Wimmera
Catchment Management
Authority

Waterways for Life.

Shays Creek Waterway Action Plan

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Prepared by
Earth Tech Engineering Pty Ltd
ABN 61 089 482 888
Horsaham Office, 62 Darlot Street
Horsham VIC 3400
Tel +61 3 **5382 2228**

Shays Creek

Waterway Action Plan

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19-08-2004	1	Heinz de Chelard		
29-08-2004	2	Paul Atherton		
28-09-2004	3	Heinz de Chelard		
01-10-2004	4		Rohan Lucas	
26-11-2004	5	Oscar Metcalfe	Heinz DeChelard	Michael Bain

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EARTH TECH

Natural Resources Group
Earth Tech Engineering Pty Ltd
ABN 61 089 482 888
Head Office 71 Queens Road
Melbourne VIC 3004
Tel +61 3 8517 9200

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Glossary

Term	Definition
aggradation	Deposition of material eroded or excavated elsewhere, raising the level of the stream bed.
armouring	A stable layer of the largest available sediment from which fines have been removed by stream flow. Acts to protect the streambed or bars from erosion.
bedrock	Exposed rock within the streambed. May act to prevent incision of the channel.
bench	Bank-attached, planar (flat) and narrow, deposits or erosional surfaces of fine grained sediment occurring at elevations between the stream bed and the floodplain
degradation	Erosive removal of materials from the stream bed, other geomorphic units or the floodplain, lowering their elevation.
confluence	The junction of two streams.
dynamic equilibrium	The condition of a stream that is experiencing relatively equal rates of degradation and aggradation. Dynamic equilibrium recognises that significant changes may occur rapidly in response to events such as flooding and fire resulting in dynamic short term change. However, over the long term the stream is in a state of dynamic equilibrium.
easting and northing coordinate system	A means of locating a position based on the Australian Map Grid (AMG) system. Used in conjunction with Global Positioning System (GPS) devices.
erosion	The group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface.
alluvial fan	A low spreading (often triangular in planform shape) deposit of sediment where there is a considerable reduction in gradient along the stream.
fluvial-geomorphology	The study of the evolution and configuration of landforms as produced by the action of a river or stream.
geomorphology	The study of the evolution and configuration of landforms (see also fluvial-geomorphology).
headcut	Vertical, or near vertical drop in channel elevation greater than 300mm
hydraulics	The physical science and technology of the static and dynamic behaviour of fluids.

Term	Definition
hydrology	The scientific study of the properties, distribution and effects of water on the Earth's surface, in the soil and underlying rocks and in the atmosphere.
incision	Lowering or downward cutting of the channel level through water erosion
left bank	The streambank on a persons left hand side when facing downstream
nick point	Vertical, or near vertical drop in channel elevation less than 300mm (see also head cut)
planform	The form of a stream as viewed directly from above (such as can be seen in aerial photographs).
reach	The basic stream management unit. Often a length of stream with similar characteristics.
right bank	The streambank on a persons right hand side when facing downstream
riparian	From the Latin word for riverbank. Pertaining to riverbanks. Riparian vegetation refers to the vegetation along streambanks.
riverine	Relating to or resembling a river.
sinuosity	Ratio of the length of the channel between two points to the straight line distance between those two points
streampower	The ability of a stream to do work. Calculated as shear stress times flow velocity.
sodic soils	Soils with high concentration of sodium ions such that the structure of the soil is affected. Sodic soils are highly dispersible on contact with fresh water.
valley fill	A layer of sediment laterally confined within a valley.

Abbreviations

ASL	Above Sea Level
DSE	Department of Sustainability & Environment
EVC	Ecological Vegetation Class
ISC	Index of Stream Condition
LWD	Large Woody Debris
NRM	Natural Resource Management
RHA	Rapid Habitat Assessment
WAP	Waterway Action Plan
Wimmera CMA	Wimmera Catchment Management Authority

Executive Summary

In 2001 the Wimmera Catchment Management Authority (Wimmera CMA) undertook a geomorphic investigation and analysis of the sediment processes within the Wimmera catchment (ID&A 2001). Entitled the 'Wimmera River Geomorphic Investigation' (ID&A 2001), this report identified an area of significant ecological and geomorphic value, in near pristine condition, located between the towns of Glynwylln and Glenorchy. This reach has since become known as the 'High Value Reach', and in accordance with the Victorian River Health Strategy (2002), the Wimmera CMA aims to protect this reach from any decline in condition.

The Wimmera River Geomorphic Investigation also identified a number of tributary streams that impact upon the health of the Wimmera River (ID&A 2001). As a major tributary, Shays Creek with a catchment area of 44km^2 and located approximately 30km east of the township of Stawell, was found to be a potential contributor of large volumes of sediment to the Wimmera River. Unnaturally high sediment loads in a waterway can fill waterholes, smother habitat in the form of large woody debris and instream vegetation, and decrease channel capacity resulting in increased flooding. Sediment contributions to the Wimmera River from Shays Creek are however limited by a large drop structure located beneath a bridge on the Joel Joel-Crowlands Road. During periods of high flow significant volumes of fine sediment may still overtop this structure and be transported downstream to the Wimmera River. Mobilisation and downstream migration of sediment originating from erosion in the Shays Creek catchment therefore poses a significant threat to the values of Shays Creek, and a potential threat to the Wimmera River and in particular the High Value Reach.

Although previous investigations have focused on protecting the Wimmera River, prior to the onset of erosion and incision events Shays Creek exhibited many of the features for which the Wimmera River is valued. Evidence from the soil profile in the downstream reaches of Shays Creek shows that a chain of ponds formation existed for a number of kilometres upstream of the Wimmera River confluence. Further upstream, flat gradients formed a discontinuous stream type as runoff descended from the steep hill country of the Pyrenees Range and spread over the floodplain.

Although the current form of Shays Creek no longer resembles its original condition, Wimmera CMA recognises that the creek has a value to the entire catchment of the Wimmera Region, and in order to address the issues of sediment generation and transport, has developed a Waterway Action Plan (WAP) for Shays Creek. The objectives of the plan are to;

1. Improve the health of Shays Creek and protect the High Value Reach (Reach 7) of the Wimmera River. This is to be achieved by determining appropriate actions to manage the current sediment load within Shays Creek.
2. Confirm values and threats identified from existing reports and community consultation, and develop appropriate management actions to enhance stream health within the catchment.
3. Develop appropriate management actions on a reach by reach basis, in conjunction with the catchment community.

The Waterway Action Plan also recognises that soil conservation works, rabbit control, deep ripping and pasture improvement programs have all been undertaken with success within the Shays Creek catchment. These works reflect the willingness

of landholders to address the significant threat of erosion and its effect on large tracts of agricultural land.

Field investigations and discussions with landholders has contributed to the identification of the following geomorphic processes occurring within the Shays Creek catchment:

- Dispersive sodic soils are resulting in the generation of large volumes of sediment from active gully erosion in the upper catchment;
- Bank collapse and stream widening as a part of the natural recovery process in the middle and lower catchment is contributing sediment to downstream reaches.
- At a number of road crossings on Shays Creek, culvert structures are acting to limit upstream deepening of the channel and storing some sediment in the stream bed.
- Flatter gradients in the lower reaches of Shays Creek form a sediment accumulation zone. In the area upstream of the Joel Joel - Crowlands Road drop structure the process of stream recovery through sediment deposition has begun. This has led to a slowing of the process of bed deepening and bank collapse. Vegetation colonising the streambank and sediment benches within the incised channel will provide further stability and ultimately reduce sediment transport to manageable levels if protected.

As a result of these findings the focus of the management actions proposed in the Waterway Action Plan are to:

- Reduce and prevent ongoing sediment generation from all areas of the catchment, and;
- To enhance the ability of the creek upstream of the drop structure to trap and hold mobile sediment within the lower reaches of the creek.

While the focus of the Waterway Action Plan is upon actions aimed at improving stream health, the plan recognises that there are many techniques available to achieve the same outcomes. Similarly, farm management practices including the establishment of perennial pastures and grazing management are significant contributors to reducing erosion causing run off during rainfall events. The plan also recognises that there are factors beyond the control of landholders, such as the significant grazing pressure of kangaroos which acts to reduce the effectiveness of revegetation and soil stabilisation programs.

Priorities for management actions were determined during a risk assessment. To assist with this assessment, Shays Creek catchment was divided into nine management reaches based on the geomorphic processes occurring in each reach. Management actions were then developed on a reach by reach basis, and are based on providing the most cost effective solution to identified issues.

1 Introduction

In 2001, the Wimmera Catchment Management Authority (Wimmera CMA) undertook a geomorphic investigation and analysis of the sediment processes within the Wimmera catchment (ID&A 2001). The investigation focused on the Wimmera River and specific tributaries that are thought to have an impact on the health of the river. As a major upper catchment tributary (Figure 1), Shays Creek was found to be a potential contributor of large volumes of sediment to the Wimmera River. If this sediment were to reach the Wimmera River, it would then pose a threat to the high ecological and geomorphic values of the Wimmera River from Joel Joel to Glenorchy.

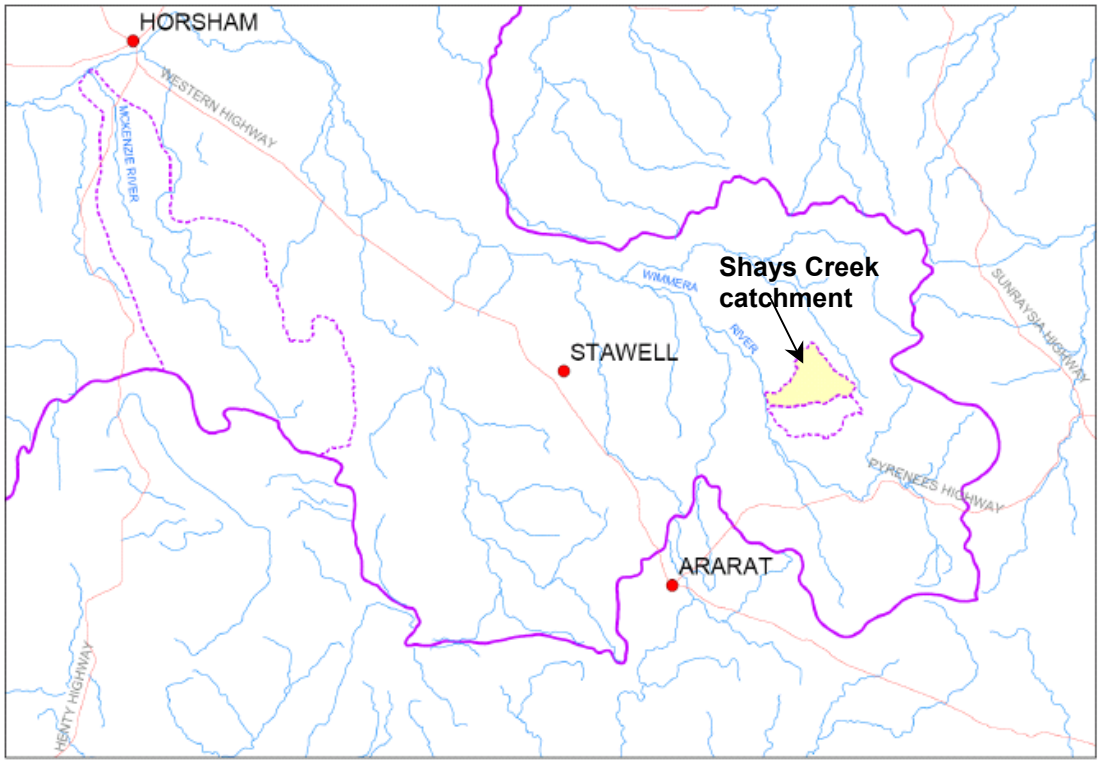


Figure 1. The location of the Shays Creek catchment within the Wimmera CMA region.

In order to reduce the possible risk posed by sediment to the High Value Reach, the Wimmera CMA proposes to undertake a stream management works program along Shays Creek. This report by Earth Tech Engineering Pty Ltd (Earth Tech) documents the analyses and outcomes of an investigation commissioned by the Wimmera CMA to develop a Waterway Action Plan (WAP) for Shays Creek. The plan has been developed to guide management and facilitate the implementation of waterway management works where required. The action plan includes:

1. The development of objectives for Shays Creek in accordance with state and regional priorities for management (*Catchment Values Threats and Management Objectives*, Section 6)
2. The current geomorphologic and ecological conditions of Shays Creek;
3. Values and threats to the creek, as perceived by stakeholders and the Shays Creek catchment community;

4. An assessment of risks to waterway health within the Shays Creek catchment, and;
5. A determination of waterway health targets for Shays Creek and a detailed action plan aimed at achieving these targets.

1.1 Scope

The scope for this project is set out in the Wimmera CMA Project Brief and comprises the following project tasks:

- A review of the relevant state and regional strategies;
- Development of detailed subcatchment management plans (Waterway Action Plans or WAPs) detailing the risks and opportunities within each subcatchment, and prioritised management actions;
- Detailed subcatchment maps showing the location of proposed management actions;
- Identification of bed and bank instabilities;
- Location of pest plant and animal species that may pose a threat to waterway health at a sub reach scale;
- Extent and condition of riparian vegetation and fencing at a sub reach scale;
- Identification of high value assets and the risks and opportunities associated with these assets;
- An indicative budget to undertake management actions;
- Development of WAPs with a “Landscape” or whole of catchment approach to natural resource management (NRM);
- The WAPs are developed with consideration for other natural resource management (NRM) programs and projects planned or underway within the catchment.

The background review and field assessments identified many issues that have an impact upon waterway health. Management of a number of these issues is achieved within other works programs, strategies and plans developed by various management organisations and individual landowners. These issues and associated management programs are detailed in the Table 1.

Table 1. Waterway and land management programs relevant to the Shays Creek catchment.

Issues identified in Waterway Action Plan	Responding Strategy / Plan / Activity
Bank erosion Stream bed instability In stream Water Quality In stream habitat Riparian zone revegetation	***Shays Creek Waterway Action Plan***
Exotic pest plants	***Wimmera Weed Action Plan***
Whole farm and pasture management	***Steep Hill Country Management Plan*** ***Whole Farm planning***
Rabbits	***Wimmera Rabbit Management Action Plan***
Other exotic pest animals	***Victorian pest management framework***
Native pest animals	***Dept. Sustainability & Environment***
Native Vegetation Management	***Victorian Biodiversity Strategy*** ***Shire Planning schemes***

The Wimmera Catchment Management Authority plans to undertake a stream management works program along the Shays Creek, which has been identified as a high priority for management. It is recognised that Shays is also named Sheas [sic]Creek in local maps, which can cause confusion. As such, this Waterway Action Plan (WAP) will use the term Shays Creek to describe the system. This Waterway Action Plan, prepared by Earth Tech Engineering, 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 are important aspects of Waterway Action Plans.

This report includes

1. A review of regional and local objectives of the Wimmera CMA via objectives referenced in relevant regional strategies and investigations. These objectives are to be observed throughout the development of the Waterway Action Plan
2. A summary of catchment conditions, sourced from reports and investigations into waterway health within the Wimmera CMA region, and

A summary of values and issues raised at meetings with stakeholders and the Shays Creek catchment community.

2 Methodology

The Waterway Action Plan for Shays Creek was compiled using the following methodology:

2.1 Background Document Review

A desktop review of existing reports, investigations into waterway health issues and associated available data was undertaken. The aim was to provide:

1. A comprehensive list of waterway health issues. This list provided the basis for data collection during fieldwork and subsequent remedial action development;
2. A comprehensive list of stakeholders to be consulted during the development of the plan and the preparation of a stakeholder consultation plan. This plan was used to obtain stakeholder input on issues and concerns about the condition of Shays Creek and works planned for the catchment.

2.2 Engagement of Stakeholders and the Community

Public notices were placed in local newspapers and a letter drop was made to all roadside mailboxes within the catchment. This was undertaken at project inception to inform the community of the commencement of the project, identify opportunities for community involvement and advise people of the dates and venues for information sessions.

Field Assessments

A specialist team including a geomorphologist, waterway engineer and vegetation specialist undertook field assessments. The inspections were conducted in the presence of Wimmera CMA waterways staff and the landholder where possible. This approach permitted a continuous exchange of information by which all parties could learn from each other.

Information collected during the field inspections included:

- Past and present geomorphic condition;
- Contemporary vegetation condition and extent;
- Habitat quality, and;
- Fencing, revegetation and engineering works required.

The methodology applied to assess this information is elaborated upon in the following paragraphs.

Stream Health

Stream health in Victoria is assessed using the Department of Sustainability and Environment's (DSE) Index of Stream Condition (ISC). ISC assessments have not previously been undertaken on Shays Creek and were not a requirement of this project. However, field observations of the components that make up an ISC score (hydrology, physical form, streamside zone, water quality and aquatic life) indicate

that Shays Creek would rate poorly if an ISC assessment was to be made. In order to measure changes in stream health it is recommended that ISC assessments be carried out prior to the commencement of works.

2.3 Contemporary Vegetation Condition and Extent

The field condition and extent of contemporary vegetation, including native, exotic and weed species, was assessed by a vegetation specialist. Vegetation was then described in terms of the pre 1750's Ecological Vegetation Class (EVC) for the relevant bio-region. These classes are further defined in terms of their Bio-regional Conservation Status and may be described as listed in Table 2. Extensive plant species lists are provided in Appendix B to assist with the ISC process.

Table 2. Summary of EVC Bioregional Conservation Status Definitions.

Symbol	Conservation Status	Brief Definition
X	Presumed Extinct	Probably no longer present in the bioregion (or, if present, below the resolution of available mapping)
E	Endangered	<10% of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status)
V	Vulnerable	10 - 30 % of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status)
D	Depleted	>30% and up to 50% of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status)
R	Rare	Rare as defined by geographic occurrence (total range generally <10 000ha, or pre-European extent in Victorian Bioregion <1000ha or patch size generally <100ha) but neither depleted, degraded nor currently threatened to an extent that would qualify as endangered, vulnerable or depleted
LC	Least Concern	>50% or pre-European extent exists and subject to little to no degradation over a majority of this area.

Source: Ecological Vegetation Class - Bioregional Conservation Status, Depletion & Tenure Area Statement on CD provided to consultants at the Native Vegetation Framework Training, September 2003.

2.4 Habitat Quality

Although not specifically required in the scope of this report, an assessment of habitat quality has been provided to enhance the value of the vegetation information collected. Note that sub-reach delineation was not determined prior to the commencement of the field inspection stage as this refinement was to be based on the geomorphic information derived from the field inspections. As a result, it was not possible to collect habitat quality information for all of the sub-reaches.

Habitat quality in the Shays Creek riparian zone was determined using the Rapid Habitat Assessment (RHA) method developed by DSE. This method is a modified version of the Habitat Hectares Method used in more comprehensive surveys. The RHA gives an estimate of vegetation / habitat quality using the following criteria,

- Retention of large old trees
- Retention of canopy cover

- Retention of the cover of, and diversity within, understorey life forms
- Presence of appropriate recruitment
- Absence of weeds
- Litter
- Logs (in woodlands and forests)
- Landscape context i.e. size of remnant patch and links to and size of neighbouring patches

At a particular site, native vegetation is assessed by comparing it to a benchmark which represents the average characteristics of a mature, long undisturbed stand of the same type of vegetation. The RHA therefore provides a 'snap-shot' of current habitat quality. Once current condition is established, sites may be ranked according to condition, enabling goals, minimum standards and management priorities to be formulated.

Habitat quality assessments vary throughout the Shays Creek catchment and as such the results are provided on a reach by reach basis in the Sub-Reach section of this report. Field notes for the assessment undertaken in each reach are provided in Appendix C

Risk Assessment & Priority Setting for Management Actions
The risk assessment process assembled the information gathered during the document review, stakeholder consultation and field assessments. Each assessment considered the values and threats to the values at the inspection sites.

The first component of the analysis identified standardised environmental values in each reach and threats to these values (Appendix D). All values were assigned a rating from Very Good (5) through to Very Poor (1).

Environmental values were determined via information gathered in the literature review and from field observations. Social and economic values were assigned a subjective rating from Very Good (5) through to Very Poor (1) based on background document review and stakeholder and community consultation.

Threats have been given a similar rating from Very High (5) through to Very Low (1). Social threats and economic threats have been determined from consultation with stakeholders. Environmental threats have been determined from information gathered in the literature review and from field observations.

In order to determine the level of "Risk", the impact of a "Threat" on a "Value" is determined by multiplying the "Value x Threat", then multiplying this rating by standardised Likelihood and Trajectory.

"Likelihood and "Trajectory" are defined as follows:

Likelihood – i.e. what is the likelihood of this threat impacting on this value;

5-almost certain
4-quite possible
3-unusual but possible
2-remotely possible
1-practically impossible

Trajectory – i.e. what is the timescale created by this impact;

5-rapid

3-slow

1-stable

Trajectory provides a time scale when prioritising risk. Trajectory also varies between reaches and has therefore been identified for every risk in every reach.

The risk to a value was determined by the resultant score from the multiplication of Value x threat x Likelihood x Trajectory. The risk rating was assigned according to the following method:

Low	<80
Medium	< 200
High	< 400
Very High	> 400

Priorities for management actions were determined by the risk rating. High priority actions correspond with very high and high risk ratings. Similarly, medium and low priority actions correspond with medium and low risk ratings respectively.

3 Management Objectives, Condition and Values

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)
- Wimmera Water Quality Strategy (2002)
- Wimmera River Geomorphic Investigation (2001)
- Geomorphic Categorisation and Stream Condition Assessment of the Wimmera River Catchment (2003)

3.1 Review of State and Regional Strategies

3.1.1. 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). To achieve this objective, a management approach based on 4 key elements will be used :

- 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 the State's rivers, and;
- Preventing damage from future management 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.

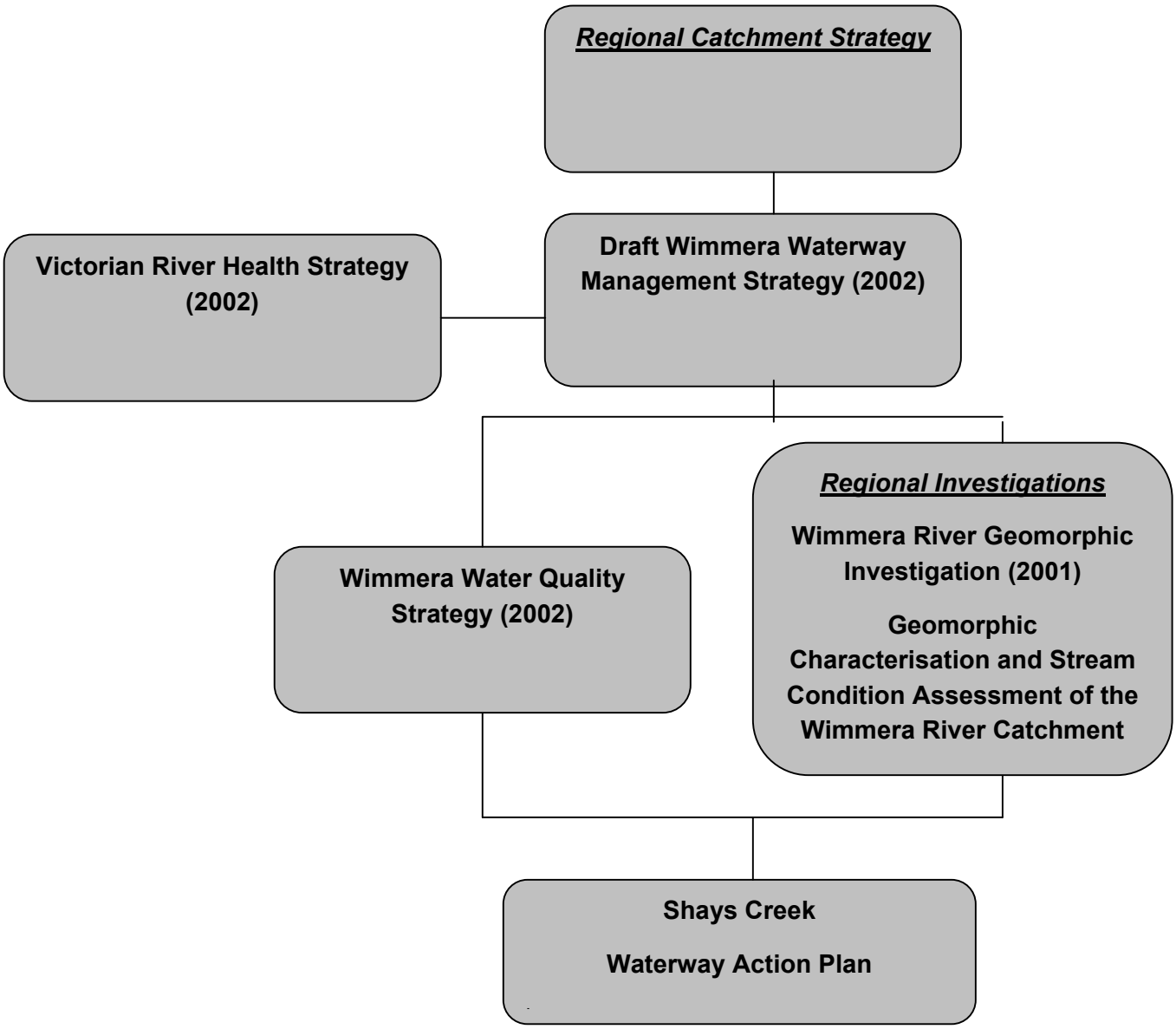


Figure 1a - Relationships between reports used to compile the Shays Creek Waterway Action Plan

3.1.2. The Wimmera Waterway Management Strategy

The Wimmera Waterway Management Strategy (WWMS) aims to, *"protect and enhance the region's waterways through fair and sustainable management, taking account of environmental, economic, cultural and social objectives".*

The 2003 Wimmera Regional Catchment Strategy identifies changed channel form as a significant waterway issue and identifies resource condition targets and actions to achieve these.

Key Resource Condition Targets in the Wimmera RCS are:

- R9 – All stream reaches identified as being of high value and in good condition in the Draft Wimmera Waterway Management Strategy be protected by 2020.
- R10 – Improvement in the 'stability condition' of high value streams rated as moderate by the Draft Wimmera Waterway Management Strategy protected or returned to good condition by 2020.

Key Management Action Targets in the Wimmera RCS are:

- WR37 – Undertake works in priority areas to restore and protect in-stream habitat.
- WR50 – Implement priority actions to protect and manage stream forms.
- WR51 – Assist with gully stabilisation where there is a direct impact on the waterway.

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

Aim: To manage structural waterway assets so as to improve the health of the waterways;

- Program 2. Waterway Repair and Maintenance

Aim: To preserve, maintain and/or rehabilitate the environmental, economic and social values of waterways;

- Program 3. Riparian Management

Aim: To improve waterway health through the sustainable management of riparian zones

- Program 4. Catchment Management

Aim: To assist in addressing land management issues that have negative impacts on waterway values.

- Program 5. Flow regimes

Aim: To improve the health of aquatic and riparian ecosystems though provision of appropriate flow regimes, and

- Program 8. Water Quality and Urban Stormwater Management

Aim: To improve the quality of water in the region's waterways and wetlands

The WWMS divided the Wimmera CMA region into 12 Waterway Management Units (WMU). The WMUs are shown in Figure 2. This report aims to confirm and elaborate on the findings of the WWMS in relation to Shays Creek which is wholly contained within Waterway Management Unit 2.

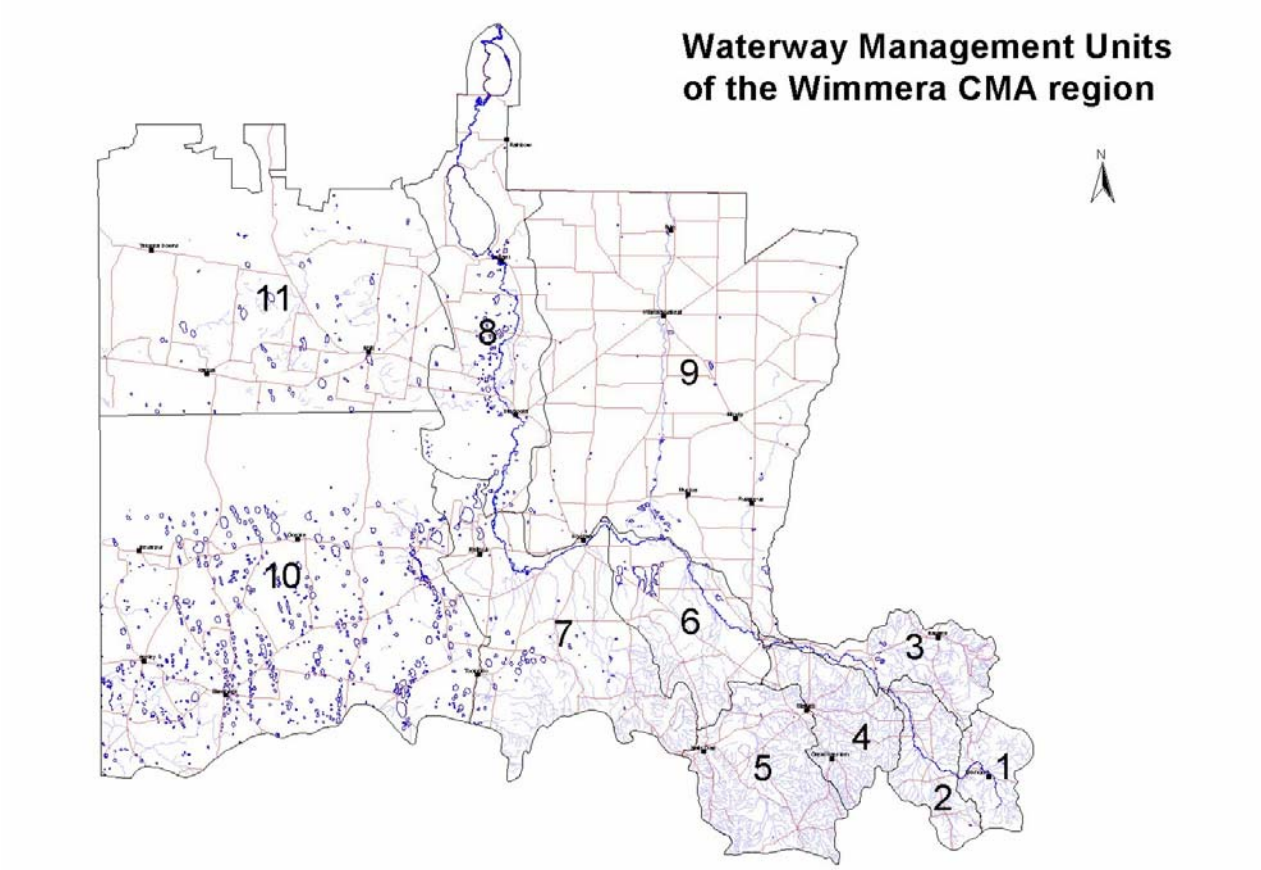


Figure 2a – Waterway Management Units of the Wimmera CMA Region

3.1.3. The Wimmera Water Quality Strategy

"The aim of the Wimmera Water Quality Strategy is to improve the quality of the Region's water that will result in environmental, social and economic benefits to the Region". Implementing the strategy could reduce total phosphorous levels in the Wimmera River by up to 42 tonnes per year (WCMA 2002b).

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.

3.1.4. The Wimmera River Geomorphic Investigation

The Wimmera River Geomorphic Investigation (WRGI) comprised 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.

3.1.5. The Wimmera River Geomorphic Categorisation and Stream Condition Assessment

The Wimmera River Geomorphic Characterisation and Stream Condition Assessment built on previous findings from the Wimmera River Geomorphic Investigation. It identified the stream types throughout the Wimmera River Catchment and provided information to assist in determining management regimes for stream types based on the geomorphic characteristics and condition of the stream. The project identified reference sites for stream types and benchmarked stream condition at those sites. The reference sites are then able to provide a template for rehabilitation of similar stream types elsewhere throughout the catchment.

The report recommended five actions be implemented:

- Protection of Rare Stream Types
- Protection of Streams in Good Condition
- Protection of Stream System Function and Diversity
- Protection of Heritage Rivers
- Defining Template Reaches using Representative Rivers as a Basis

3.2 Shays Creek Condition

Shays Creek is a highly degraded tributary of the Wimmera River. As part of the Wimmera River Geomorphic Investigation, ID&A (2001) broke down the system into a number of reaches that has different physical attributes and associated stream health issues. Reach 6 of the Wimmera River was defined from just upstream of the junction of Glendhu Creek and the Wimmera River to just downstream of the Joel Joel Bridge. This reach of the Wimmera River is considered to be highly degraded, with excessive sedimentation in the channel zone identified as being the largest problem. The next reach downstream, Reach 7 extends from just below the Joel Joel Bridge to Glenorchy and is considered to be of much higher ecological and geomorphologic value because it has not been affected by excessive sedimentation or other issues.

Shays Creek enters the Wimmera River in Reach 6 and is currently delivering excessively high quantities of fine-grained sediment to the system. As such, priorities have been put in place to prevent Reach 7 from being affected by issues arising from further upstream. Management of these issues needs to be addressed as close to the source as close as possible (eg: preventing a tributary from depositing large quantities of sediment in the main trunk by attempting to lock it up

within the catchment). This is the main management objective for the Shays Creek Catchment.

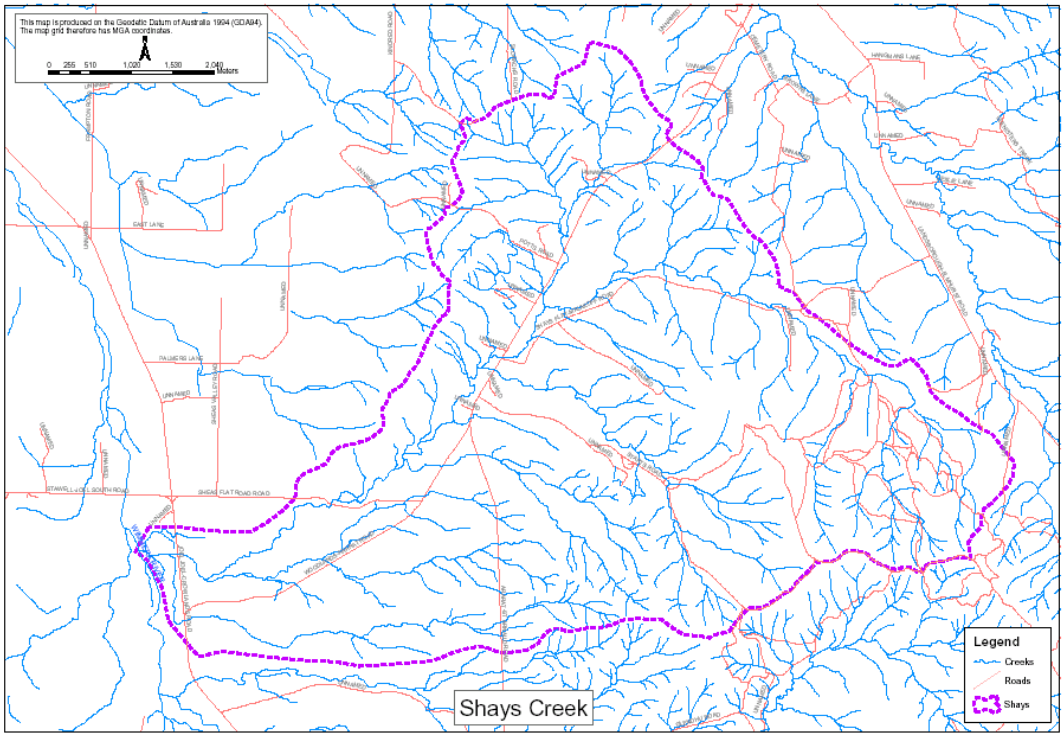


Figure 2 – Location Map of Shays Creek

Physical form

Prior to European settlement in the area, it is thought that much of the Glendhu and Shays catchments were dominated by a discontinuous channel system, or chain of ponds. Historical channel changes on Sheas [sic] Creek have seen the transformation from a very stable system to one that is highly susceptible to channel change. The catchment has undergone extensive gully erosion, which is still occurring today. The likely cause of this degradation is thought to have been the combined effects of catchment clearing and land use change as well as the incision of the Wimmera River initiating headward erosion (ID&A, 2001).

"The major issues perceived include incidences of severe bed and bank erosion and the downstream water quality impacts from sediment and nutrient generation particularly following high flow events. Gully and tunnel erosion are extremely prevalent in these systems. Sheet and rill erosion are also present within the system, but do not exert as much of an impact. There are high grazing pressures on these streams and they are also prone to high levels of salinity" (WCMA 2002a).

"This stream is likely to have delivered substantial volumes of sediment in the Wimmera River prior to the construction of a drop structure (>4m high) at the Joel Joel-Crowlands Road. This drop structure effectively traps most, if not all bed material sediment upstream, with only a small proportion of suspended sediment passing further downstream. A substantial deposit of recent sediment has accumulated upstream of the road. As such, this structure is vitally important in preventing further headcuts back up the valley. Downstream of the structure, the

stream has been channelised with a straight cut through the floodplain to its confluence with the Wimmera River to accommodate changes in base level of the main channel. The longitudinal profile of Sheas [sic] Creek has been altered substantially following European settlement of the area with the creek experiencing major bed degradation and subsequent adjustments in stream form. This reach is over enlarged, has near vertical erodable banks and is sediment starved" (ID&A 2001).

"The reduction of soil erosion (particularly gully erosion) in the upper catchment of the Wimmera River system is a key requirement for nutrient reduction. This conclusion is certainly supported by observations made at Sheas [sic] Creek, which carries large quantities of fine-grained sediment and nutrients to the river. In contrast, some other scours in the area may not be so important. Inspections and aerial photograph interpretations indicate that much of the sediment that has been liberated from upper catchment erosion is currently stored in depositional fans in the lower reaches and floodplain areas prior to reaching the river. It is vital that these zones remain stable" (ID&A 2001).

"In the summary of waterway conditions and issues, Sheas [sic] Creek rates poorly for stability condition and very poor for ecological condition. There are high recordings of stream erosion and medium levels of sedimentation and loss of in-stream habitat. There are low issues for pestilent plants with medium concerns for stream vegetation losses, frontage degradation losses and water quality. Sheas [sic] Creek catchment presents high levels of saline groundwater intrusion and catchment erosion salinity" (WCMA 2002a).

Management

"If the objective is to restore the fill of the river valley and possibly a chain of ponds, the contribution of excess sediment loads from tributaries experiencing severe erosion may help accelerate the restoration process. However, it is thought coarse sediment, found in the contemporary bed of the channel does not typify the sediment in chain of ponds stream types, may not be most suitable. The valley fill which forms chains of ponds is generally believed to be finer than sand. That being the case, management of the tributary stream should aim to reduce coarse sediment inputs, while still allowing fine sediment to reach the river. This is actually occurring at Sheas [sic] Creek as a result of the drop structure and is aiding the recovery of reach 6. However upstream, Glendhu Creek is currently delivering all sizes of sediment, including substantial volumes of sand and gravel. This sediment is contributing to the infilling of the river in this reach. If the management objective is to maintain the continuous channel, these sediment inputs from tributaries will continually work against that objective. Management of the type and quantity of sediment coming into, and out of the catchment, in conjunction with in-stream and riparian vegetation should be able to encourage the regeneration of degraded chain of ponds and fresh water meadows" (ID&A 2001).

"The Wimmera CMA program for remedial structural measures to address key waterway management issues considers the primary management response for Sheas [sic] Creek catchment is bed stabilisation and is one of the highest priorities recognised within the greater Wimmera catchment" (WCMA 2002a).

3.3 Values and Issues of Shays Creek

A meeting for relevant stakeholders for Shays Creek Catchment was held at the Wimmera CMA offices on June 23rd, 2004. The issues raised at this meeting were;

- *Vegetation management*
- *Erosion control*
- *Location of existing and planned erosion control works*
- *Spread and containment of weeds, particularly Spiny Rush and Serrated Tussock*
- *Fencing and revegetation measures*

A community consultation meeting was also held for Shays Creek Catchment at the Crowlands Hall on June 24th, 2004. The issues raised at this meeting were;

- *High rates of erosion (slopes, minor drainage lines and the main trunk stream) – gully erosion seems to be the main problems with many headward erosion points progressing upstream*
- *Sedimentation*
- *Gravel extraction*
- *Stock management*
- *Grazing pressures exerted by kangaroo populations*
- *Significant fencing and revegetation initiatives have been planned and implemented*
- *In conjunction with fencing, significant gully battering, dam construction and construction of drop structures has also occurred in the Shays Creek catchment.*

3.4 Waterway Action Plan Objectives

In accordance with State and Regional plans and strategies, the objectives of the Shays Creek Waterway Action Plan are;

4. To protect the health and vitality of Shays Creek and the health of Reach 7 of the Wimmera River.

   This will involve

   - determining appropriate actions to manage the current sediment load within Shays Creek
   - assessing the water quality from the Shays Creek catchment and its potential impacts on the Wimmera River
   - assessing the potential for weeds to be transported into the Wimmera River

5. To confirm values and threats identified through existing reports and community consultation and devise appropriate management actions to enhance stream health for the catchment.

To develop appropriate management actions on a reach by reach basis, in conjunction with the catchment community.

4 The Shays Creek Catchment

4.1 Catchment Description

Shays Creek is a right-bank tributary of the Wimmera River that originates from steep hill slopes on the western side of the Pyrenees Ranges. The catchment is located approximately 30km east of the township of Stawell, with the Joel-Joel-Crowlands Road being the major traffic thoroughfare through the lower portion of the catchment (see Figure 2, Locality Map). Grazing has traditionally been the predominant land use within the catchment, however recent expansion of the viticulture industry around Malakoff has seen parts of the upper catchment converted to this alternative land use. Further landscape changes are likely with the proposed construction of electricity generating wind turbines on the higher ridges of the catchment.

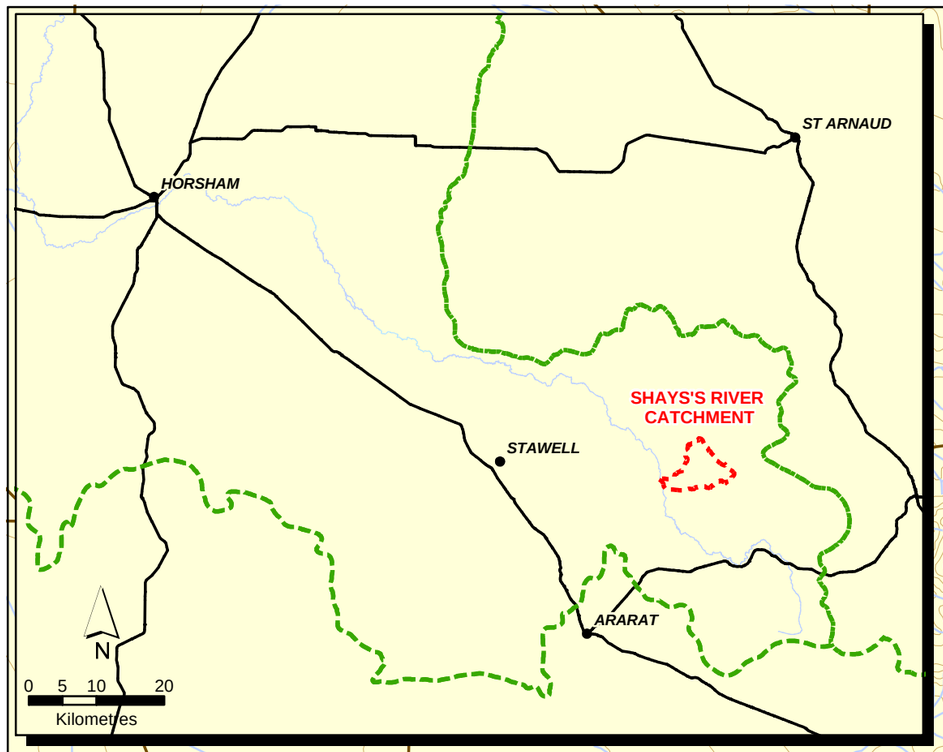
4.1.1. Geomorphology

The Shays Creek catchment covers an area of 44 km^2 with elevations ranging from 250m to 526m above sea level (ASL). Soils within the catchment are highly dispersive and erodable. This factor, combined with widespread clearing of the catchment since settlement, has led to a majority of the drainage lines within the catchment becoming deeply eroded.

Comparison of recent aerial photography with some taken in the 1940's, shows that many erosion gullies that were active during this time are still eroding and contributing significant quantities of sediment to the creek. Particle sizes in the mobilised sediment range from silts through to sands and gravel. A lack of in-stream vegetation and natural bed controls such as bedrock or armouring, has led to incision that provides longitudinal connectivity between the upper slopes and the mouth of the Wimmera River. This in turn provides a channel for the transport of large quantities of sediment into the lower reaches of Shays Creek. Mobilised sediment is then infilling existing pools and degrading the in-stream habitat, physical form and water quality of the channel. During high flow events some of the finer sediment is carried over the drop structure on the Joel Joel – Crowlands Road and downstream to the Wimmera River.

Soil conservation works that aim to reduce erosion within the Shays Creek catchment, have been ongoing since the 1940's. These works have included the construction of concrete drop structures, gully plug dams, contour water diversion banks, gully battering, and fencing and revegetation with both pasture and tree species. Although many have succeeded in stopping the progress of actively eroding gullies, some of these works have failed with a subsequent re-initiation of headward erosion. Hard engineered structures are more prone than other methods to sudden and catastrophic failure as they age. This is particularly the case in highly dispersive soils such as those found within the catchment.

Figure 2. Location Map of Shays Creek



Location of Shay's Creek

Legend

- Catchment Boundary
- CMA Boundary
- Waterways
- Shay's Creek

N

0 200 400 600 800 1,000
Metres

Wimmera Catchment Management Authority

Waterways for Life.

EARTH TECH

SLORAGHS ROAD
CEMETERY ROAD
HANGMANS-L
LESL
MALAKOFF CREEK
POTTS ROAD
BORROUGH-ELMHURST ROAD
PALMERS LANE
SHEAS VALLEY ROAD
WIMMERA RIVER
SHEAS FLAT ROAD-ROAD
JOEL JOEL-CROWLANDS ROAD
WOODLANDS-ARARAT ROAD
ARARAT-ST ARNAUD ROAD
STARTS ROAD
GLENDHU ROAD

063_M004

In the upper catchment of Shays Creek a combination of poorly vegetated slopes controlling the capacity for infiltration, and the steep nature of the upper portion of the catchment, results in the rapid concentration of rainfall runoff. Short high intensity rainfall events under these conditions have high stream powers that erode bare banks and transport large volumes of all sizes of sediment. Smaller events that occur following a larger event then have the potential to remove (winnow) finer sediment from the bed and deposit it further downstream. This leaves the coarser material in the bed (as lower flow velocities do not have the capacity to mobilise larger sediments), to form an armouring gravel layer. When left undisturbed, this gravel layer has the ability to limit further bed incision. Once bed armouring is established the streambed is less likely to deepen further, and unless otherwise restricted, the channel will undergo a process of widening as illustrated in Figure 3. Examples of active stream widening as a result of this mechanism can be found at a number of locations on Shays Creek.

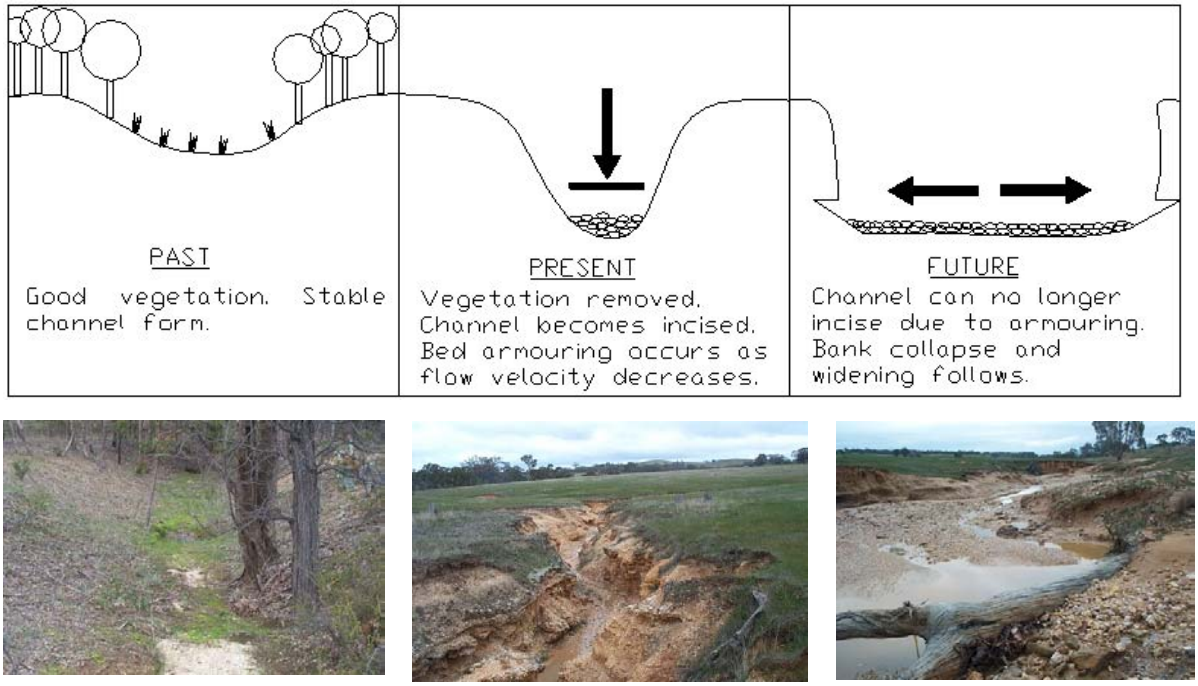


Figure 3. The process of vegetation removal that leads to stream incision and later bed armouring in the upper catchment of Shays Creek.

The lack of woody vegetation in the riparian zone, on the rest of the floodplain and surrounding hill slopes, limits the terrestrial habitat values within the catchment. In the steep headwaters of the catchment the ecological in-stream values improve as stock access to the riparian zone is limited by steep bank and channel gradients. Where streamside vegetation has been cleared, the in-stream vegetation has been allowed to grow. This has prevented the incised channel from widening further and has, in places, encouraged the bed elevation of the channel to become raised, reducing the streambed gradient and subsequently reducing the erosive power of water in the channel.

Evidence for the existence of a chain of ponds morphology can be seen in the exposed soil profile at many locations within the banks of the incised channel. This surface is typically black or dark grey and reflects the saturated anaerobic subsurface conditions that would have been experienced in the undisturbed system. Many of these surfaces have now been covered, as a result of the incision and erosion process, with a veneer of sand and silt, up to 1m thick in some places. In

the contemporary condition, there are no remaining examples of the original chain of ponds stream type .

4.1.2. Upper Catchment Geology

In the upper portion of the catchment, the geology is mainly composed of sedimentary rocks. Conglomerates, comprising quartz pebbles are the dominant rock type. This has led to the formation of deeply weathered soils, particularly along the drainage lines. Many of these soils have sodic properties and are highly susceptible to erosion when disturbed. The steeper areas of the upper catchment are currently generating large volumes of sediment as headcuts extend upstream into intact valley fills and adjacent hill slopes.

4.1.3. Lower Catchment Geology

The lower portion of the catchment is dominated by flatter valley gradients made up of Quaternary alluvial and colluvial sediments overlying the regional sedimentary and metamorphic rocks. The latter part of the Quaternary period would have seen the valley floor undergoing long periods of fine sediment accumulation, punctuated by catastrophic events combining drought and/or fire and flood that lead to incision and deposition of coarse sediment. The fine sediment consists of organic-rich soil horizons that have been overlain by recent (post-European) deposits of sand and silt.

4.1.4. Vegetation

The native vegetation along the majority of Shays Creek is of poor quality . The riparian zone is dominated by exotic pasture species with an overstorey of scattered, mature River Red Gums (*Eucalyptus camaldulensis*). Occasional remnant patches of indigenous grasses and herbs are located where stock access is limited. Shrubs and woody species recruitment is absent along most of the stream frontage and on the adjacent floodplain. The quality and abundance of indigenous vegetation remnants increases further upstream in the catchment.

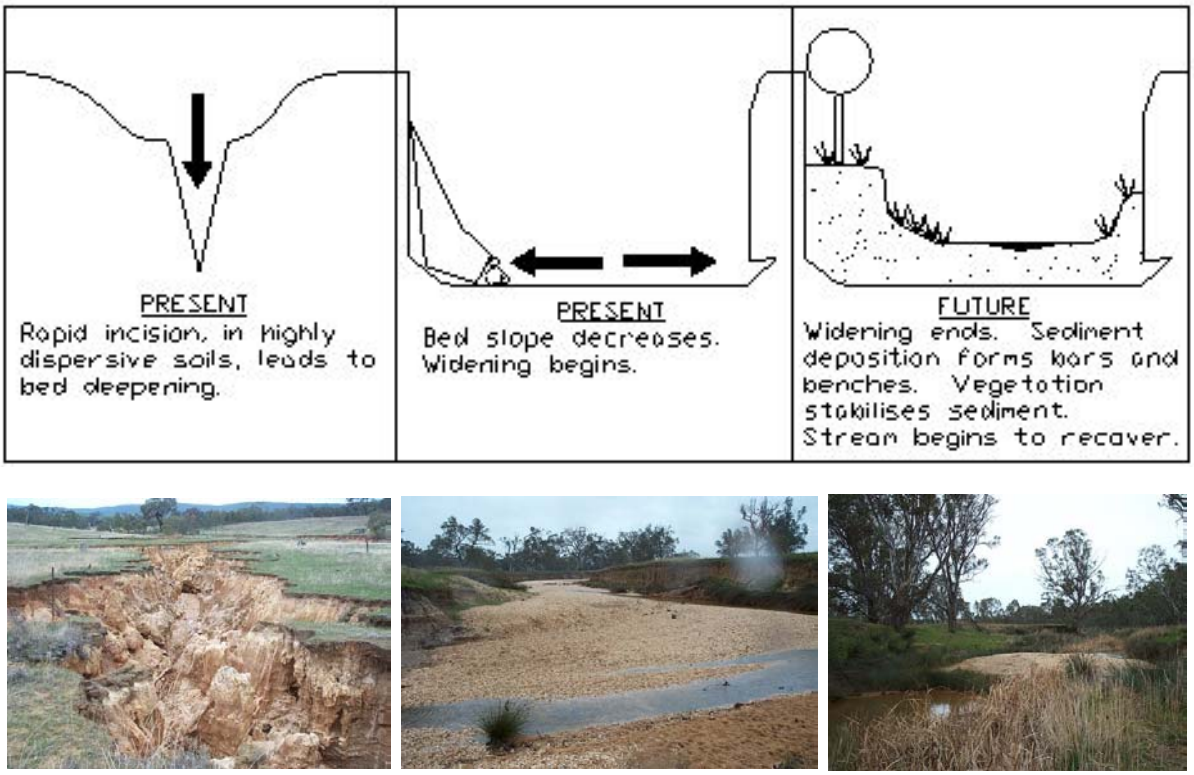


Figure 4. Steps in the process of stream degradation and recovery occurring in the lower reaches of Shays Creek.

4.1.5. Habitat Quality

Habitat quality varies throughout the Shays Creek catchment. Table 3 is a summary of the state of habitat quality as determined using the Rapid Habitat Hectares assessment method. More detailed habitat assessments are provided on a reach by reach basis in the reach section of this report.

Table 3.: Habitat quality assessment results for Shays Creek.

Veg Site	Preliminary Score	Habitat Quality
1	12	High
2	10	Medium
3	15.5	High
4	11	Medium
5	4	Low
6	2	Low
7	6	Low
8	6	Low
9	0	Low
10	4	Low
11	0	Low

Note: 0-6.5 = Low Habitat Quality, 7-11.5 = Medium Habitat Quality, 12-20 = High Habitat Quality

4.2 Waterway Management Targets

In order for the management actions proposed in the Shays Creek Waterway Action Plan to contribute to the achievement of Statewide River Health Targets (see Table 4), the following waterway management targets for Shays Creek have been developed. These targets are the basis on which the proposed works are prioritised:

1. Progressively reduce the amount of sediment originating from Shays Creek and subsequently entering the Wimmera River. Measuring achievement of this target through monitoring sediment input from the Shays Creek at its confluence with the Wimmera River is difficult. Improvements in bed and bank stability, measured as part of Index of Stream Condition Assessments, may be used to extrapolate decreased sediment inputs.
2. Achieve an average Index of Stream Condition rating of 'Moderate' throughout the catchment.

A single ISC Assessment was made in 2002 on an unnamed tributary of Shays Creek, up stream of the Ararat – St Arnaud Road. The ISC score for this assessment rated the site as being in 'very poor' condition (Earth Tech 2003). No other ISC assessments have been made. Based on the field inspections undertaken as part of this study, it is expected that most of the reaches in Shays Creek would rate as poor to very poor if assessed under the ISC criteria.

An improvement in the ISC rating results from an increase in the 5 sub index scores which comprise the ratings. These sub indices are hydrology, physical form, streamside zone, water quality and aquatic life. Increases in scores of the sub indices indicate improving stream health. All management actions within the Waterway Action Plan are aimed at increasing these sub index scores. Of particular note, within Shays Creek, is the need to improve habitat quality over the whole reach. Inturn, habitat quality improvement will result in an improvement of the streamside zone and physical form within the Shays catchment, and an improvement in water quality within Shays Creek and the Wimmera River, thereby lifting the ISC score. A minimum score of 'Medium', based on the modified Habitat Hectares assessment method is an achievable target within the Shays Creek catchment. Protecting the intact valley fills in the upper reaches of Shays Creek is necessary to protect hydrologic regimes and the physical form of the stream. Protecting intact valley fills will assist in retarding runoff and reducing stream powers, thereby reducing the erosive capacity of flow events.

Due to the poor overall condition of the creek, it is expected that a long term (up to ten years) works program will need to be implemented to achieve these management targets. Higher targets, greater effort and longer timeframes would be required if higher habitat/connectivity targets were sought.

Table 4. Statewide River Health Targets relevant to the Shays Creek.

By 2011:

- *4800 of rivers with improvement of one rating in the measurement of riparian condition*
- *an increase of 7000 hectares of riparian areas under management agreements*
- *600 km of rivers where instream habitat has been reinstated*
- *60% of all lowland monitoring sites will meet SEPP environmental quality objectives*
- *1000 high value public assets provided with appropriate level of protection*

4.3 Options for Waterway Management

There are a number of techniques that can and have been successfully used in undertaking the repair and protection of land and waterways. Each of these techniques has its own advantages and disadvantages, and in the upper Wimmera catchment, many of these techniques have been and continue to be used. Among the methods applied are:

Concrete chutes	Drop structures
Fencing and revegetation	Gully battering
Gully plug dams	Grass chutes
Rock chutes	Rock beaching
Timber pile fields	Trickle pipes

In considering appropriate management actions for Shays Creek, it is recognised that many of the above techniques may be applicable. Options for management have been determined based on providing the most cost effective solution. Costs for the actions recommended in this report are included in section 10 to allow comparison with other solutions.

5 Management Reaches

For ease of management and in order to refine the assessment process and works program, Shays Creek has been divided into nine reaches. This delineation has been based on the geomorphic processes currently occurring within each reach. The decision to divide the catchment on geomorphic grounds is based on the premise that geomorphology determines the form of the creek and therefore has a major influence on vegetation and habitat values within any particular reach. The location and extent of each reach is shown on Figure 5, with the Easting and Northing of the reach delineators listed in Table 5.

Table 5: Reach delineation of Shays Creek

Reach	Location
Reach 1	Headwaters of Shays Creek to Shays Flat-Malakoff Road crossing.
Reach 2	Crossing with Shays Flat-Malakoff Rod to confluence of major right-bank tributary (E 687 052..N 5 897 370)
Reach 3	Headwaters of major right-bank tributary to confluence with Shays Creek (E 687 052..N 5 897 370)
Reach 4	Headwaters of major left-bank tributary to Starts Road Crossing
Reach 5	Starts Road crossing to confluence with Shays Creek (E 686 290 .N 5 896 653)
Reach 6	Confluence of major right-bank tributary (E 687 062.N.5 897 377) to (E 685 941.N 5 895 981)
Reach 7	(E 685 941.N 5 895 981) to confluence with major left bank tributary (E 682 869.N 5 894 040)
Reach 8	Headwaters of major southern tributary to Joel Joel-Crowlands Road crossing
Reach 9	Joel Joel Crowlands Road crossing to the confluence with Wimmera River

Appendix A shows the location of each reach on a longitudinal section of the main trunk of Shays Creek. Bedslope information for these drawings has been determined by using the ten metre contour interval from a topographic map of the catchment. As stream bedslope plays a major role in geomorphic processes, illustrating reach delineation in this manner allows a rapid appraisal of potential locations of geomorphic change.

Figure 5. Sub-reaches of the Shays Creek

Legend

- Waterways
- Roads
- Shays Catchment
- Cadastre

Shays Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Reach 6
- Reach 7
- Reach 8
- Reach 9
- Low quality habitat
- Medium quality habitat
- High quality habitat
- Veg Site

KINDRED ROAD
SLORACHS ROAD
ARARAT-ST ARNAUD ROAD
CEMETERY ROAD
MALAKOFF CREEK
BROWNS LANE
HANGMANS LANE
LESLIE LANE
LANDSBOROUGH/ELMHURST ROAD
EAST LANE
POTTS ROAD
SHAYS FLAT-MALAKOFF ROAD
PALMERS LANE
SHEAS VALLEY ROAD
STARTS ROAD
STAWELL-JOEL SOUTH ROAD
SHEAS FLAT ROAD ROAD
JOEL JOEL-CROWLANDS ROAD
WIMMERA RIVER
WOODLANDS-ARARAT ROAD
GLENDHU ROAD

N

490 245 0 490

Meters

This map is produced on the Geodetic Datum of Australia 1994 (GDA94). The map grid therefore has MGA coordinates.

EARTH TECH

Shays Creek Waterway Action Plan

Wimmera Catchment Management Authority

Waterways for Life.

063_M008

5.1 Reach 1: Headwaters of Shays Creek to Shays Flat-Malakoff Road crossing

5.1.1. Geomorphology

Reach 1 incorporates the steep slopes of the catchment headwaters and the main channel of Shays Creek. The majority of the gullies dissecting the steep hill slopes are deeply incised with the depth of incision decreasing upslope. There is evidence that a number of these drainage lines have been previously battered, however, some of these sites are undergoing a second phase of incision. At the base of the steep slopes the gradient is considerably flatter and here the floodplain acts as a sediment storage zone. At these locations sediment is deposited in large fans that have significant headcuts up to 2m deep extending back upstream. Due to the sodic nature of the soil in this area these active headcuts have a high potential to continue eroding.

Many of these gullies have not yet reached full depth of incision and only some have widened, therefore without treatment large volumes of sediment are likely to be exported from these eroding channels.

Figure 6. Photo left: deep incision occurring in the upper catchment. Photo right: sediment deposition in the downstream end of the main stem of Reach 1 (August 2004).

5.1.2. Vegetation

Pre 1750s EVC mapping indicates that vegetation in this reach was once dominated by Alluvial Terraces Herb Rich Woodland. This EVC is characterised by a Eucalyptus overstorey comprised of Grey Box (*Eucalyptus microcarpa*), Yellow Box (*Eucalyptus melliodora*), Yellow Gum (*Eucalyptus leucoxylon*) and Buloke (*Allocasuarina luehmannii*). Understorey shrubs include Golden Wattle (*Acacia pycnantha*), Gold-dust Wattle (*Acacia acinacea s.l.*), Hedge Wattle (*Acacia paradoxa*), and Spreading Wattle (*Acacia genistifolia*). Ground layer species include Smooth Solenogyne (*Solenogyne dominii*), Wattle Mat-rush (*Lomandra filiformis*), Common Wheat Grass (*Elymus scaber* var. *scaber*), Black-anther Flax-lily (*Dianella revolute s.l.*) and various Spear Grasses (*Austrostripa* sp.).

On the nearby hills, Dry Grassy Forest was the dominant EVC. This EVC is characterised by a Eucalyptus overstorey comprised of Red Stringybark (*Eucalyptus macrorhyncha*), Red Box (*Eucalyptus polyanthemos*), Yellow Box (*Eucalyptus melliodora*) and Bundy (*Eucalyptus goniocalyx s.s.*). Understorey shrubs include Hedge Wattle (*Acacia paradoxa*), Drooping Cassinia (*Cassinia arcuata*), Gorse Bitter-pea (*Davesia ulicifolia*) and Gold-dust Wattle (*Acacia acinacea s.l.*). Ground layer species include Wattle Mat Rush (*Lomandra filiformis*) and various Spear Grasses (*Austrostripa* sp.), Grey Tussock-grass (*Poa sieberiana*) and Wallaby Grasses (*Austrodanthonia* sp.).

This reach is dominated by exotic pasture grasses with an overstorey of scattered Eucalypts such as Red Stringybark (*Eucalyptus macrorhyncha*) and Red Box (*Eucalyptus polyanthemos*) on the hill slopes and River Red Gums (*Eucalyptus camaldulensis*) closer to the channel. Sheep currently graze the majority of this reach, although some remnant communities on hill slopes have been fenced from stock. In these areas a diverse range of overstorey and understorey species proliferate. The Dry Grassy Forest EVC is listed as 'depleted' in the Goldfields Bioregion.

A vegetation assessment was performed in this reach. At this site, which has been fenced from stock, a large number of indigenous species were identified. Species present include Eucalypts (*Eucalyptus camaldulensis, Eucalyptus melliodora, Eucalyptus microcarpa, Eucalyptus polyanthemos*), Wattles (*Acacia implexa, Acacia melanoxylon*), Chocolate-lily (*Arthropodium strictum*), Cranberry Heath (*Astroloma humifusum*), Daphne Heath (*Brachyloma daphnoides*) Supple Spear-grass (*Austrostipa mollis*), Dwarf Sundew (*Drosera pygmaea*), Scented Sundew (*Drosera whittakeri ssp aberrans*), Peach Heath (*Lissanthe strigose*), Dwarf Mat-rush (*Lomandra nana*) and numerous lichens.

5.1.3. Habitat Quality

This site, number 1, scored 12/20 in the habitat quality assessment and is considered to offer 'High' habitat quality. Although the site did not have many large trees or logs, understorey diversity and cover were excellent, more than 75% of woody species were recruiting, litter was above the benchmark percentage cover and weediness was low. It is expected that in time the habitat quality at this site will improve as existing trees mature and limbs are shed.

5.1.4. Threats and Risks

Threat	Risk
Active erosion of sediment fans in the lower sections of the reach, with the potential for large quantities of sediment to be mobilised.	High
Active erosion of the steeper slopes. Hill slope vegetation and shallow soils limit the potential for major damage in some places.	High
Widening of the channel – more likely through the fans	High
Smothering of in-stream vegetation by mobilised sediment.	Moderate

Management Actions and Cost estimates determined for Reach 1 are detailed in section 10. Works locations are shown in Appendix E.

5.2 Reach 2: Crossing with Shays Flat-Malakoff Rod to junction of major right-bank tributary (E 687 052..N 5 897 370)

5.2.1. Geomorphology

The channel within this reach is largely controlled by the valley gradient, which has led to the formation of a steep channel with low sinuosity. The upper section of the reach has a narrow and deep channel that flows over small bedrock riffles and cascades with very small discontinuous floodplains evident along its length. Due to numerous bedrock outcrops in the channel and also in the banks there is no opportunity for further incision or large-scale channel widening. Channel widths in the upstream length of this reach are around 10m, with depths up to 2m. Within the channel, gravel is present and highly mobile due to the steep streambed gradient. Small bars and benches have formed in the channel and have potential for natural revegetation if the quantities of mobile sediment can be decreased.

Approximately 1.3km downstream from the crossing with the Shays Flat-Malakoff Road, the valley widens, decreasing the channel confinement. The channel within the lower section of Reach 2 is over-widened, with some areas having maximum channel widths of 50m and depths of 2 to 3m. It is not obvious if this increase in channel width has been due to natural events causing erosion, or whether much of the reach has previously been part of a gravel extraction operation. However, the dramatic increase in channel width for the position in the catchment suggests that the latter may have been the case. Bars and benches are now re-forming in the channel bed and are slowly becoming colonised with native vegetation. In time, provided channel stability is maintained, these bars and benches will continue to aggrade. **This reach has a high potential to store large quantities of sediment in the channel zone as increased channel capacities allow for increased rates of sediment deposition**.

Figure 7. Photo left: Bedrock control of the channel and banks confining the channel in the upstream end of Reach 2. Photo right: Widening and sediment deposition in the downstream end of Reach 2 (August 2004).

5.2.2. Vegetation

Pre 1750s EVC mapping indicates that vegetation in this reach was a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland. Low Rises Grassy Woodland is characterised by a Eucalyptus overstorey comprised of Grey Box (*Eucalyptus microcarpa*) and Yellow Gum (*Eucalyptus leucoxylon*). Understorey shrubs include Drooping Cassinia (*Cassinia arcuata*), Golden Wattle (*Acacia pycnantha*), Gold-dust Wattle (*Acacia acinacea s.l.*) and Wedge-leaf Hop-bush (*Dodonaea viscosa* ssp. *cuneata*). Ground layer species include Stinking Pennywort (*Hydrocotyle laxiflora*), Grey Tussock-grass (*Poa sieberiana*), various Spear

Grasses (*Austrostripa* sp.) and Wallaby Grasses (*Austrodanthonia* sp.). On the nearby hill slopes, Dry Grassy Forest occurred.

This reach is now dominated by exotic pasture grasses and very occasional River Red Gums (*Eucalyptus camaldulensis*) along the channel banks. On the rise south of the main stem of the creek, the density of Eucalyptus species increases.

In sections of this reach the channel is very wide. Natural regeneration of indigenous species such as River Red Gum (*Eucalyptus camaldulensis),* Wattles (*Acacia* sp.) and Rush (*Juncus* sp.) is occurring.

5.2.3. Habitat Quality

One habitat assessment was completed in this reach. This site, number 2, scored 10/20 and was of 'Medium' habitat quality. Large trees were present, although below benchmark quantity, canopy cover was excellent, understorey species number was high although cover was reduced, weed cover was 5-25 %, 25-75% of woody species were recruiting, organic litter was above the benchmark percentage cover and logs were absent.

5.2.4. Threats and Risks

Threat	Risk
Loss of in-stream vegetation due to smothering by sediment.	High
Highly active and uncontrolled transportation of in-stream sediment	High

Management Actions and Cost estimates determined for Reach 2 are detailed in section 10. Works locations are shown in Appendix E.

5.3 Reach 3: Headwaters of major right-bank tributary to junction with Shays Creek

5.3.1. Geomorphology

The formation of well-defined bars and benches within the channel of this reach indicate that land management practices currently applied are different to the rest of the catchment. There is evidence of past localised gravel extraction at a number of locations within this reach. Vegetation encroachment, particularly in the riparian zone has enabled the bars and benches to further establish and continue aggrading.

The channel is deeply incised, primarily due to bed level control in the main trunk of Shays Creek. Downstream of the Ararat-St Arnaud Road, the channel dimensions vary from 30m wide and 3-4m deep, to 5m wide and 3m deep. Where the channel is at its widest there is evidence of past bank battering works. Where the channel is at its narrowest, banks are stable and well vegetated.

Sediment transport through this reach is low to moderate. In-stream vegetation has allowed gravel benches and bars to develop, which decreases sediment delivery to the main trunk of Shays Creek. The intact nature of the vegetation and the amount of natural regrowth that is currently occurring suggest that stock have been excluded from the channel zone throughout the entire reach. Towards the upper portions of the reach, however, large active headcuts threaten the remaining intact valley fill. These headcuts are approximately 3-4m high and have the potential to continue incising unless appropriate action is taken. The surrounding paddocks contain some of the best, most diverse remnant native grassland vegetation in the Wimmera region and are considered to be of very high value.

Figure 8. Photo left: Active erosion in the upstream end of the reach. Photo right: Sediment storage in the downstream end of Reach 3. Note the presence of stabilising vegetation (August 2004).

5.3.2. Vegetation

This reach was also dominated by a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland pre 1750s. On the nearby hill slopes, Dry Grassy Forest occurred.

Today, some properties within this reach are 'the most diverse in the western Wimmera' (Neil Marriot, 2004. *pers com.*). Located on the north western side of the Ararat-St Arnaud Rd, they feature a wide range of ground cover, understorey and overstorey species. Stock are excluded for most of the year or are grazed only in very low numbers. In contrast, on the other side of the Ararat St-Arnaud Rd, sections of this reach are dominated by exotic pasture grasses with very occasional Eucalypts.

5.3.3. Habitat Quality

Several habitat quality assessments were completed in this reach. Sites 3 and 4 are located on the north western side of the Ararat-St Arnaud Rd. Site 3 scored 15.5/20 and is considered to offer 'High' habitat quality. This property is adjacent to the Landsborough South Bushland Reserve. At the assessment site, understorey species diversity and cover, litter and logs were excellent and weediness was extremely low. However, large trees were below the expected benchmark level and canopy cover was 25-50% of the benchmark. It is expected that if the current management regime continues, large trees and canopy cover will improve with time.

Site 4 scored 11/20 and is considered to offer 'Medium' habitat quality. At this site, recruitment and organic litter are excellent, understorey cover is reduced although species diversity is high. Weeds cover 5-25% of the area sampled. Large trees, logs and canopy cover were absent at the site sampled. Considering the high rate of recruitment at this site, these metrics are expected to improve over time.

Site 5 is located on the south eastern side of the Ararat-St Arnaud Rd. This site scored 4/20 and offers 'Low' habitat quality. In contrast to sites 3 and 4, weediness is very high and recruitment, logs and organic litter are very low. Some understorey species are present but cover of these species is low.

5.3.4. Threats and Risks

Threat	Risk
Loss of in-stream vegetation due to smothering by mobile sediment.	High
Erosion of intact valley fill causing depletion of high-value native grasslands.	High
Destruction of areas that contain high habitat quality through excessive erosion and/or sedimentation.	Moderate

Management Actions and Cost estimates determined for Reach 3 are detailed in section 10. Works locations are shown in Appendix E.

5.4 Reach 4: Headwaters of major left-bank tributary to Starts Road Crossing

5.4.1. Geomorphology

The channel at this location within the catchment is largely controlled by the valley gradient and alignment, and therefore has minimal capacity to actively migrate across the floodplain. The gullies that dissect the steep hillslopes are incised and still actively generating sediment which is then transported further downstream. At the base of the steep slopes the gradient is considerably flatter with the result that the floodplain acts as a sediment deposition zone. At these locations, sediment is deposited in small fans, that currently have major headcuts extending back upstream.

The bedload is gravel-based and, in particular locations has now started to form an armour layer. It should be noted that the armour layer is susceptible to deformation and degradation due to stock access in the channel zone. Degradation of the armoured layer predisposes the streambed to further incision, ultimately increasing the amount of sediment transported downstream. The main trunk is deeply incised and the bed profile is stepped with bedrock and gravel riffles separating shallow pools. There is very little riparian vegetation in the channel zone. As such, sediment mobilisation and transportation throughout the reach is very high. Bars and benches are beginning to form, however these will not stabilise while stock are allowed to access the streambed and banks.

The main channel and a number of the tributaries entering Reach 4 have bare banks. These are actively eroding and depositing large quantities of sediment in the main channel. Some of these have previously been battered and sown with pasture. These areas are beginning to re-incise as the gully initiation process begins again. Numerous soil conservation works have been undertaken in Reach 4, however not all have been successful. Examples of works that show evidence of failure include contour banks and gully plug dams.

Figure 9. Photos showing sediment deposition in the flatter gradient area downstream of the steep hill slopes in Reach 4 (August 2004).

5.4.2. Vegetation

Pre 1750s EVC mapping indicates that this reach once featured Alluvial Terraces Herb Rich Woodland in the gullies and low lying areas and Dry Grassy Forest on the hill slopes. Today the vegetation in this reach is dominated by exotic pasture species and a scattered overstorey of Eucalypts. On the surrounding hills, the density of Eucalypts increases. Stock currently graze the majority of this reach. A vegetation assessment was not performed in this reach.

5.4.3. Habitat Quality

Habitat Quality assessments were undertaken where sections of the stream were representative of stream condition. Upon delineation of stream reaches for management purposes, some reaches did not have an assessment undertaken within them.

A habitat quality assessment was not undertaken in Reach 4. Habitat quality is expected to be low within this reach.

5.4.4. Threats and Risks

Threat	Risk
Continued incision and erosion of hillslope material.	High
Widening of the channel – particularly through the fans (natural process after incision) however all drainage lines in this reach are susceptible to further widening.	High
Highly active and uncontrolled transportation of in-stream sediment (gravel). This smothers any natural regrowth that may occur in the channel zone.	High
Excess sediment transfer through the reach	High

Management Actions and Cost estimates determined for Reach 4 are detailed in section 10. Works locations are shown in Appendix E.

5.5 Reach 5: Starts Road crossing to junction with Shays Creek

5.5.1. Geomorphology

Downstream of the boundary with Reach 4 the valley margins widen, the floodplain increases in width and becomes continuous on both sides of the channel as valley gradient decreases. The bedload consists mostly of gravels which in some locations have started to form an armour layer. This armour layer is susceptible to deformation and degradation from stock access to the channel zone. Degradation of the armoured layer enhances further bed incision, ultimately increasing the amount of sediment that is generated within the reach. The main channel is deeply incised and the bed profile is stepped, with bedrock and gravel riffles separating shallow pools. There is little vegetation in the channel zone and as such, sediment mobilisation and transportation throughout the reach is very high. Bars and benches are beginning to form, however these will not stabilise while stock have access to the bed and banks of the channel.

The main channel and a number of the tributaries entering Reach 5 have bare banks and are actively eroding and depositing large quantities of sediment into the downstream reaches. Some of these tributaries have been battered and sown with pasture, however not all of these works have been successful as there is evidence of active headcutting as the gully initiation process begins again.

5.5.2. Vegetation

This reach was dominated by a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland pre 1750s. On the nearby hill slopes, Dry Grassy Forest occurred. At present, this reach is dominated by exotic pasture species and very occasional Eucalyptus species. Stock have access to the majority of this reach. A vegetation assessment was not performed in this reach.

5.5.3. Habitat Quality

Habitat Quality assessments were undertaken where sections of the stream were representative of stream condition. Upon delineation of stream reaches for management purposes, some reaches did not have an assessment undertaken within them.

A habitat quality assessment was not undertaken in Reach 5. Habitat quality is likely to be low within this reach.

5.5.4. Threats and Risks

Threat	Risk
Highly active and uncontrolled transportation of in-stream sediment (gravels). This smothers any natural regrowth that may occur in the channel zone. Its location at the downstream end of the valley, means that Reach 5 is an opportune location to trap and hold sediment.	High
Colonisation of stream bed by weeds	High

Management Actions and Cost estimates determined for Reach 5 are detailed in Section 6. Works locations are shown in Appendix E.

5.6 Reach 6: Junction of major right-bank tributary

5.6.1. Geomorphology

The channel at this location has moderate to high sinuosity, reflecting the decreasing valley gradient and increasing width. The channel is up to 60m wide in places while most of the reach is approximately 35m wide and 3-4m deep. Gravel bars and benches are present throughout and are slowly aggrading with the assistance of small areas of vegetation in the channel bed. In these areas the low flow channel has developed a moderate sinuosity between the gravel bars. Due to a lack of vegetation in much of the channel bed there is still a large proportion of actively mobile sediment. Bank erosion is active where no riparian trees exist.

Figure 10. Sediment aggradation in the flatter gradients of Reach 6. Note that this sediment is highly mobile due to a lack of stabilising vegetation in the over widened channel (August 2004).

5.6.2. Vegetation

Reach 6 is a small reach which featured a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland, pre 1750s. Today the reach is dominated by exotic pasture species and scattered River Red Gums (*Eucalyptus camaldulensis*). However, closer to the creek, understorey diversity increases and species include Blackwood (*Acacia melanoxylon*), Kneed Wallaby-grass (*Austrodanthonia geniculata),* Common Wheat-grass (*Elymus scabrous),* Weeping Grass (*Microlaena stipoides),* Cumbungi (*Typha domingensis)* and Common Tussock-grass (*Poa labillardieri).* Corkscrew Spear-grass (*Austrostipa setacea)* which is rare in Victoria, was also found in this reach.

5.6.3. Habitat Quality

One habitat quality assessment was completed in this reach. Site 6 scored 4/20 and is considered to offer 'Low' habitat quality. Large trees, canopy cover, organic litter and logs are absent at the site sampled. Understorey cover is reduced and species number was low. Recruitment was average and weediness was very high.

5.6.4. Threats and Risks

Threat	Risk
Highly active and uncontrolled transportation of in-stream sediment (gravel). This smothers any natural regrowth that may occur in the channel zone. Being located in the middle to downstream end of the of the valley, it is an opportune location to prevent excessive bedload entering the main trunk of the Wimmera River and further degrading the in-stream values of Shays Creek.	High
Colonisation of stream bed by weeds	High

Management Actions and Cost estimates determined for Reach 6 are detailed in section 10. Works locations are shown in Appendix E.

5.7 Reach 7: (E 685 941.N.5 895 981) to confluence with major left bank tributary (E 682 869.N 5 894 040)

5.7.1. Geomorphology

Reach 7 in the Shays Creek catchment has floodplains on both sides of the channel. This indicates that the position within the catchment is a natural sediment storage zone. The channel is up to 40m wide in some locations. In other locations the channel can be as narrow as 25m. Channel depths also vary between 2-4m. Bedrock is present in the bed and banks of the channel at a number of locations, with the most significant outcrop extending approximately 500m downstream of the Shays Flat Road. This bedrock limits the amount of channel deepening possible at this location. However, there is still a high potential for sediment currently stored in the channel to become mobilised due to continuing stock access and lack of vegetation in the channel zone.

Sediment contained within the channel is variable in textural composition. This reflects changes in bed elevation that have occurred since the construction of a 4m drop structure in the downstream reach, beneath the Joel Joel - Crowlands Road bridge. Prior to the construction of this drop structure, the bed throughout Reach 7 was dominated by sand and gravel. Over the last 20 years the channel has aggraded significantly upstream of the structure. This has led to a decrease in the channel gradient and the deposition of finer sediment. As the bed continues to aggrade fine-grained sediment is progressively deposited further upstream, a process that is leading to stabilisation of the creek bed and banks within the reach.

This process is also occurring upstream of a culvert/ford on Shays Flat Road. However, due to its small size, the extent of aggradation upstream of this structure is less than that caused by the structure on the Joel Joel -Crowlands Road. Below the Shays Flat Road crossing, the texture of the material in the channel has decreased from predominantly coarse gravel to fine gravel, sand and silt. Upstream of the Shays Flat Road, the sediment within the channel is predominantly sand and gravel that is still highly mobile due to the steeper streambed gradient.

In the lower portion of the reach there is a high risk of the channel changing its flow path (avulsion). This threat arises from the higher elevation of the contemporary floodplain of Shays Creek, than the elevation of the adjacent floodplain formed by a left bank tributary. If sufficient discharge occurs in times of flood and flows across the floodplain into the tributary channel, erosion by initiated and a new channel formed.

Figure 11. Photo left: Sediment aggradation in the upstream end of Reach 10. Photo right: The drop structure on the Joel Joel – Crowlands Road crossing (August 2004).

5.7.2. Vegetation

Pre 1750s EVC mapping indicates that this reach was once dominated by a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland as well as Creekline Grassy Woodland. Creekline Grassy Woodland features an overstorey of Grey Box (*Eucalyptus microcarpa*), River Red Gum (*Eucalyptus camaldulensis*) and Yellow Box (*Eucalyptus melliodora*). Understorey species include Golden Wattle (*Acacia pycnantha*), Gorse Bitter-pea (*Davesia ulicifolia*), Drooping Cassinia (*Cassinia arcuata*), Common Tussock-grass (*Poa labilliardierei*) and Weeping Grass (*Microlaena stipoides).* Dry Grassy Forest was found on the surrounding hills.

Today this area mainly supports a cover of exotic pasture species and occasional River Red Gums (*Eucalyptus camaldulensis*). However, some pockets of extremely valuable remnant vegetation are present within this reach.

One site of note is just upstream of the Shays Creek ford on the Shays Flat Road. This patch is likely to have been excluded from stock and cropping due to the adjacent deep creek bed. The area supports a very important native grassland remnant. It is strongly recommended that a detailed spring/summer survey be completed in this remnant patch to ascertain full species diversity. At the time of the study, several Spear grasses, including the rare Corkscrew Spear-grass (*Austrostipa setacea),* and Kneed Wallaby Grass (*Austrodanthonia geniculata*) were identified at this site. Corkscrew Spear-grass (*Austrostipa setacea)* was also identified downstream of the ford where habitat quality assessment site 8 was located.

5.7.3. Habitat Quality

Several habitat quality assessments were performed in this reach. Site 7 is located at the remnant grassland patch described above. This site scored 6/20 and despite high species diversity and cover, is considered to offer ‘Low’ habitat quality. Large trees, canopy cover, recruitment of woody species, organic litter and logs were absent. However, understorey cover and species number were excellent and weed cover was 5-25%.

Site 8 is located just downstream of the ford on the Shays Flat Road. This site scored 6/20 and is considered to offer ‘Low’ habitat quality. At this site, large trees and canopy cover were below 50% of the benchmark level, understorey cover was low, organic litter and logs were absent and weediness was high. The one woody species present River Red Gum (*Eucalyptus camaldulensis*) was recruiting.

Site 9 scored 0/20 and is considered to offer ‘Low’ habitat quality. At this particular site, large trees, canopy cover, understorey, recruitment, organic litter and logs were absent. Weediness was high.

5.7.4. Threats and Risks

Threat	Risk
Highly active and uncontrolled transportation and deposition of in-stream sediment (silt, sand and gravel). This smothers any natural regrowth that may occur in the channel zone and also decreases channel capacity, inturn increasing flooding potential. Being located at the downstream end of the valley, it is an opportune location to prevent excessive bedload entering the main trunk of the Wimmera River and further degrading in-stream values Shays Creek.	High
Channel avulsion as a result of the main trunk of Shays Creek being perched approximately 1m above the floodplain elevation of a left bank tributary.	High
Colonisation of stream bed by weeds	High

Management Actions and Cost estimates determined for Reach 7 are detailed in section 10. Works locations are shown in Appendix E.

5.8 Reach 8: Headwaters of major southern tributary to Joel Joel-Crowlands Road crossing

5.8.1. Geomorphology

Reach 8 has a steep streambed gradient as it flows through undulating hill slopes. This has led to a channel without a significant floodplain. Sediment is largely derived from weathered hillslope material and bedrock and is approximately 3m deep for a large majority for the lower portion of the reach. The sediment in the upper portion of the reach is approximately 1-2m deep and decreases in depth with elevation. The channel is deeply incised and is approximately 2-3m deep, yet has not substantially increased in width. This is due to the steep and partly confined nature of the reach providing a low potential for the channel to erode. Sediment transportation through the reach is limited due to a decreased channel gradient in the lower portion of the reach and a drop structure beneath a bridge on the Joel Joel-Crowlands Road. This drop structure is preventing large quantities of sediment from becoming mobilised and moving into the Wimmera River.

5.8.2. Vegetation

Pre 1750s EVC mapping suggests that vegetation in this reach was mainly a mosaic of Alluvial Terraces Herb Rich Woodland and Low Rises Grassy Woodland. At present, this reach is dominated by exotic pasture species and very occasional Eucalypts. Stock have access to the majority of this reach. A vegetation assessment was not performed in this reach.

5.8.3. Habitat Quality

Habitat Quality assessments were undertaken where sections of the stream were representative of stream condition. Upon delineation of stream reaches for management purposes, some reaches did not have an assessment undertaken within them.

A habitat quality assessment was not undertaken in Reach 4. Habitat quality is expected to be low within this reach.

5.8.4. Threats and Risks

Threat	Risk
Active erosion and transportation of in-stream sediment (silt, sand and gravel) in the upper sections of the reach.	Moderate
Excessive sedimentation (primarily silt and sand) in the lower portion of the reach. This smothers any natural regrowth that may occur in the channel zone.	Moderate
Colonisation of the stream bed by weeds	High

Management Actions and Cost estimates determined for Reach 8 are detailed in section 10. Works locations are shown in Appendix E.

5.9 Reach 9: Joel Joel Crowlands Road crossing to the confluence of the Wimmera River

5.9.1. Geomorphology

Reach 9 consists of a channel that has been excavated between the Joel Joel - Crowlands Road bridge and the Wimmera River. At the Joel Joel - Crowlands Road, a 4m high concrete drop structure regulates the channel gradient and is currently preventing large amounts of sediment from moving into the Wimmera River. This structure, constructed approximately 30 years ago, is in good condition and performs a critical role in trapping sediment on its upstream side. Extending approximately 400m upstream of the Joel-Joel Crowlands Road, the channel has being realigned and is currently aggrading. Similar to the lower portion of the reach upstream, excessive sedimentation is an issue in the upper section of reach 9.

Sediment contained within the channel upstream of the Joel Joel - Crowlands Road bridge is variable in textural composition. This is a result of decreasing bed slopes that have occurred since the construction of the drop structure. As the streambed continues to aggrade, fine-grained sediment is progressively deposited further upstream. With the passage of time this process will lead to a stabilisation of the streambed and bank further upstream in the catchment.

Downstream of the structure, the channel is very incised. Over the last 20 years, as the sediment above the drop structure has been retained, it has prevented large quantities of sediment from being deposited downstream. Approximately 0.5 - 1m of fine-grained sediment from the upstream catchment has been deposited over the floodplains of both Shays Creek and the Wimmera River. This sediment is most likely to be post European settlement alluvium as it has covered the existing organic-rich soil profile with sand and silt.

Figure 12. Photo left: The recovering channel on the upstream side of the Joel Joel – Crowlands Road drop structure. Photo right: The channel downstream of the drop structure with the bed stabilised by Spiny Rush (August 2004).

5.9.2. Vegetation

This reach was dominated by Creekline Grassy Woodland and Alluvial Terraces Herb Rich Woodland, pre 1750s. At present this area is grazed by sheep and supports mainly exotic pasture species and occasional River Red Gums (*Eucalyptus camaldulensis*). One rare indigenous species was identified in this reach, Corkscrew Spear-grass (*Austrostipa setacea).*

5.9.3. Habitat Quality

Two habitat quality assessments were completed in this reach. Site 10 scored 4/10 and is considered to offer 'Low' habitat quality. At this site there were some large trees, logs and understorey species present. Canopy cover, recruitment of woody species and organic litter were low. Weediness was high.

Site 11, downstream of the road, scored 0/10 and did not support any large trees, canopy cover, understorey, recruitment, organic litter or logs. Again, weediness was high.

5.9.4. Threats and Risks

Threat	Risk
Sediment starvation causing the channel to erode and enlarge its banks. The creek is also re-incising the bed of the channel with a series of small headcuts, however, these do not have the potential to travel far due to the drop structure and a dense cover of spiny rush.	Moderate
Colonisation of stream bed by weeds	High

Management Actions and Cost estimates determined for Reach 9 are detailed in section 10. Works locations are shown in Appendix E.

6 Works Program and Cost Estimate for implementation of Management Actions

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
		Easting	Northing						
	Reach 1								
1.1	Place grade control structures to address multiple headcuts.	691 125	5 895 323				$50,000	Multiple headcuts in this vicinity	High
1.2	Undertake longitudinal and cross section survey of left bank tributary to determine location for grade control structures	691 037	5 896 533					Survey included as part of entire Shays Creek survey. Other organisations have work planned for this area	Medium
1.3	Install grade control structures	691 037	5 896 533				$20,000		Medium
1.4	Repair rock structure	690 103	5 897 228	1		$10,000.00	$10,000		Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
1.5	Revegetate benches and stabilise sand	690 032	5 897 356				$1,000		Medium
1.6	Fence and revegetate stream			8100	metres	$6.00	$48,600		Medium
1.7	Undertake a thorough vegetation survey during Spring / Summer to identify and map remnant native vegetation patches, including rare / endangered plant species			1		$500.00	$500		Medium
1.8	Control rabbits on the slopes, particularly in the tributaries.	Cost borne by other programs							Medium
1.9	Increase soil recharge through steep hill planting.	Cost borne by other programs							Medium
	Reach 2								
2.1	Survey and undertake works to control headcut	689 814	5 896 365	1	each		$20,000		High

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
2.2	Survey and undertake works to control multiple headcut	689 421	5 896 631	To be determined following survey			$25,000		High
2.3	Control rabbits	689 892	5 897 409	Cost borne by other programs					Medium
2.4	Revegetate the bed and banks of the channel. Fence where currently not fenced.	688 381	5 897 800				$5,000		Medium
2.5	Treat occurrence of serrated tussock	Cost to be borne by other programs							Medium
2.6	Treat actively eroding tributary	688 590	5 898 115	Works and cost sharing already determined with DPI					Medium
2.7	Control rabbits, before any fencing, structural or revegetation works begin.								Medium
2.8	Increase soil recharge through steep hill planting.								Medium
2.9	Fence and revegetate banks			3200	metres	$6.00	$19,200		Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
	Reach 3								
3.1	Control headcuts to protect good quality remnant vegetation	688 101	5 899 185				$8,000		Medium
3.2	Fence and revegetate to protect good quality vegetation	688 101	5 899 185	750	metres	$6.00	$4,500		Medium
3.3	Control multiple active headcuts	687 521	5 899 758	To be determined following survey			$15,000		High
3.4	Fence and revegetate to protect rare species within area	687 521	5 899 758	2440	metres	$6.00	$14,640		Medium
3.5	Control multiple active headcuts	686 844	5 899 357	To be determined following survey			$15,000		High
3.6	Fence and revegetate to protect rare species within area	686 844	5 899 357	2200	metres	$6.00	$13,200		Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
3.7	Control woody weeds i.e. Poplars (*Populus* sp.),	687 257	5 897 841				$1,000		Medium
3.8	Fence and revegetate riparian zone with species of local provenance.	687 257	5 897 841	830	metres	$6.00	$4,980		Medium
3.9	Control rabbits, before any fencing, structural or revegetation works begin.	Cost borne by other programs							Medium
	Reach 4								
4.1	Control rabbits	689177	5 893 810	Cost borne by other programs					Medium
4.2	Fence and revegetate	Start:688 990 End: 689 328	Start: 5 894 053 End: 5 893 632	1420	metres	$6.00	$8,520		Medium
4.3	Revegetate stream fence bed and banks	Start: 688 547 End: 688 990	Start: 5 895 196 End: 5 894 053	2600	metres	$6.00	$15,600		Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
4.4	Control rabbits, before any fencing, structural or revegetation works begin.	Cost borne by other programs							Medium
4.5	Increase soil recharge through steep hill planting.	Cost borne by other programs							Medium
	Reach 5								
5.1	Survey of bed	Start: 686 441 End: 688 578	Start: 5 896 586 End: 5 895 211	Refer action CW1 & CW2					Low
5.2	Install grade control structures to provide sediment accumulation	Start: 686 441 End: 688 578	Start: 5 896 586 End: 5 895 211	To be determined following survey			$30,000		Low
5.3	Fence and revegetate bed and bank to assist with sediment trapping	Start: 686 441 End: 688 578	Start: 5 896 586 End: 5 895 211	6500	metres	$6.00	$39,000		Medium
	Reach 6								
6.1	Control spiny broom downstream to and along Wimmera River	Cost borne by other programs							Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
6.2	Undertake longitudinal and cross section survey to determine location for grade control structures	Start: 685 940 End: 687 057	Start: 5 895 977 End:5 897 367	Refer CW1 & CW2				Part of overall Shays Creek survey	Medium
6.3	Install grade control structures to provide sediment accumulation	Start: 685 940 End: 687 057	Start: 5 895 977 End:5 897 367	To be determined following survey			$20,000		Medium
6.4	Fence and revegetate	Start: 685 940 End: 687 057	Start: 5 895 977 End:5 897 367	4360	metres	$6.00	$26,160		Medium
6.5	Weed control, including targeted attack of Spiny Rush and Flax Leaf Broom (*Genista linifolia*)	Cost borne by other programs							Medium
	Reach 7						**414900**		
7.1	Undertake longitudinal and cross section survey of eroding tributary	Start: 685 321 End: 685 744	Start: 5 895 448 End: 5 895 435				$1000		Medium

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
7.2	Repair damaged drop structure and install additional grade control structures.	Start: 685 321 End: 685 744	Start: 5 895 448 End: 5 895 435	To be determined following survey			$30,000		Medium
7.3	Fence and revegetate	Start: 685 321 End: 685 744	Start: 5 895 448 End: 5 895 435	1100	metres	$6.00	$6,600		Medium
7.4	Undertake longitudinal and cross section survey of reach	Start: 684 428 End: 682 894	Start: 5 894 960 End: 5 894 019	Refer action CW1 & CW2					Medium
7.5	Install additional grade control structures.	Start: 684 428 End: 682 894	Start: 5 894 960 End: 5 894 019	To be determined following survey			$40,000		Medium
7.6	Fence and revegetate	Start: 684 428 End: 682 894	Start: 5 894 960 End: 5 894 019	8400	metres	$6.00	$50,400		Medium
7.7	Protect eroding left and right banks	683 312	5 894 323	50	metres	$70.00	$3,500		Medium
7.8	Repair minor headcut	682 894	5 894 019	1	each		$1,000		High
	Reach 8								
No action required									

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
	Reach 9								
9.1	Undertake longitudinal and cross section survey of reach	Start: 682 529 End: 682 894	Start: 5 894 330 End: 5 894 019	Refer action CW1 & CW2				Survey undertaken as part of overall Shays Creek survey	Medium
9.2	Install grade control structures.	Start: 682 529 End: 682 894	Start: 5 894 330 End: 5 894 019						Medium
9.3	Fence and revegetate	Start: 682 529 End: 682 894	Start: 5 894 330 End: 5 894 019	1060	metres	$6.00	$6,360		High
9.4	Fence and revegetate downstream of bridge	Start: 682 065 End: 682 529	Start: 5 894 393 End: 5 894 330	960	metres	$6.00	$5,760		High
9.5	Weed control, including targeted attack of Spiny Rush Spiny Broom (*Calicotome spinosa*), Flax Leaf Broom (*Genista linifolia*)	Cost borne by other programs							High

Action Number	Management Action	Location		Provisional Quantity.	Unit	Rate ($)	Provisional Total* ($)	Notes	Priority
9.6	Trial phased eradication and replacement of Spiny Rush with indigenous semi-aquatic species such as Common Reed (*Phragmites australis)* or native *Juncus* species.						$10,000		High
	Catchment Wide Action								
CW1	Longitudinal & cross section survey from the Wimmera River confluence to the upper catchment						**$14,000**		High
CW2	Sediment transport & streampower modelling						**$7000**		High
						Total Works Program Cost	**$590,520**		

*Total Cost has not considered cost sharing

Wimmera CMA offers landholders incentive rates to undertake fencing and revegetation of streamside areas. Details of this scheme are outlined in the following table:

7 Wimmera CMA 04/05 Incentive Rates

The rates following represent the full incentives that will be paid. They have been calculated to consider the full cost of the works. For example, the price of $1.00 for a plant, includes plant establishment costs such as weed control, deep ripping and tree guards, as well as the purchase of the plant. As these costs have been considered in the incentive rates, additional funding is not available for these activities.

Activity	Priority	WCMA cost share	Criteria		Incentive	Unit
Waterways Fencing	VH	90%	Frontage >20m & Very High, High or medium conservation significance		Contact Glenn Dixon, WCMA, regarding waterway works prior to inspecting proposed projects. 5382 1544	
	H	80%	Frontage >20m, low conservation significance			
	M	60%	Frontage 10 - 20m			
	L	40%	Frontage <10m			
Off stream watering	VH	50%	Solar pump. 50% of total project cost. Maximum grant $3000			
	H	50%	Dam. 50%of construction cost. Maximum grant $1000			
Remnant Vegetation Fencing	VH	100%	Very high, high or medium conservation significance, with Trust for Nature Conservation covenant in place		$ 3.55	m
	H	75%	High to Very High Conservation significance		$ 2.65	m
	M	65%	Medium to Low conservation significance		$ 2.30	m
Land class fencing	M	60%	Fencing land class 4 & 5		$ 2.15	m
Revegetation fencing	VH	80%	Very High Conservation significance potential	PMP*	$ 2.85	m
		70%		No PMP	$ 2.50	m
	H	70%	High Conservation significance potential	PMP	$ 2.50	m
		60%		No PMP	$ 2.15	m
	M	55%	Medium Conservation significance potential	PMP	$ 1.95	m
		45%		No PMP	$ 1.60	m
	L	35%	Low Conservation significance potential	PMP	$ 1.25	m
		25%		No PMP	$ 0.90	m
Revegetation	H	80%	Plants: 80% of cost of plants, guards and follow up weed control for 12 months.		$ 1.00	each
	H	80%	Direct Seeding: 80% of cost of seed and follow up weed control for 12 months.		$ 160	km
Erosion control works	VH	80%	Works are part of an existing Property Management Plan / whole farm plan		Up to 80% of cost of Priority works	
	H	60%	No Property Management Plan / Whole Farm Plan completed		Up to 60% of cost of Priority works	
Saline Pasture	M	20%			$48	Ha
Saltbush	M	65%	Costing includes cost of plants and mounding.		$0.25	each
Fencing to protect salinity management works#	VH	80%	Works in “Implementation” priority GFS	PMP	$ 2.85	m
		70%		No PMP	$ 2.50	m
	H	70%	Works in “Research and development” priority GFS	PMP	$ 2.50	m
		60%		No PMP	$ 2.15	m
	M	55%	Works in “Co-investment” priority GFS	PMP	$ 1.95	m
		45%		No PMP	$ 1.60	m
	L	35%	Discharge Fencing	PMP	$ 1.25	m
		25%		No PMP	$ 0.90	m

* To be eligible for higher rates, inspecting officer must sight completed Property Management Plan or Whole Farm Plan

Higher incentive rates may be available for salinity works if they have conservation outcomes. In such cases rates for revegetation may be applied.

8 References

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

Earth Tech. 2003, *Geomorphic Categorisation and Stream Condition Assessment of the Wimmera River Catchment.* Earth Tech Victoria

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WCMA (Wimmera Catchment Management Authority), 2002b. *Wimmera Water Quality Strategy*, WCMA Horsham Victoria.

ID&A, 2001. *Wimmera River Geomorphic Investigation*, ID&A, Melbourne Australia.