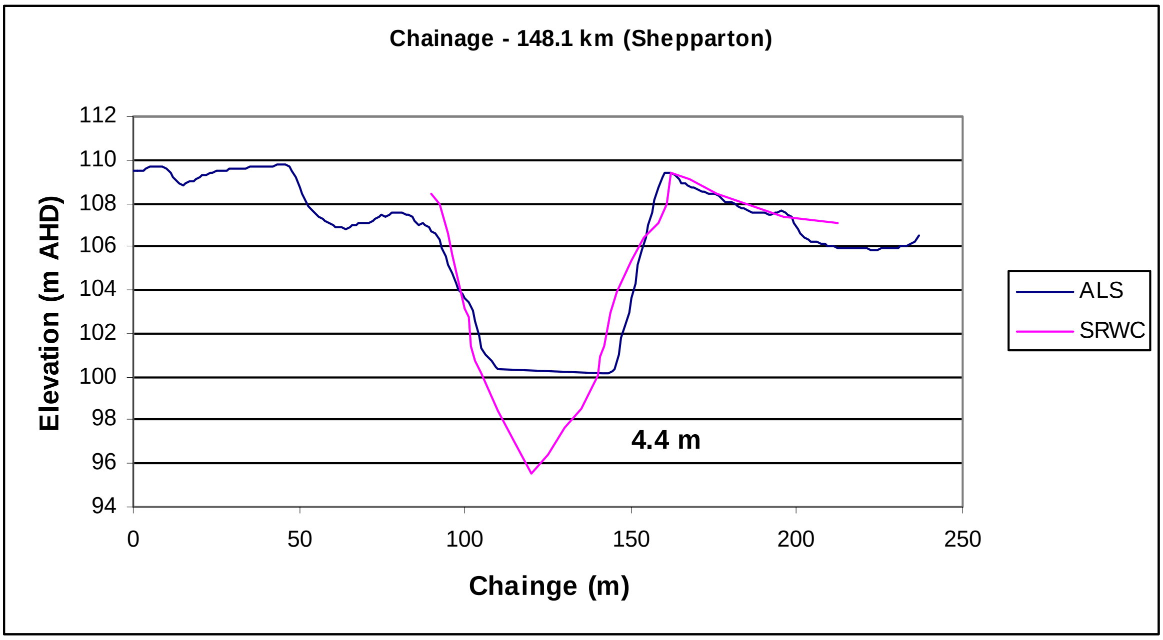
Elevation (m AHD)
110
108
106
104
102
100
98
96
0
50
100
150
200
250
Chaingage (m)
2.0 m
ALS
SR&WSC


Chainage - 148.8 km (Shepparton)
Elevation (m AHD)
110
108
106
104
102
100
98
96
0
50
100
150
200
250
300
Chainge (m)
2.5 m
ALS
SR&WSC


Chainage - 148.1 km (Shepparton)
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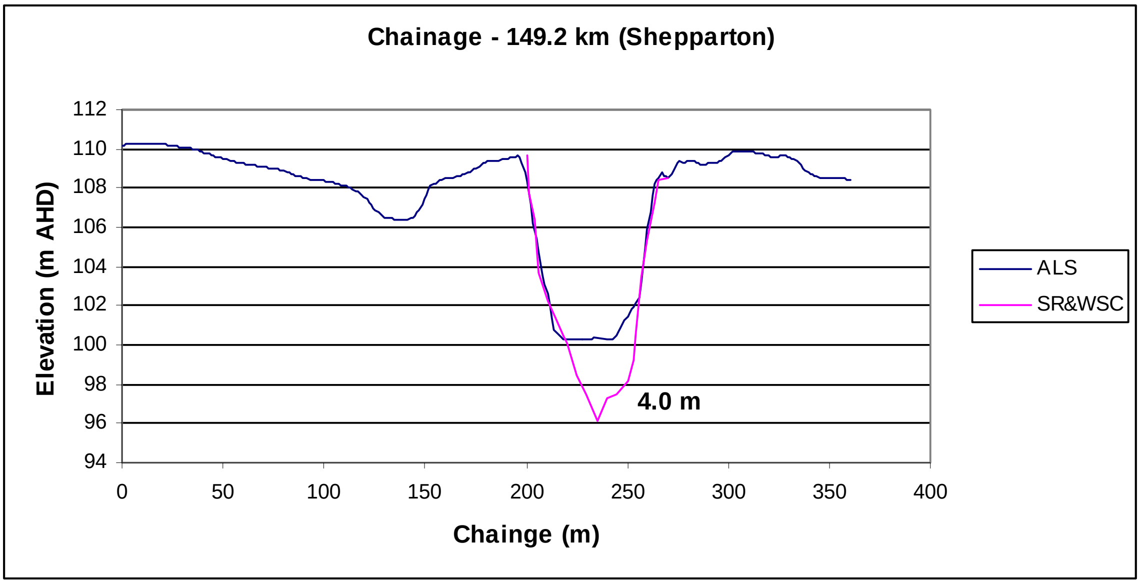
110
108
106
104
102
100
98
96
94
Elevation (m AHD)
0
50
100
150
200
250
Chainge (m)
4.4 m
ALS
SRWC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110
108
106
104
102
100
98
96
94
Elevation (m AHD)
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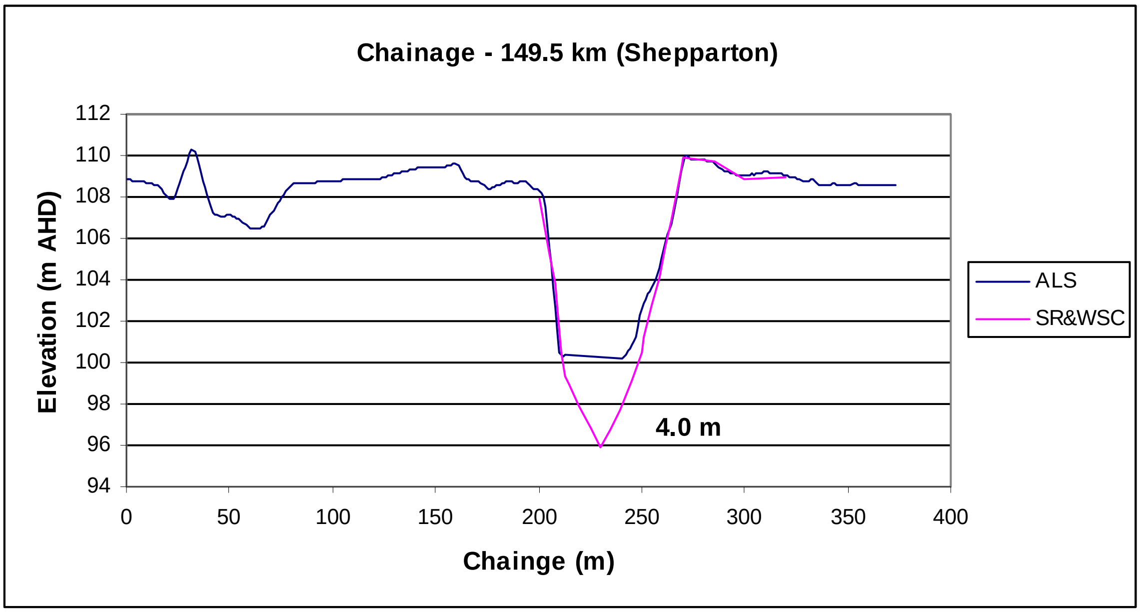
100
150
200
250
300
350
400
Chainge (m)
4.0 m
ALS
SR&WSC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Elevation (m AHD)
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110
108
106
104
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94
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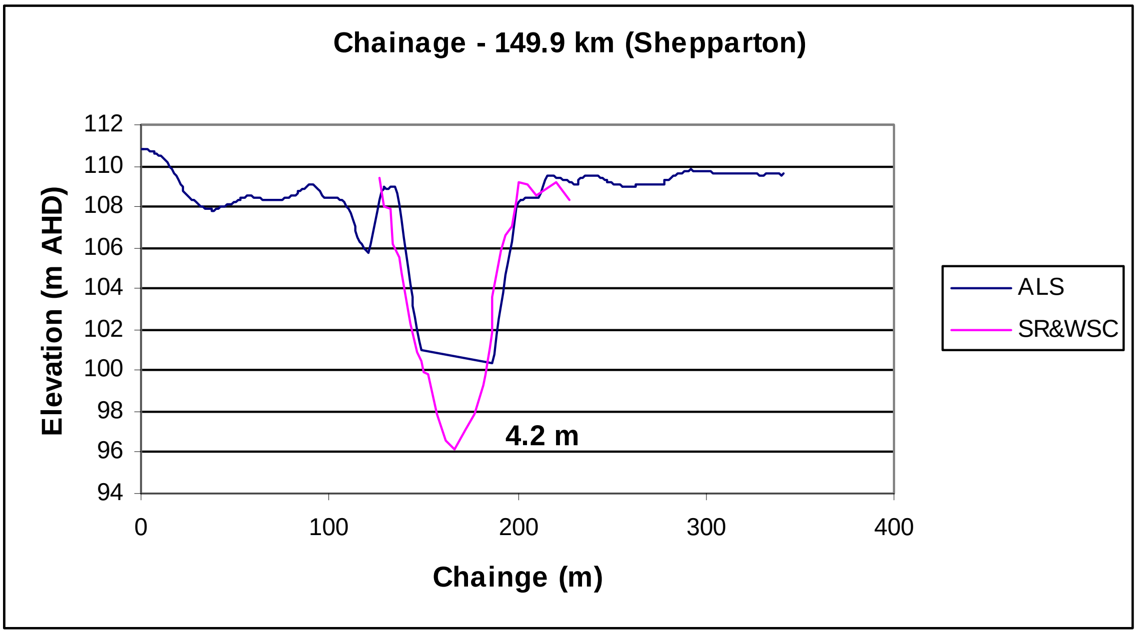
100
150
200
250
300
350
400
Chainge (m)
ALS
SR&WSC
4.0 m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Elevation (m AHD)
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110
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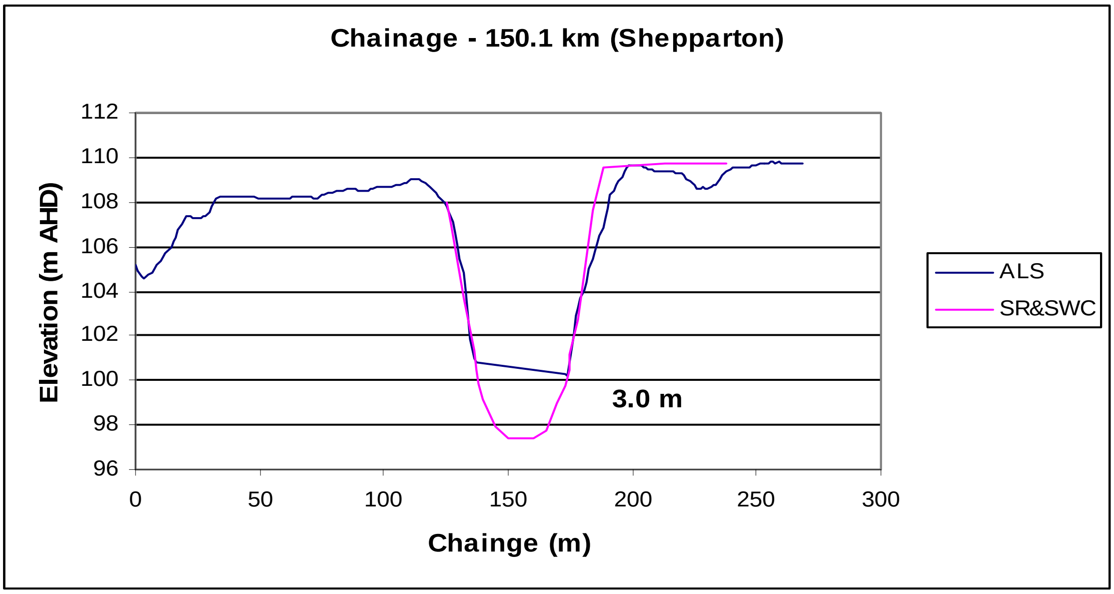
200
300
400
Chainge (m)
ALS
SR&WSC
4.2 m


Chainage - 150.1 km (Shepparton)
Elevation (m AHD)
Chainge (m)
3.0 m
ALS
SR&SWC
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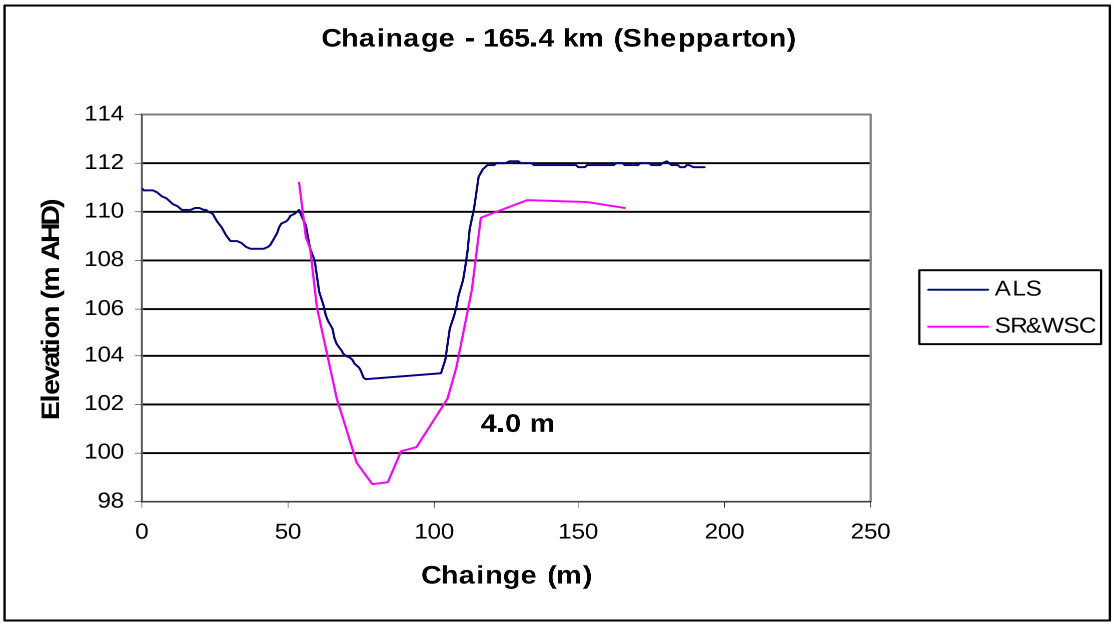
110
108
106
104
102
100
98
96
0
50
100
150
200
250
300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Elevation (m AHD)
Chainge (m)
4.0 m
ALS
SR&WSC
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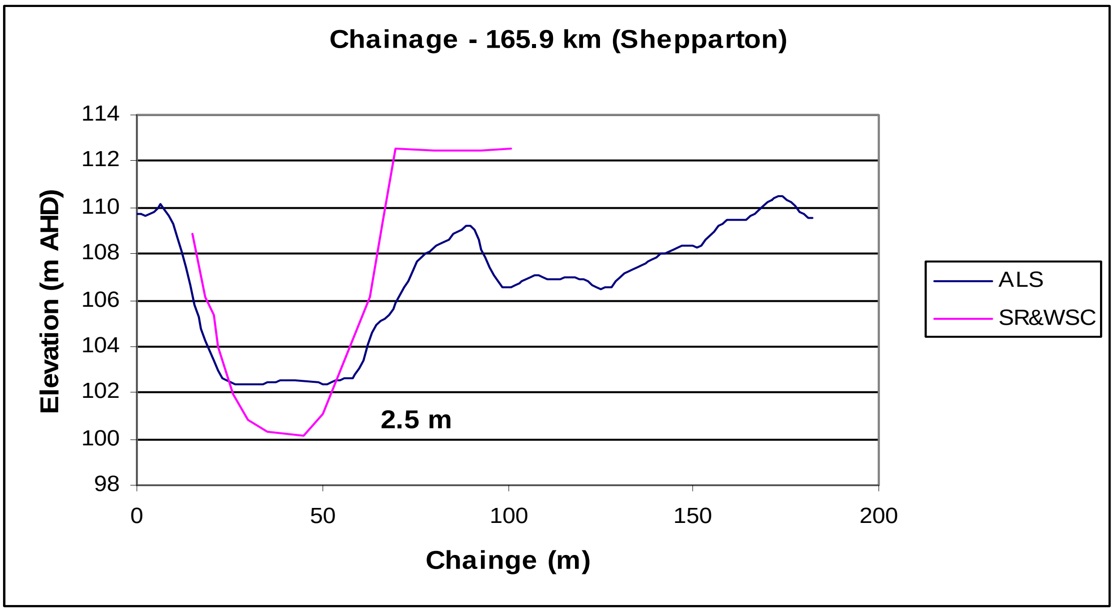
112
110
108
106
104
102
100
98
0
50
100
150
200
250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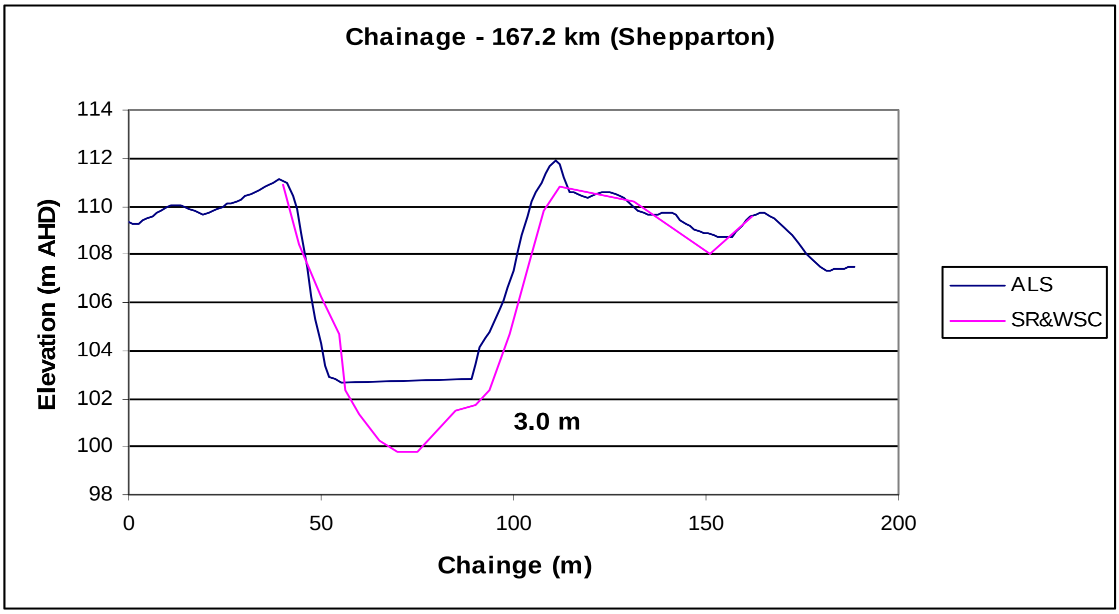
Elevation (m AHD)
114
112
110
108
106
104
102
100
98
0
50
100
150
200
Chainge (m)
2.5 m
ALS
SR&WSC


Chainage - 167.2 km (Shepparton)
Elevation (m AHD)
114
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110
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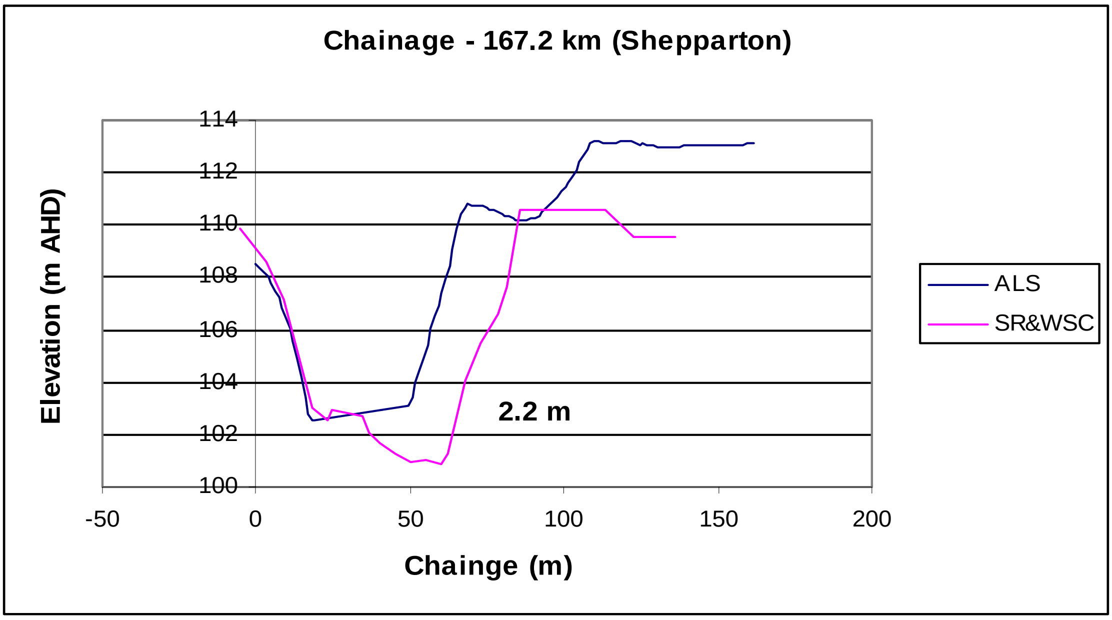
106
104
102
100
98
0
50
100
150
200
Chainge (m)
3.0 m
ALS
SR&WSC


Chainage - 167.2 km (Shepparton)
Elevation (m AHD)
114
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110
108
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100
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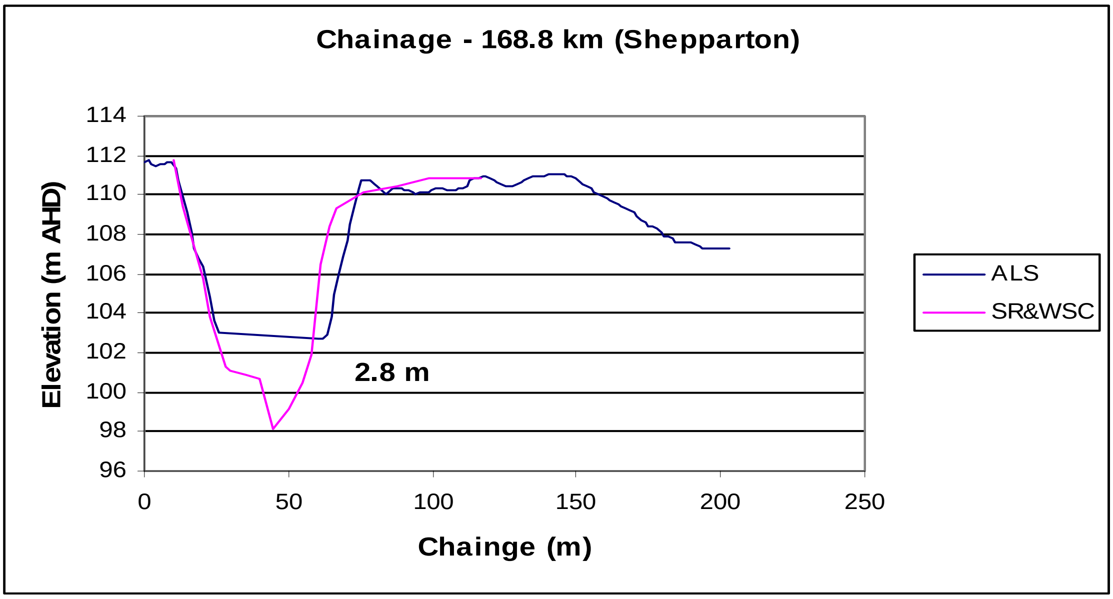
100
150
200
Chainge (m)
2.2 m
ALS
SR&WSC


Chainage - 168.8 km (Shepparton)
Elevation (m AHD)
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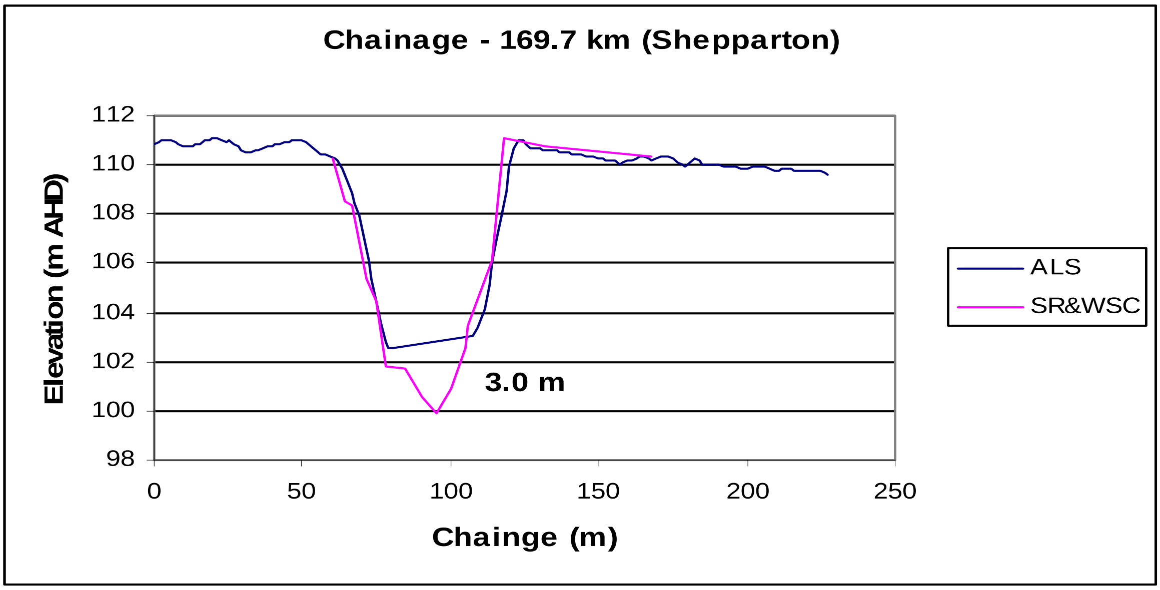
100
150
200
250
Chainge (m)
2.8 m
ALS
SR&WSC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Elevation (m AHD)
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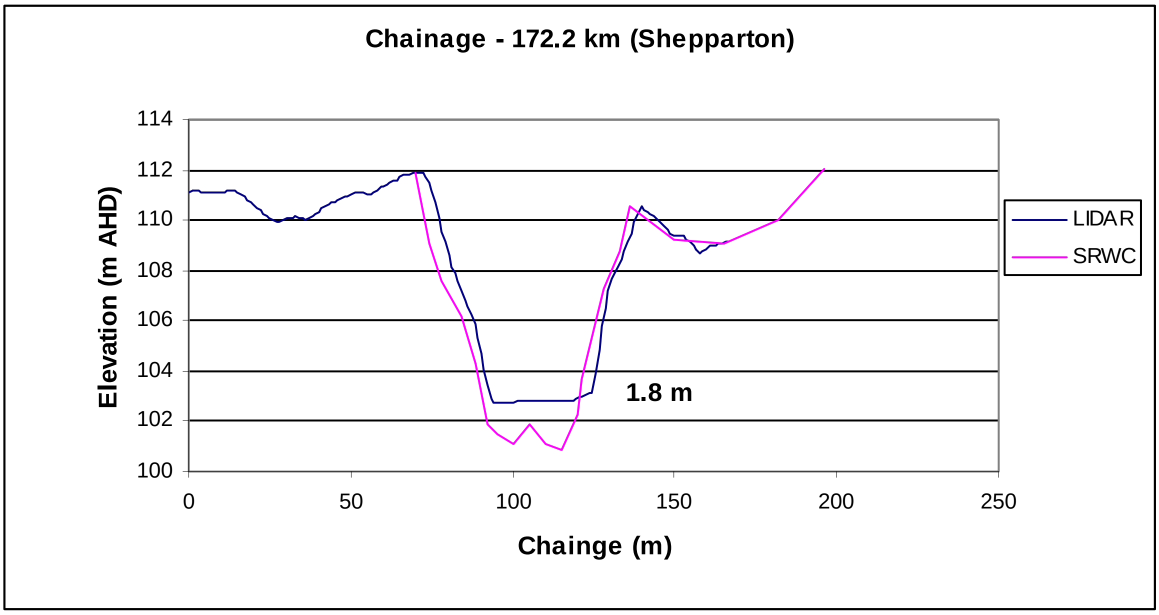
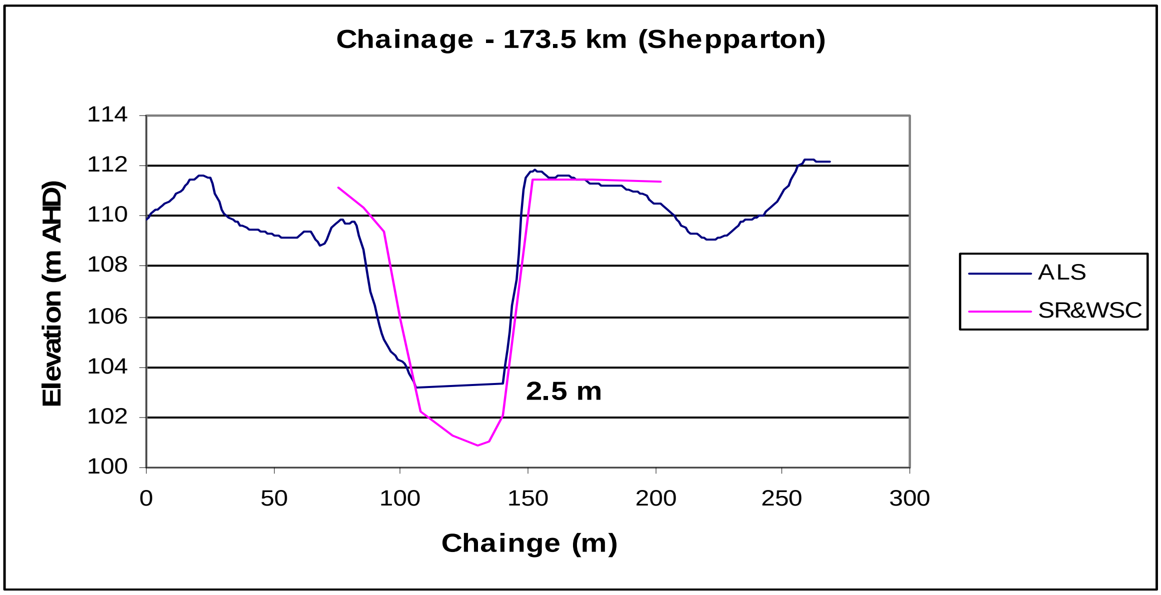
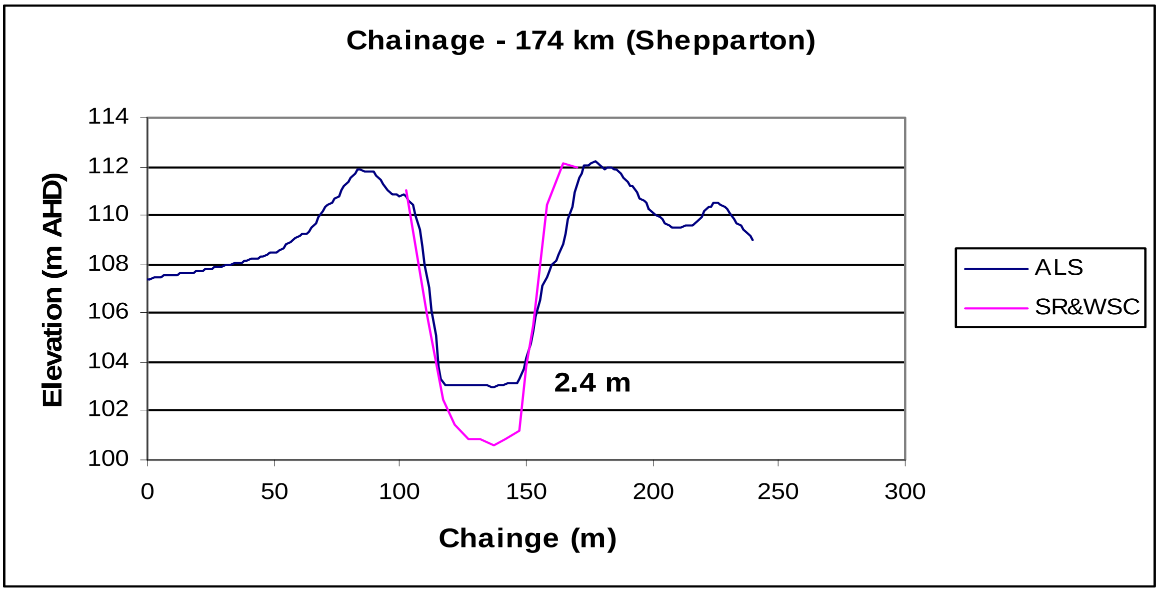
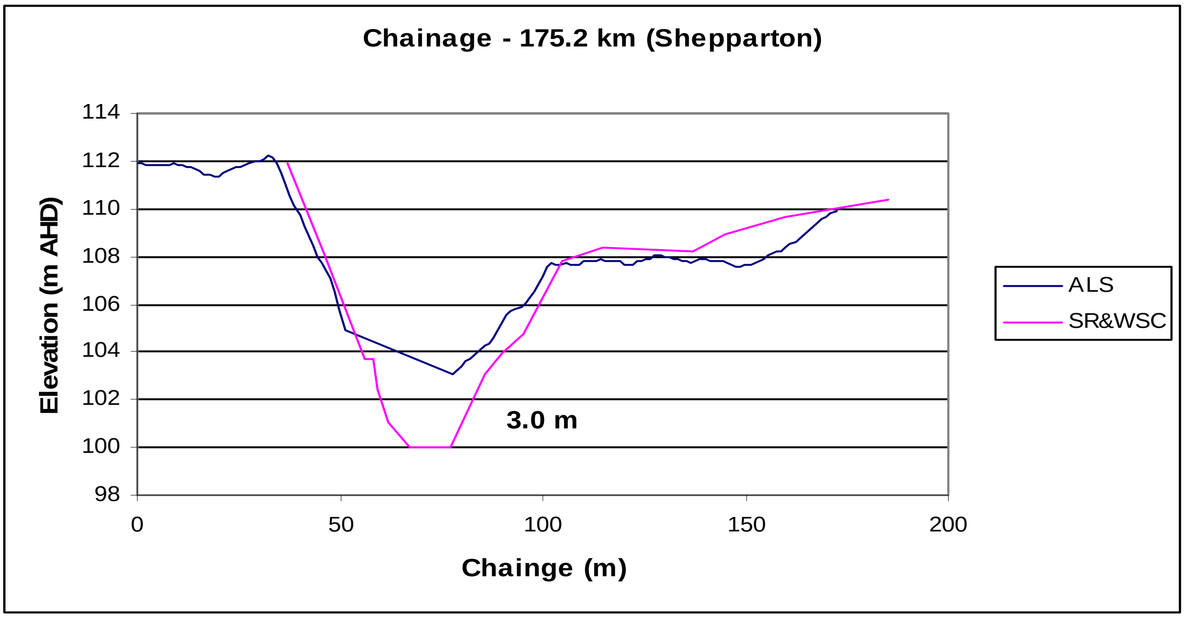
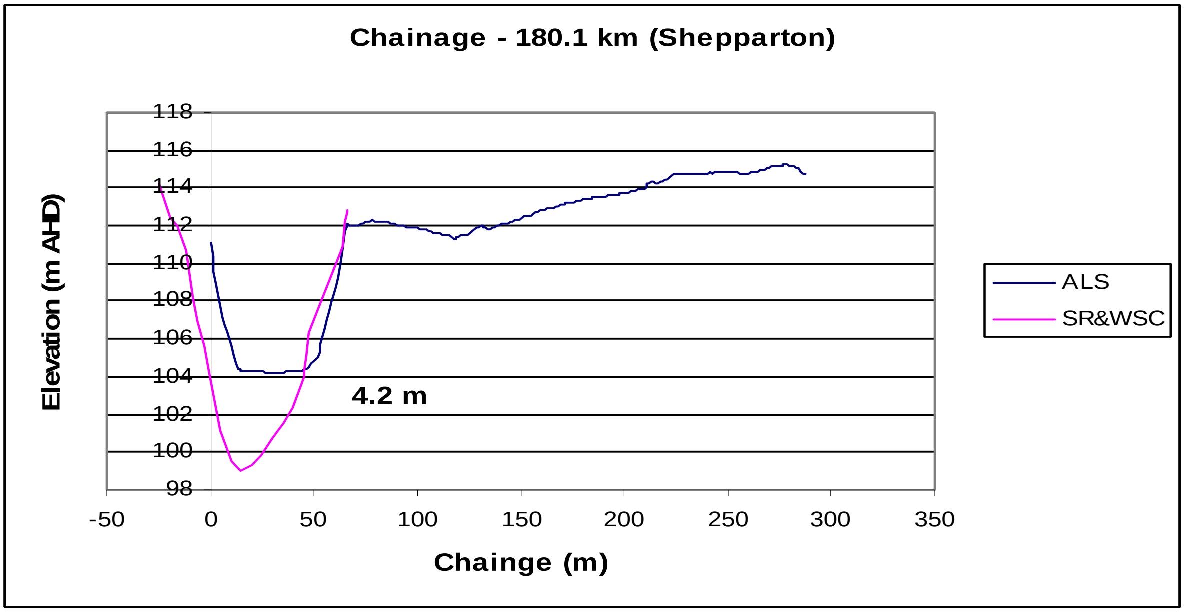
200
250
Chainge (m)
3.0 m
ALS
SR&WSC

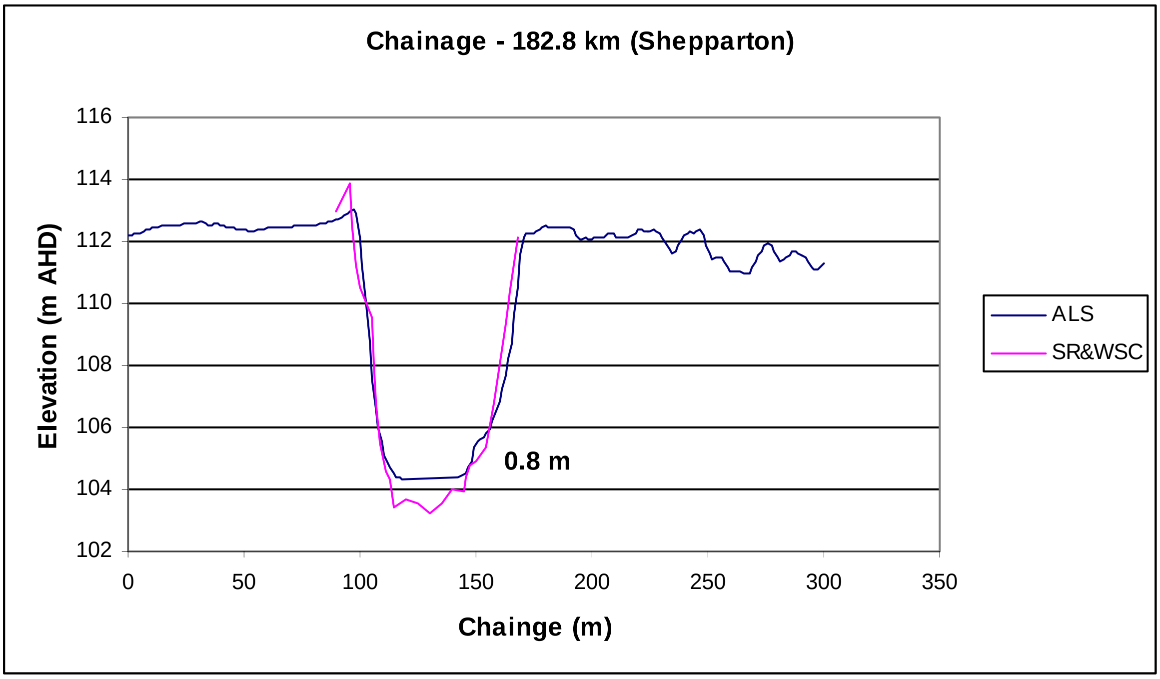

Chainage - 172.2 km (Shepparton)
Elevation (m AHD)
Chainge (m)
LIDAR
SRWC
1.8 m
114
112
110
108
106
104
102
100
0
50
100
150
200
250


Chainage - 173.5 km (Shepparton)
Elevation (m AHD)
Chainge (m)
ALS
SR&WSC
2.5 m
114
112
110
108
106
104
102
100
0
50
100
150
200
250
300


Chainage - 174 km (Shepparton)
Elevation (m AHD)
114
112
110
108
106
104
102
100
0
50
100
150
200
250
300
Chainge (m)
2.4 m
ALS
SR&WSC

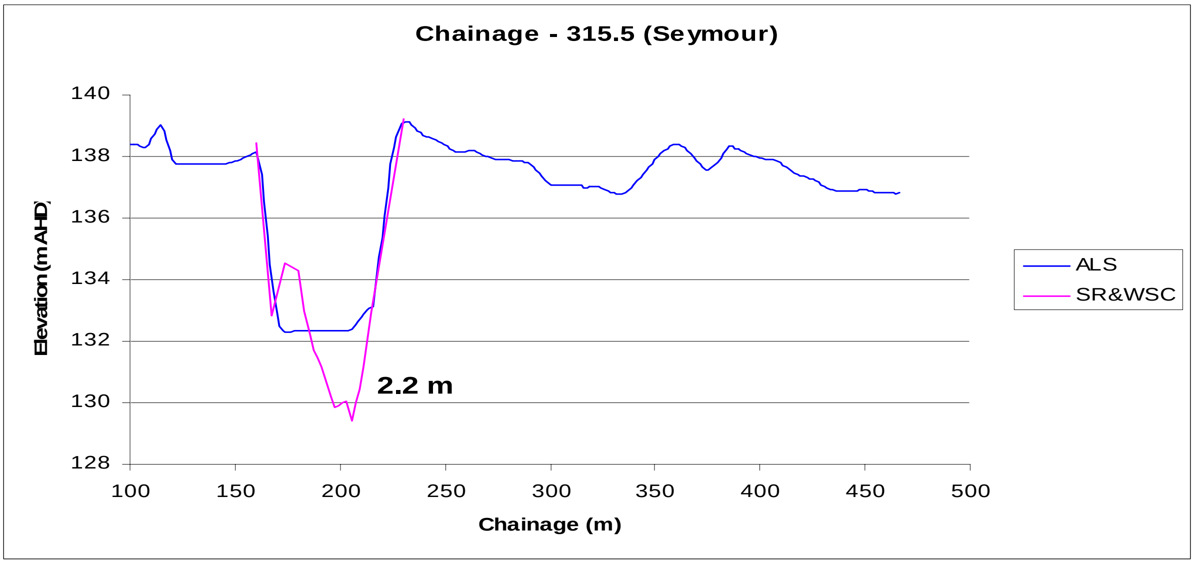

Chainage - 175.2 km (Shepparton)
Elevation (m AHD)
114
112
110
108
106
104
102
100
98
0
50
100
150
200
Chainge (m)
3.0 m
ALS
SR&WSC

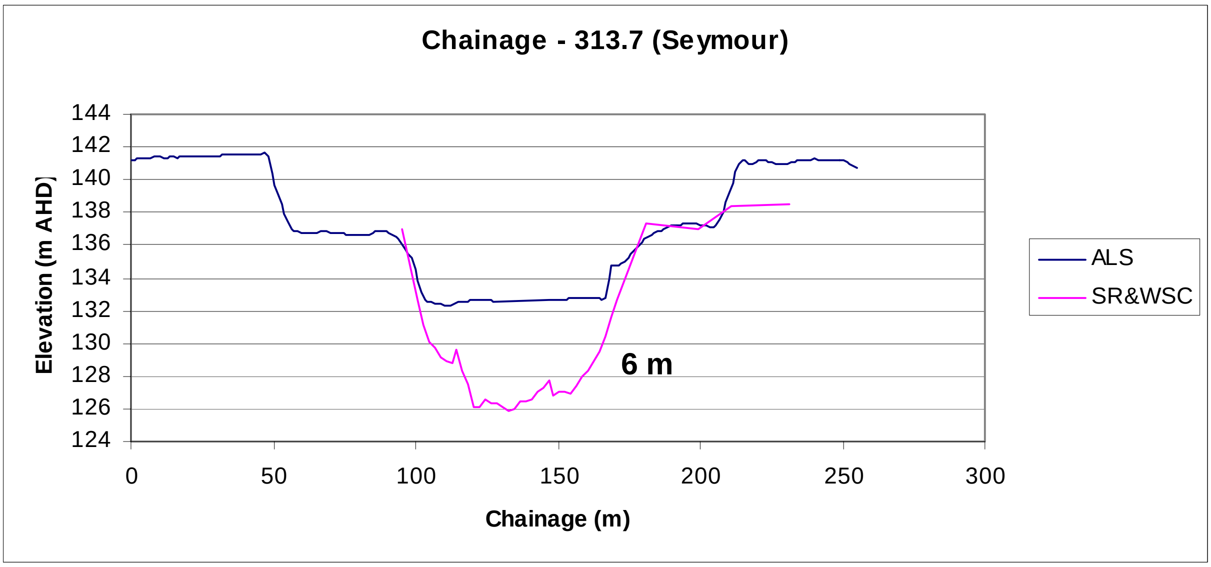

Chainage - 180.1 km (Shepparton)
Elevation (m AHD)
118
116
114
112
110
108
106
104
102
100
98
-50
0
50
100
150
200
250
300
350
Chainge (m)
4.2 m
ALS
SR&WSC

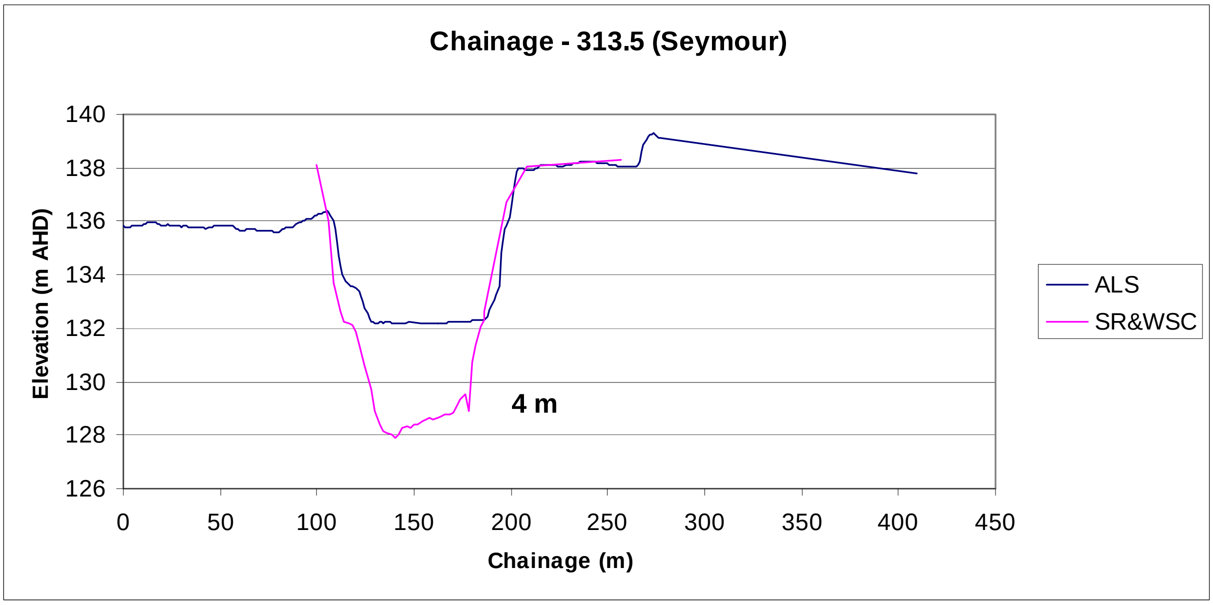

Chainage - 182.8 km (Shepparton)
116
114
112
110
108
106
104
102
Elevation (m AHD)
0
50
100
150
200
250
300
350
Chainge (m)
0.8 m
ALS
SR&WSC

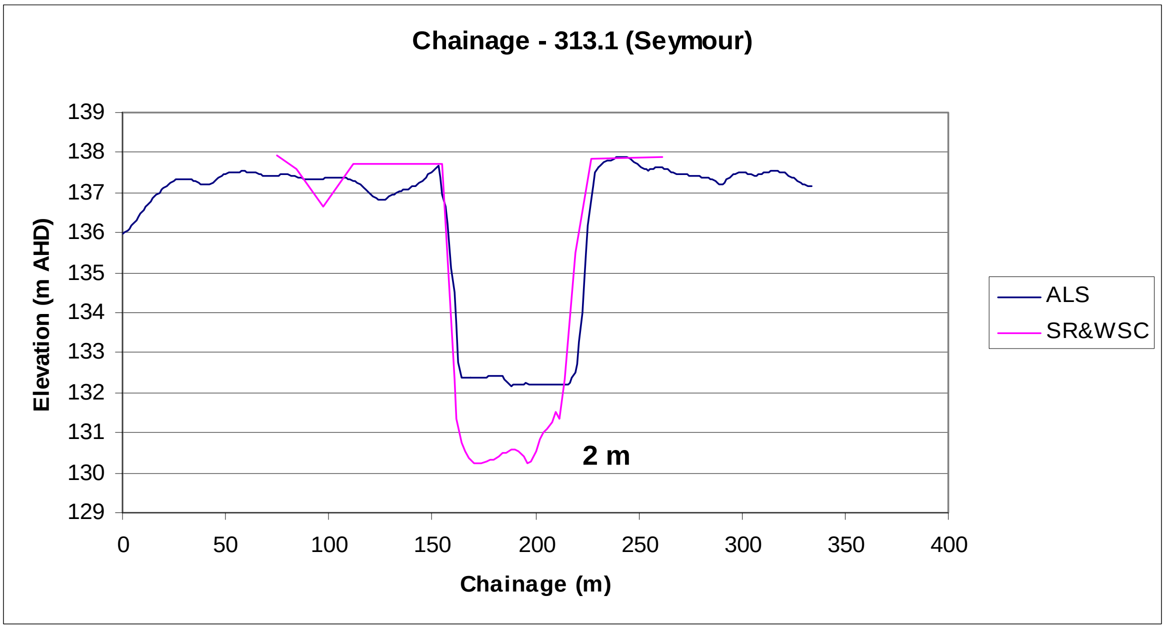
Seymour

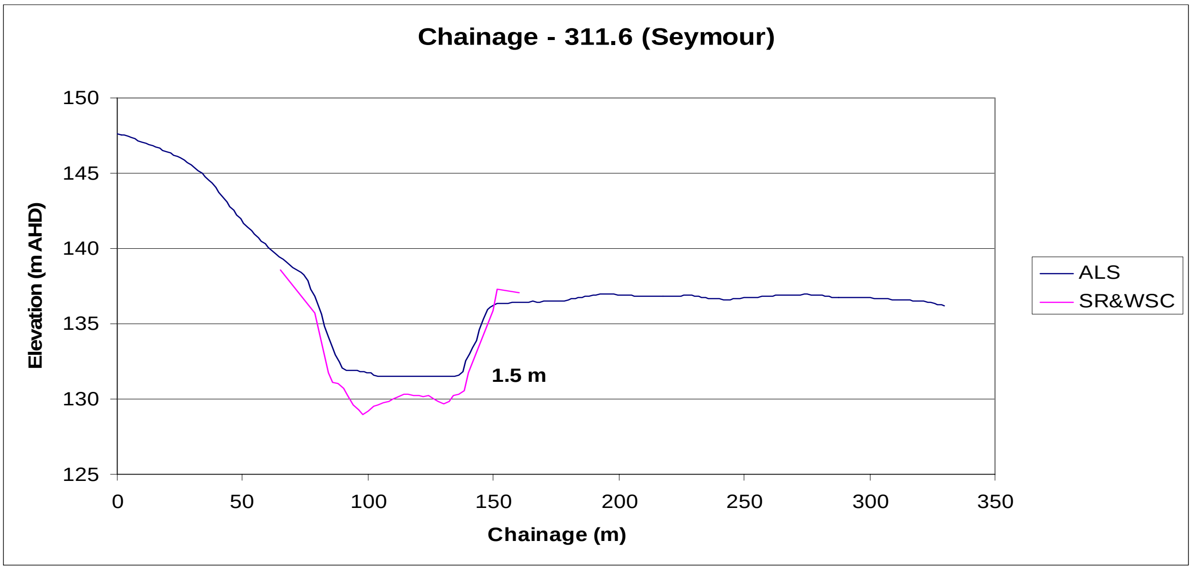
Cross section comparison

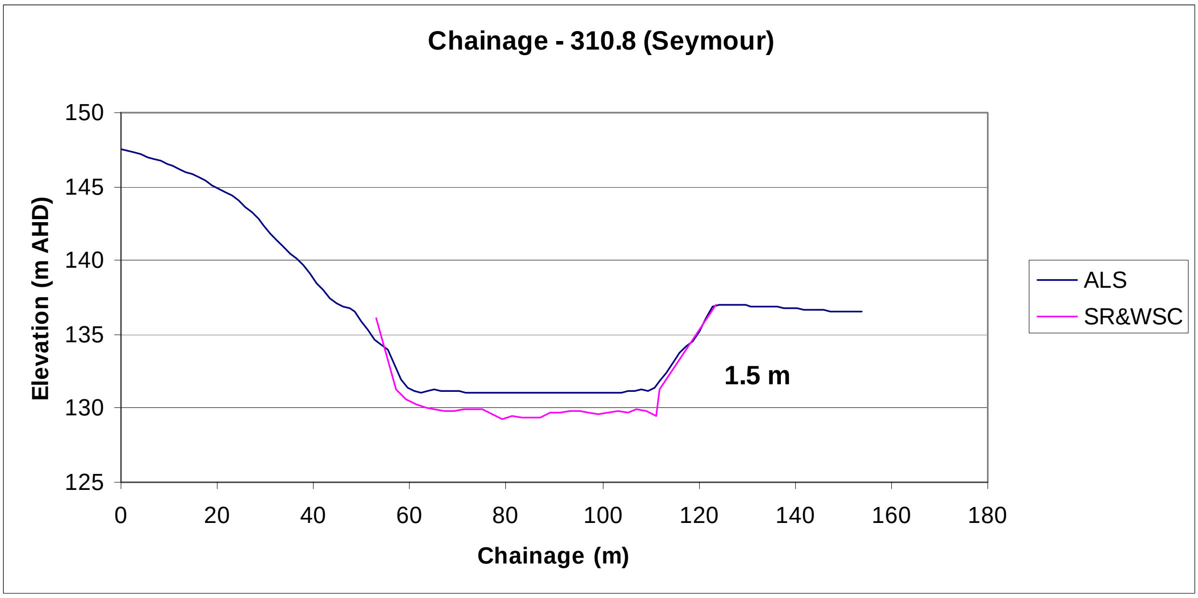


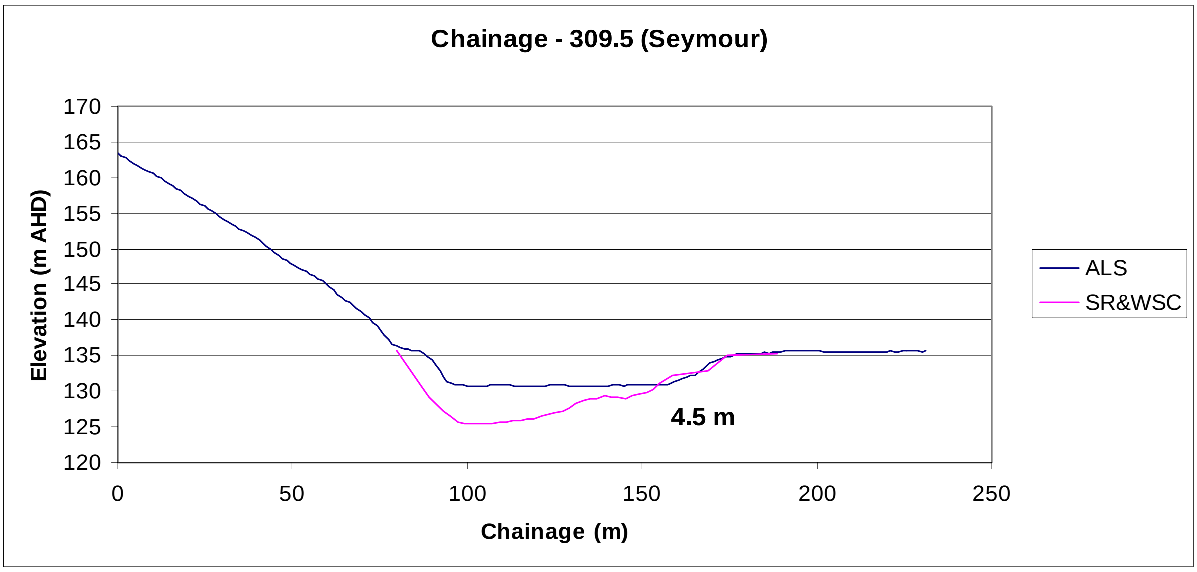


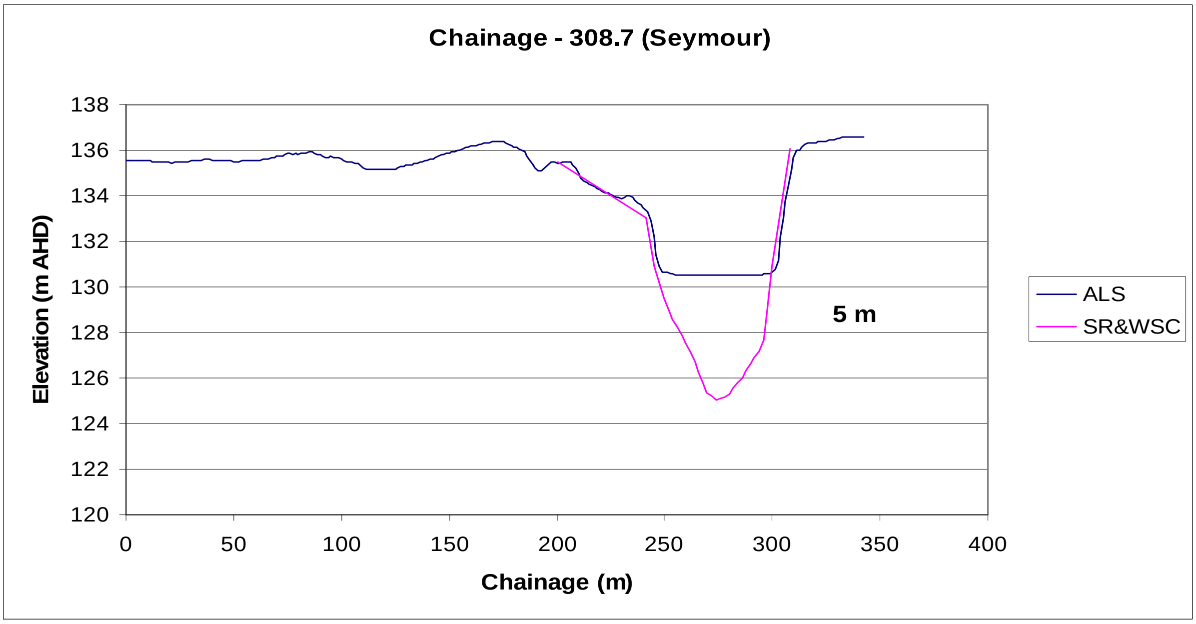

Chainage - 313.5 (Seymour)
Elevation (m AHD)
140
138
136
134
132
130
128
126
0
50
100
150
200
250
300
350
400
450
Chainage (m)
4 m
ALS
SR&WSC

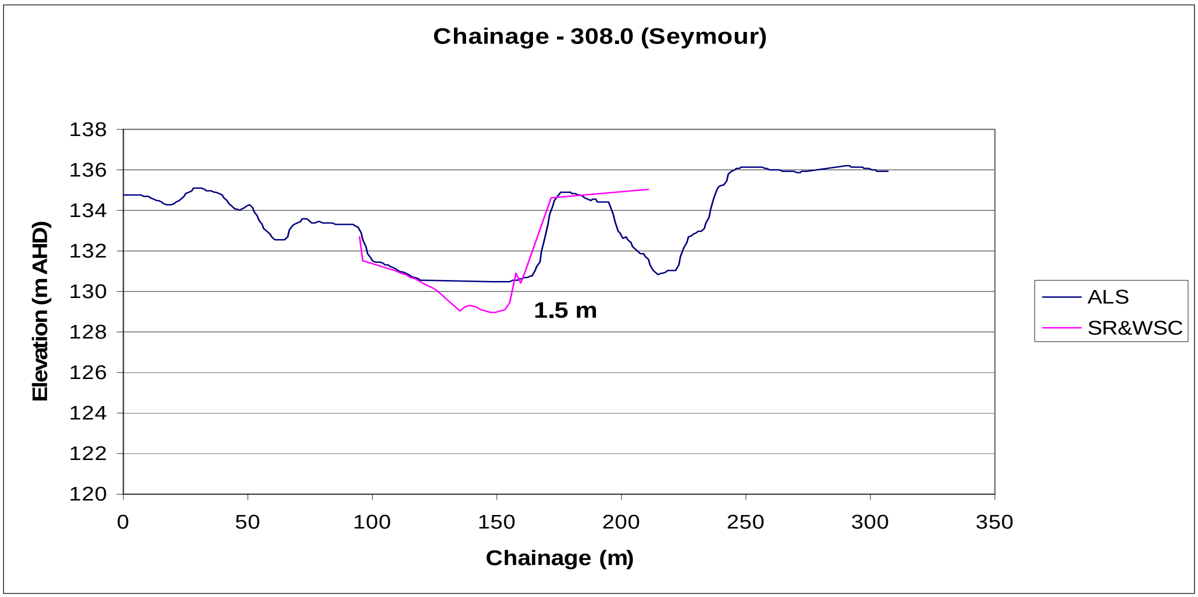

Chainage - 313.1 (Seymour)
Elevation (m AHD)
139
138
137
136
135
134
133
132
131
130
129
0
50
100
150
200
250
300
350
400
Chainage (m)
2 m
ALS
SR&WSC

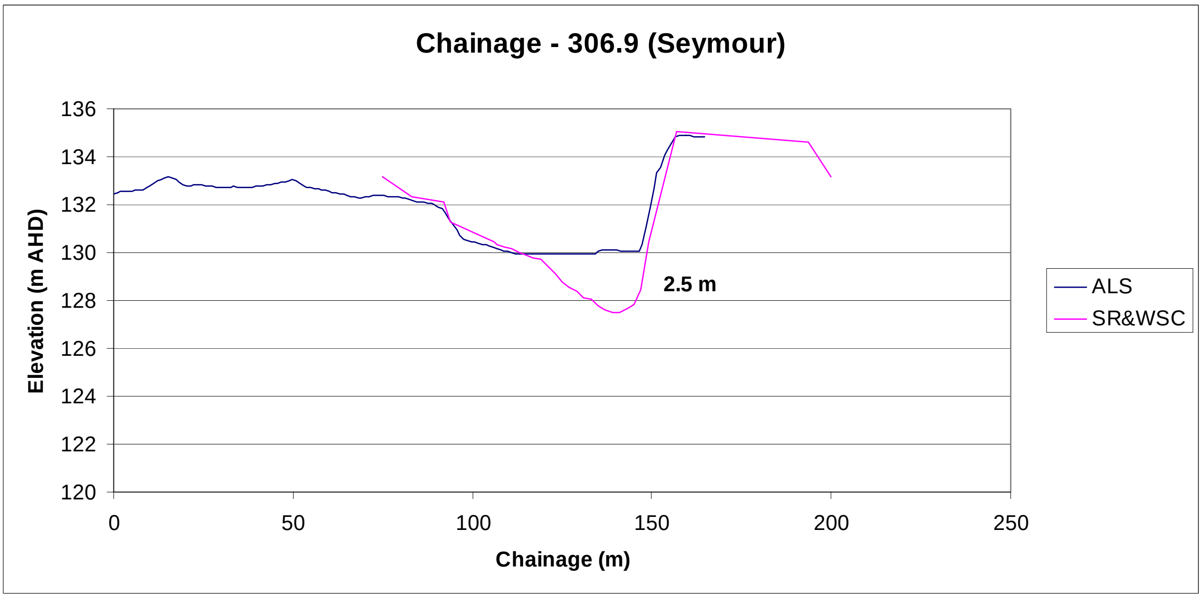

Chainage - 311.6 (Seymour)
Elevation (m AHD)
Chainage (m)
150
145
140
135
130
125
0
50
100
150
200
250
300
350
1.5 m
ALS
SR&WSC

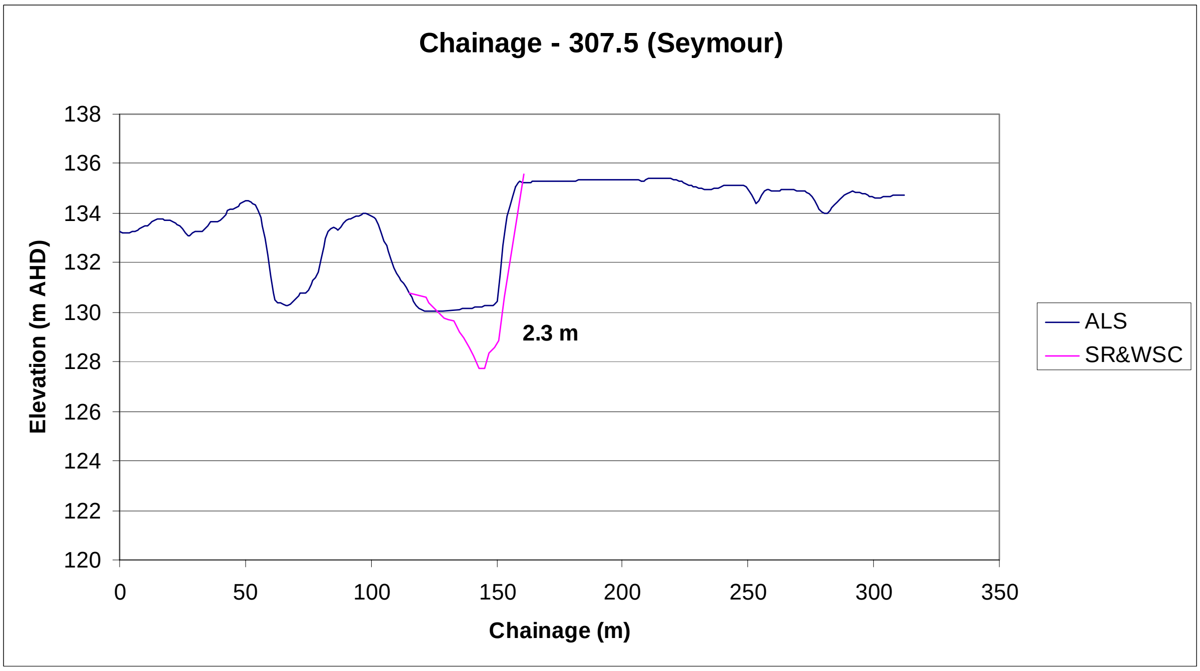

Chainage - 310.8 (Seymour)
Elevation (m AHD)
Chainage (m)
150
145
140
135
130
125
0
20
40
60
80
100
120
140
160
180
1.5 m
ALS
SR&WSC


Chainage - 309.5 (Seymour)
Elevation (m AHD)
Chainage (m)
170
165
160
155
150
145
140
135
130
125
120
0
50
100
150
200
250
4.5 m
ALS
SR&WSC

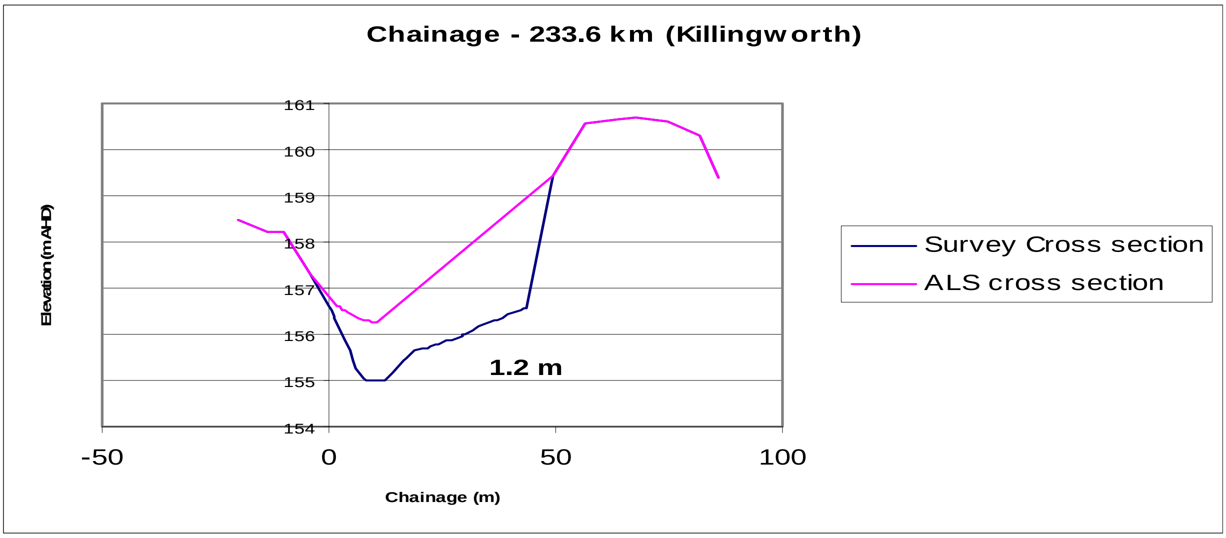

Chainage - 308.7 (Seymour)
Elevation (m AHD)
138
136
134
132
130
128
126
124
122
120
0
50
100
150
200
250
300
350
400
Chainage (m)
5 m
ALS
SR&WSC

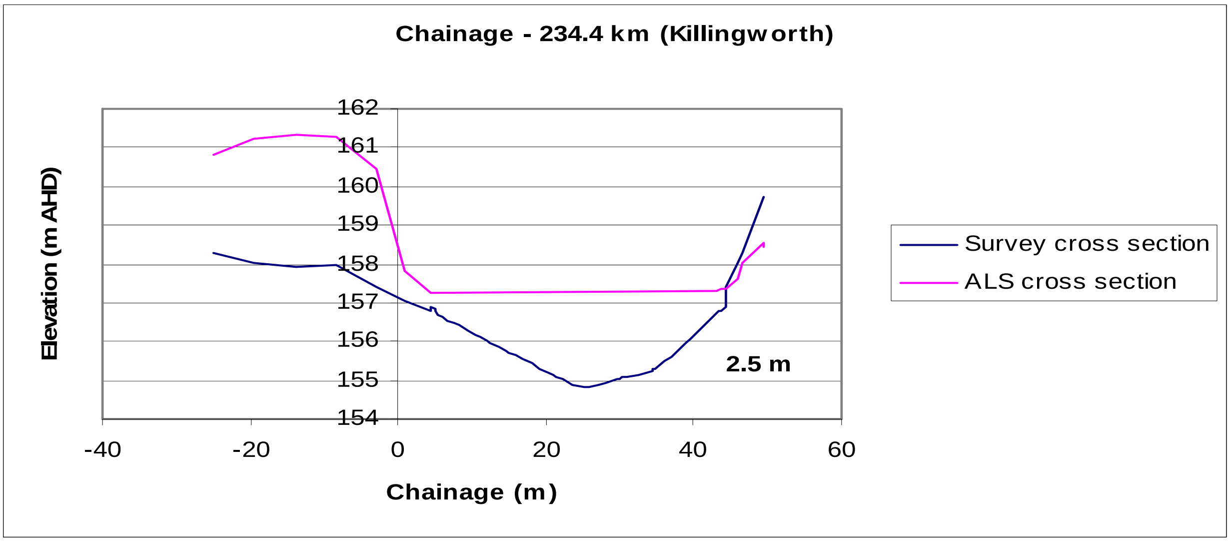

Chainage - 308.0 (Seymour)
Elevation (m AHD)
138
136
134
132
130
128
126
124
122
120
0
50
100
150
200
250
300
350
Chainage (m)
1.5 m
ALS
SR&WSC

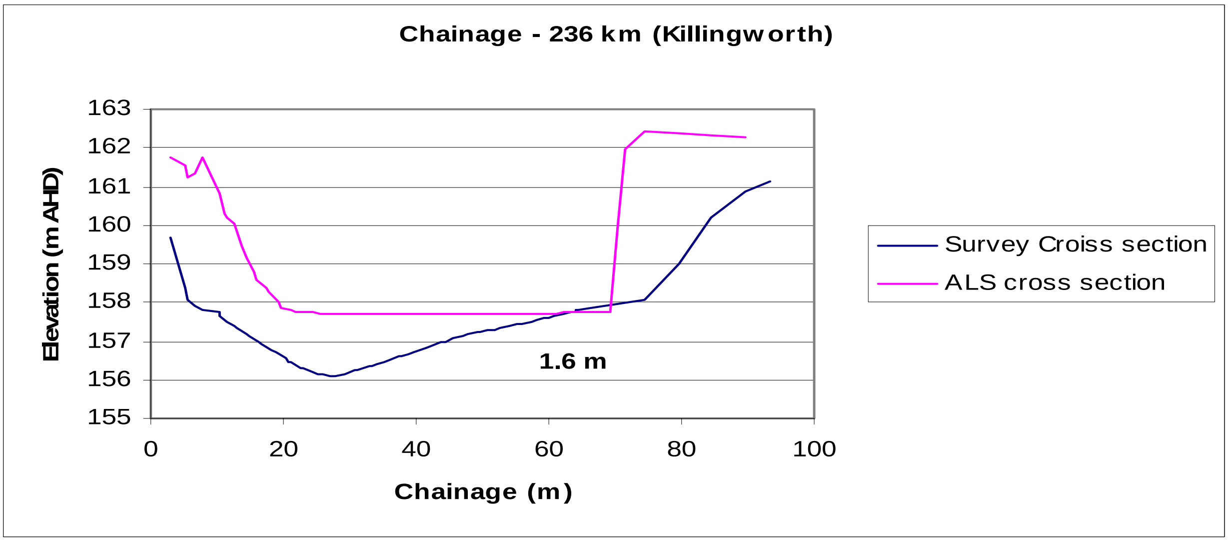

Chainage - 306.9 (Seymour)
Elevation (m AHD)
Chainage (m)
2.5 m
ALS
SR&WSC
136
134
132
130
128
126
124
122
120
0
50
100
150
200
250

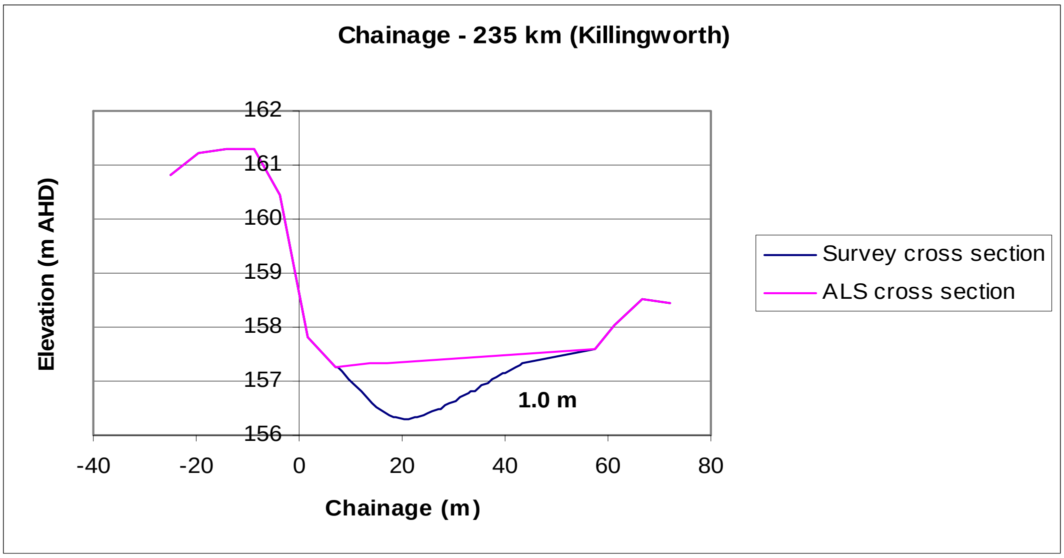

Chainage - 307.5 (Seymour)
Elevation (m AHD)
Chainage (m)
2.3 m
ALS
SR&WSC
138
136
134
132
130
128
126
124
122
120
0
50
100
150
200
250
300
350

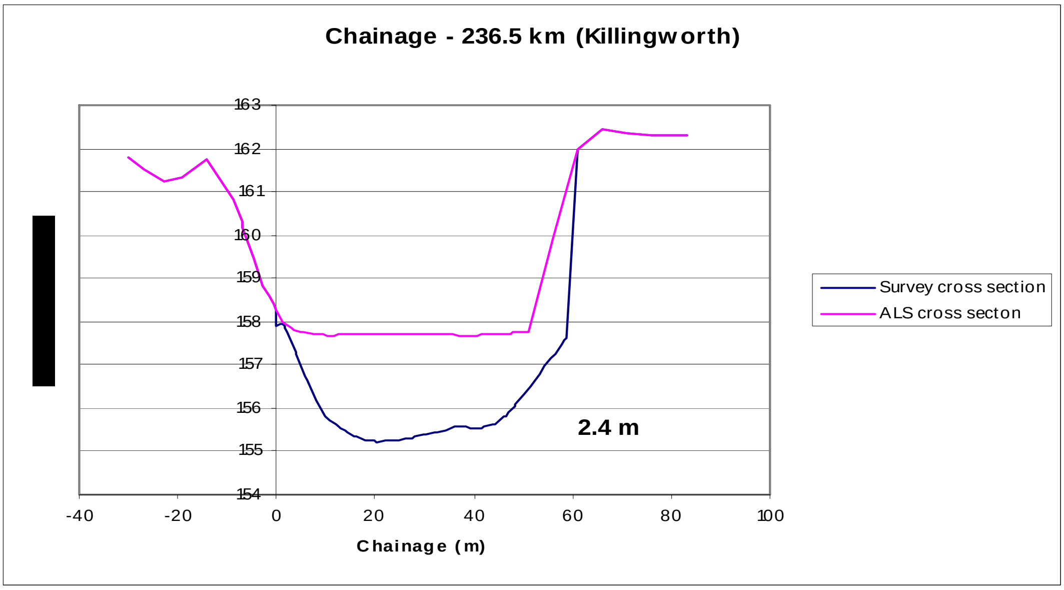
Killingworth
Cross section comparison

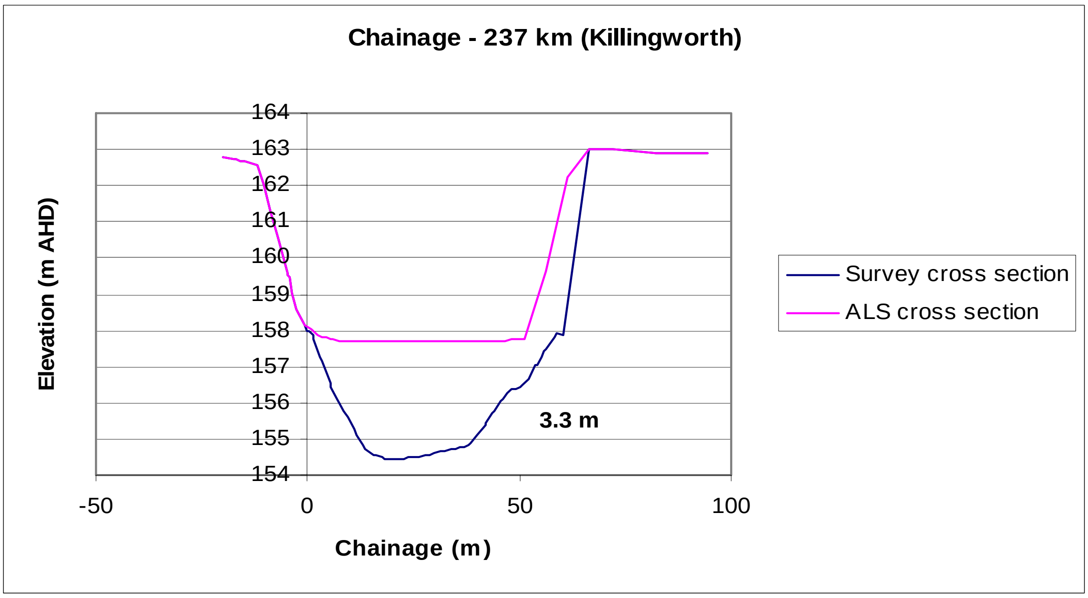


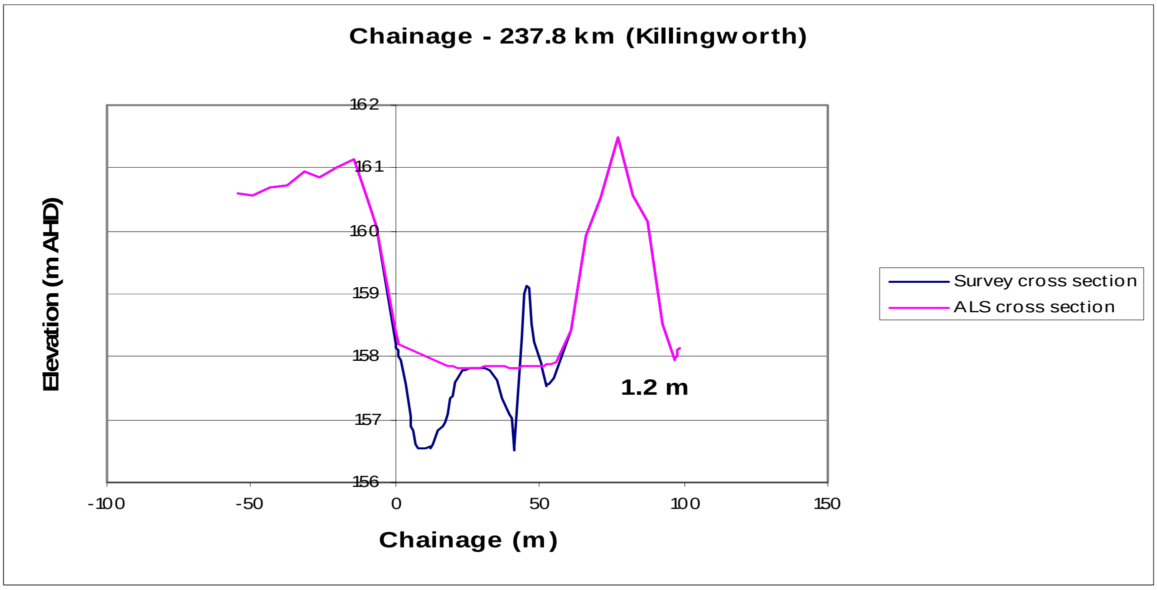


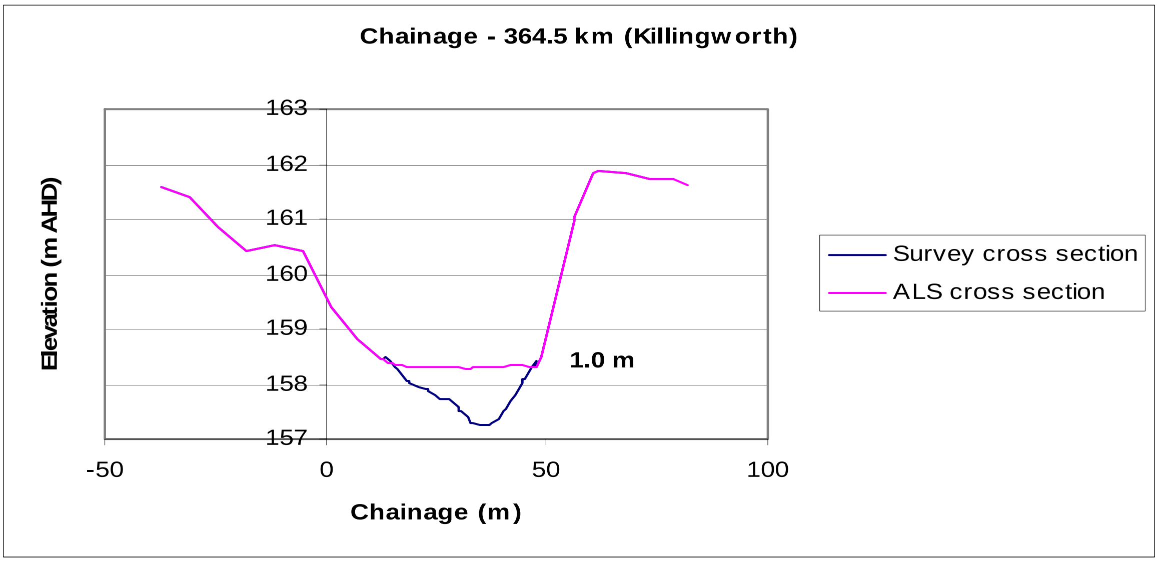


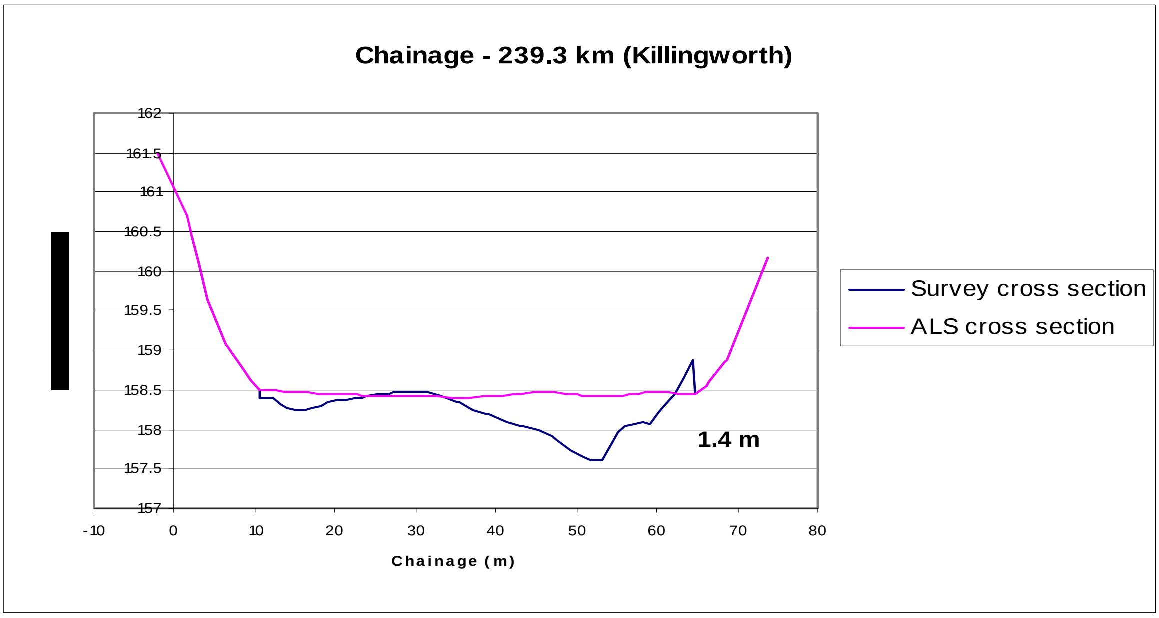

Chainage - 235 km (Killingworth)
Elevation (m AHD)
162
161
160
159
158
157
156
-40
-20
0
20
40
60
80
Chainage (m)
1.0 m
Survey cross section
ALS cross section

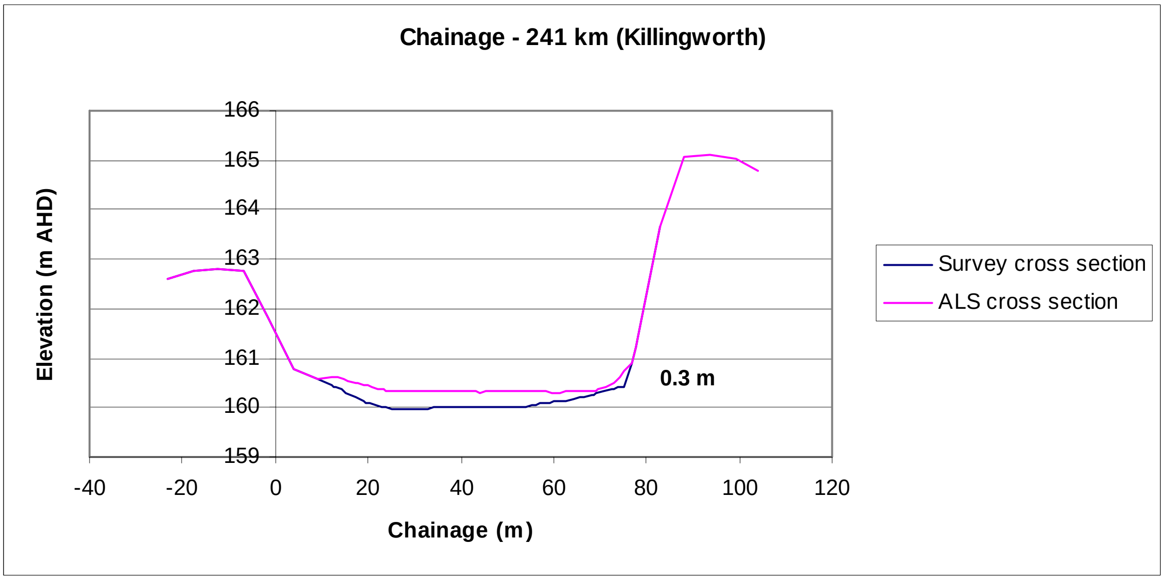

Chainage - 236.5 km (Killingworth)
[redacted]
163
162
161
160
159
158
157
156
155
154
-40
-20
0
20
40
60
80
100
Chainage (m)
2.4 m
Survey cross section
ALS cross secton

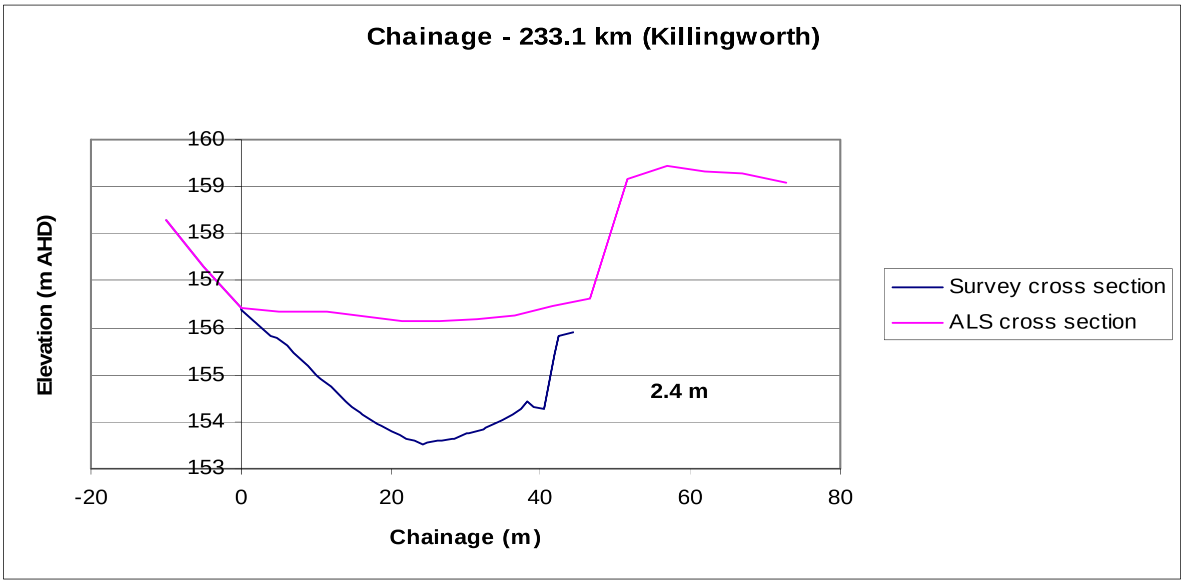

Chainage - 237 km (Killingworth)
Elevation (m AHD)
164
163
162
161
160
159
158
157
156
155
154
-50
0
50
100
Chainage (m)
3.3 m
Survey cross section
ALS cross section

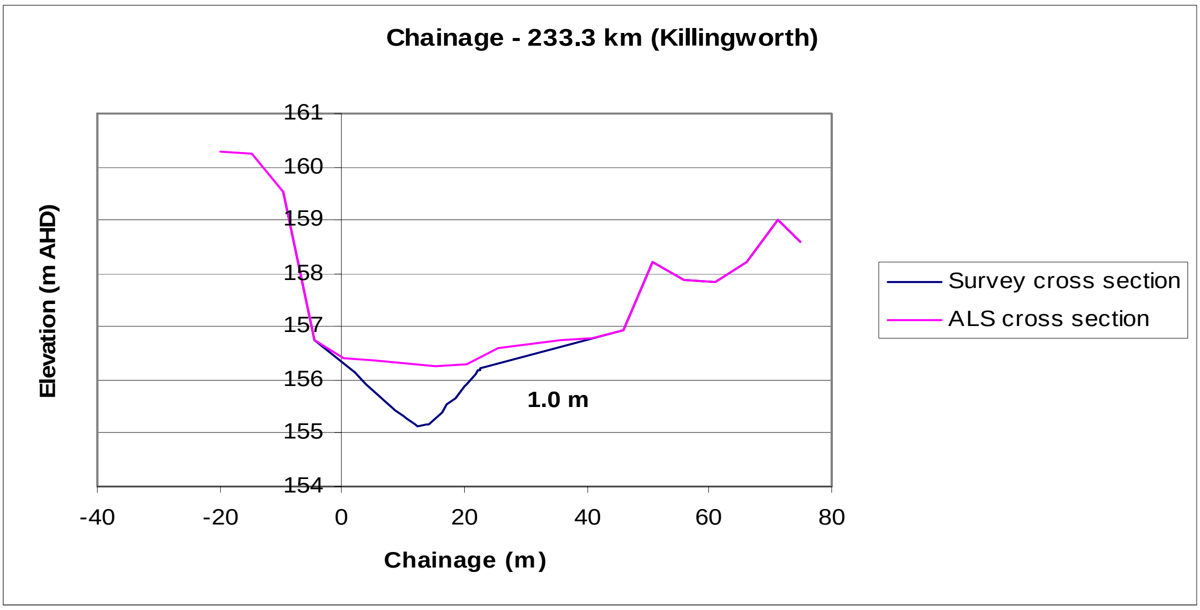

Chainage - 237.8 km (Killingworth)
Elevation (m AHD)
162
161
160
159
158
157
156
-100
-50
0
50
100
150
Chainage (m)
1.2 m
Survey cross section
ALS cross section

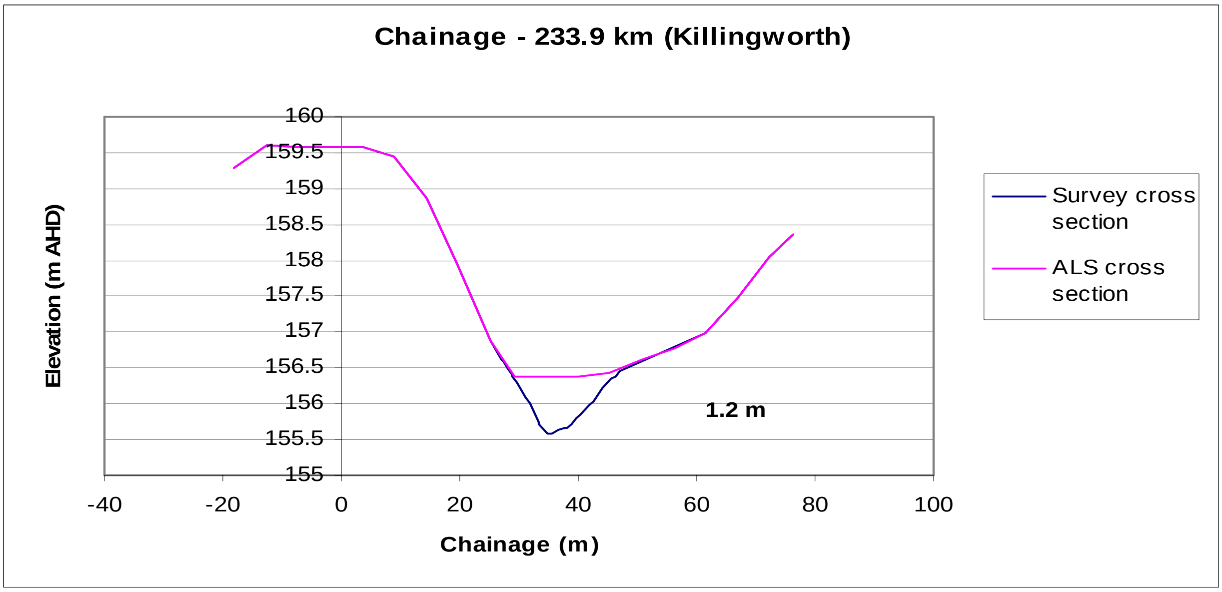

Chainage - 364.5 km (Killingworth)
Elevation (m AHD)
163
162
161
160
159
158
157
-50
0
50
100
Chainage (m)
1.0 m
Survey cross section
ALS cross section

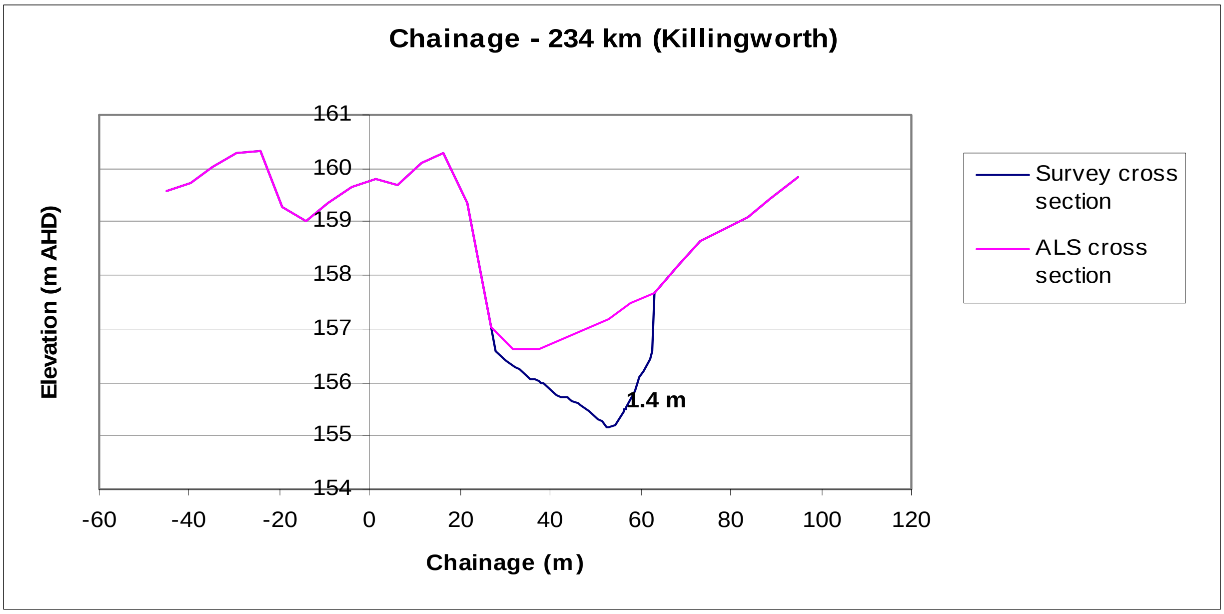

Chainage - 239.3 km (Killingworth)
[redacted]
162
161.5
161
160.5
160
159.5
159
158.5
158
157.5
157
-10
0
10
20
30
40
50
60
70
80
Chainage (m)
1.4 m
Survey cross section
ALS cross section

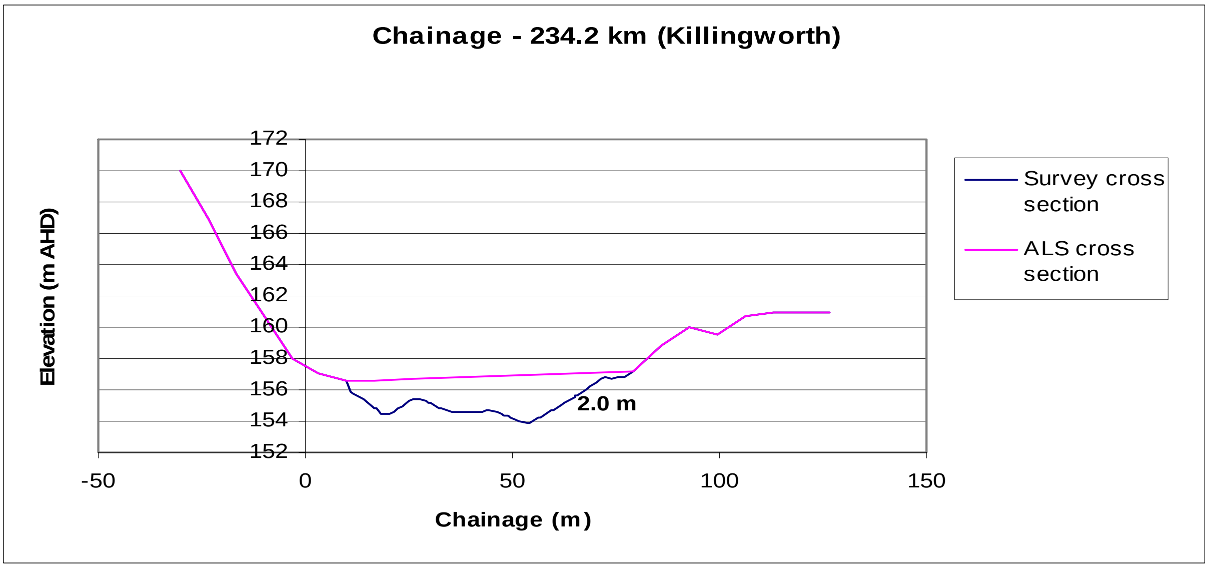

Chainage - 241 km (Killingworth)
Elevation (m AHD)
166
165
164
163
162
161
160
159
-40
-20
0
20
40
60
80
100
120
Chainage (m)
0.3 m
Survey cross section
ALS cross section

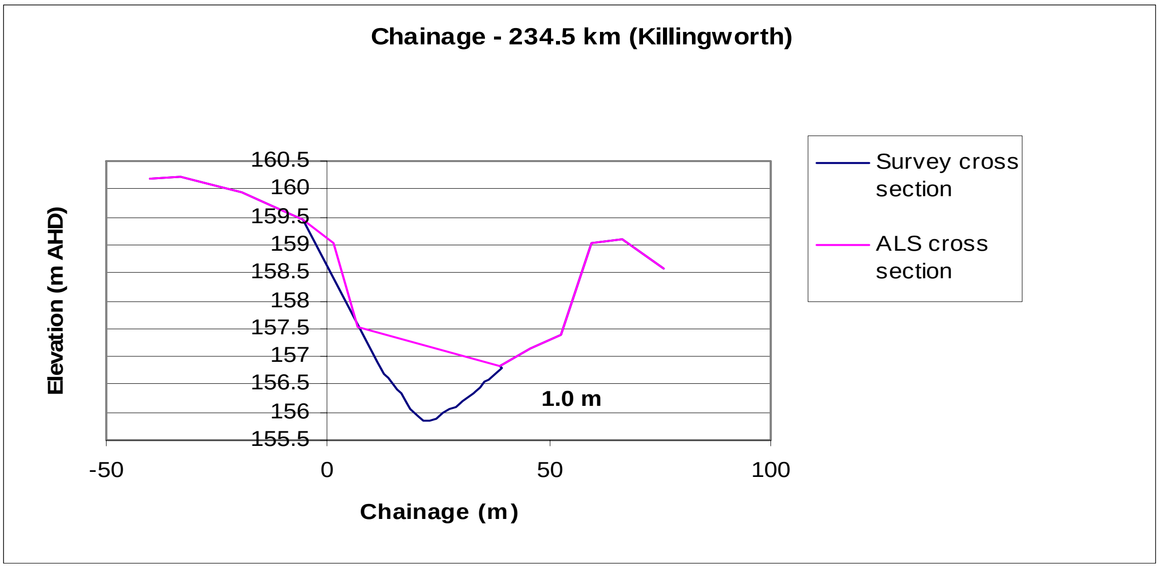

Chainage - 233.1 km (Killingworth)
Elevation (m AHD)
160
159
158
157
156
155
154
153
-20
0
20
40
60
80
Chainage (m)
2.4 m
Survey cross section
ALS cross section

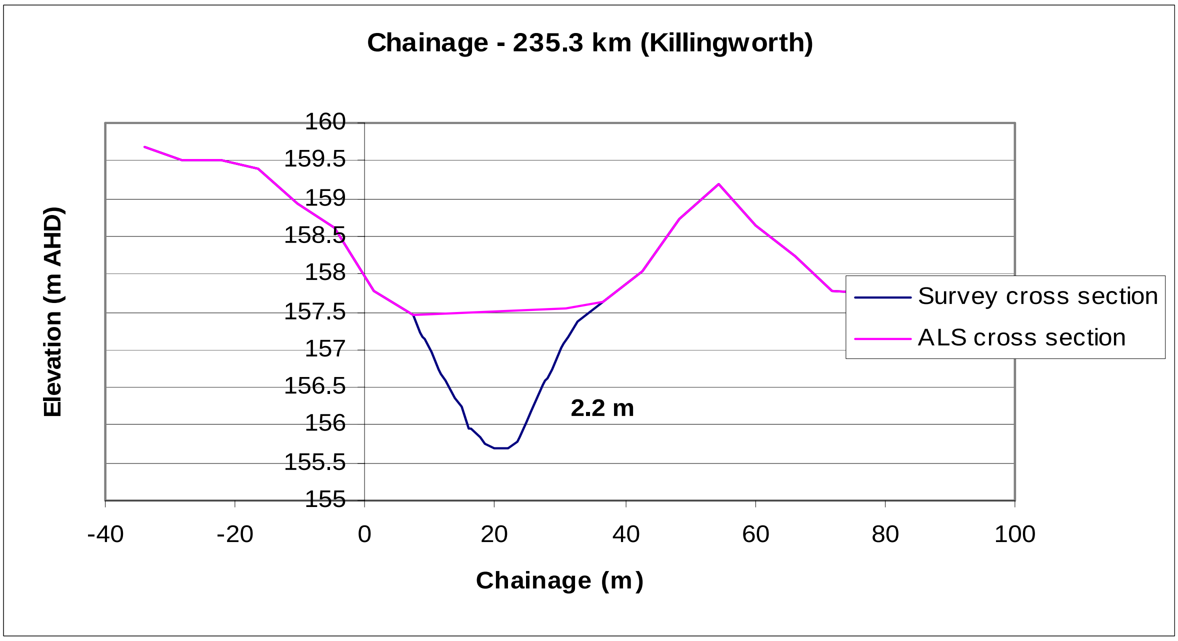

Chainage - 233.3 km (Killingworth)
Elevation (m AHD)
161
160
159
158
157
156
155
154
-40
-20
0
20
40
60
80
Chainage (m)
1.0 m
Survey cross section
ALS cross section

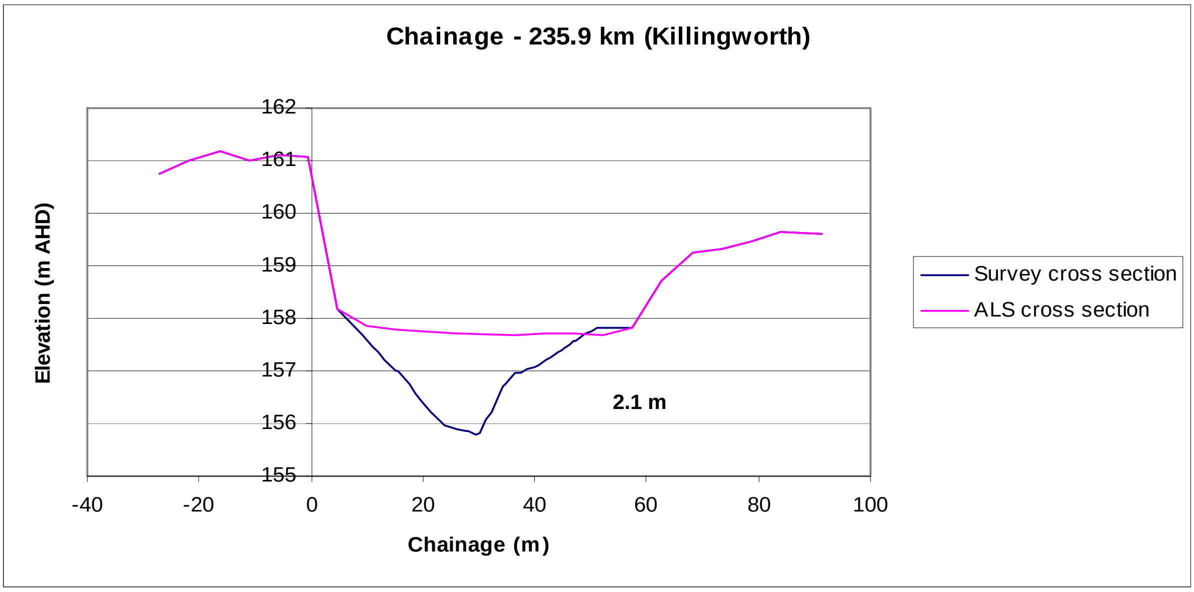

Chainage - 233.9 km (Killingworth)
Elevation (m AHD)
160
159.5
159
158.5
158
157.5
157
156.5
156
155.5
155
-40
-20
0
20
40
60
80
100
Chainage (m)
1.2 m
Survey cross section
ALS cross section

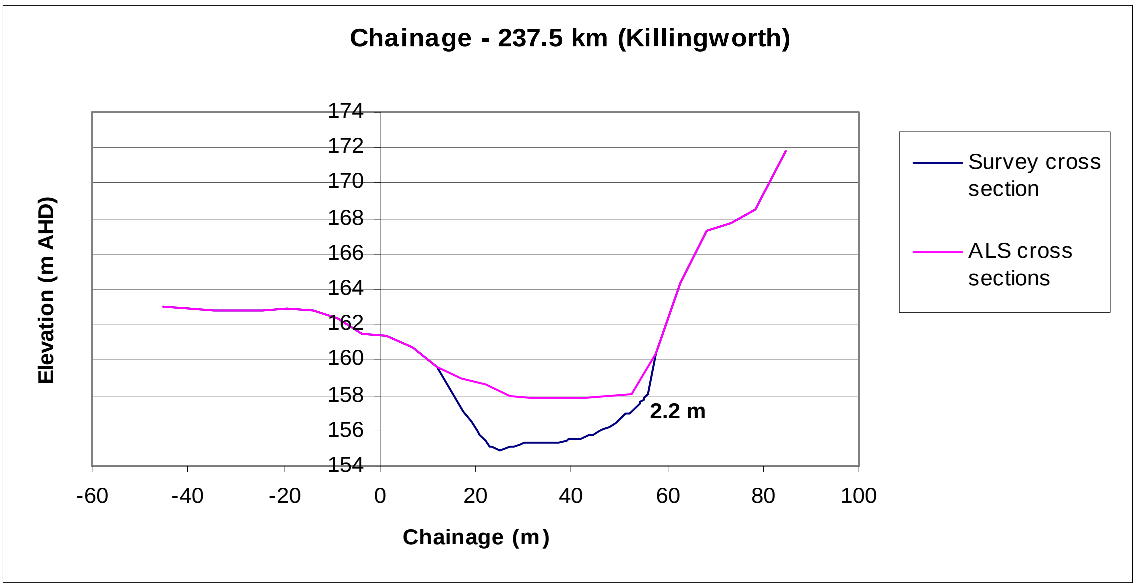

Chainage - 234 km (Killingworth)
Elevation (m AHD)
161
160
159
158
157
156
155
154
-60
-40
-20
0
20
40
60
80
100
120
Chainage (m)
1.4 m
Survey cross section
ALS cross section

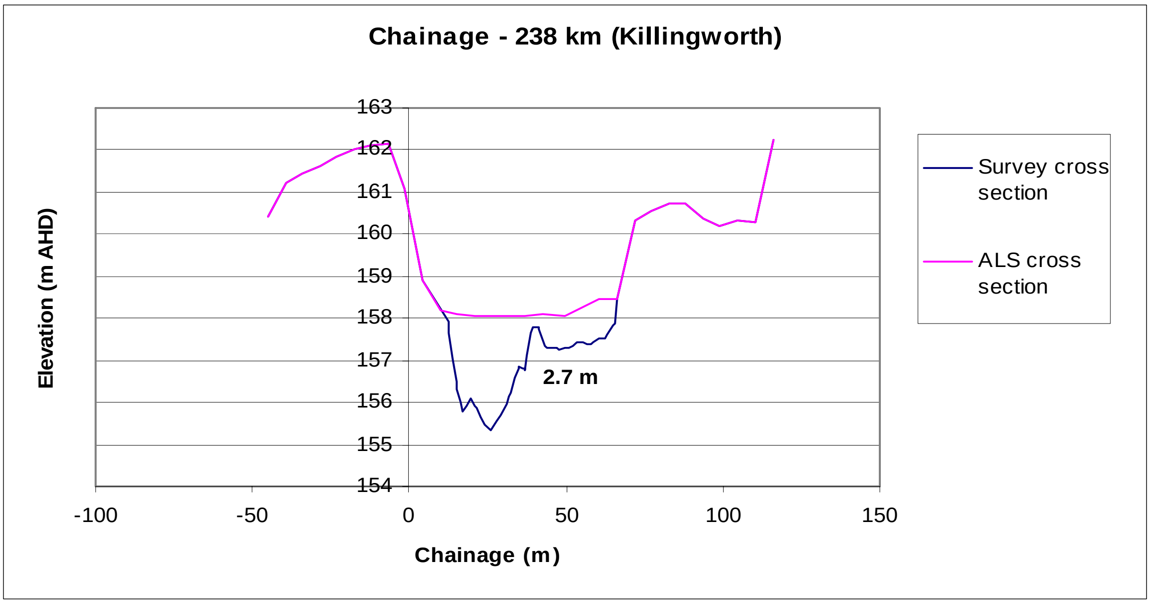

Chainage - 234.2 km (Killingworth)
Elevation (m AHD)
172
170
168
166
164
162
160
158
156
154
152
-50
0
50
100
150
Chainage (m)
2.0 m
Survey cross section
ALS cross section

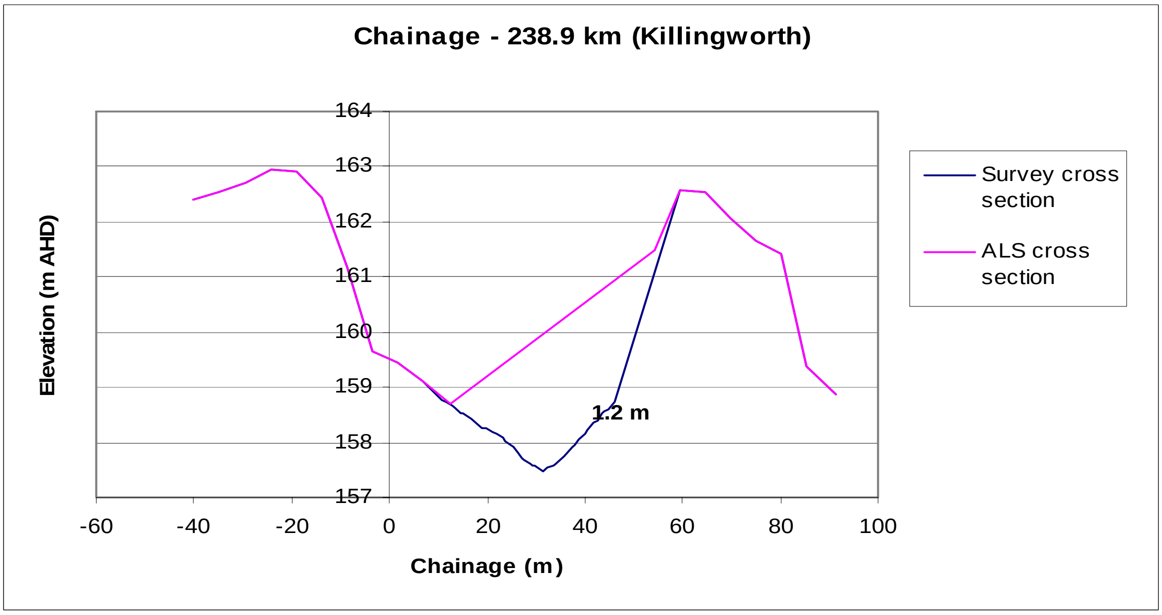

Chainage - 234.5 km (Killingworth)
Survey cross section
ALS cross section
Elevation (m AHD)
160.5
160
159.5
159
158.5
158
157.5
157
156.5
156
155.5
-50
0
50
100
Chainage (m)
1.0 m

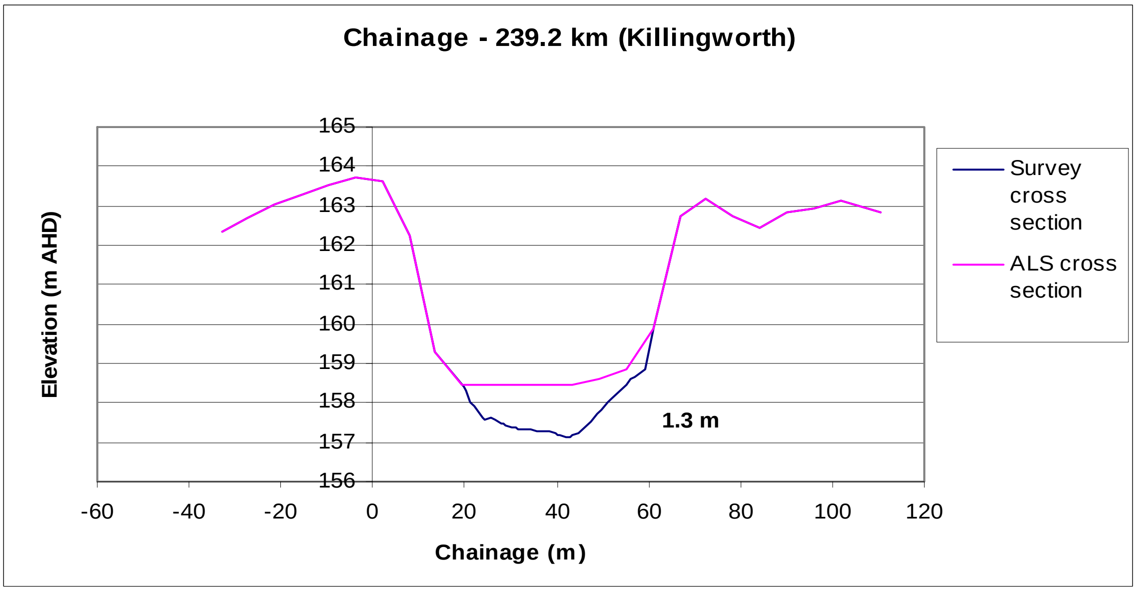

Chainage - 235.3 km (Killingworth)
Survey cross section
ALS cross section
Elevation (m AHD)
160
159.5
159
158.5
158
157.5
157
156.5
156
155.5
155
-40
-20
0
20
40
60
80
100
Chainage (m)
2.2 m

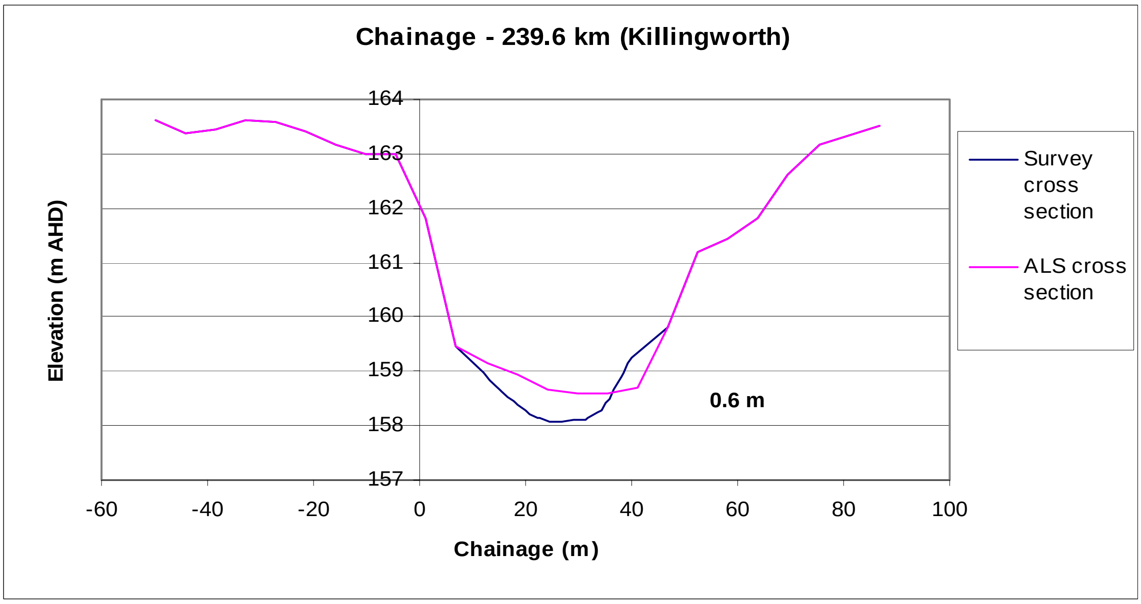

Chainage - 235.9 km (Killingworth)
Elevation (m AHD)
162
161
160
159
158
157
156
155
-40
-20
0
20
40
60
80
100
Chainage (m)
2.1 m
Survey cross section
ALS cross section

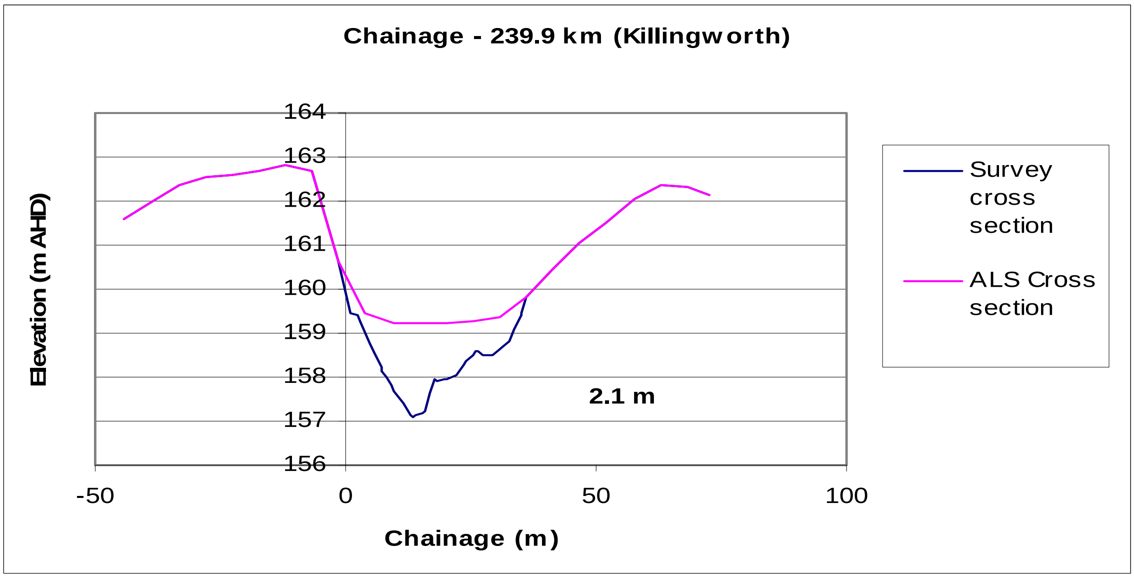

Chainage - 237.5 km (Killingworth)
Elevation (m AHD)
174
172
170
168
166
164
162
160
158
156
154
-60
-40
-20
0
20
40
60
80
100
Chainage (m)
2.2 m
Survey cross section
ALS cross sections

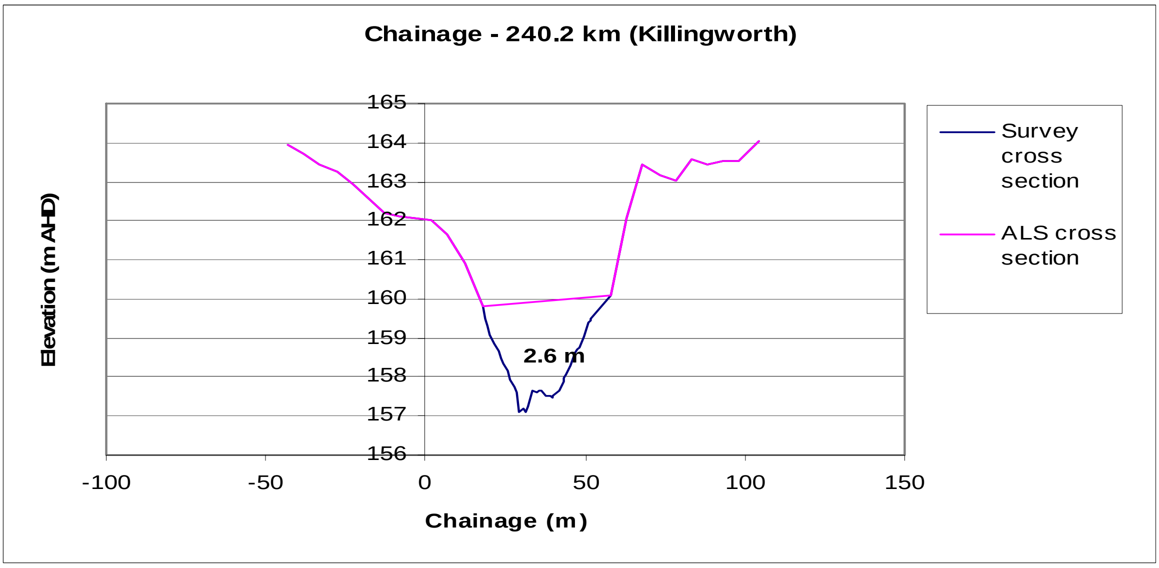

Chainage - 238 km (Killingworth)
Elevation (m AHD)
163
162
161
160
159
158
157
156
155
154
-100
-50
0
50
100
150
Chainage (m)
2.7 m
Survey cross section
ALS cross section

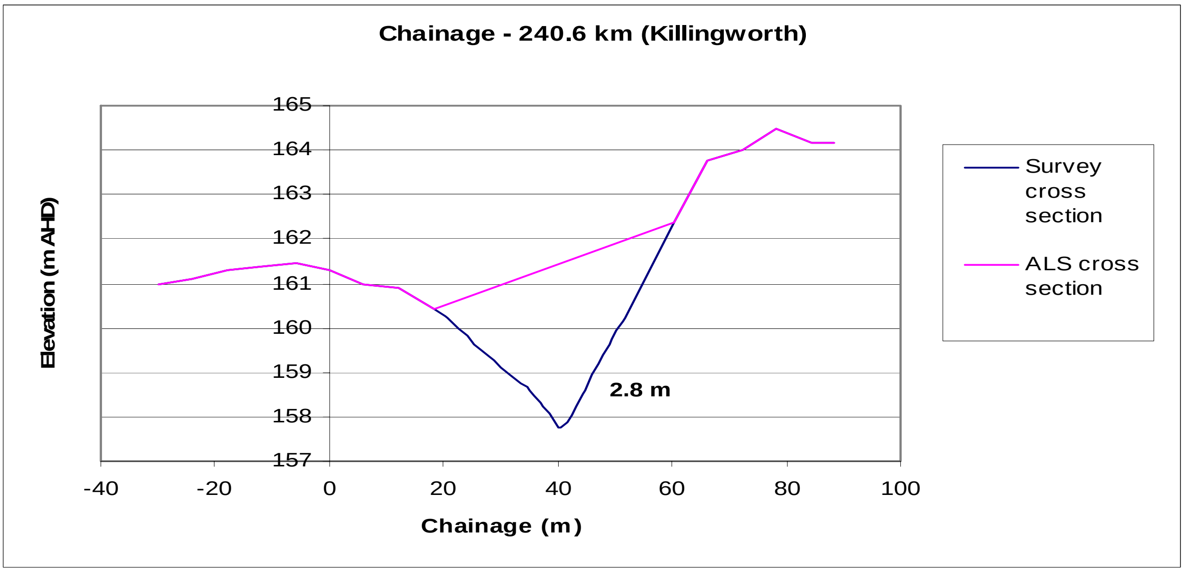

Chainage - 238.9 km (Killingworth)
Elevation (m AHD)
164
163
162
161
160
159
158
157
-60
-40
-20
0
20
40
60
80
100
Chainage (m)
1.2 m
Survey cross section
ALS cross section

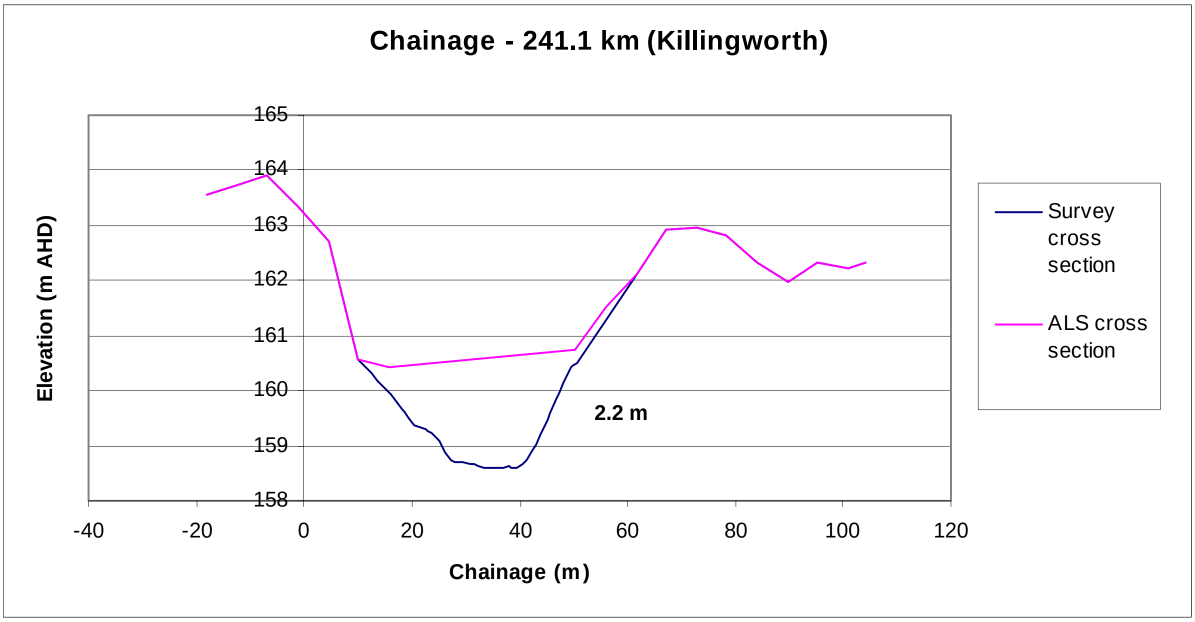

Chainage - 239.2 km (Killingworth)
Elevation (m AHD)
165
164
163
162
161
160
159
158
157
156
-60
-40
-20
0
20
40
60
80
100
120
Chainage (m)
1.3 m
Survey cross section
ALS cross section

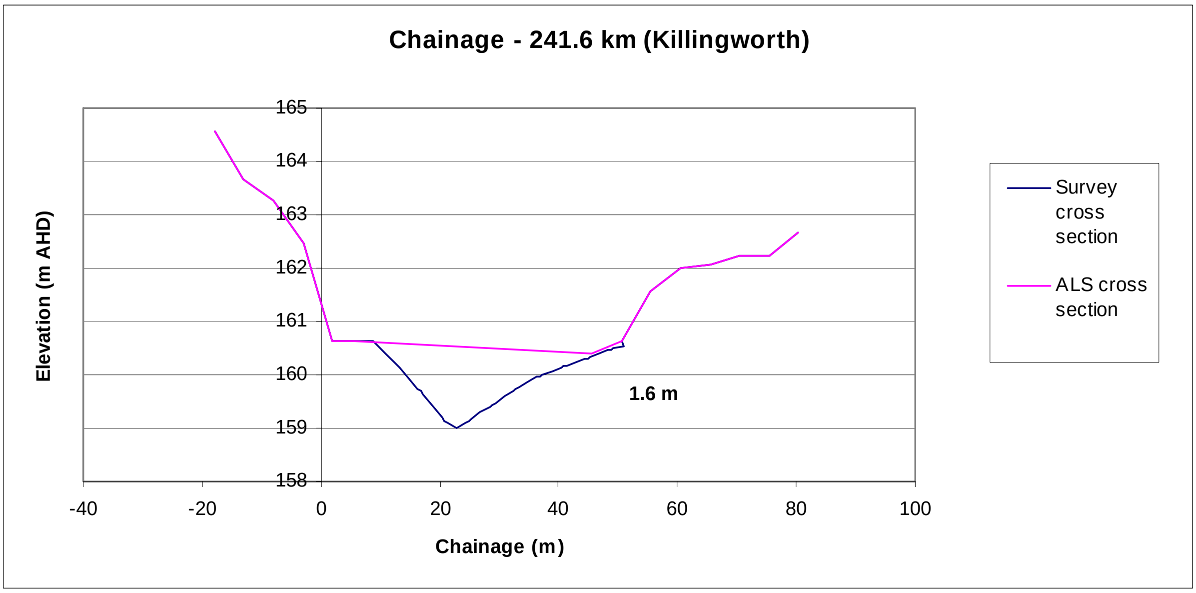

Chainage - 239.6 km (Killingworth)
Elevation (m AHD)
164
163
162
161
160
159
158
157
-60
-40
-20
0
20
40
60
80
100
Chainage (m)
0.6 m
Survey cross section
ALS cross section


Chainage - 239.9 km (Killingworth)
Elevation (m AHD)
164
163
162
161
160
159
158
157
156
-50
0
50
100
Chainage (m)
2.1 m
Survey cross section
ALS Cross section


Chainage - 240.2 km (Killingworth)
Elevation (m AHD)
165
164
163
162
161
160
159
158
157
156
-100
-50
0
50
100
150
Chainage (m)
2.6 m
Survey cross section
ALS cross section


Chainage - 240.6 km (Killingworth)
Elevation (m AHD)
165
164
163
162
161
160
159
158
157
-40
-20
0
20
40
60
80
100
Chainage (m)
2.8 m
Survey cross section
ALS cross section


Chainage - 241.1 km (Killingworth)
Elevation (m AHD)
165
164
163
162
161
160
159
158
-40
-20
0
20
40
60
80
100
120
Chainage (m)
2.2 m
Survey cross section
ALS cross section


Chainage - 241.6 km (Killingworth)
Elevation (m AHD)
165
164
163
162
161
160
159
158
-40
-20
0
20
40
60
80
100
Chainage (m)
1.6 m
Survey cross section
ALS cross section