Wimmera River
Reach 2
Waterway Action Plan

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Wimmera Catchment Management Authority

Wimmera River Reach 2 Waterway Action Plan

Contents

Introduction

This Waterway Action Plan for Reach 2 of the Wimmera River has been prepared by Earth Tech Engineering for the Wimmera Catchment Management Authority.

The Wimmera Catchment Management Authority plans to undertake a stream management works program along this reach of the Wimmera River, which has been identified as a high priority for management. This Waterway Action Plan has been completed to help facilitate the implementation of the waterway management works. The development of local community support, the investigation of reach wide issues and the subsequent provision of a technical and financial basis for the works to government, are important aspects of this Action Plan.

This report includes a discussion of stream processes, habitat, riparian vegetation, stream flow and water quality issues and establishes a technical basis for determining the priorities for works implementation. In determining these priorities the investigation also considers the objectives of the Wimmera Catchment Management Authority via objectives referenced in the relevant regional strategies.

Once these priorities have been set, the works program will be developed in consultation with the local community. Individual works sites will be assessed in the field against the priorities set for the program and associated financial considerations.

Regional Objectives

The regional strategies and policies which are relevant to the Wimmera River Catchment are the:

- Victorian River Health Strategy (2002)
- Draft Wimmera Waterway Management Strategy (2002)
- Draft Wimmera Water Quality Strategy (2001)
- Wimmera River Geomorphic Investigation (2002)

Review of Regional Strategies

The Victorian River Health Strategy

The objective of the Victorian River Health Strategy (VRHS) is to achieve healthy rivers, streams and floodplains which meet the environmental, economic, recreational and cultural needs of current and future generations (DNRE, 2002). This goal is to be attained using the following four key elements of the strategy (DNRE, 2002):

- Protecting rivers that are of the highest community value from any decline in condition;
- Maintaining the condition of ecologically healthy rivers;
- Achieving an 'overall improvement' in the environmental condition of the remainder of rivers, and;
- Preventing damage from future activities.

Implementation of this management approach will be by:

- Providing special protection for rivers of very high value;
- Establishing regional five and 10 year targets for river protection and restoration through community-driven regional planning processes; and
- Establishing policies for specific management activities aimed at preventing damage to river health from future management activities.

Regional River Health Strategies, of which this report is a part, aim to:

- Identify environmental, recreational, social and economic assets;
- Identify threats to assets;
- Set broad priorities for protection and restoration based on a risk-based approach and a level of community commitment;
- Identify broad actions required;
- Include detailed issue specific action plans which identify:
    - Detailed options for actions and analyse these using the cost-benefit approach;
    - Priority actions;
    - Roles and responsibilities;
    - The cost sharing arrangements;
    - Timetable for implementation; and

  - Five year implementation targets and 10 year resource condition targets;
- Integrate five year implementation targets and 10 year resource condition targets for major river reaches;
- Set integrated river health objectives and targets for major river reaches; and
- Include monitoring, reporting and review programs.

The VRHS goes on to briefly describe some of the details of managing:

- Water quality;
- Riparian lands; and
- River channels.

The Wimmera Waterway Management Strategy

The Wimmera Waterway Management Strategy (WWMS) aims to provide direction for waterway management within the Wimmera region (Sinclair Knight Merz 1999). The goal of the strategy is to, "protect and enhance the region's waterways through fair and sustainable management, taking account of environmental, economic, cultural and social objectives. In 1997 the Wimmera Regional Catchment Strategy recognised the need to develop and implement an integrated waterway management program for the two river basins within the Wimmera CMA region. A series of programs, which are consistent with the Wimmera Regional Catchment Strategy, are detailed in the WWMS. Of particular relevance to this Waterway Action Plan are:

- Program 1. Asset Management, the aim of which is to manage structural waterway assets so as to improve the health of the waterways;
- Program 2. Waterway Repair and Maintenance, the aim of which is to preserve, maintain and/or rehabilitate the environmental, economic and social values of waterways;
- Program 3. Riparian Management, the aim of which is to improve waterway health through the sustainable management of riparian zones; and
- Program 4. Catchment Management, the aim of which is to assist in addressing land management issues that have negative impacts on waterway values.

Appendix A of the WWMS describes the method used to divide the Wimmera CMA into 12 Waterway Management Units (WMU). Detailed information on each river reach which makes up a WMU has been gathered through literature reviews and field inspections. Tables summarizing the stability, ecological condition and estimated cost of works required for each reach are provided. This report aims to confirm and elaborate on the findings of the WWMS in relation to Reach 2 as defined in the Wimmera River Geomorphic Investigation. Reach 2 is wholly contained within Waterway Management Unit 1.

The Wimmera Water Quality Strategy

The aim of the Wimmera Water Quality Strategy is to improve the quality of river water so as to bring environmental, social and economic benefits to the region. Poor water quality has resulted in a significant number of blue green algae blooms in the past. Implementing the strategy could reduce total phosphorous levels in the Wimmera River by up to 42 tonnes per year (WCMA 2001).

The strategy is to be applied through a number of Programs. Of these, Program 7; Catchment and River Health Management, is most relevant to this report. Its objective is to, “ensure that catchment and river health management in the region will result in improved water quality”. This is to be achieved through:

- Waterway repair and maintenance;
- Flow regimes;
- Riparian management; and
- Catchment management.

It has been estimated that catchment wide implementation of these strategies could reduce total phosphorous input to the catchment by 24.1 tonnes per year.

The Wimmera River Geomorphic Investigation

The Wimmera River Geomorphic Investigation (WRGI) comprises a review and analysis of sediment processes within the Wimmera catchment, with a focus primarily on the Wimmera River. This report recommends that the following priorities, based on the principles of best practice catchment management, be applied:

- Preserve areas with near pristine values;
- Restore areas of high value;
- Rehabilitate areas that place other values at risk or provide good opportunity for restoring values; and
- Maintain degraded areas to prevent values declining to unacceptable levels.

Broadly examining the upper catchment areas, the Geomorphic Investigation found that some streams and tributaries are delivering high sediment loads to the Wimmera River. This excess sediment is threatening reaches harbouring rare geomorphic and ecological features. In particular the report found that Reaches 2, 4 and 6 are high priorities for management intervention.

With regard to Reach 2 the WRGI (ID&A 2002) noted the following Management Implications for Reach 2 and its tributaries.

Wimmera River

“The contemporary adjustments to geomorphic character that have occurred due to drainage works and subsequent gully erosion have not altered the geomorphic behaviour of this reach. Due to some of the reach boundary conditions, which have not changed since European settlement, this reach will naturally accumulate sediment and in some sense recreate the swampy environment possibly containing a Chain of Ponds. Working with these stream processes will be the most effective river rehabilitation strategy”.

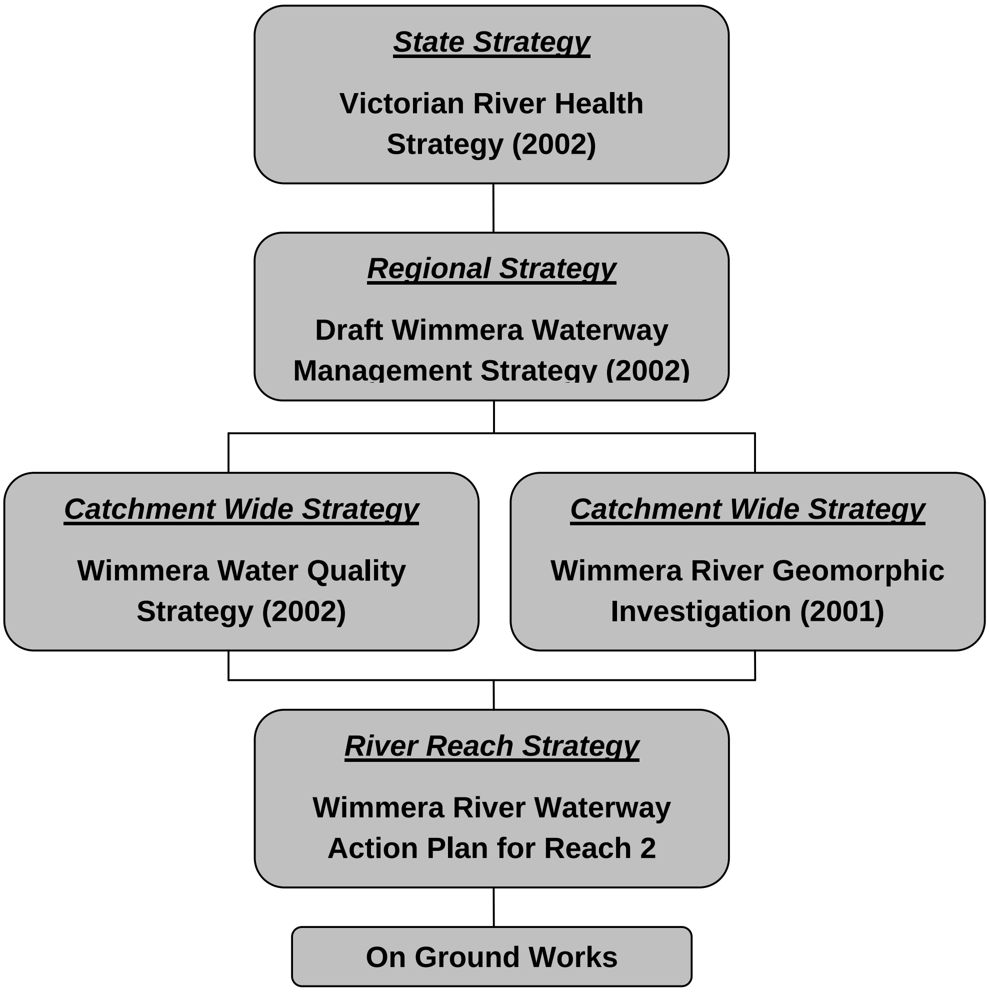
“*Reaches 2.1 and 2.3 are intact fill, containing freshwater meadows and chain of ponds, protection of these reaches should be high priority for management.” “….it is a high priority to ensure no further degradation of those geomorphically intact reaches, 2.1 and 2.3, occurs. High priority should also be given to the rehabilitation of reach 2.23, it is short, between reaches 2.1 and 2.3 and poses a threat to their status.”*

Tributaries

"Objectives for the management of the tributaries contain two categories:

- *management for processes that impact on stream health and land management within the tributary system*
- *management for process that impact on the Wimmera River.*

"Management should be directed at reducing the rate of sediment input from the upper catchment areas…by trapping sediment within the tributary system."



Relationships between reports used to compile the Wimmera River Waterway Action Plan for Reach 2.

River Health Assessment

Overview of Reach 2

The Wimmera River Geomorphic Investigation (IDA 2002) divided the Wimmera River into 20 management reaches based on geomorphic characteristics and behaviour. The reaches commenced at the upstream end of the Wimmera River and finished at Lake Hindmarsh.

Reach 2 is approximately 16 kilometres in length, commencing upstream of a significant freshwater meadow on Crown Land immediately upstream of Lower Wimmera Road. The reach finishes at the confluence of the Wimmera River and the Glenlofty Creek. The reach passes through agricultural land, predominantly used for grazing, and the township of Elmhurst. A number of named and unnamed tributaries join the Wimmera River within the reach. Named tributaries include:

- Tom the Tailor Creek
- Little Wimmera River
- Hickman Creek
- Rocky Creek
- Sandy Creek
- Glenpatrick Creek
- Nowhere Creek

(see Figure 1).

For most of its length, Reach 2 is within Crown Water Frontage. However given the swampy nature of much of the reach, there are significant waterway values on adjacent private property. There are 3 sections which are not on Crown Water Frontage;

1. a small section downstream of Lower Wimmera Road,
2. within the township of Elmhurst, and
3. approximately 2 kilometres upstream of the Glenlofty Creek.

Artificial channelisation, undertaken in the past, initiated channel incision resulting in the formation of a continuous, defined channel along the majority of Reach 2. The very upper parts of the Wimmera River (Reach 1) and the Little Wimmera River, which have intact chain of ponds, are the only sections unaffected by the deepening process.

Upstream of the Pyrenees Highway, a chain of ponds morphology is the dominant feature. The river alternates from shallow, swampy reaches with a non-defined channel, abundant instream vegetation and very little overstorey, to a stable incised channel with slow pools separated by long sections with abundant instream vegetation and patchy, narrow bands of overstorey riparian vegetation.

Swampy sections are very stable, heavily vegetated and provide good habitat to bird life and instream fauna. Incised sections that appear to be reverting to their original form generally comprise long pools separated by longer sections of thick instream vegetation (usually phragmites and/or cumbungi).

Stock access is not restricted from all of this section, however it does not pose a major threat to stream health, as the type and thickness of vegetation and the extent and duration of inundation is a deterrent to stock. There is no evidence of stock significantly impacting on the physical characteristics of this reach although it is likely that they impact on water quality.

Willows and poplars dominate some of the incised reaches, reducing the abundance of aquatic plants, riparian diversity and in stream habitat. Willow roots in the stream are presently holding a number of small erosion heads. Whether the willows are preventing their upstream migration or in fact are the cause of them is difficult to determine (the only erosion heads noted upstream of the Highway were among willow roots except those that have already passed into the Hanging Swamp).

A concrete drop structure upstream of the Hickman Creek confluence, (approximately 5 km upstream of Elmhurst) marks a significant change from a poorly vegetated and incised reach to a swampy reach with abundant reeds and poorly defined channel. The structure was constructed in the 1960's in a joint effort between local Government and landholders to address channel incision in the Wimmera River. The structure was refurbished in 1990 by local landholders and in 2000 was again repaired by the Wimmera CMA. The structure is now a key asset of the Wimmera CMA.

In December 2001 Fisher Stewart Pty Ltd (on behalf of the Wimmera CMA) undertook an engineering survey of the Wimmera River between Elmhurst and the Hanging Swamp (Appendix B). Approximately 150 metres within Reach 2.2 was inaccessible. The results of the survey were incorporated into an assessment of Hanging Swamp (Appendix C). The survey of the Wimmera River is approximately 8.5 km in length. Cross sections were surveyed at an average interval of 250 m.

Assessment of the survey information indicates the following:

- The average bed grade between the concrete drop structure and the Hanging Swamp is 1 in 250 (0.004 m/m) which is also a low energy system but contains a pre European settlement channel form
- The average bed grade downstream of the concrete drop structure is approximately 1 in 330 (0.003 m/m) indicating a low energy fluvial system demonstrated by the accumulation of fine grained sediment within the active river channel.

Downstream of the Pyrenees Highway, the Wimmera River maintains a more open channel with larger flow capacity, and more overstorey vegetation but less instream vegetation. The overstorey vegetation, although still inadequate, provides a substantial portion of instream debris, which is required to maintain habitat and channel stability.

The Wimmera River at Elmhurst has undergone extensive infilling of the floodplain in this section which appears to have been exacerbated by the Avoca - Ararat Railway line at the downstream end of Elmhurst. The Elmhurst Landcare Group in conjunction with the Wimmera CMA carried out extensive waterway works in this section of the river in 1999/2000. Pool and riffle sequences were created and extensive weed control undertaken to improve the overall amenity of the area and create sediment traps.

Sandy Creek and the Glenpatrick /Nowhere Creek system are major tributaries which enter the Wimmera River at Elmhurst. Both systems have undergone incision in the past which has contributed sediment to the Wimmera River. Erosion processes are still active in the Glenpatrick and Nowhere Creeks. Incision is less active in Sandy Creek.

Native riparian vegetation is sparse along the length of Reach 2 and where it exists it is usually in narrow strips. This has resulted in poor shading and a low portion of instream debris to provide habitat. The abundance of instream debris improves downstream of the Elmhurst - Glenpatrick Road.

The main threats to river health upstream of the highway are bed instability, pest plants (willows, poplars, gorse), and bank instability and declining water quality due to stock access.

The main threats to river health downstream of the highway are pest plants (mostly gorse, some willows and poplars), stock access, lack of riparian vegetation and variable instream habitat.

Figure 2 Typical Freshwater Meadow upstream of Pyrenees Highway

Overview of Reach 2 tributaries

Little Wimmera River

The Little Wimmera River occurs within Crown Water Frontage before entering State Forest. The river is characterised by an upper and lower section separated by a private vehicle crossing off the Lower Wimmera Road. The upper section is an example of an intact chain of ponds reach in excellent condition. The lower reach is a well vegetated, incised reach that is reasonably stable although some small erosion heads are migrating towards the crossing. Stock access is limited although riparian vegetation and fencing could be improved. The main management issues for the two reaches are control of the active headcuts that threaten the upper reach and improvement of riparian vegetation and instream habitat.

Figure 3 Upper section of Little Wimmera River in excellent condition

Tom the Tailor Creek

The creek, on private property, has incised up to three metres and more in some parts with vertical sides and localised instabilities. Previously active gully heads are currently stable and the creek itself is mostly stable. The biggest threat is from stock access and over grazing although a large portion of the creek is located within land used for tree plantations. Future logging operations may pose a threat if a vegetated buffer is not maintained between the logging and the stream banks. The main management objectives are to maintain creek stability and improve riparian vegetation to prevent impacts on downstream receiving reaches.

Figure 4 Tom the Tailor Creek, incised but stable - note plantation in the background

Hickman Creek

Hickman Creek, Rocky Creek and Sandy Creek all flow off granitic hills, have undergone gully erosion and are therefore likely to have delivered large quantities of sediment to the Wimmera River and its floodplain. Hickman Creek is on private property for all but a small section. The creek appears to have stabilised with good instream vegetation where it enters the Wimmera River. Monitoring of sediment inputs from the creek should be undertaken. The major landholder on Hickman Creek is currently investing significantly in fencing, revegetation and off stream watering along the creek.

Rocky Creek

Rocky Creek occurs on private property and is stable where it enters the Wimmera River. A concrete drop structure, approximately 100 metres from the Wimmera River confluence, has been incorporated into the road bridge on the Elmhurst – Beaufort Road. The structure has stabilised the creek immediately upstream of the road. There is, however, a large sediment slug, of unknown origin, in the Wimmera River at its confluence with Rocky Creek. Less than 1 kilometre upstream of the Elmhurst –Beaufort Road, Rocky Creek is highly degraded. Stock have unlimited access to the creek, there is little to no riparian vegetation and an active head scour is working its way up the creek.

Sandy Creek

Sandy Creek has undergone incision in the past but is now stable. There are minor instabilities in the upper reaches but sediment is not transported to the Wimmera River. Upstream of Sandy's Lane much of the creek occurs within or adjacent to the Pyrenees Hwy road reserve and thus is well vegetated. Downstream of Sandy's Lane the creek is within Glenpatrick Streamside Reserve and is similarly well vegetated. Fencing of private property downstream of Glenpatrick Streamside

Reserve has resulted in a stable, well vegetated creek although overstorey vegetation and recruitment is sparse. Approximately 100 metres upstream of Wiltshire's Lane to its confluence with the Wimmera River the creek is unfenced and in poor condition. Whilst the creek is stable, stock access is unlimited and gorse and rabbits are prevalent.

Glenpatrick/Nowhere Creek

The lower reaches of Glenpatrick and Nowhere creeks occur within Crown Water Frontage. This creek system has also undergone substantial gully erosion and incision. Continual filling of the floodout zone through increased sedimentation rates has resulted in continued attempts to maintain channel capacity through excavation. The excess sediment inputs from gully erosion in the upper catchment exacerbate this process and thus pose land use hindrances. Management should be directed at reducing the rate of sediment input in the upper catchment areas by trapping sediment within the tributary system (ID&A, 2002).

Other tributaries

The last major right bank tributary in Reach 2, shortly upstream of the Elmhurst Landsborough Road, has experienced severe gully erosion that is contributing substantially accelerated rates of sediment input to the Wimmera River (ID&A, 2002).

Left bank tributaries between Elmhurst and the end of Reach 2 have undergone incision in the past. Head erosion at the upstream end of these tributaries is still active but appears to not be contributing sediment to the Wimmera River. The Pyrenees Highway and the Ararat – Avoca Railway line, which are approximately 100 metres from the Wimmera River in this section, are acting to trap sediment before it enters the river. The greatest threat to the stability of these areas is from works in road and railway reserves.

Overview of Management Reaches

The Wimmera River Reach 2 has been divided into 4 management reaches based on the Wimmera River Geomorphic Investigation (WRGI 2001) and field inspection (Appendix D)

- Reach 2.1 - "Hanging Swamp" to Lower Wimmera Road
- Reach 2.2 - Lower Wimmera Road to end of poplars
- Reach 2.3 - End of poplars to Drop Structure upstream of Hickman's Creek
- Reach 2.4 - Drop Structure upstream of Hickman's Creek to Glenlofty Creek

Recommendations for management activities in each of the reaches is detailed in Appendix A. Chainages shown below for reaches are based on the Plan of Survey & Cross Sections, Wimmera River Elmhurst (Appendix B).

Reach 2.1 - "Hanging Swamp" to Lower Wimmera Road

(Survey Chainage CH: 7900 – CH: 8400)

The sub-reach commences immediately upstream of the freshwater meadow within State Forest, upstream of Lower Wimmera Road. The confluence of the Little Wimmera River and Tom the Tailor Creek with the Wimmera River is the end of the reach. The reach represents the upper-most sub-reach of Reach 2.

The dominant feature of the sub-reach is the freshwater meadow. Due to its perched nature, the freshwater meadow has been colloquially termed "Hanging Swamp"

Hanging Swamp is in excellent condition although it is currently under threat from headward erosion in the Wimmera River. Multiple erosion heads have already progressed into the downstream edge of the swamp and are migrating upstream along different paths. Stock have no access to the swamp. The assessment of Hanging Swamp detailed the following.

- *"An erosion head of approximately 3.5 m drop is located immediately downstream of the Hanging Swamp*
- *Approximately 3.0 m of this drop is located within the first 20 m downstream of the Hanging Swamp*
- *An erosion head of similar size is located within the first 100 m of the Little Wimmera River, downstream of a farm access crossing"*

"….Under existing conditions the Hanging Swamp and Little Wimmera River are not at immediate threat of wide spread damage: incision processes are occurring at a slow rate."

"….The willows downstream of the Hanging Swamp currently have a beneficial value in stabilising a small erosion head. If this erosion head were to join with the erosion head at the Hanging Swamp then the rate of incision could increase."

A recently established blue gum plantation is located adjacent to the Hanging Swamp. Future plantation activities may impact upon and pose a threat to the swamp.

Immediately downstream of Hanging Swamp instream willows are growing almost to the confluence with Tom the Tailor Creek. The willows are effectively stopping the progression of further erosion heads from reaching the Hanging Swamp.

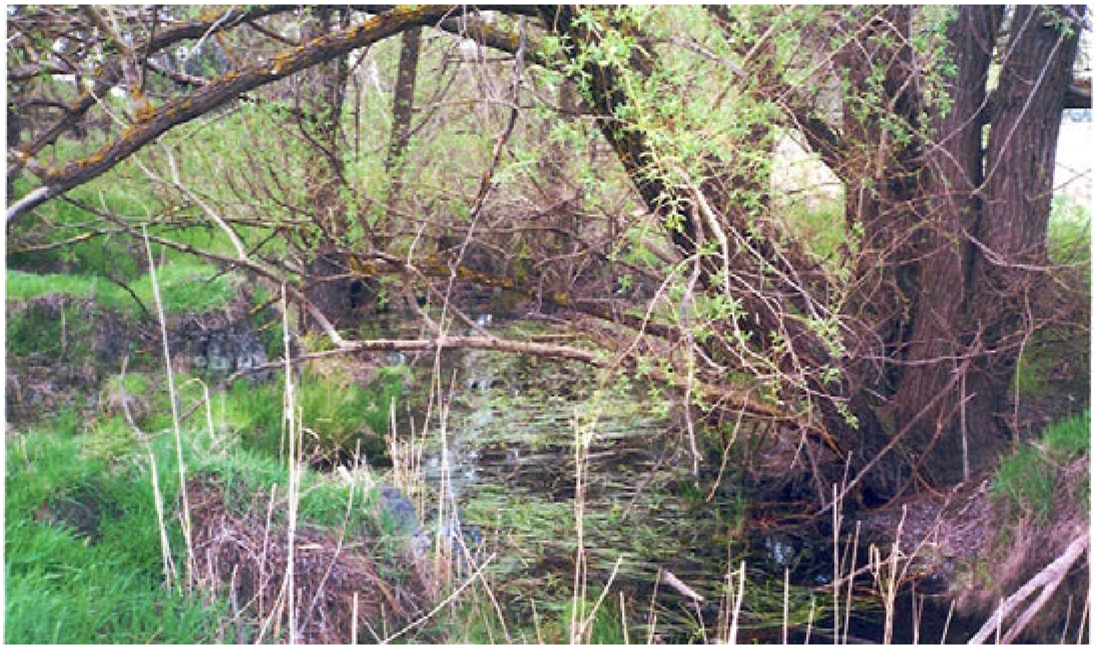


Figure 5 Willows holding erosion heads immediately downstream of Hanging Swamp

Immediately below its confluence with Tom The Tailor Creek the Wimmera River is incised but stable due to the thick growth of phragmites and some cumbungi in the streambed. A culvert on the Lower Wimmera Rd provides further stability to the stream bed due to its backwater effect. The stream is fenced and has been revegetated on both banks downstream of the culvert. The banks are quite steep but reasonably stable due to the existing riparian vegetation and lack of stock access.

Reach 2.2 - Lower Wimmera Road to end of poplars

(Survey Chainage CH: 6950 – CH:7900)

Sub-reach 2.2 is a short reach of approximately 900 metres. It has Tom the Tailor Creek and the Little Wimmera River as its major tributaries at the upstream end of the reach. The WRGI described the sub-reach as *"….clearly a man-made drain that has been lined with exotic tress (primarily willow)".*

The sub-reach is incised but does not have high banks and its riparian zone is dominated by exotic vegetation in the form of willows and poplars. There are some small patches of native vegetation providing instream and bank habitat although the riparian zone along the entire length is very narrow. Fencing exists along the right bank, albeit too close to the river, for the entire length although it has been damaged in places due to fallen trees. There is no fencing along the left bank for the entire reach. Willow roots are holding some erosion heads upstream of the plantation although the reach is generally stable. Instream habitat is limited.

Tom The Tailor Creek has incised up to three metres and more in some parts with vertical sides and localised instabilities. Previously active gully heads are currently stable and the creek itself is mostly stable. The biggest threat is from new instabilities as a result of stock access and over grazing although a large portion of the creek is located within land used for tree plantations. Creek crossings may be required in the plantation area when operations begin and this may pose a threat to stream stability.

The upstream section of the Little Wimmera River is an example of a chain of ponds reach in excellent condition. The lower section of the river is an incised reach that is reasonably stable although some small erosion heads are migrating towards a private crossing. Instream vegetation is very good and stock access is limited although riparian vegetation and fencing could be improved.

Reach 2.3 - End of poplars to Drop Structure upstream of Hickman's Creek

(Survey Chainage CH: 5000 – CH: 6950)

Reach 2.3 sees the river returning to a stable floodplain reach. A large concrete drop structure marks the downstream end of the reach where the stream changes dramatically from a heavily vegetated swamp to a deeply incised channel with little instream and riparian vegetation.

The upper section of the reach is generally stable and is dominated by instream vegetation of phragmites and cumbungi. There are very few trees with a consequent low diversity of instream habitat. Fencing exists in places although it is not strategically positioned for protection of the river. Stock access is of concern where banks are more vulnerable and slightly unstable. For the majority of the reach stream stability is not affected by stock access although water quality may be affected. The river appears to divide into two or more channels through a swampy section and three or four young willows are growing in the middle of the stream.

In the mid sections the reach becomes channelised with willows along the majority of the length and almost no native overstorey. Erosion heads are being held by willow roots (behind the Keith household). Discontinuous fencing on both banks is ineffective at restricting stock access however, the nature of the stream (spiny rushes and often inundated with water) is a deterrent to stock.

In the lower sections it is very stable and heavily vegetated with instream reeds, rushes on the floodplain and very little overstorey as the stream turns back to a swamp-like waterway. Although it is fenced off in the lower parts stock can access the stream.

The end of the reach is defined by a drop structure upstream of the confluence of Hickman's Creek. The history of the structure is described above.

Figure 6: Drop structure on Wimmera River upstream of Hickman Creek

Reach 2.4 - Drop Structure upstream of Hickman's Creek to Glenlofty Creek

(Survey Chainage CH: 0 – CH: 5000 and length of river downstream of start of survey point)

The Wimmera River downstream of the drop structure has a clearly defined channel due to past incision. Instream and riparian vegetation is patchy although gradually improving downstream of the drop structure. The bed and banks are generally stable although stock access impacts on bank stability and vegetation establishment.

Fencing is well underway with some sections completed and others with pegs in place marking future fencing alignments. Unfortunately some of the fences are too close to the bank to provide any long-term benefits as there is no room for riparian vegetation to establish. There are some good patches of instream habitat provided by reeds and LWD, however, these are often separated by large lengths of uniform channel with no riparian vegetation.

The most upstream sighting of gorse is near the confluence with Rocky Creek.

Figure 7 Looking downstream from concrete drop structure

Downstream of the confluence with Rocky Creek there is another swampy section that is stable, well vegetated and in good overall condition. Small patches of gorse, coming from the upstream reach, some recently planted willows and blackberry are also present. Rabbits are evident although they do not appear to be a major problem. There is little overstorey vegetation although with recent fencing on both sides eucalypts are beginning to regenerate naturally. Just upstream of the Pyrenees Highway (500m) marks the end of the swampy section and the beginning of the stream channel becoming more defined.

To a point approximately 500m upstream of the Elmhurst Landsborough Road there are short sections that are dominated by instream vegetation and little overstorey, however, the stream channel remains defined throughout. The river is fenced on both sides although the fencing is often too close to the bank edge to provide sustainable benefits. Native riparian vegetation is almost continuous but is in very narrow bands or only on one bank. Gorse is a major weed problem, particularly between the railway line and the confluence with Sandy Creek. There is a good variety of instream habitat provided by snags, pools and reeds in sections of the reach.

Downstream to the confluence with Glenlofty Creek the stream is incised with sediment in the streambed and banks are collapsing due to cattle access. Isolated Red gums appear along the banks and in the streambed. Gorse is beginning to take over in the riparian zone. Instream habitat is limited and water quality is very poor due to the sediment filled bed, cattle access and no LWD.

Figure 8 Gorse on banks and direct stock access at the downstream end of Reach 2

References

DNRE (Department of Natural Resources & Environment), 2002, *Draft Victorian River Health Strategy*, Catchment & Water division DNRE, Melbourne, Australia.

Earth Tech Engineering, 2002, *Habitat Restoration Project for the Glenelg River at Harrow; Conceptual Design*, Earth Tech, Hamilton, Victoria.

Land Technology, 2000, *Concongella Landcare Group, Astons Scour Group: Catchment Management Plan, Astons Scour,* Land Technology Pty Ltd, Horsham, Victoria.

Rutherfurd, I D, Jerie K & Marsh N, 2000, *A Rehabilitation Manual for Australian Streams Volume 2,* Co-operative Research Centre for Catchment Hydrology, Department of Civil Engineering Monash University, Melbourne, Victoria.

Treadwell S (ed), 1999, 'Managing snags and Large Woody Debris' in S.Lovett and P.Price (eds), *Riparian Land Management Technical Guidelines, Volume two: On-ground Management Tools and Techniques*, Land and Water Resources Research and Development Corporation, Canberra, pp.15-22

WCMA (Wimmera Catchment Management Authority), 1999, *Wimmera Waterways Management Strategy*, WCMA, Horsham, Victoria.

WCMA (Wimmera Catchment Management Authority), 2001, *Wimmera Water Quality Strategy*, WCMA, Horsham, Victoria.

ID&A, 2002, *Wimmera River Geomorphic Investigation*, ID&A, Melbourne, Australia.

Appendix A: Proposed Program of Activities for Reach 2

Reach 2.1 - "Hanging Swamp" to Lower Wimmera Road

Management Objectives

- Control of the erosion heads that threaten Hanging Swamp
- Prevent upstream migration of the erosion heads (and hence resultant sediment release downstream)
- Prevention of the erosion heads within willows moving upstream and into the Hanging Swamp
- Improvement of the instream habitat and riparian vegetation values

Recommended actions	Priority
Monitor the rate of movement of the erosion heads through the swamp using ground survey (including pegs in ground, photos, and measurement) Undertake grade control if required Investigate future activities in adjacent plantation to determine possible impacts on swamp Monitor movement of erosion heads among exotic vegetation Selective poisoning/removal of willows in reach pending results of monitoring. Any actions here will depend on outcomes of monitoring heads on the edge of the swamp Fence both sides of river from Hanging Swamp to the Little Wimmera Road crossing (approximately 225m) if stock have access	High
Monitor for stability and pest plants from upstream in short section below confluence with Tom The Tailor Creek Determine whether stock access the section upstream of the culvert and fence if required.	Low

Reach 2.2 - Lower Wimmera Road to end of poplars

Management Objectives

- Improve riparian zone and instream habitat values
- Maintain stream stability

Recommended actions	Priority
Monitor and control, if necessary, erosion heads currently located among some willow roots Poison and follow-up removal of willows and poplars through reach over approximately 400m. Install fencing on both sides of river to restrict stock access Fence out the left bank (400m) and repair damaged sections of the right fence Longitudinal bed survey Monitor erosion heads and implement stabilisation measures where required.	Medium

Tom The Tailor Creek

Management Objectives

- Maintain and improve present stream stability
- Reduce stock access or improve management of grazing within riparian zone.

Recommended Actions	Priority
Fence and revegetate right and left banks (approximately 5300m). Improve grazing management through landholder consultation	Low

Little Wimmera River

Management Objectives

- Monitor and control erosion heads
- Improvement in riparian vegetation and instream habitat

Recommended Actions	Priority
Monitor progress of erosion heads Fence and revegetate the left bank above private crossing (approximately 1470m). Revegetate banks below private crossing to confluence with Wimmera River (approximately 70 metres. Banks already fenced)	Low

Reach 2.3 - End of poplars to Drop Structure

Management Objectives

- Improve riparian zone and instream habitat values
- Maintain bed stability
- Maintain condition of drop structure

Recommended actions	Priority
Within the section dominated by willows and Hawthorn, remove exotic vegetation and fence and revegetate (approximately 600m). Manage erosion heads among the willow roots to ensure they don't progress into the stable upstream section of reach	Medium
Fencing and revegetation at start of reach to protect vulnerable banks (approximately 190m either side). Fence and revegetate other unfenced sections of river (300m right bank, 600m left bank)	Low

Reach 2.4 - Drop Structure upstream of Hickman's Creek to Glenlofty Creek

Management Objectives

- Link up high value swampy reaches
- Protect the function of the drop structure, which provides stability to the upstream reach
- Increase abundance of riparian and instream vegetation and width of riparian zone
- Control and prevent the spread of exotic vegetation
- Control pest animals

Recommended actions	Priority
From drop structure to downstream end of section where river reverts to swamp complete fencing on both banks (approximately 1100m total), increasing width Revegetate left and right banks.	High
Remove exotic vegetation from river and Rocky Creek confluence (approximately 200m)	High
Commencing 1100 metres upstream of Elmhurst – Glenpatrick Road Bridge • Remove gorse (1100m) • Revegetate to railway line (some parts already done)	High
Fence both banks between railway line and Elmhurst Glenpatrick Rd (approximately 200m either side). Existing fencing on right bank is to be replaced.	High
Between Eyrie Stud boundary and Landsborough Road • Fence gaps and revegetate on left and right banks, approximately 300m • Approach landholders to increase the setback of current fencing along the river - if not the permanent fencing at least the temporary fencing • Remove exotic vegetation (some willows)	High

Recommended actions	Priority
Remove exotic vegetation from river in swampy section downstream of Rocky Creek confluence to 500 m upstream of Pyrenees Hwy (approximately 750m)	Medium
Remove exotic vegetation and fence left bank and revegetate both banks upstream of Pyrenees Hwy (170m) Fence and revegetate right bank downstream of Pyrenees Hwy (470m) Remove exotic vegetation downstream of Pyrenees Hwy (470m)	Medium
From Elmhurst Glenpatrick Rd Bridge to downstream property boundary of Eyrie Stud (ex deer farm) • Fence and revegetate both banks (750m either side), and • Re-introduce LWD	Medium
Revegetate left and right banks (approximately 380m) from downstream of property boundary of Eyrie Stud Continue gorse control in above section	Medium
From just upstream of Landsborough Road to confluence with Glenlofty Creek • Remove gorse • Fence and revegetate left and right banks (approximately 1500m) • Re-introduce LWD for habitat	Medium
Investigate provision of fish passage past the drop structure	Low

Issues Arising From the Works Program

Instream Reed Growth

Cumbungi and phragmites are the two main species of reeds that occur throughout the Wimmera catchment area. The growth of these reeds in the stream bed is essential to stream stability and provides a means of trapping and holding sediment in the reach. Although sediment trapping is essential for the rehabilitation of Reach 2, and for the protection of Reach 3, landholders may have concerns that trapped sediment is filling waterholes used for stock watering. Other landholder perceptions are that reed growth leads to increased flooding and an increased fire hazard.

Loss of Stock Watering Holes

Without intervention to maintain a channelised stream, the Wimmera River will, due to geomorphic processes, revert to its original chain of ponds nature (ID&A, 2002). This process is evident in Reach 2. Low velocity flows result from a decrease in streambed gradient and reduced channel capacity. During low flows reed beds throughout the reach are trapping and holding sediments, leading to the formation of a chain of ponds sequence. Without this trapping action by reeds, an open channel with a low gradient will fill with sediment, leading to a homogenous streambed lacking waterholes and geomorphic diversity. Along some reaches the works program outlined in Appendix A calls for stock access to be denied at all times. In such cases it is recommended that off-stream watering points be implemented.

Increased Flooding Due to Reeds

Low flows with an accompanying decrease in flow velocity lead to an increase in the deposition of sediment from erosion processes upstream. This in turn leads to a decrease in a river's ability to contain higher flow events. Low flow velocities and shallow flow depths contribute to an increase in reeds within the affected reach. In many cases reed growth is a symptom of a channel's decreased capacity to carry higher flows. Landholder perception, therefore, is that reed growth is leading to increased flooding.

As the upper reaches of the Wimmera River originally assumed a low flow chain of ponds morphology, its ability to carry higher flows was limited. Higher flows readily spread onto the land alongside the river. Without constant and costly mechanical intervention to maintain an open channel, the river will attempt to resume a similar morphology to that which it had prior to European intervention (ID&A, 2002). Therefore increased flooding is to be expected, due to decreased channel capacity, whether or not reeds are present in the stream bed.

Increased Fire Hazard Due to Reeds

Landholders may be concerned that a fire is able to spread faster or cross a waterway due to burning reeds. The works program calls for some sections of stream to be kept free of stock at all times. This is to enable reed growth for sediment trapping and bed stability purposes. Although little can be done to reduce the fire hazard in such cases, the length of stream to which stock access is excluded is relatively small.

In other well-vegetated areas where stock access does not pose a major threat to stream health, limited access will be possible. Due to the ephemeral nature and dense vegetation of chain of ponds sections, stock access can be timed so that reeds are grazed to reduce the fire hazard while not affecting their ability to trap sediment on regrowing. It is suggested that reeds are grazed in late winter to early spring.

Increased Flooding Due to Large Woody Debris

Large Woody Debris (LWD) consists of the fallen trunks and branches of trees which occupy the riparian zone. LWD is recognised as an important structural and ecological component of many stream environments, and as such the objective of stream management projects is to manage snags and LWD in such a way that the ecological health of rivers is enhanced at the same time that risks of flooding and streambank erosion are diminished (Treadwell, 1999).

Past works to remove LWD were undertaken in the belief that trees lying in the river contributed to increased flooding of upstream areas. Evidence from research now suggests that removing single logs from a stream will have little effect on flood stage (Rutherfurd *et al*, 2000). Recent computer modelling (Earth Tech, 2002) has clearly shown that the re-introduction of LWD to a reach of the Glenelg River at Harrow will have a minimal effect on flood height. With an average log distribution density of 15 logs per 100m of stream bed, the maximum average increase in water level of 0.11 metres during a 1 in 2 year flood event was shown to occur

By re-introducing LWD in a strategic manner, it is proposed that, through the creation of hydraulic and depth diversity, significant and rapid increases in the ecology of the stream will occur (Gippel *et al*, 1998), with an almost insignificant risk of increased flooding.

Appendix B: Plan of Survey and Cross Sections, Wimmera River Elmhurst

Appendix C: Hanging Swamp Stability Assessment

Appendix D: Wimmera River Reach 2, Landholder Property Boundaries

EARTH TECH

Wimmera Catchment Management Authority

Hanging Swamp Stability Assessment

Job 2901049

February 2002

APPROVED	CHECKED
DATE	DATE

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Head Office 71 Queens Road
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Incorporating ID&A

Wimmera Catchment Management Authority

Hanging Swamp Stability Assessment

Job 2901049

Contents

Introduction

This report details the stability assessment for two sections of waterway:

- The Hanging Swamp, a section of the Wimmera River which commences upstream of Lower Wimmera Road, Elmhurst and continues for approximately 2 km.
- The Little Wimmera River, a tributary of the Wimmera River, which joins the Wimmera River just downstream of Lower Wimmera Road, Elmhurst.

These sections of waterway are freshwater meadows or chain of ponds type streams. They are a rare geomorphic unit that is poorly represented throughout Australia.

Drainage works have lead to the incision of the Wimmera River downstream of these reaches. The incision process has progressed upstream and large erosion heads now form the downstream boundaries of the Hanging Swamp and Little Wimmera River.

Stability Assessment

Site Inspection

The Hanging Swamp and Little Wimmera River were initially inspected by ID&A (now Earth Tech Engineering) as part of the Wimmera River Geomorphic Investigation. This inspection identified the high values of these reaches and the incision processes threatening their stability.

Further inspections were undertaken in December 2001 to direct the survey party in the collection of data and again in January 2002 to assess the survey information.

Both of these waterways are densely colonised by in-stream vegetation such as phragmites, typha and sedges. A large fall in bed elevation (erosion head) is clearly visible at the downstream boundary of the Hanging Swamp. It is apparent that the dense vegetation has resisted and continues to resist the upstream progression of incision processes.

Mature willows in the incised section of the Wimmera River downstream of the Hanging Swamp form a useful reference point to indicate the rate of incision processes. The presence of these willows suggests the erosion heads of the Hanging Swamp have progressed upstream by a maximum of 20 m in the last 20 – 50 years.

A large fall in bed elevation occurs in the Little Wimmera River in its last 100 m before joining the Wimmera River. Unlike the Hanging Swamp, this fall in bed elevation is gradual. It is apparent that the vehicle crossing approximately 100 m upstream of the Little Wimmera River/Wimmera River junction is also assisting in preventing the upstream progression of the incision processes.

Plates 1 to 4 show various features of the Wimmera and Little Wimmera Rivers.

Engineering Survey

Fisher Stewart Pty Ltd (on behalf of the Wimmera CMA) undertook an engineering survey of the Wimmera River between Elmhurst and the Hanging Swamp in December 2001. This reach of the Wimmera River is approximately 8.5 km in length. Cross sections were surveyed at an average interval of 250 m.

Assessment of the survey information indicates the following:

- The average bed grade downstream of the Wimmera River concrete drop structure is approximately 1 in 330 (0.003 m/m)
- The average bed grade between the Wimmera River concrete drop structure and the Hanging Swamp is 1 in 250 (0.004 m/m)
- An erosion head of approximately 3.5 m drop is located immediately downstream of the Hanging Swamp
- Approximately 3.0 m of this drop is located within the first 20 m downstream of the Hanging Swamp
- An erosion head of similar size is located within the first 100 m of the Little Wimmera River, downstream of a farm access crossing

Plate 1
Wimmera River, Hanging Swamp looking upstream near downstream boundary

Plate 2
Little Wimmera River looking upstream near junction with Wimmera River

Plate 3
Wimmera River, Hanging Swamp

Plate 4
Wimmera River just downstream of Hanging Swamp showing willows

Hydraulic Analysis

The rational method for Victoria presented by Australian Rainfall and Runoff (1998) has been utilised for flow estimation.

Stream flow calculations can be seen in Appendix A. Flow estimates for the Hanging Swamp and Little Wimmera River are shown in **Table 1**.

Table 1: Flow Estimates

Catchment	**Area** (km^2)	**Design Flows for ARI in Years** (m^3/s)						
		1	**2**	**5**	**10**	**20**	**50**	**100**
Little Wimmera River at Wimmera River Junction	9.1	2.21	3.66	5.97	7.81	10.3	13.9	17.4
Wimmera River Upstream of Tom-the-Tailor Creek	12.8	2.83	4.68	7.61	9.94	13.1	17.6	22.1
Wimmera River Upstream of Little Wimmera River	40.4	6.66	11.0	17.8	23.1	30.3	40.6	50.7
Wimmera River Downstream of Little Wimmera River	49.5	7.79	12.9	20.8	27.0	35.4	47.4	59.1

Together with survey information, this flow data was utilised to construct a HEC-RAS hydraulic model of the Wimmera River Geomorphic Reach 2.2 (i.e. the incised reach downstream of the Hanging Swamp).

Stream power is a tool that can indicate the potential of a watercourse to undergo change. Field research has shown that:

- Waterways with bank full stream power less than 35 N/ms are unlikely to undergo significant change
- Waterways with bank full stream power between 35 and 100 N/ms are likely to undergo minor change, such as localised bank erosion
- Waterways with bank full stream power in excess of 100 N/ms are likely to undergo major change, such as bed deepening and widening.

These change processes can be resisted by bedrock, coarse bed sediment and dense vegetation.

Table 2 displays stream power estimates for bank full conditions.

These results indicate that the reach is unlikely to undergo major change. Cross section 8163.13 is protected from significant change by the presence of willows. Bank erosion could be expected at cross sections 7968.72 and 7744.18. Instream vegetation may resist this process.

Table 2: Stream Power Estimates

Cross Section Chainage (m)	**Cross Section Description**	**Bankfull Flow ARI** (years)	**Bankfull Stream Power** (N/m s)	**2 year Stream Power** (N/m s)	**50 year Stream Power** (N/m s)
8245.25	Just downstream of Hanging Swamp	> 100	8	9	8
8163.13	Just upstream of Tom-the-Tailor Creek junction	>100	82	65	74
7968.72	Just downstream of Little Wimmera River junction	> 100	79	27	64
7744.18	Wimmera River	< 50	110	60	110
7180.16	Wimmera River	< 1	9	9	40
6918.14	Start of reach 2.3	< 1	17	17	58

Conclusions and Recommendations for Management

Conclusions

The site, survey and hydraulic assessments indicate the following:

- A 3.0 m erosion head is present at the downstream boundary of the Hanging Swamp
- It appears that the rate of progression of this erosion head is less than 1 m per year
- A small erosion head is held within the willows immediately downstream of the Hanging Swamp
- Stream power within the incised reach of the Wimmera River downstream of the Hanging Swamp is of a magnitude such that significant bed deepening and channel enlargement is not expected
- A large erosion head is present within the last 100 m of the Little Wimmera River. This erosion head is not progressing at a significant rate

Recommendations

Under existing conditions the Hanging Swamp and Little Wimmera River are not at immediate threat of wide spread damage: incision processes are occurring at a slow rate.

However, these waterways are at threat from catastrophic events such as bushfire followed by flood. Under such a scenario the stabilising effects of vegetation may be lost and boundary conditions will lead to instability. The likelihood of this occurrence is low and the extent of damage is difficult to predict.

Works to increase the stability of these waterways could be undertaken. A number of options have been considered. Structures located downstream of the reaches would rely on a sediment supply to be effective. The intact fresh water meadows act as sediment traps meaning little sediment would be supplied to fill the bed behind the structures.

Construction at the downstream boundary of the intact reaches would involve their disturbance and possibly the destabilisation of the accumulated sediments on which they are formed.

Each of the options considered would involve risks that are considered greater than those currently faced.

It is therefore proposed that no works be undertaken at this point in time. **The rate of incision should be monitored** and works reconsidered if the rate of incision increases significantly.

The willows downstream of the Hanging Swamp currently have a beneficial value in stabilising a small erosion head. If this erosion head were to join with the erosion head at the Hanging Swamp then the rate of incision could increase.

If these willows are propagating and require removal then the stabilisation of the site should be reconsidered.

Appendix 1 – Design Flow Calculations

Flow Calculations using Rational Method

Design Rainfall Parameters (ARR Vol 2)

1 hour duration / 2 year average recurrence interval	${}^{2}I_{1}$	19.00 mm/h
12 hour duration / 2 year average recurrence interval	${}^{2}I_{12}$	3.50 mm/h
72 hour duration / 2 year average recurrence interval	${}^{2}I_{72}$	1.00 mm/h
1 hour duration / 50 year average recurrence interval	${}^{50}I_{1}$	42.00 mm/h
12 hour duration / 50 year average recurrence interval	${}^{50}I_{12}$	7.00 mm/h
72 hour duration / 50 year average recurrence interval	${}^{50}I_{72}$	1.90 mm/h
Average Regional Skewness	G	0.30
Geographical Factor for a 6 minute, 2 year ARI	F2	4.37
Geographical Factor for a 6 minute, 50 year ARI	F50	14.85

Runoff Coefficient (ARR, Vol 2, Figure 5.3b, page 107)

Runoff coefficient for ARI 10 years	C_{10}	0.15%

Frequency Factors (ARR, Vol 1, Table 5.4, page 103)

Frequency Factor for 1 year event	FF_1	0.60
Frequency Factor for 2 year event	FF_2	0.75
Frequency Factor for 5 year event	FF_5	0.90
Frequency Factor for 10 year event	FF_{10}	1.00
Frequency Factor for 20 year event	FF_{20}	1.10
Frequency Factor for 50 year event	FF_{50}	1.20
Frequency Factor for 100 year event	FF_{100}	1.30

Runoff Coefficients (C_{10} x FF)

Runoff coefficient for 1 year event	C_1	0.090 %
Runoff coefficient for 2 year event	C_2	0.113 %
Runoff coefficient for 5 year event	C_5	0.135 %
Runoff coefficient for 10 year event	C_{10}	0.150 %
Runoff coefficient for 20 year event	C_{20}	0.165 %
Runoff coefficient for 50 year event	C_{50}	0.180 %
Runoff coefficient for 100 year event	C_{100}	0.195 %

Catchment	Area (km^2)	Time of Conc.		Design Flows (m^3/s) for ARI in Years						
		Hours	Mins	1	2	5	10	20	50	100
1	9.1	1.76	106	2.21	3.66	5.97	7.81	10.3	13.9	17.4
2	12.8	2.00	120	2.83	4.68	7.61	9.94	13.1	17.6	22.1
3	40.4	3.10	186	6.66	11.0	17.8	23.1	30.3	40.6	50.7
4	49.5	3.35	201	7.79	12.9	20.8	27.0	35.4	47.4	59.1

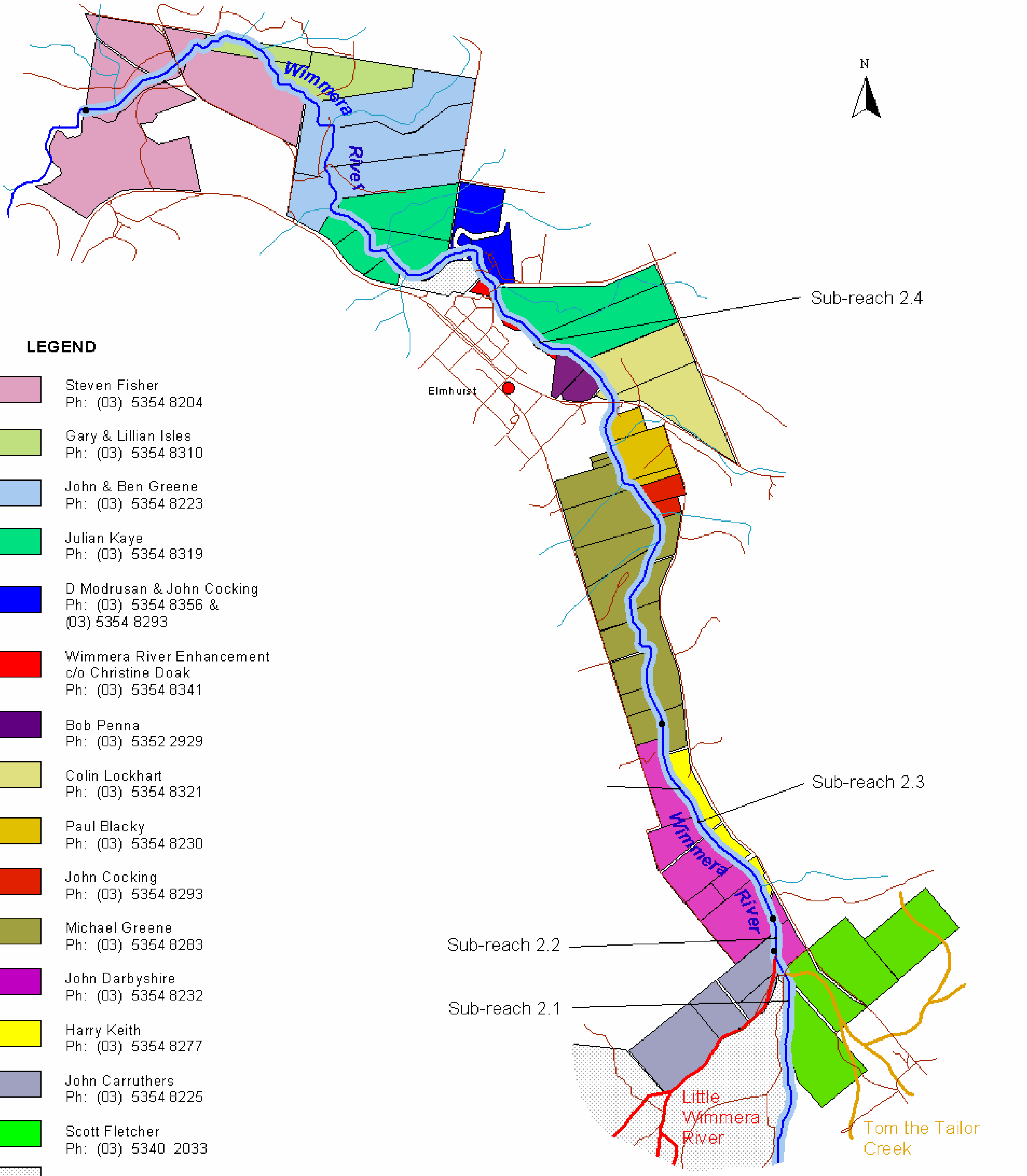
Catchment Areas

1 Little Wimmera River at Wimmera River Junction

2 Wimmera River Upstream of Tom-the-Tailor Creek

3 Wimmera River Upstream of Little Wimmera River

4 Wimmera River Downstream of Little Wimmera River



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- John & Ben Greene Ph: (03) 5354 8223
- Julian Kaye Ph: (03) 5354 8319
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- John Carruthers Ph: (03) 5354 8225
- Scott Fletcher Ph: (03) 5340 2033
- Crown Land
- Reach Delimiter

Wimmera Catchment Management Authority

Wimmera River Waterway Action Plan

Reach 2 Landholders

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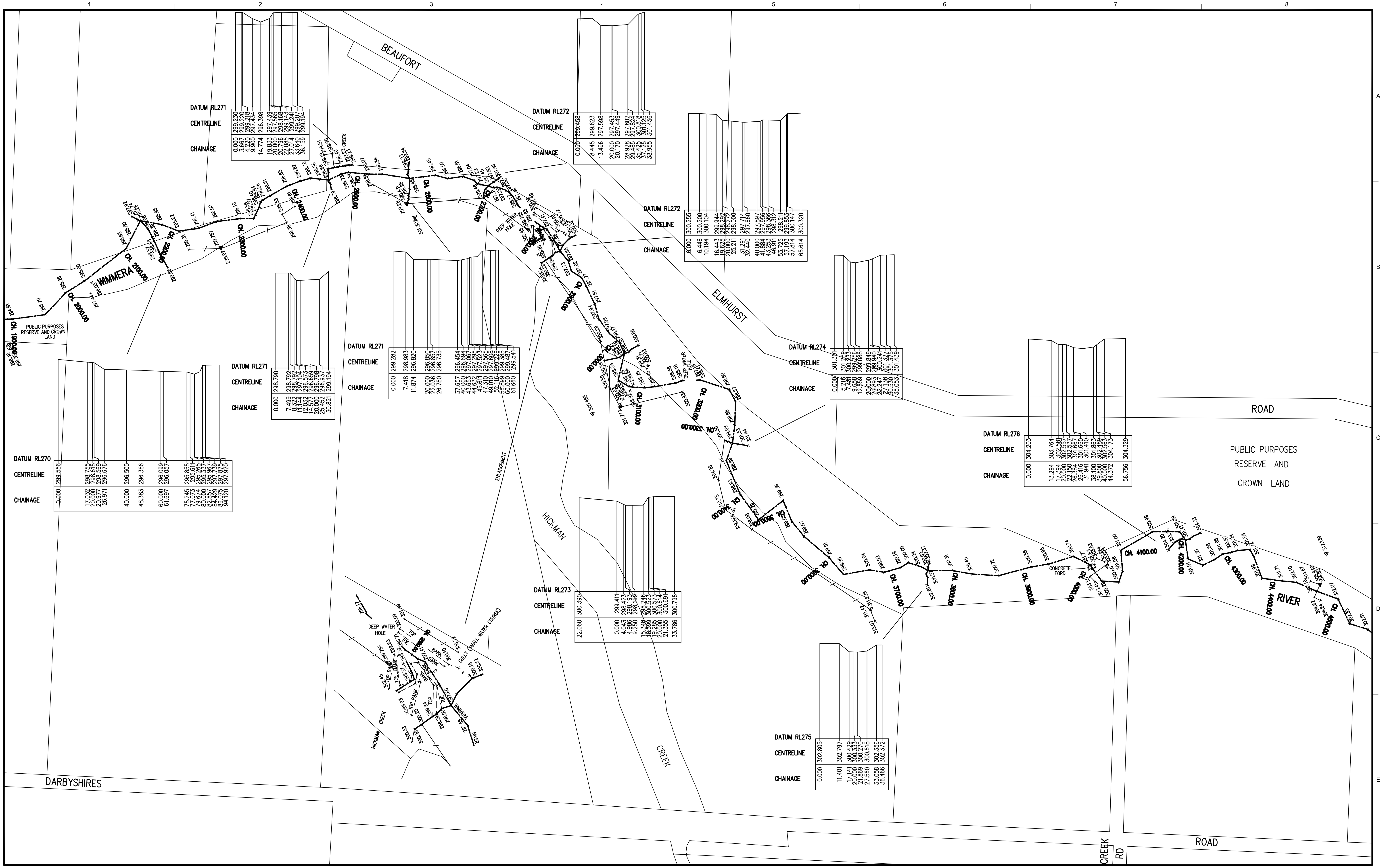
November 2002



DATUM RL270

CHAINAGE	CENTRELINE
0.000	299.556
17.032	298.755
20.000	298.615
20.977	298.569
26.971	296.676
40.000	296.500
48.383	296.386
60.000	296.099
61.697	296.057
75.245	295.855
77.073	295.611
79.674	295.265
80.000	295.337
82.857	295.967
84.429	297.739
86.075	297.875
94.120	297.920

DATUM RL271

CHAINAGE	CENTRELINE
0.000	299.230
3.667	299.220
4.220	299.218
9.900	297.434
14.774	296.398
19.833	297.439
20.000	297.565
20.796	298.168
22.085	299.143
27.014	299.241
33.640	299.207
36.159	299.194

DATUM RL271

CHAINAGE	CENTRELINE
0.000	298.790
7.499	298.792
8.322	298.792
11.144	297.104
12.032	296.573
14.577	296.659
20.000	296.798
25.452	296.937
30.821	299.194

DATUM RL271

CHAINAGE	CENTRELINE
0.000	299.282
7.418	298.983
11.874	296.820
20.000	296.850
22.036	296.857
26.780	296.735
37.657	296.454
40.000	296.694
43.653	297.067
44.632	297.295
45.611	297.523
47.310	297.565
49.010	297.608
52.116	299.229
56.899	299.385
60.000	299.487
61.660	299.541

DATUM RL272

CHAINAGE	CENTRELINE
0.000	299.458
8.445	299.623
13.496	297.598
20.000	297.453
20.170	297.449
28.928	297.802
29.485	297.824
35.425	300.818
37.125	301.125
38.955	301.456

DATUM RL272

CHAINAGE	CENTRELINE
0.000	300.255
6.446	300.200
10.194	300.104
16.443	299.944
19.625	298.292
20.000	298.272
25.211	298.000
31.291	297.714
32.440	297.660
40.000	297.897
41.884	297.956
43.253	298.366
46.911	298.312
53.725	298.211
57.193	299.853
57.814	300.147
65.614	300.320

DATUM RL273

CHAINAGE	CENTRELINE
22.060	300.390
0.000	299.411
4.043	298.423
4.986	298.193
9.250	298.199
15.348	298.246
18.399	300.523
19.285	300.573
20.000	300.614
21.355	300.691
33.786	300.798

DATUM RL274

CHAINAGE	CENTRELINE
0.000	301.301
5.216	301.259
7.481	300.233
9.658	299.256
12.859	299.088
20.000	299.849
20.893	299.940
22.247	300.241
27.138	301.327
30.530	301.375
35.053	301.439

DATUM RL275

CHAINAGE	CENTRELINE
0.000	302.805
11.401	302.797
17.141	300.429
20.000	300.333
21.869	300.270
27.560	300.618
33.058	302.356
36.466	302.372

DATUM RL276

CHAINAGE	CENTRELINE
0.000	304.203
13.294	303.764
17.394	302.581
20.000	302.557
22.150	302.537
26.384	301.667
26.416	301.660
31.941	301.410
38.100	301.863
39.800	302.489
40.000	302.563
44.372	304.173
56.756	304.329

PRINCIPAL
GEOFF VIETZ
I.D. & A.
MELBOURNE OFFICE
71 QUEENS ROAD
MELBOURNE

REVISION	DATE	ZONE

NOTES:

1. SCALE OF CROSS SECTIONS ARE HORZ 1 : 1000
   VERT 1 : 500
2. DATUM AS PER PM's GLENPATRICK 35 & 36
3. THIS SURVEY DOES NOT INVOLVE THE RE-ESTABLISHMENT OF PROPERTY BOUNDARIES.
4. BOUNDARY LINES SHOWN ON THIS PLAN HAVE BEEN DERIVED FROM A DIGITAL CADASTRAL DATABASE, AND BOUNDARIES SHOWN ARE NOT CONFIRMED TO ACCORD TITLE DIMENSIONS.
5. WHERE ANY DESIGN OR CONSTRUCTION WORKS ARE DESIGNED FROM OR BASED UPON THE PROPERTY BOUNDARIES THE APPROPRIATE LEVEL OF PROPERTY BOUNDARY RE-ESTABLISHMENT MUST BE UNDERTAKEN.

N

Datum
Horizontal AMG ZONE 54
Vertical AHD

0 25 50 100

Scale AS SHOWN

Fisher Stewart
SURVEY & MAPPING GROUP
GEELONG. Ph (03) 52 264200

Surveyor A. NEWMAN
Drawn R. HUNTER 11/01/2002
Checked
Approved

PLAN OF SURVEY & CROSS SECTIONS
WIMMERA RIVER
ELMHURST

Drawing No. 1701577-G1 **Rev**
Sheet No. 2 of 4
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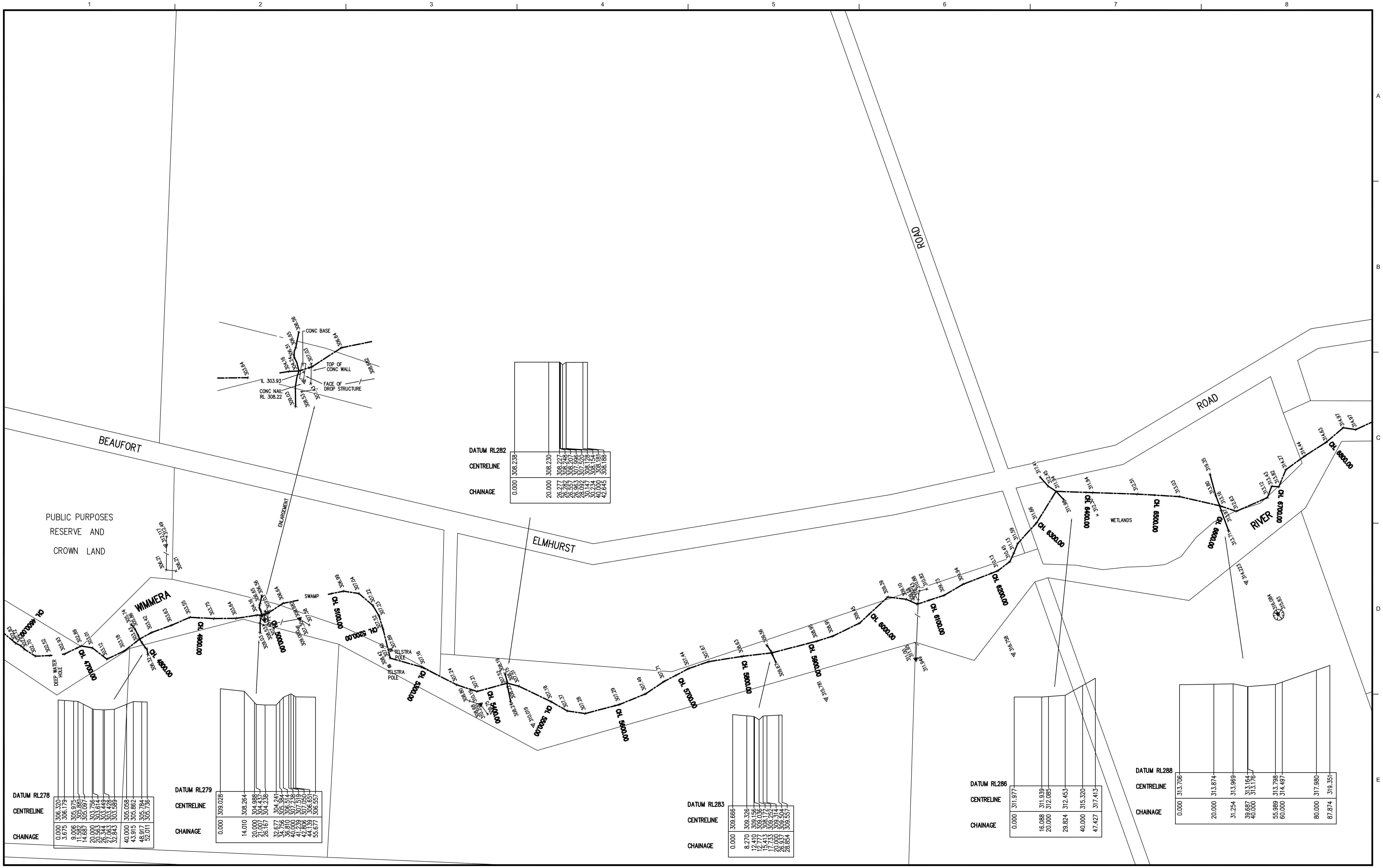

PRINCIPAL
GEOFF VIETZ
I.D. & A.
MELBOURNE OFFICE
71 QUEENS ROAD
MELBOURNE

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N

Datum
Horizontal AMG ZONE 54
Vertical AHD
0 25 50 100
Scale AS SHOWN

Fisher Stewart
SURVEY & MAPPING GROUP
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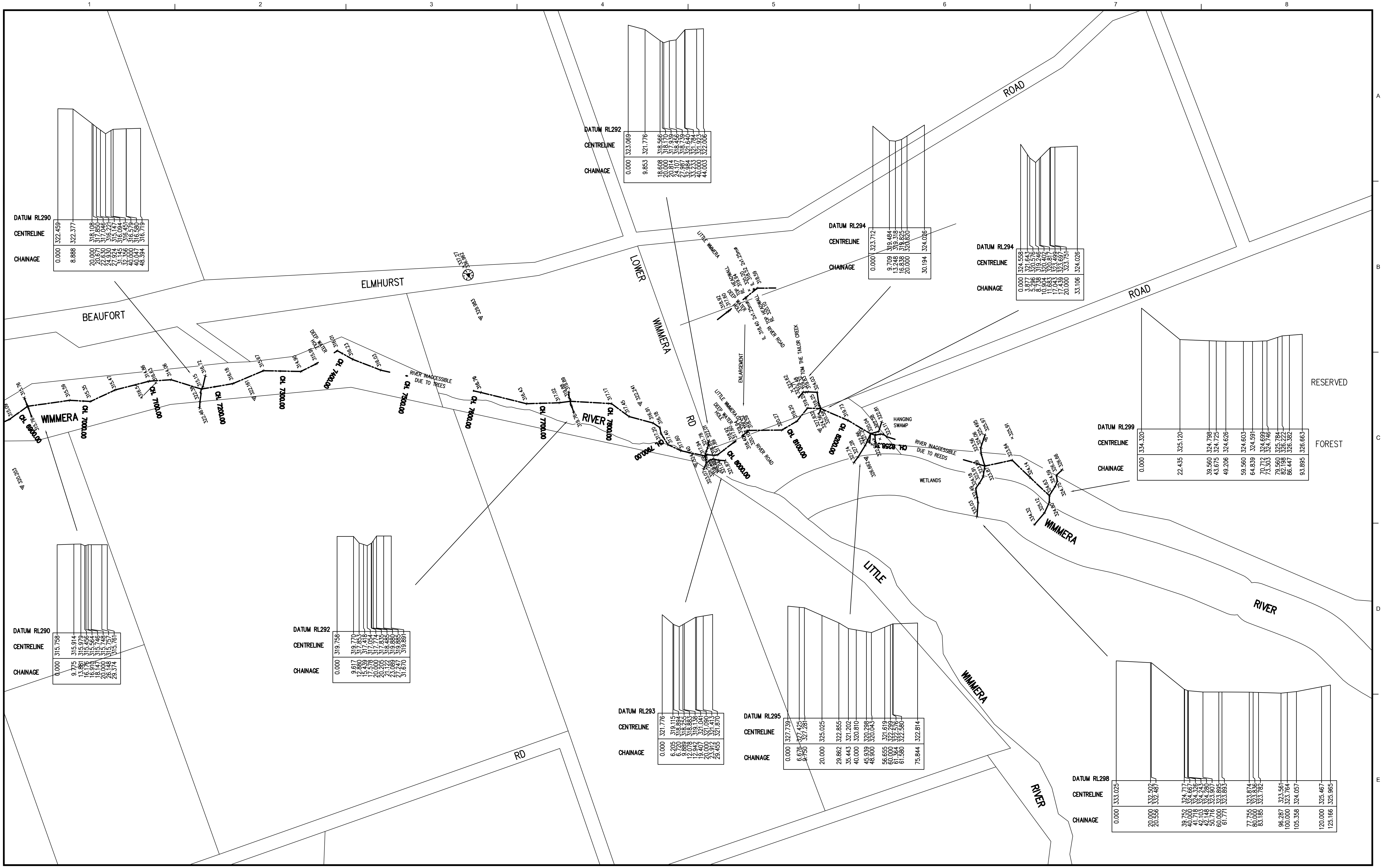
Surveyor A. NEWMAN
Drawn R. HUNTER 11/01/2002
Checked
Approved

PLAN OF SURVEY & CROSS SECTIONS
WIMMERA RIVER
ELMHURST

Drawing No. 1701577-G1 Rev
Sheet No. 3 of 4
1701577-G1.dwg

A1



PRINCIPAL
GEOFF VIETZ
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MELBOURNE OFFICE
71 QUEENS ROAD
MELBOURNE

REVISION	DATE	ZONE

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N

Datum
Horizontal AMG ZONE 54
Vertical AHD

0 25 50 100
Scale AS SHOWN

Fisher Stewart
SURVEY & MAPPING GROUP
GEELONG. Ph (03) 52 264200

Surveyor	A. NEWMAN	
Drawn	R. HUNTER	11/01/2002
Checked		
Approved		

PLAN OF SURVEY & CROSS SECTIONS
WIMMERA RIVER
ELMHURST

Drawing No. 1701577-G1 **Rev**
Sheet No. 4 of 4
1701577-G1.dwg

A1

CHAINAGE	CENTRELINE (DATUM RL277)	
0.000	290.706	APPROX 42m SOUTH FROM SOUTHERN FENCE LINE OF McKAY STREET ROAD RESERVE
38.314	290.632	
79.482	290.708	
111.285	290.179	
183.397	290.048	
206.946	290.447	
240.238	290.536	
245.078	290.844	
275.621	290.557	
288.579	290.976	
298.407	290.966	
317.337	290.410	
329.941	291.111	
350.896	290.619	
374.432	290.140	
382.692	290.342	
394.039	291.351	
416.871	290.738	
438.195	291.375	
473.008	291.312	
485.522	291.315	
500.000	291.056	
511.243	290.855	
525.230	291.080	
548.449	291.316	
575.900	291.761	
592.271	290.395	
611.541	291.190	
649.728	291.043	
670.388	291.024	
698.358	291.334	
725.553	291.716	
757.955	291.156	
763.749	290.529	DEEP WATER HOLE
789.398	290.844	
824.827	291.697	
844.374	292.083	
859.231	291.754	
879.934	291.343	DEEP WATER HOLE
915.380	291.055	
968.272	290.148	BRIDGE PYRENEES HIGHWAY
1000.000	292.021	
1010.363	292.633	
1040.805	292.230	
1057.967	292.629	
1067.184	292.496	
1068.951	291.614	
1073.813	291.071	
1085.167	292.460	
1102.426	291.618	
1128.572	292.851	
1150.203	292.692	
1166.186	292.226	
1178.065	292.301	
1182.753	293.079	
1194.749	292.701	
1223.877	292.791	
1264.793	291.880	
1299.677	293.507	
1326.257	293.717	
1340.557	293.377	
1352.343	292.245	
1362.904	293.287	
1396.723	293.796	
1413.010	293.972	
1450.292	294.020	
1478.361	294.121	
1500.000	294.217	
1502.838	294.230	
1565.232	294.342	
1594.093	294.611	
1600.000	294.575	

CHAINAGE	CENTRELINE (DATUM RL281)	
1600.000	294.575	
1612.675	294.497	
1618.965	294.775	
1627.043	293.679	DEEP WATER HOLE
1656.294	294.416	
1687.307	294.593	
1720.828	294.475	
1754.936	294.563	
1795.519	294.494	
1821.809	294.703	
1876.517	294.949	
1907.011	294.905	
1955.065	295.197	
1999.004	295.262	
2000.000	295.254	
2031.738	295.003	
2108.564	295.632	
2108.674	295.631	
2154.055	295.265	
2185.977	295.953	
2212.495	295.820	
2241.422	295.413	
2270.651	296.001	
2305.204	296.097	
2324.517	295.582	
2329.679	296.275	
2342.695	296.396	
2350.203	295.937	
2354.419	296.256	
2368.740	296.513	
2394.823	296.626	
2416.700	296.818	
2432.560	296.758	
2432.715	296.758	
2446.380	296.562	
2458.911	296.659	
2479.538	296.732	
2489.881	296.335	
2500.000	296.245	
2520.365	296.065	
2539.666	296.341	
2580.181	296.454	
2617.854	296.455	
2637.358	296.501	
2659.008	296.510	
2676.846	297.043	
2681.818	296.814	
2684.011	297.260	
2688.016	297.223	
2699.642	297.449	
2707.207	297.314	
2709.594	297.048	
2714.020	297.203	
2726.617	297.466	
2735.090	297.059	
2739.617	297.487	DEEP WATER HOLE HICKMAN CREEK
2749.781	297.480	
2754.083	297.279	
2755.171	296.170	
2793.324	296.712	
2805.276	296.745	
2810.991	297.413	
2831.082	297.574	
2848.236	297.660	
2866.852	297.546	
2882.599	297.732	
2900.377	297.622	
2915.625	297.766	
2944.528	297.813	
2966.059	297.938	
2992.243	297.991	
3000.000	298.065	
3011.581	298.175	
3029.529	298.199	
3069.633	298.340	
3088.346	298.277	
3110.268	298.290	
3125.011	298.447	
3156.934	298.579	
3166.437	298.180	DEEP WATER HOLE
3192.080	297.178	
3193.817	298.410	
3200.000	298.465	

CHAINAGE	CENTRELINE (DATUM RL285)	
3200.000	298.465	
3237.999	298.800	
3257.758	298.872	
3292.234	298.883	
3318.594	299.088	
3345.956	298.894	
3398.469	298.830	
3444.961	299.291	
3490.400	299.362	
3500.000	299.446	
3523.256	299.651	
3551.476	299.670	
3551.496	299.670	
3599.698	299.910	
3631.885	299.897	
3670.750	300.036	
3692.322	298.919	
3717.383	299.188	
3730.709	299.995	
3750.945	300.241	
3761.851	300.270	
3797.502	300.309	
3827.024	300.446	
3865.363	300.722	
3915.309	300.578	
3940.850	300.947	
3978.734	300.744	
4000.000	300.870	
4007.323	300.913	CONCRETE FORD
4012.939	300.954	
4035.416	300.293	
4060.641	300.656	
4077.423	301.076	
4108.243	300.997	
4161.891	300.994	
4201.382	301.287	
4216.054	301.410	
4243.941	301.007	
4267.563	301.347	
4286.464	301.583	
4300.283	301.658	
4313.334	300.872	
4322.972	301.245	
4341.095	301.580	
4352.199	301.739	
4387.016	301.990	
4416.817	301.713	
4437.595	302.096	
4468.131	302.161	
4500.000	302.079	
4503.322	302.070	
4543.246	302.326	
4570.905	302.506	
4602.553	302.833	
4610.761	302.124	
4617.912	302.633	
4637.107	302.704	
4658.433	302.515	DEEP WATER HOLE
4679.743	302.926	
4706.767	302.891	
4723.379	303.009	
4750.041	303.120	
4778.019	303.182	
4800.000	303.371	

HOR 1:2500 — 0 25 50 100 150 200 250

VER 1:250 — 0 2.5 5 10 15 20 25

PRINCIPAL
GEOFF VIETZ
I.D. & A.
MELBOURNE OFFICE
71 QUEENS ROAD
MELBOURNE

REVISION	DATE	ZONE

Datum
Horizontal 1 : 2500
Vertical 1 : 250

Scale AS SHOWN

Fisher Stewart
SURVEY & MAPPING GROUP
GEELONG. Ph (03) 52 264200

Surveyor A. NEWMAN
Drawn R. HUNTER
Checked
Approved 10/01/02

LONGITUDINAL SECTIONS CH 00 - 4800m
WIMMERA RIVER
ELMHURST

Drawing No. 170157-G2
Sheet No. 1 of 2
Rev

170157-G2.dwg
A1

PRINCIPAL
GEOFF VIETZ
I.D. & A.
MELBOURNE OFFICE
71 QUEENS ROAD
MELBOURNE

REVISION	DATE	ZONE

DATUM RL290

CHAINAGE	CENTRELINE	
4800.000	303.371	
4806.638	303.428	
4826.284	303.422	
4857.329	303.632	
4886.970	303.548	
4921.828	303.747	
4954.540	303.645	
4985.063	304.159	
4992.276	304.238	IL WALL RL 303.93m
4996.941	306.950	TOP DROP STRUCTURE RL 307.03m
5001.650	307.030	
5002.366	306.764	
5027.969	306.644	
		SWAMP
5118.128	306.989	
5140.635	307.038	
5167.435	307.225	
5185.075	307.227	
5205.196	307.524	
5249.186	307.399	
5296.846	307.158	
5354.246	307.244	
5385.548	307.205	
5431.385	307.520	
5448.834	307.507	
5500.000	307.191	
5501.965	307.179	
5528.637	307.373	
5554.915	307.282	
5606.568	307.292	
5647.990	307.486	
5680.082	307.708	
5720.886	307.438	
5751.790	307.666	
5802.481	308.634	
5844.777	308.172	
5913.477	308.948	
5937.491	308.907	
5981.018	309.446	
6000.000	309.427	
6037.282	309.390	
6064.541	309.096	
6082.033	309.191	
6123.425	309.734	
6155.435	309.938	
6209.686	310.127	
6232.036	310.446	
6245.656	311.131	
6261.055	311.587	
6302.294	311.659	
6355.978	311.939	
6400.000	311.941	

DATUM RL299

CHAINAGE	CENTRELINE	
6400.000	311.941	
6409.645	311.941	
6475.061	312.508	
6500.000	312.719	
6536.506	313.027	
6596.875	313.164	
6622.527	312.629	
6672.219	313.118	
6689.849	313.431	
6700.220	313.818	
6727.014	314.273	
6760.690	314.443	
6797.974	314.627	
6831.185	314.974	
6849.589	314.966	
6885.728	315.094	
6918.137	315.456	
6980.289	315.587	
7000.000	315.435	
7010.674	315.353	
7050.750	315.467	
7101.770	314.860	
7133.810	314.064	
7180.159	315.147	
7227.046	316.179	
7275.635	315.672	
7330.154	314.901	
7355.262	315.911	
		DEEP WATER HOLE
7391.671	316.011	
7417.325	316.230	
7461.196	316.034	
		RIVER INACCESSIBLE
7611.063	316.700	
7611.123	316.707	
7680.016	316.429	
7728.156	317.022	
7744.177	317.054	
7804.272	317.170	
7836.313	317.450	
7872.549	316.908	
7884.420	316.181	
7893.408	317.197	
7912.592	317.401	
7933.282	317.599	
7968.720	317.939	
7973.106	316.876	LITTLE WIMMERA RIVER
7983.514	316.866	DEEP WATER HOLE
7988.163	317.888	
8000.000	318.295	

DATUM RL305

CHAINAGE	CENTRELINE	
8000.000	318.295	
8018.097	318.918	
8019.916	317.603	DEEP HOLE LOWER WIMMERA RIVER ROAD CROSSING
8046.145	318.594	
8094.263	320.266	
8119.565	319.203	
8144.236	319.288	TOM THE TAYLOR CREEK
8163.128	319.246	
8206.813	319.726	
8245.250	320.043	
8258.306	321.800	START OF HANGING SWAMP

HOR 1:2500 0 25 50 100 150 200 250
VER 1:250 0 2.5 5 10 15 20 25

Datum
Horizontal 1 : 2500
Vertical 1 : 250
Scale AS SHOWN

Fisher Stewart
SURVEY & MAPPING GROUP
GEELONG. Ph (03) 52 264200

Surveyor A. NEWMAN
Drawn R. HUNTER 10/01/02
Checked
Approved

LONGITUDINAL SECTIONS
CH 4800 - 8258.306m
WIMMERA RIVER
ELMHURST

Drawing No. 170157-G2 Rev
Sheet No. 2 of 2
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