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Supporting Information for the development of a River Rehabilitation Plan for Araluen Creek and Tributaries.

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Acknowledgments

Upper Deua Catchment Landcare Group

Foreword

1. This report has been prepared as part of a Catchment Planning project managed by the Upper Shoalhaven Landcare Council, for the Upper Deua Catchment Landcare group, to assist them in planning on-ground activities with a focus on riparian rehabilitation.

2. This report will assess the condition of riparian areas within a defined area of Araluen Creek and tributaries, bound by the base of the escarpment, downstream to the Nerringla Road crossing. This is a particular area of interest to the Upper Deua Catchment Landcare Group. Condition will be assessed via a combination of desktop analysis and field knowledge with the aim of identifying critical activities for the maintenance of a healthy and resilient riverine ecosystem.

3. The area of interest for this study includes the Araluen Creek upstream of the Nerringla Road crossing, including tributaries to the base of the escarpment, as defined in the attached maps. The area of interest includes the village of Araluen.

4. The current land uses within the catchments are dominated by, horticulture including fruit trees, market vegetable gardens and crop production, grazing enterprises (cattle & sheep), forestry and conservation (National Park and State Forest) and alternative agriculture. There has been an increase in the number of small rural and rural residential holdings in the past few years, these lifestyle properties often having creek or river frontage. Other land uses include the small village of Araluen.

5. The area of interest has had a turbulent past with significant disturbance occurring to main waterways via extensive gold mining/ dredging activities from the 1850's, resulting in highly disturbed and modified landscapes, impacting on groundwater levels and surface runoff.

6. The condition of riparian lands varies considerably within the sub-catchment, with the main influence on condition being landuse and position. Areas with predominantly good condition include those in the upper reaches of the catchments on escarpments. Areas in moderate condition occur within the central and western parts of the catchment , areas in poor condition occur generally in the eastern reaches of the catchment where historical land disturbance has occurred and grazing and other agricultural pursuits are now the common land use.

7. Many studies have been completed investigating the condition of the area of interest. These studies have a range of focus from location and extent of erosion, geomorphic condition, riparian vegetation cover, significant vegetation, hydrological stress and groundwater quantity and quality. A literature review has been carried out of these studies and information compiled to allow for the investigation of riparian health.

8. After comparison of sub-catchments has been completed, priority for rehabilitation activities is recommended with consideration of giving:

    - Priority to the protection of good geomorphic condition areas;
    - Priority to projects within sub-catchments considered to be in relatively good overall condition with strong community interest.
    - Priority to the protection and enhancement of native riparian vegetation in river reaches, particularly those with areas of significant vegetation identified or opportunity to create connectivity within the Araluen Valley.

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Aim

The Upper Deua Catchment Landcare group have a vision for the rehabilitation of waterways within the Araluen valley. With a vision that includes good water quality, low levels of weed infestation, increased stability and maximising the retention of surface and groundwater for the benefit of the catchment and Araluen water users.

A variety of people rely on surface and mainly groundwater water within Araluen, including local graziers and fruit and vegetable growers and local residents. All have a requirement for a safe and reliable source of water for their various interests. There is also strong interest within the Araluen community for the rehabilitation and protection of natural assets within local waterways.

This report aims to provide a stream rehabilitation plan, including recommended actions for the next 5 – 10 years for waterways within the area of interest to the Upper Deua Catchment Landcare Group – including Araluen Creek and major tributaries upstream of the Nerringla Bridge crossing to the base of the Araluen escarpment.

This report will assess the condition of riparian areas within this area of interest, via a combination of desktop analysis and field knowledge with the aim of identifying critical activities for the maintenance of a healthy and resilient riverine ecosystem.

This plan will provide direction for on-ground projects such as stream bank and bed erosion control, riparian vegetation management and improvement and wetland protection within these riparian areas.

Current River Rehabilitation in the Upper Deua Catchment

The important function that riparian lands play in the landscape is recognised by the community of Araluen. Riparian land is the area of land immediately adjacent to watercourses. They are often the most fertile land, support the most diverse vegetation and provide important connectivity within the landscape. However, they can also be the most fragile parts of the landscape and require active management. Protecting the integrity of complex riparian ecosystems can provide benefits to both their health and productivity and to the wider catchment.

Araluen Creek and surrounds has a history of extreme disturbance due to historical gold mining activities, followed by agricultural practices of sheep & cattle grazing, cropping, fruit and vegetable production. All these activities has had impact on the stability and health of waterways and the reliability of & dependence on water within the catchment.

The Upper Deua Catchment Landcare group, and former natural resource management organisations, have a long history of carrying out a range of works to improve the health of the Araluen Creek and its' tributaries. Projects carried out have addressed a range of issues including streambed and bank instability, unmanaged riparian weeds, unmanaged native vegetation regrowth along riparian lands and management of stock access to waterways. This support has been offered via advice and extension work with landholders, along with securing funding to carry out rehabilitation activities. The Landcare group have enjoyed good working relationship with former natural resource management organisations (DLWC, SRCMA) and have received technical and practical assistance to contribute to their countless volunteer hours.

There are three terms generally used to describe river works (see *A Rehabilitation Manual for Australia Streams Vol 1, 2000*). These are:

- Restoration – used to describe restoring streams to their pre-European condition. This is seldom possible because of huge changes to the stream and the surrounding catchment.
- Rehabilitation – although restoration may be impossible, this does not mean a degraded stream is without hope. By improving the most important aspects of the stream environment, you may create a stream that,

although only resembling the pre-European condition, is nevertheless an improvement on the degraded stream and often a valuable environment in it's own right.
- Remediation – is to improve the ecological condition of the stream, but the end point of that improvement will not necessarily resemble the original state of the stream (e.g. many urban streams).

In general, the term rehabilitation has been adopted in approaches to stream rehabilitation in the Upper Shoalhaven and Upper Deua catchments. The five main principles of riparian rehabilitation program have been to:

1. Protect reaches that support valuable organisms or their communities (aquatic or terrestrial) first;
2. Protect streams that are in the best general condition before trying to improve those in poor condition, including the protection of their floodplains and shallow groundwater systems;
3. Stop streams in a 'good' geomorphic condition from deteriorating, as studies have demonstrated that 'good' geomorphic condition waterways support significantly higher numbers of indigenous flora and fauna;
4. Improve the condition of reaches that are damaged, including their linkages to floodplains and groundwater systems; and
5. Support interested communities in their efforts to rehabilitate their watercourses and drainage lines

For every project implemented, the following points have been aspired to:

- The projects demonstrate best practice or new innovative techniques in river rehabilitation, utilising the best science available;
- That there is opportunity for strong community involvement and education;
- That quality outcomes are well maintained in the future;
- That monitoring and reporting aspects are included in all projects to ensure we learn from our efforts; and
- Each project is promoted to highlight the work of local communities.

Rehabilitation of riparian lands can be considered to be a daunting task, with a large range of long term degradation issues along with varying levels of landholder interest and ability. Future investment in this area requires formulation of carefully considered project aims to ensure the effective use of limited resources.

Resilience in Riparian Management

Resilience thinking provides a model under which to consider the sustainable management of water resources (Parsons et al, 2009). Rivers are complex social-ecological systems where social, economical and environmental factors must all be considered as important. Resilience thinking accepts that people are part of the natural, ever changing, system.

Resilience thinking offers the following principles to consider in managing river ecosystems:

- Recognising that alternatives exist for stable states within a river system;
- Recognising that river system properties can vary significantly within a stable state;
- Recognising that river systems can display significant variability at different scales within a stable state;
- That thresholds exist within river systems that may act as a changing point between two alternate states;
- Thresholds can exists at multiple scales, but not all result in a shift to an alternate state;
- 'slow' variables are important in driving regime shifts;
- River systems cycle through adaptive loops and their position within the loop sets their form and function;
- Rivers are social-ecological systems that integrate ecosystems and human society;
- Managing rivers for resilience requires adaptability or the capacity to adapt to and influence change (Parsons et. al., 2009)

Ensuring resilience is considered to be the aim of river ecosystem management. Managing for resilience means "maintaining the capacity of the system to absorb change or disturbance while remaining in essentially the same state that retains the same function, structure and feedbacks" (Parsons et.al., 2009).

Maintaining resilience within river ecosystems will rely on the maintenance of functional systems. The highest priority should be given to the protection of high value and least disturbed riverine and floodplain assets as these often play a critical role in maintaining the resilience of river systems.

Suggested thresholds for the maintenance of resilient river ecosystems include:

- Aim for a 'good' geomorphic condition. Studies have demonstrated that maintaining reaches in a good geomorphic condition is critical for the maintenance of diverse indigenous biodiversity (Chessman et al, 2006);
- Geomorphic fragility is 'moderate' or 'low', in good condition reaches as high fragility reaches are considered to be on the verge of significant change;
- Recruitment of native riparian vegetation is higher that attrition;
- Wetlands are not drained, dammed or modified.

Why Plan

The preparation of a rehabilitation plan is an important step in the rehabilitation and protection of riparian lands.

Making decisions about river rehabilitation measures can be difficult due to the uncertainty in the outcomes, the number of stakeholders with an interest, partly conflicting objectives and the often difficult and time consuming process of obtaining appropriate approvals for planned activities (Reichert et. al, 2004). Often river rehabilitation measures can be met with a lack of support or even opposition by stakeholders due to a lack of transparency regarding how different goals, outcomes and concerns were considered during the decision making process (Reichert, 2004).

This plan proposes to provide a clear and comprehensive plan identifying and prioritising riparian rehabilitation projects within the Araluen Creek upstream of Nerringla Road crossing to ensure that projects contribute to improving the resilience of catchment. The plan will analyse the cause and effect of a range of impacts on the health of the riparian lands, rather than promoting projects that may only address symptoms, to ensure that future investment is directed in the most effective and strategic manner.

The preparation of this plan will identify priority areas for rehabilitation within the catchments, based on best available information. This plan will provide direction for on-ground projects such as stream bank and bed erosion control, riparian vegetation management and improvement and wetland protection.

A decision making process will be used to help with these goals, using the following steps:

- Definition of the problems (including definition of sub-catchments, management issues and stakeholders);
- Identification of Rehabilitation objectives;
- Consultation with stakeholders;
- Ranking of rehabilitation options; and
- Assessment of results presented.

Catchment Setting

Araluen Creek catchment is located between Braidwood and Moruya in south east NSW. The catchment area of interest includes Araluen Creek and its' tributaries between the Nerringla Road Bridge, upstream to the base of the escarpment.

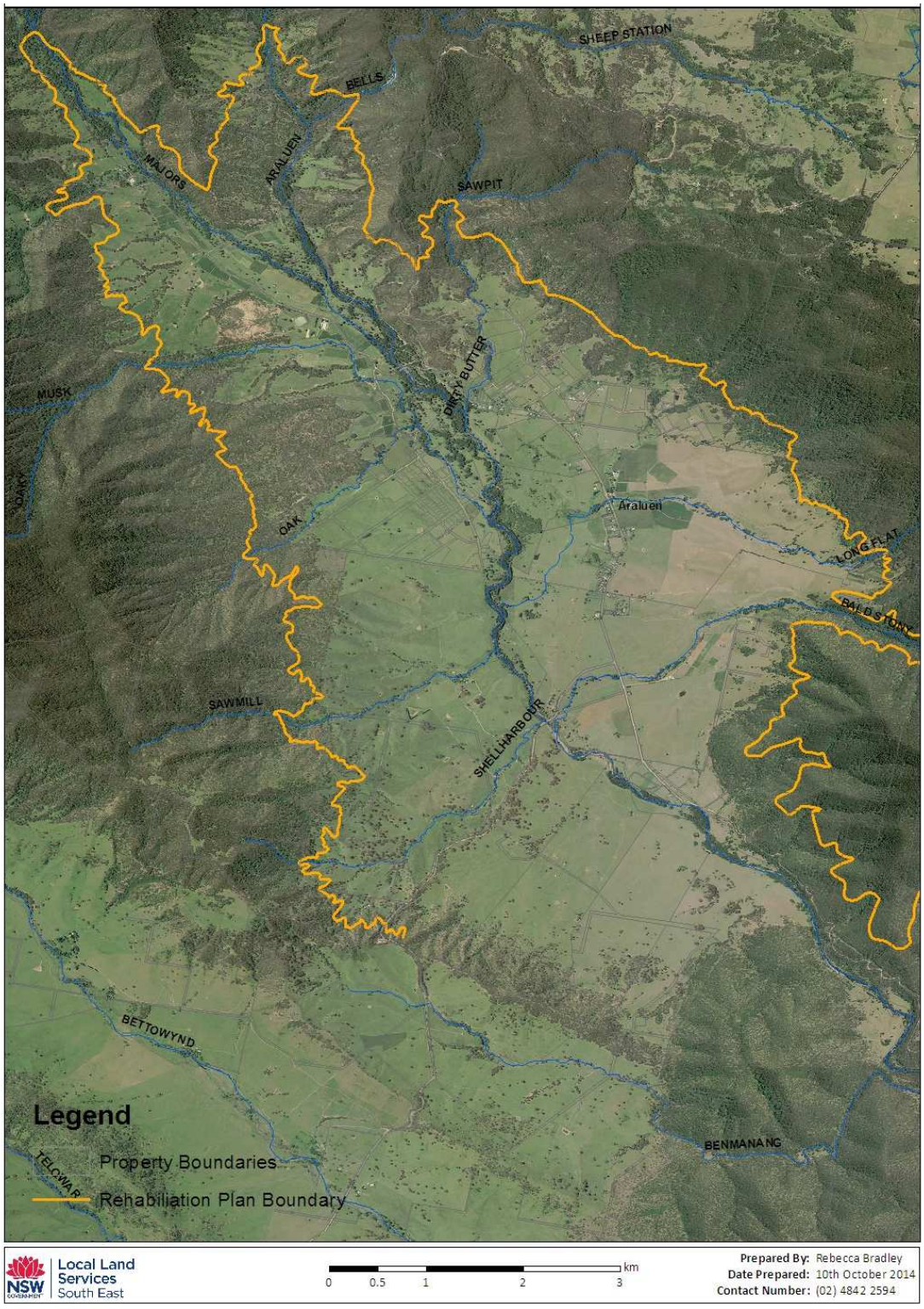

Figure 1: Catchment Location

Topography

Araluen is located 56 km northwest of Moruya. It is located within a narrow steep-sided valley formed by Araluen Creek. The source of Araluen Creek is in steep country near the village of Majors Creek and flows south to its' confluence with the Deua River. Araluen valley is flat and low-lying ringed by a plateau of high elevation, forming what is supposed to be the deepest valley in Australia (Pritchard S, 2000).

Climate

Climate and rainfall patterns ae affected by the unique topography of the Araluen Valley (Pritchard, 2000). Rainfall patterns within the Araluen Valley can vary significantly according to geographic location (Pritchard, 2000).

The Department of Environment, Climate Change and Water (2010) have provided predictions regarding the likely changes to climate and predicted impact on the environment in NSW. Predictions have been made for the Southern Tablelands, including:

- Average daily temperatures are likely to increase, 2-3 degrees in winter and 1.5-2 degrees in summer;
- Rainfall is likely to increase in summer and decrease in winter;
- Increased evaporation is likely in spring and summer;
- It is assumed that El-Nino – Southern Oscillation years will be hotter and continue to be drier than average. It is assumed that El-Nino events will mean greater water stress.
- There is likely to be drier soil conditions in spring and winter.
- Summer run-off to increase but overall runoff will decrease and drought will be more severe.

These predictions in climate change indicate that changes are likely in the future, changes that may have a negative impact on the health of our waterways, such as:

- Heavier summer rains contributing to increased erosion;
- Higher stream flows in late summer may impact on bank stability;
- Overall lower runoff may impact on stream flows and affect aquatic organisms ability to survive periods of no or low flow.

To increase waterway health and resilience to these potential changes, focus should be made on improving stream stability to increase ability to withhold increased summer runoff and flows, enhance water storage capacity within channels and the adjacent floodplains to increase resilience of waterways during hotter and drier climates and encourage shade forming vegetation to maintain water temperatures and protect aquatic organisms and water quality.

Geology

The geology of the valley includes two main types of Braidwood Granodiorite (a coarse grained intrusive) and alluvium (variable sized material) (Pritchard, 2000). In the base of the valey, the ranodiorite is deply weathered and outcrops are sparse. The alluvium formed as floodplain deposits have been intensively reworked during mining activities in places (Pritchard, 2000).

Groundwater

Residents and agri-businesses within Araluen Valley rely heavily on groundwater for the supply of irrigation of orchards & stock fodder, stock watering and a high level of reliance for provision of domestic water.

In 1998, this aquifer system was ranked the third most “at risk” aquifer in the Sydney South Coast Region, based on quantity and quality pressures in the groundwater resource (DLWC, 1998).

The Department of Primary Industries (office of water) have identified the groundwater aquifer within Araluen Valley to be highly connected to the alluvium meaning that the levels of surface water within Araluen Creek have a direct influence on the groundwater.

Vegetation

Araluen valley is a predominantly cleared landscape, with disturbance associated with past mining and agricultural activities.

Native vegetation occurs within the valley, broadly following patterns of geology and landform. Waterways are sparsely vegetated, identified by SKIVI mapping as Riverbank Forest dominated by *Casuarina cunninghamia.* The valley floor is predominantly grassland with a mixture of native and improved species. The eastern slopes are dominated by *Far South Coast Grassy Woodland* and the top of the escarpment surrounding Araluen valley dominated by *Araluen scarp Grassy Forest.*

Native vegetation is threatened by weed infestations including Privet, Blackberry and Tree of Heaven along riparian areas, along with high infestations of Broom in upstream areas of Majors Creek.

Historical Land Use

The Araluen valley is a well-known gold field from the 1850's with extensive areas disturbed via a range of mining methods. The village of Braidwood consists of many small land allotments as a result of these former settlements. Araluen Creek and tributaries were mined including dredging activities resulting in a highly disturbed landscape. For information regarding historical disturbance due to gold mining, refer to *Conservation and heritage overview of the Araluen Catchment Area, incorporating the Araluen, Bell's Creek and Majors Creek goldfields* by Barry McGowan.

Since this time, agriculture has been the predominant land use within the valley with a range of enteprises including orchards, production of crops for stock fodder, livestock grazing and rural residential living.

Current Land Use

The Araluen Valley is a rural catchment with major land uses including established orchards, vegetable production, crops for stock fodder and beef cattle and lamb & wool production.

In 2008, Southern Rivers CMA undertook a survey of landholders within the Southern Rivers CMA region to gauge landholder beliefs in relation to natural resource management. This study has highlighted the need for the Southern Rivers CMA to increase the awareness of landholders to the significance of land management issues contributing to waterway degradation and methods for addressing these issues, particularly to landholders with smaller holdings.

Many government and non-government organisations with an interest in riparian management within the Araluen valley exist. Some of these including:

Palerang Council

Palerang Council oversee land use and management in Araluen, with their Local Environment Plan and associated documents outlining the various conditions of land use within the Palerang Council area. An aim of the LEP includes "to retain and protect wetlands, watercourses and water quality and enhance biodiversity and wildlife corridors by encouraging the linking of fragmented core habitat areas within Palerang."

NSW Office of Water
NSW State government agency charged with the responsibility of the Water Management Act 2000, placing restrictions on activities within 40 metres of a waterway, water storage within properties and water use, their

objective being the “sustainable and integrated management of the state’s water for the benefit of present and future generations”. This agency have also prepared the draft Water Sharing Plan for the Deua Unregulated and Alluvial water sources and therefore have an interest in the use of and conservation of groundwater resources within the valley.

LPMA

The Land and Property Management Authority are the managers of Crown land within NSW, much of which is located along waterways. LPMA require their involvement and approval when proposing activities within identified Crown Land.

NSW DPI (Fisheries)

NSW State government agency charged with the responsibility of protecting natural habitat for native fish. Any activities within a named water course requires consultation with this agency to ensure no further negative impacts are created on potential fish habitat.

Sub-catchments

For the purpose of this plan, the Araluen Creek and tributaries, upstream of the confluence of Araluen Creek and Bald Stony Creek (Nerringla Road). For the purpose of this assessment, the study area will include the following tributaries, within the Araluen Valley only (to the base of the escarpment), being the area of interest to this Landcare Group.

- Araluen Creek;
- Bald Stony Creek;
- Long Flat Creek;
- Dirty Butter Creek;
- Shellharbour Creek;
- Sawmill Creek;
- Oak Creek;
- Oaky Creek; and
- Majors Creek.

Definition of ‘Riparian Zone’

Riparian land is recognised as any land adjacent to and near a watercourse that immediately effects on watercourse stability, health and water quality.

“The area of land that adjoins, regularly influences, or is influenced by, a river’ (Ede & Hunt, 2008)

This rehabilitation plan is to be prepared with a view to the identification and prioritisation of management issues within the riparian land of the Upper Shoalhaven River sub-catchments.

Widths of Riparian lands can vary according to stream order and land form. For the purposes of this rehabilitation plan, SRCMA consider that:

- First order streams are not to be considered ‘riparian land’, as a majority are merely depressions within the landscape with no clearly defined channel, often being prime agricultural land;
- All other water courses will be considered, along with adjacent lands up to 40 metres either side of the watercourse, which is the areas of land recommended for protection from development by NSW Office of Water and local government. Upper Deua Landcare group recognise that in reality, riparian widths will vary.

Sub-catchment Analysis

The following parameters will be considered in identifying rehabilitation needs and priorities for the area of interest. With the aim of cost effective rehabilitation of waterways, it is anticipated that this analysis will identify those areas that have higher potential for recovery based on past and recommended rehabilitation efforts. The matrix criteria for determining River Rehabilitation Priorities, SRCMA Coastal Catchments prepared by the Southern Rivers CMA will be used as a guideline, with criteria for assessment including:

Current Physical Condition, a consideration of:

- Geomorphic processes (Bed and bank stability, sediment transport)
- Riparian vegetation (presence/ absence and extent of weed infestations)
- Water Quality (any major pollutant sources)
- Hydrological Stress
- Connectivity (in-stream and riparian vegetation connectivity); and
- Floodplain functionality (connectivity, wetland functionality, floodplain clearing).

Recovery Potential, a measure of the stream capacity to return to a good condition given limiting controls and a realistic rehabilitation effort, with a consideration of:

- Condition (as above)
- Capacity of the riparian environment to recover;
- Land use pressure that may impact upon capacity to recover.

Downstream Impacts, consideration of any significant processes that may have a negative environmental or economic impact to downstream environments.

Necessity to Act, consideration of severe problems that have been identified which may push a sub-catchment beyond critical thresholds;

Practicality, an assessment of how practical it would be to address key issues including financial requirements, accessibility, the nature of the work required;

Community Desirablity, an assessment of aboriginal cultural and heritage value or sensitivity of the landscape. Along with comments regarding the level of community participation, enthusiasm and reliance on the riparian environment.

Literature Review

For each of these sub-catchments, an analysis of information previously prepared for the Araluen Valley's riparian condition will be undertaken, collating information from:

SRCMA Riverstyles Report 2012

Utilising predominantly desktop interpretation, an updated Riverstyles assessment has been completed for the Southern Rivers CMA region. Within this study Riverstyles for each named watercourse are identified which expands on and updates the work completed by Brierley et al (1999). The condition and recovery potential of these waterways are provided, based on use of ADS40 and SPOT 5 imagery and limited field work.

Geomorphic condition is defined within this study as:

Good condition – must contain all of the following characteristics:

- River character and behaviour is similar to the pre-development state presenting a high potential for ecological diversity.
- Minimal alteration to catchment controls such as sediment supply and the hydrological regime allowing fast recovery from natural disturbance.

- Relatively intact and effective vegetation coverage dominated by native species, giving resistance to natural disturbance and accelerated erosion.

Reaches in good condition most commonly occur in the confined valley setting River styles. Typically good condition reaches are uncommon within the middle sections catchments due to threatening processes and higher capacity for change. Good condition reaches are considered critical for maintenance of native biodiversity within the river corridor.

Moderate condition – contains one or more of the following characteristics:

- Localised degradation of river character and behavior, typically marked by modified patterns of geomorphic units.
- Patchy effective vegetation coverage allowing some localised accelerated erosion.

These reaches generally occur in the mid and lower catchments in partly confined and laterally unconfinved valley settings.

Poor condition – contains one or more of the following characteristics:

- Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and / or inappropriate patterns or rates of planform change and/or bank and bed erosion).
- Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity.
- Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

These reaches are typically over-widened degraded reaches where sediment regimes have

been altered through intense land use and vegetation removal. Significant erosion of bed

and banks is evident. There is generally very little riparian vegetation, often requiring significant in-stream structures to assist in rehabilitation.

This updated River styles assessment also provides a measure of the recovery potential of each reach analysed, with definitions of Recovery Potential including:

- **Conservation**, must contain all of the following :
  - Good geomorphic condition.
  - No recovery occurring or required.
  - Has not been recently disturbed or has fully recovered from past disturbances.
- **Strategic** Must contain one or more of the following:
  - Specific locations of rapid change from good geomorphic condition to moderate or poor condition with the effects usually detrimentally affecting upstream and/or downstream reaches.
  - A headcut or bend cutoff present or imminent or;
  - A site of recent bed material extraction, vegetation clearing or large woody debris removal or;
  - A site of accelerated bank erosion or a gully that is supplying excess sediment to downstream reaches or;
  - Poorly represented riparian vegetation community or;
  - Upstream or downstream of a poorly represented / unique / fragile stream category and has the potential to impact upon the poorly represented / unique / fragile stream category or;
  - Small reach in moderate/poor condition separating larger upstream or downstream conservation reaches or;
  - Poorly represented, unique or fragile stream category

- **Rapid Recovery**, Must contain all of the following:
  - Moderate geomorphic condition not fully recovered from past disturbances
  - Recovery presently occurring quickly due to a connection with upstream reaches in good condition (eg supplying seed, large woody debris and

    sediment if required to allow channel contraction recovery).

  - No excess sediment supply sediment balance neutral.
  - Generally degradation has stopped or has been reduced so that natural recovery is occurring at a relatively quick pace.

- **High Recovery**, Must contain all of the following:
  - Moderate geomorphic condition.
  - Potential to recover quickly if existing pressures are removed (eg livestock access) or;
  - Recovery presently occurring at a moderate rate due to a lack of connection with good condition reaches upstream (eg supplying seed, large woody debris and sediment if required to allow channel contraction recovery).
  - Excess sediment supply arriving in small slugs eg inappropriate sediment distribution on bars or shallow pools.
  - Will recover faster if connected to good condition upstream reaches or if recovery requirements are artificially provided in this reach.
  - Generally these are reaches where a more intense level of land use is occurring or has recently ceased. They are in a relatively moderate condition with some degradation pressures still occurring and are usually downstream of a conservation or rapid recovery reach.

- **Moderate Recovery,** Must contain all of the following:
  - Moderate to poor geomorphic condition.
  - Potential to recover at a slow to moderate rate if existing pressures are removed (eg livestock access).

  - Recovery presently occurring at a slow rate.
  - Little sediment, seed or large woody debris input (if required to allow channel contraction recovery) or;

  - Excess sediment supply in moderate slugs.
  - Can only recover faster if upstream reaches are rehabilitated and this reach receives rehabilitation works.

- **Low Recovery,** Must contain two or more of the following:
  - Poor geomorphic condition.
  - No or very little recovery occurring. Often degradation still occurring.
  - Has recently changed or is on the verge of changing style category.
  - No sediment/seed/ large woody debris input (if required to allow channel contraction recovery) or;

    Excess sediment supply large and continuous.

- **None,** Must contain two or more of the following:
  - Moderate to Poor geomorphic condition.
  - No longer has fluvial geomorphological processes operating due to inundation.
  - Locked in position by concrete or rock lining.

In addition to the above, a decision regarding the level of fragility of each watercourse has also provided. Fragility is a measure of the susceptibility and sensitivity of a system. A site identified with high fragility indicates this area is extremely susceptible to change, with a significant potential for adjustment, resilience thresholds are low and easily breached. This measure will help provide direction for rehabiliation priorities as protection and/or

rehabiliation of these high fragility reaches will assist in enhancing catchment resilience to areas with a priority of rehabilitation based on improving resilience.

The three levels of stream fragility outlined by Outhet *et al* (2004) are derived from rivers

potential to geomorphically adjust and include:

- **Low Fragility** – Not easily destroyed, this river has little potential to be disturbed or change its geomorphic category however, some slight changes in bedform may occur.
- **Moderate Fragility** – The potential for adjustment is limited to only localised changes where there is a direct exposure to threatening processes. The geomorphic character can alter

  significantly however there is only a slight potential for changes in overall geomorphic

  category as resilience thresholds are high.

- **High Fragility** – This river is highly susceptible and sensitive and has a significant potential for adjustment. Greater lengths of river are also altered when disturbances are introduced.

  The geomorphic character can alter significantly as can the geomorphic category as

  resilience thresholds are low and easily breached.

Recommendations for catchment wide river rehabilitation have been provided within this study and include:

- Support the protection of 'Conservation' reaches by removing threatening processes. Best achieved by targeting 'strategic' reaches for rehabilitation. Primary focus should be on good condition reaches of swampy meadow group River styles.
- In High Recovery Potential reaches, promote low cost rehabilitation works such as fencing and revegetation, land use change and weed management;
- Do no encourage activities that may exacerbate channel instability;
- In moderate/low recovery potential sites are unlikely to improve in condition without significant investment, consideration of triple-bottom-line factors should be considered prior to instigating investment in these sites.
- Conservation value native vegetation;

Native Vegetation

Spatial analysis of the known areas of conservation value native vegetation will be undertaken, a priority for sub-catchments will be determined based on the presence or absence of this type of vegetation within the sub-catchment with particular focus on the riparian zone. Vegetation types to be identified include potential Endangered Ecological Communities and SRCMA CAP priority vegetation (being EEC's and under-represented vegetation types, those with less that 30% of their original distribution remaining).

Predicted Endangered Ecological Communities occurring within the Araluen Creek sub-catchment include:

- Araluen Scarp Grassy Forest in the South East Corner Bioregion; and
- Lowland Grassy woodland in the South East Corner Bioregion.

Threatened species – presence/absence

Consideration will be given to the prediction of and reporting of the number of threatened species occurring within riparian areas within the Araluen Creek catchment, this consideration contributing to the the consideration of 'current condition' of vegetation.

A search of the NSW Wildlife atlas has been completed with provides mapping of the location of all known occurrences of threatened species within sub-catchments. Multiple records of *Eucalyptus kartzoffiana* (Araluen Gum) has been recorded along many waterways within the area of interest.

Filters and Funnels – A survey of stream degradation in the Upper Shoalhaven and Upper Deua Catchments

Completed in 2003, this study was commissioned by the Upper Shoalhaven Landcare Council. The purpose of the study was to identify areas of streambed erosion within select tributaries of the Upper Shoalhaven River Catchment. The aim of the study was determining the extent of streambed lowering across the catchment, the severity of this erosion and to identify sites of strategic importance for rehabilitation. A small sample was taken along Araluen Creek, upstream of the Nerringla Road Bridge, finding on average 4 nick points per km, with Bruce Radke noting significant historical stream incision within Araluen Creek at confluences with tributaries.

Reducing the impact of road crossings on aquatic habitat in coastal waterways- Southern Rivers NSW

A study completed by the NSW Department of Primary Industries (Fisheries) where road crossings over waterways were assessed for their suitability as fish friendly passageways. This assessment was completed in 2004-2005 across the Southern Rivers CMA region. The structures providing a road crossing over a waterway were assessed for their design, the obstructions they may create for the easy passage of aquatic fauna, along with the habitat value of the upstream and downstream waterway. Crossings with obstructions identified were assessed and provided a ranking of “high”, “medium” or “low” priority for rehabilitation, based on a variety of factors incorporating habitat value and the impact of the particular structure.

Location and extent of erosion

Spatial analysis of this digital information, of soil erosion mapping completing in the mid 1980’s, will be undertaken to identify areas of known erosion within the sub-catchments, an assessment of their severity will be undertaken based on comparison with soil types and vegetation present within the riparian zones.

Land use

Identification of land use within sub-catchments will be made to identify community requirements in certain sub-catchments, along with potential pressures.

Location of riparian weeds

Known weed infestations along riparian areas will be noted, consulting with local government mapping and other interest groups to contribute to the picture of the ‘current condition’ of sub-catchments.

The Southern Rivers Regional Weed Management Strategy 2010-2014 has been prepared which identifies regional weed management issues and priority weed management issues. The need to prevent new weed infestations, reduce the impact of existing weeds and increase education and awareness to weed management techniques were identified.

Priority sites for weed management identified within this strategy include:

- African lovegrass in Natural Temperate grasslands;
- Serrated Tussock in Natural Temperate grasslands;
- Blackberry in Riparian areas; and
- Scotch Broom in riparian areas.

Draft Water Sharing Plan

Prepared by the NSW DPI (Office of Water) this plan provides information regarding groundwater behaviour within the Araluen Valley, along with considerations of the condition of the waterway via their report cards.

Groundwater Evaluations

Completed in 1999/ 2000 two studies have been completed evaluating groundwater and water quality within these reserves, providing information relating to catchment condition and assisting in identifying priority areas for rehabilitation.

Catchment Assessment

Riverstyles assessment has been completed for the tributaries of interest, identifying several main Riverstyles types including:

Unconfined Low sinuosity, grave Riverstyle is identified as occurring for the majority of Araluen Creek from the base of the escarpment to beyond Nerringla Road, along Majors Creek within this plan area and along Bald Stony and Long Flat Creeks (to the eastern side of the plan area). This type of Riverstyle is identified as one that will demonstrate high rates of lateral (sideways) and vertical movement if highly modified or lacking in riparian vegetation to provide stability. This has been demonstrated for the length of Araluen Creek where streambed lowering and streambank erosion has been common.

Planform controlled Low sinuosity, gravel Riverstyle is identified as occurring along Dirty Butter Creek, a River style that will also demonstrate high rates of lateral (sideways) and vertical movement if highly modified or lacking in riparian vegetation to provide stability, however potential for movement is slightly reduced due to the influence of valley margins. Again streambed stability and the presence of vegetation along the banks are important considerations.

Floodplain pockets, gravel Occurs along western tributary of Shellharbour, Sawmill & Oaky Creeks where the channel width and shape may adjust where floodplains occur, otherwise it is constrained by bedrock. Bank erosion is generally restricted to areas of flooplain pockets.

Channelised Fill Riverstyle is present along western tributary of Oak Creek being a defined channel that has the potential to demonstrate high rates of lateral (sideways) and vertical movement if highly modified or lacking in riparian vegetation to provide stability.

Bedrock controlled, gravel Riverstyles has been identified along Shellharbour Creek within the property Yurramie. This Riverstyle tends to have a discontinuous floodplain and transfers sediment progressively from point bar to point bar. Sediment accumulation tends to be confined to the inside of bends, sediment removal from outside bends. Provided suitable vegetation is established along outside bends to prevent over widening of the channel

Headwater & Gorge generally located at the upstream reaches of allt ributaries within the plan area. These Riverstyles both being confined within a narrow and steep valley. These areas acto to flush sediments to lower areas in the landscape, have no opportunity for lateral movement and tend to be bedrock with pool/rifle sequesnces. Generally within the area of interest, no activities are required to rehabiliate these areas beyond management of weed infestation s within well vegetated stream banks.

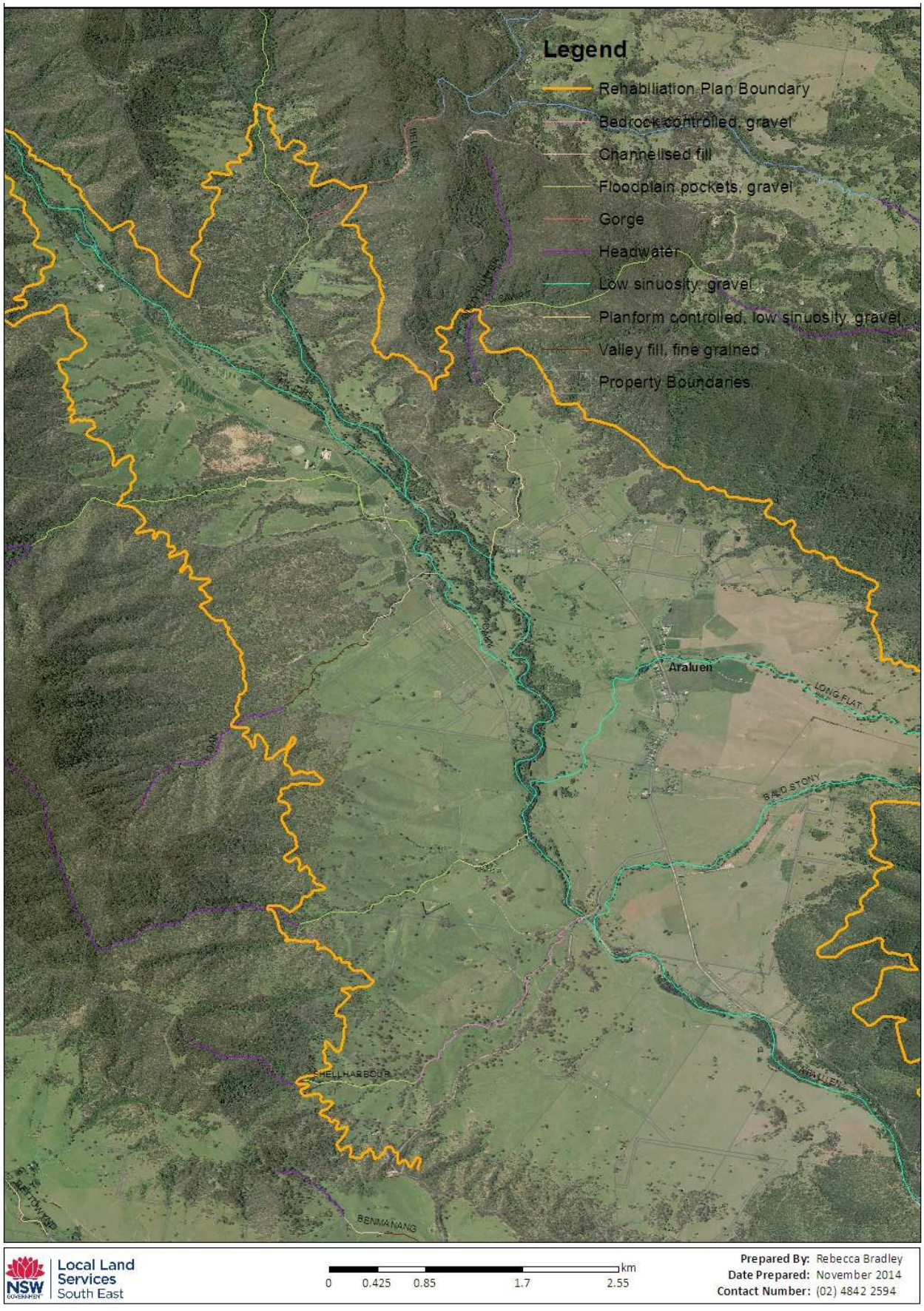

Figure 2: Riverstyles

Current Physical Condition

According to Riverstyles assessment (2012), the geomorphic condition of the eastern tributaries and a majority of Araluen Creek is 'moderate' transitioning to a poor condition downstream of the Nerringla Road crossing. The definition of 'moderate' condition being:

- localised degradation of river character and behavior, typically marked by modified patterns of geomorphic units;
- Patchy effective vegetation coverage allowing some localised accelerated erosion.

According to this same assessment, the geomorphic condition of the western tributaries is predominantly 'poor' condition. The definition of 'poor' condition being:

- Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and / or inappropriate patterns or rates of planform change and/or bank and bed erosion).
- Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity.
- Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

Areas upstream of the defined plan area, in step hills and the escarpment have been identified as being in 'good' condition due to their confined nature and presence of vegetation, which provides a good upstream source to assist in rehabilitation of native vegetation.

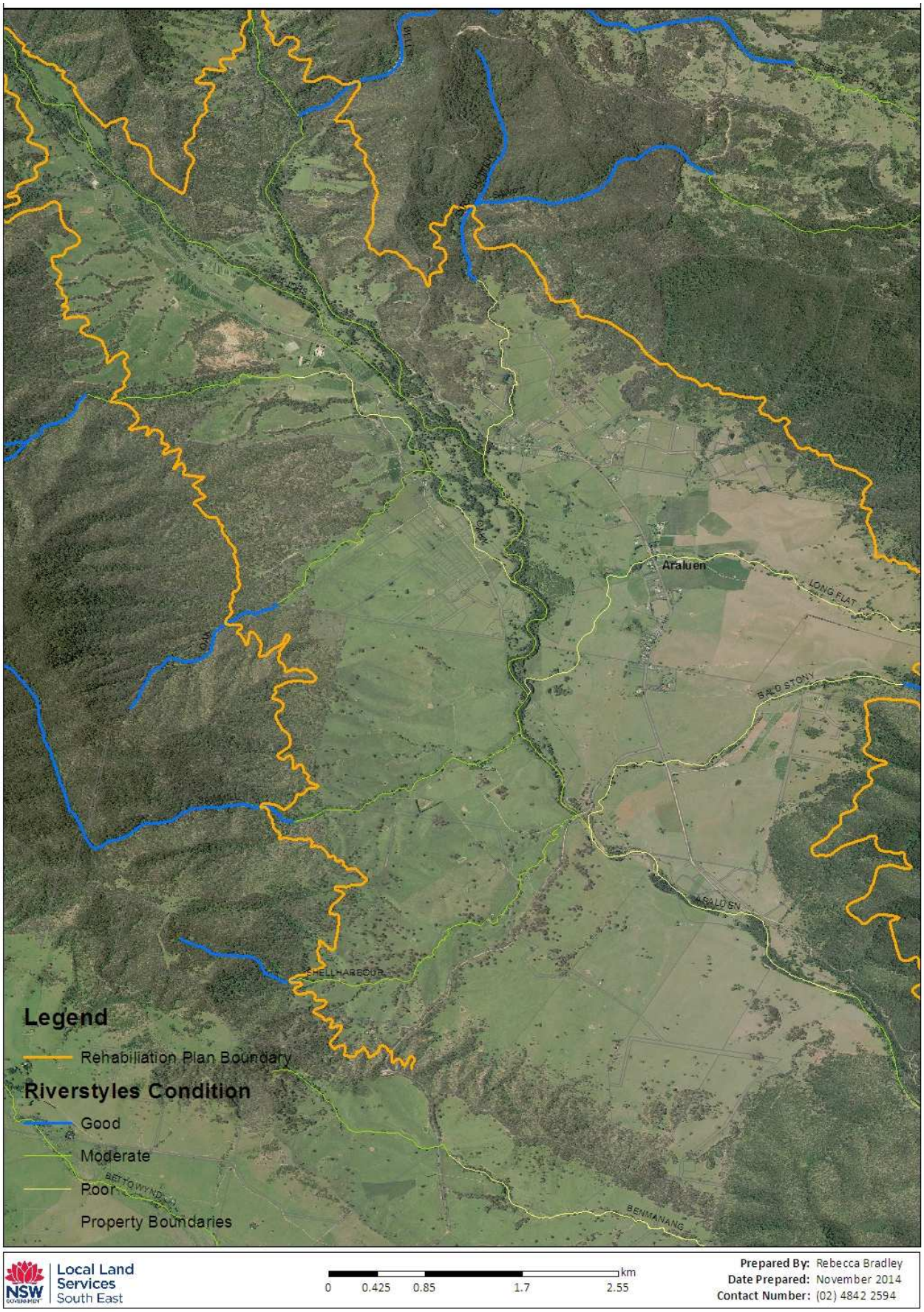

Figure 3: Geomorphic Condition

Erosion

Historical erosion mapping (completed in the 1980's) has identified considerable streambank and gully erosion within the area of this plan.

Upper Deua Landcare Group has spent considerable time identifying and rehabilitating areas of streambank and streambed erosion along Araluen Creek, within these areas identified on the following map. Recent assessment of past works has identified areas for repair to ensure on-going effective erosion control. Without maintenance to existing structures, active erosion may again occur along sections of Araluen Creek.

Tributaries to araluen Creek show signs of historical erosion but, in general, have stabilised without evidence of substantial movement, ensuring stability in lateral and vertical movement within Araluen Creek will assist in reducing active erosion within tributaries.

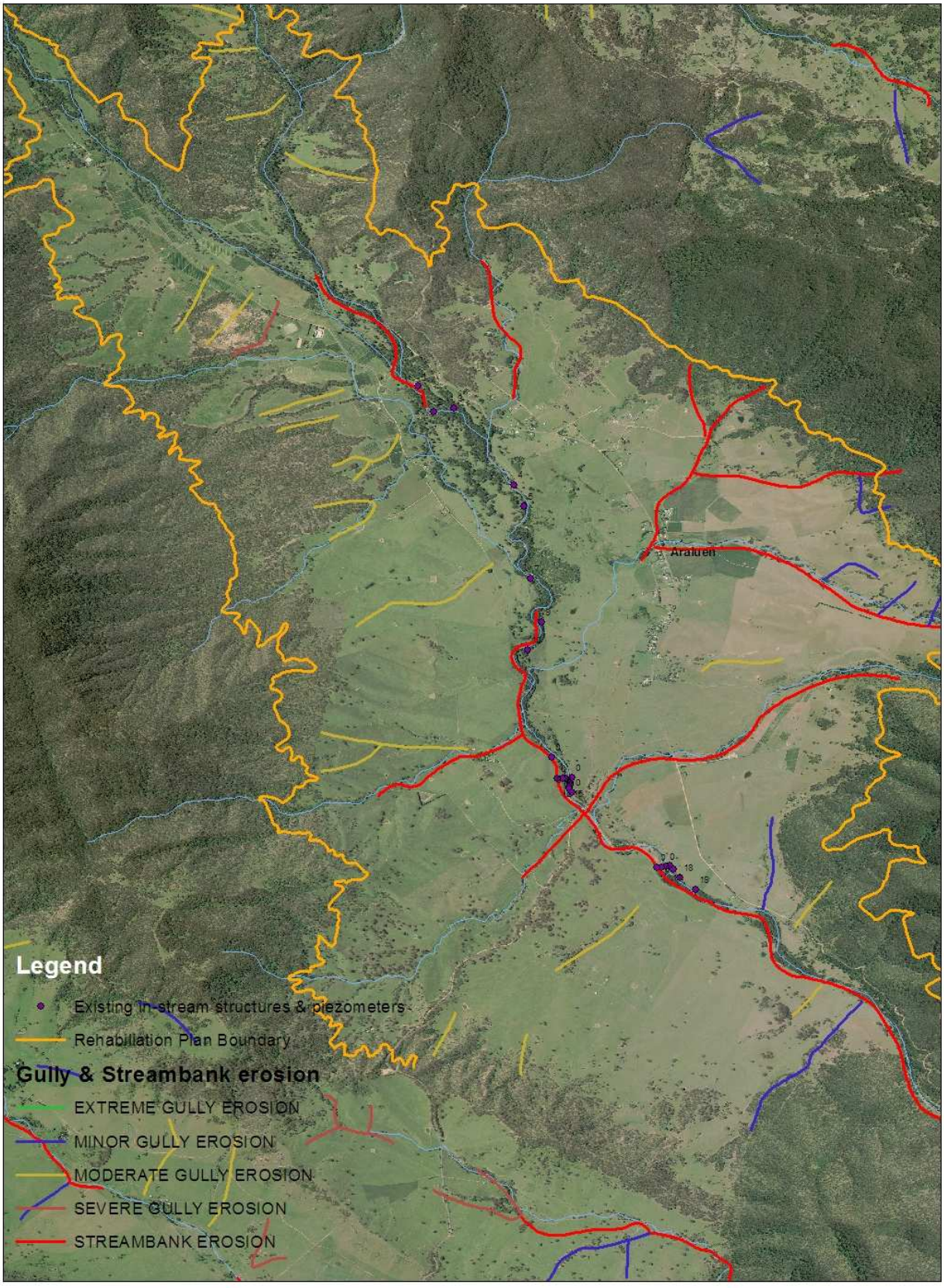

Figure 4: Potential Erosion & existing in-stream works *(piezometers identified with the number 0, existing structures numbered 1 – 19).*

Native Vegetation

Vegetation Mapping (SKIVI) has identified the vegetation along Araluen Creek as being predominantly well vegetated with *Riverbank Forest* dominated by mature *Casuarina* forest, understorey levels vary due different levels of access by livestock.

A Rapid assessment of riparian condition has been completed at several sites along Araluen Creek and some tributaries by Rebecca Bradley using the Rapid assessment of Riparian Condition methodology. Overall, vegetation condition has been found to be poor to very poor condition compared to other SENSW riparian lands, due to the lack of diversity along riparian zones and/ or the presence of woody weeds including Privet, Tree of Heaven and Blackberry or the distance to large area of remnant vegetation.

Assessments were completed along Araluen Creek at the camping ground, adjacent to “site 3” and adjacent to “site 15” within the area of interest, which is well vegetated with an almost continuous canopy of mature and regenerating *Casuarina cunninghamia.* However understorey species are sparse and are generally limited to Black wattle, boxthorn or woody weeds including privet, tree of heaven and blackberry. Some examples of the native vegetation along Araluen Creek:

Figure 5: Vegetation along Araluen Creek, upstream of the Majors Creek Bridge (mature Casuarina, fallen timber and presence of weeds including blackberry, ivy).

Figure 6: A view of riparian vegetation along Araluen Creek, downstream of “site 3”.

Figure 7: A view of riparian vegetation along Araluen Creek (immediately upstream of Nerringla Road Bridge), where a presence of grazing livestock has impacted on the presence of an understorey.

Areas along tributaries of Oak Creek, Oaky Creek, Shellharbour Creek and Bald Stony Creek were also assessed using the same methodology. These waterways are considered to have very poor condition vegetation due to a lack of riparian vegetation, with many areas cleared of all vegetation and generally only scattered mature trees, a lack of understorey or native groundcover and the presence of weeds including privet and blackberry (however not as high level infestations compared to Araluen Creek.

Figure 8: Oaky Creek, note the dry creek bed and scattered mature trees but generally an absence of native vegetation.

Figure 9: remnant vegetation patches along Oak Creek.

Vegetation mapping within the Araluen Valley (SKIVI mapping) has identified native vegetation communities on the escarpment (Araluen scarp grassy forest) and on the valley slopes (Far south coast grassy woodland). However the majority of the valley within the plan areas presents a cleared and modified landscape, predominantly used for agricultural purposes.

Scattered remnant vegetation exists along riparian zones of the various tributaries, providing opportunity to enhance connectivity within the valley. However substantial revegetation efforts will be required to link remnant patches.

A search of the NSW Bionet (wildlife Atlas) which provides records of known locations of threatened species, multiple occurrences of *Eucalyptus kartzoffiana (*Araluen Gum) has been identified along Araluen Creek. The *Draft Water Sharing Plan for the Deua River Unregulated and Alluvial Water Sources* identifies 1 threatened fish

species, 9 threatened frog species, 2 threatened macroinvertebrae species, 5 threatened bird species and 2 other threatened fauna as occurring within the Araluen Creek catchment.

The *Draft Water Sharing Plan for the Deua Unregulated and Alluvial Water Sources* identified relative in-stream value (based on adjacent landuse and presence of threatened species) to be Medium for Araluen Creek due to the presence of a range of threatened species (aquatic and terrestrial) with the value reduced due to the considerable impact of agricultural development on Araluen Creek.

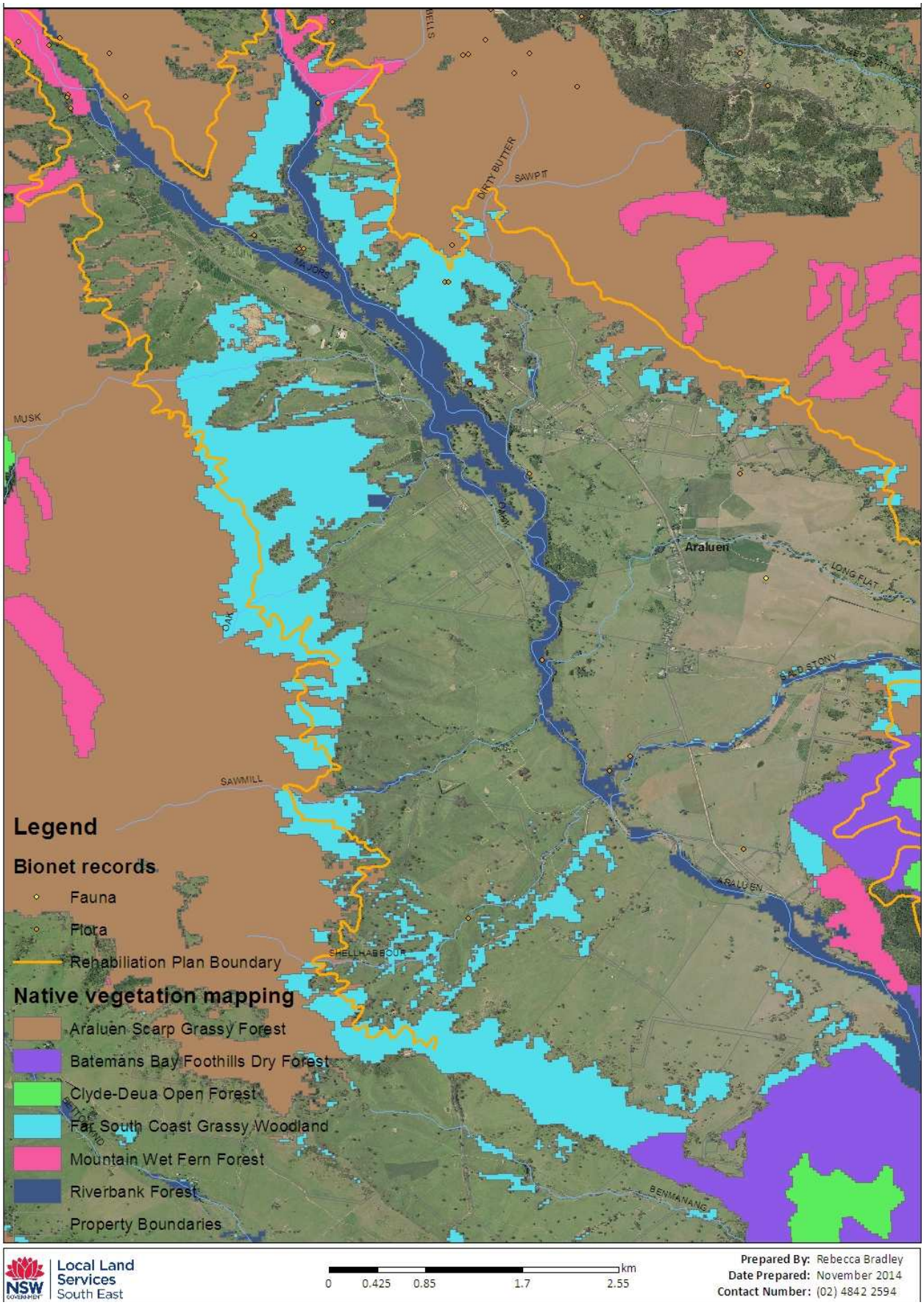

Figure 10: Native vegetation mapping

Riparian Weeds

Presence of weeds along riparian areas within the plans area of interest varies considerably. Creek walk inspections have identified weeds commonly occurring along the majority of Araluen Creek within the plan area including Privet, Tree of Heaven, Blackberry and Ivy. Lower reaches, downstream of "log sill 10" to the Nerringla Road are relatively free of these woody weeds, likely due to the presence of cattle grazing along the waterway.

Tributaries to Araluen Creek vary in the presence of weeds. A majority of these riparian lands are cleared of vegetation and therefore woody weeds are alos absent. However lower reaches of Oaky Creek, Oak Creek and Dirty Butter Creek also show infestations of woody weeds, likely influenced by the proximity to weeds along Araluen Creek.

Hydrological Stress

The Draft *Water Sharing Plan for the Deua River unregulated and Alluvial Water Sources* was prepared in 2013. This Plan has provided water users with guidelines for the equitable use of water, allowing for essential basic human needs, agricultural production and for the health and survival of native flora and fauna.

Specific issues are identified within the plan area, relating to access rules, trading rules, annual extraction limits and growth in water use, protecting pools, rules for stock and domestic licenses and prohibition of in-river dams.

In many catchments, alluvial aquifers are "highly connected" with adjacent streams – that is, water readily flows from the aquifers to the streams and vice versa. Extraction of water from a highly connected alluvial aquifer will encourage water to move from the stream to the aquifer, the hydrologic impact on the stream will be as if water had been extracted directly from the watercourse. The Draft water sharing plan identifies a large section of Araluen Creek to contain a "Highly connected" alluvial aquifer and therefore any changes to the waterway will have an impact on groundwater.

A report card prepared for the Araluen Creek Water Source (Office of Water, 2013), has assessed water use within all surface waters and underlying aquifers contained within the hydrological catchment of Araluen Creek.

This report card identifies Hydrological stress at low stream flow to be High due to the peak daily demand being greater than the 80th percentile daily flow.

Due to this classification, rehabilitation activities that may assist in enhancing water storage capacity within Araluen Creek and the adjacent alluvial aquifer (upstream of the Nerringla Bridge) is considered to be of high priority.

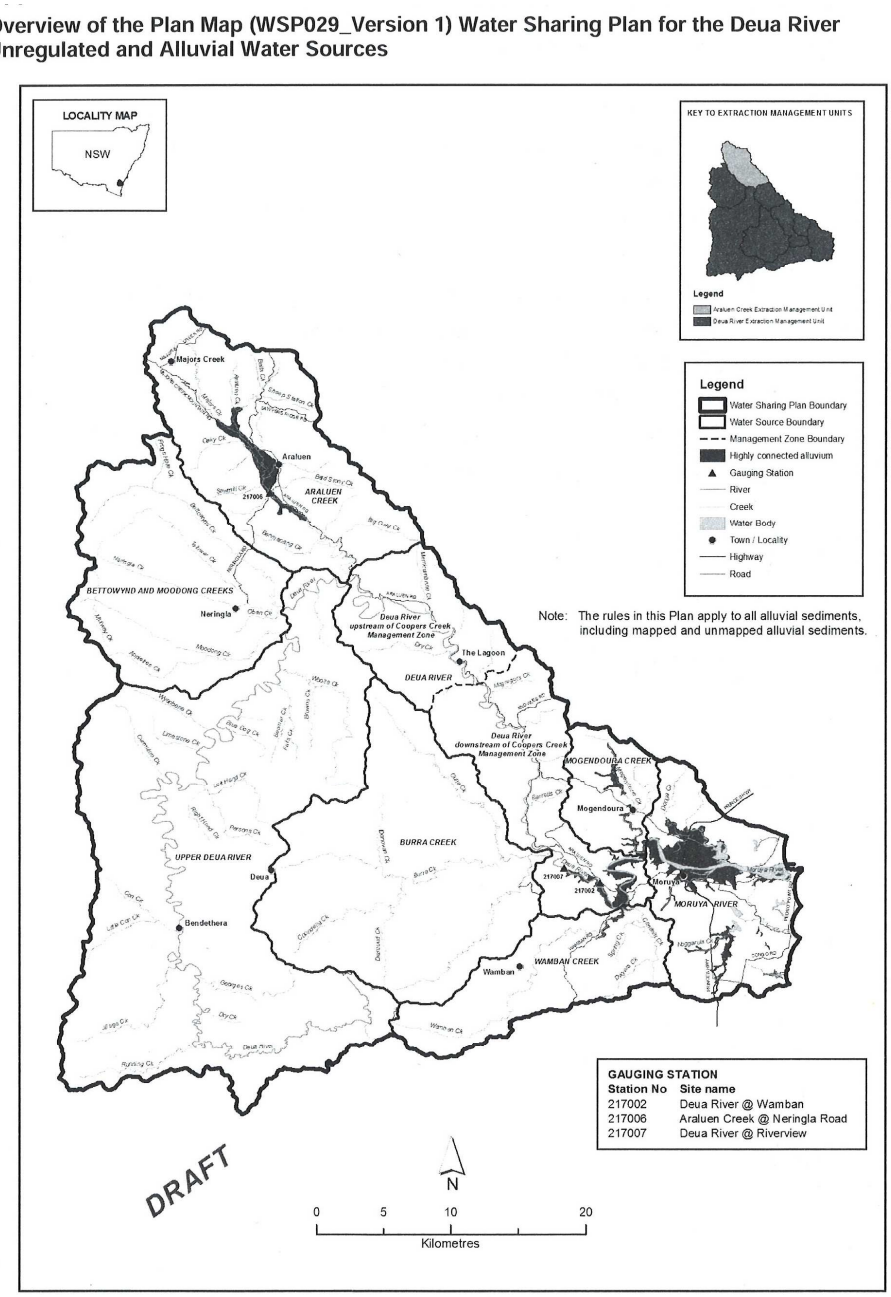

Figure 11: Highly connected alluvium (*source:NSW DPI, 2013, Draft water Sharing Plan for the Deua River Unregulated and Alluvial Water Sources – Order*)

Water Quality

The community within Araluen is almost totally dependent on their groundwater for domestic, stock and agricultural water use. In 1998, this aquifer system was ranked the third most “at risk” aquifer in the Sydney South Coast Region, based on quantity and quality pressures in the groundwater resource (DLWC, 1998).

In response to local concerns regarding groundwater water quality, the Department of Land and Water Conservation completed water quality sampling an 1997 and again in 2000. Samples included private bores, DLWC monitoring bores and surface water samples. These studies confirmed that most parameters tested were in low concentrations, however several microbiological analytes that have health problems associated were identified with faecal coliforms the main area of concern, with sources considered to be leakage from septic tanks and livestock grazing within the valley.

This study also identified that less than 40% of flow within Araluen Creek is sourced from rainwater, with the remainder coming from either shallow or deep groundwater, or a source outside of the valley. This understanding that water within Araluen Creek is a mixture of surface water runoff and several groundwater sources was also confirmed in a *A Hydrogeological Assessment of the Araluen aquifer using geophysical, hydrochemical and isotopic techniques (2001).*

Recovery Potential

Araluen Creek has been identified as having mainly a moderate recovery potential, transitioning to a high recovery potential in upstream areas identified as *Floodplain pockets* Riverstyle, with the definition of a moderate recovery potential to include:

- Moderate to poor geomorphic condition.
- Potential to recover at a slow to moderate rate if existing pressures are removed (eg livestock access).
- Recovery presently occurring at a slow rate.
- Little sediment, seed or large woody debris input (if required to allow channel contraction recovery) or;
- Excess sediment supply in moderate slugs.
- Can only recover faster if upstream reaches are rehabilitated and this reach receives rehabilitation works.

Significant investment of time and money has already been made along Araluen Creek, with over $150,000 and thousands of volunteer hours already contributing to the rehabilitation of Araluen Creek by installing a range of erosion control structures and reducing riparian weeds.

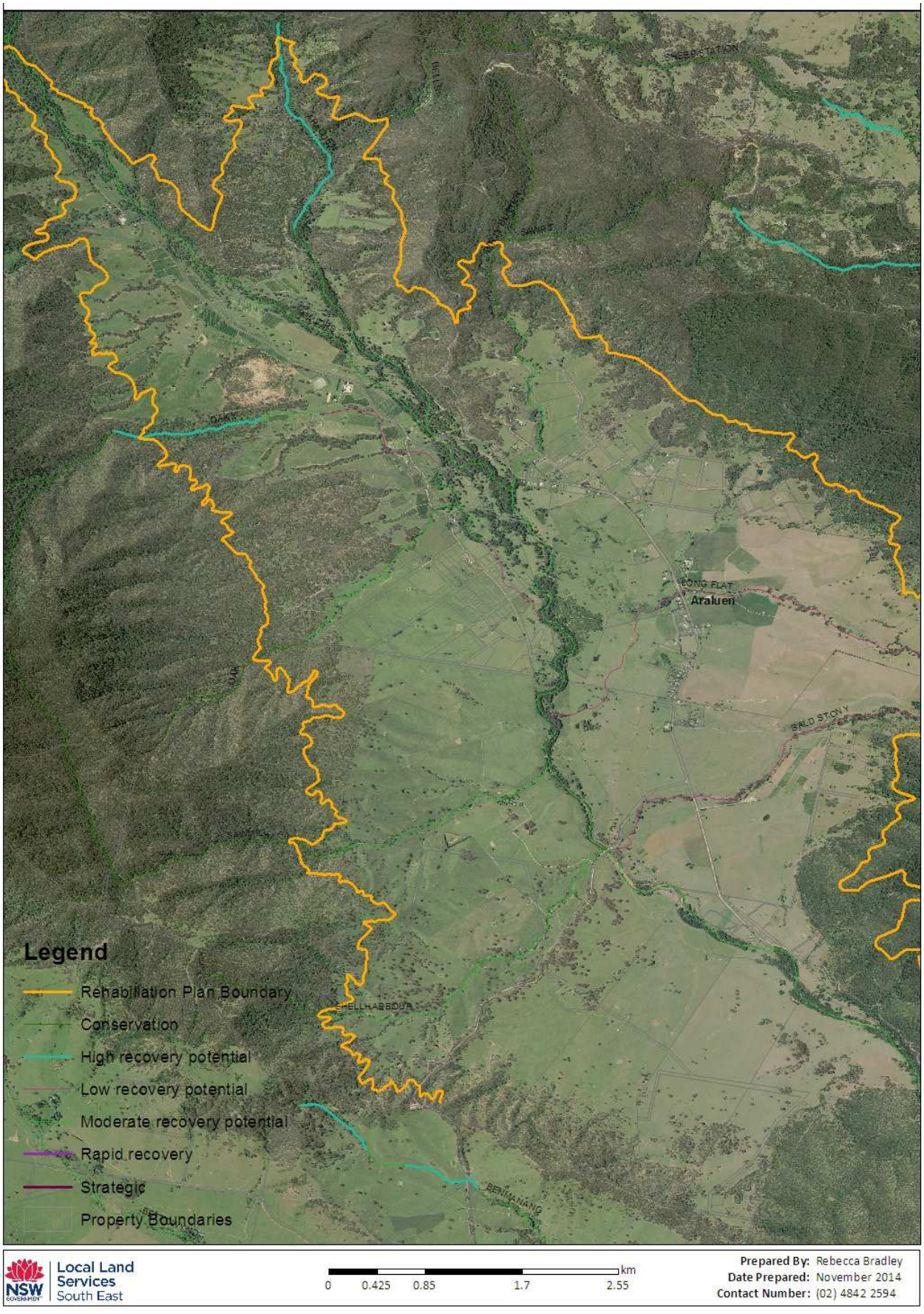

Figure 12: Riverstyles Recovery Potential

Downstream Impacts

Influences on the plan area from upstream include good condition, stable reaches providing potential seed source for revegetation of managed areas. Upstream reaches of Majors Creek have high density areas of Broom and Blackberry with the potential to impact on Majors Creek and Araluen Creek, landholders will need to continue to monitor and manage weed outbreaks within riparian areas to prevent the spread of these weeds.

Degradation to riparian areas within the area of this plan has potential significant negative impacts on downstream areas with Majors Creek and Araluen Creek demonstrating the capacity to release significant amounts of sediment to downstream areas if not suitably stabilised, given their current Riverstyle classification. This type of erosion also has the potential to negatively impact on the stability of adjacent tributaries and the water holding capacity within adjacent alluvial aquifers, impacting on all water users within Araluen Valley.

Necessity to Act

With a high level of reliance of reliable groundwater supplies by residents and primary producers within the Araluen Valley, activities to improve water storage capacity of the groundwater system is a high priority. History of activities completed by the Landcare group has demonstrated (via monitoring piezometers) that installation of in-stream works to halt streambed lowering and raise streambed levels has had a direct and positive impact on groundwater levels adjacent to Araluen Creek.

Landholders downstream of the Nerringla Road Bridge have identified their reliance on surface water pools for provision of domestic water. The construction and maintenance of upstream in-stream strucures has assisted with the retention of sand and loose sediment upstream, protecting these downstream pools.

Riverstyles identified within Araluen and Majors Creek indicates a high potential for lateral and vertical movement without intervention in the form of erosion control activities and protection of vegetation to stabilize streambanks.

Practicality

Upper Deua landcare Group, via their past interventions, have demonstrated that rehabilitation activities within these waterways is possible, with coorperative landholders and effective activities.

Access to labour assistance via volunteers, contributions by state government agencies and other initiatives such as greencorps in the past have all contributed to the practicality.

While restoring these waterways to pristine condition is not practical, activities to promote stability and enhance connectivity within the valley are possible,

Community Desirability

The Upper Deua Landcare Group have demonstrated their enthusiasm for and commitment to rehabilitation activities within Araluen Creek (between the two road bridges) having dedicated an enormous amount of volunteer effort towards erosion control and weed management in the past. The community is very supportive of their past efforts being maintained in the future.

Principles for Prioritisation

A good riparian rehabilitation program will include the following aims:

- Protect reaches that support valuable organisms or their communities (aquatic or terrestrial) first;
- Protect streams that are in the best general condition before trying to improve those in poor condition, including the protection of their floodplains and shallow groundwater systems;
- Stop streams in a ‘good’ condition from deteriorating;

- Improve the condition of reaches that are damaged, including their linkages to floodplains and groundwater systems; and
- Support interested communities in their efforts to rehabilitate their watercourses and drainage lines

Significant investment has been made by the Upper Deua Landcare Group in rehabilitation activities along Araluen Creek, these activities are to be recognised and provided some priority to maintain and enhance the work of these projects

Challenges in Implementation of a River Rehabilitation Plan

History of involvement with landholders in a range of river rehabilitation projects has highlighted certain challenges in implementing these types of projects and an overall River rehabiliation Plan. Consideration of these challenges should be included when setting new priorities for River rehabilitation activites. These challenges include:

1. Successfully engaging landholders in areas where River rehabilitation has been identified as a priority by a plan, but may not be instigated by the various landholders. If the following challenges cannot be overcome, then the investment made at the identified site is likely to be a wasted investment over time. These challenges include:
    - engaging the landholder in cooperation for the project, providing their consent;
    - engaging the landholder in active participation of the project- recognising the value of committing funds and/or their own time to the implementation of required project activities;
    - securing the commitment of the landholder in the on-going maintenance of the project site.

2. Successfully attracting financial support from funding providers for the rehabilitation and/or protection of sites identified to be of strategic significance that may be outside of priority focus of the particular funding body;

3. Ensuring that enthusiastic landholders and community groups that are not within these targeted areas are not alienated from River rehabilitation activities. Ensuring that we do not lose community enthusiasm for river rehabilitation activities;

4. Education of community to justify priorities that have been set for the benefit of the sub-catchment as a whole.

Priority Management Activities

1. Due to overall condition, important linkages to the groundwater system, community interest and past interventaion, first priority management activities are along Araluen Creek and include:

    a. Repair and improve existing in-stream structures with the aim of ensuring long term stability to streambed and banks within Araluen Creek which has been identified as being highly susceptible to lateral and vertical movement. These in-stream sturctures have played an important role in reducing the transfer of loose sediment and sand to downstream areas and have had a positive impact on retention of groundwater within the valley. This work may include maintenance of existing structures, establishment of new structures and removal of problem vegetation which may be creating erosion issues;

    b. Protection and enhancement of existing native vegetation along Araluen Creek to ensure long term stability and protection of in-stream works and transitioning to a ‘good’ geomorphic condition. Minimal works are required due to the presence of vegetation which should be protected from constant grazing stock via riparian fencing, providing opportunity for the establishment of understorey species.

    c. Weed management along Araluen Creek with a focus on invasive woody weeds such a blackberry, privet and tree of heaven which, once established, prevent the growth of native species should continue as a priority to the group, preventing the spread of these species to downstream aras.

2. The second Priority will be to protect and enhance areas of significant native vegetation which provide habitat and connectivity opportunities within the valley. Enhancing existing vegetation provides multiple benefits and is more economical than establishment in bare areas. Araluen valley is a significantly cleared landscape, riparian areas provide opportunity to create pathways across the landscape. Priority should be given to western tributaries due to their current overall condition, presence of existing vegetation in the upstream reaches, identification of significant species (Araluen Gum) and shorter distance to existing remnants, including:

    a. Oaky Creek: Currently identified as being in 'moderate condition', with reaches of High recovery potential due to the presence of native vegetation. Priority should be given to the protection of this native vegetation along riparian areas, particularly where native vegetation is already present (upstream sections of this reach).

    b. Majors Creek: Currently identified as being in 'moderate condition'. The in-stream works that have occurred downstream within Araluen Creek will have influence on streambed stability within Majors Creek. Good vegetation cover is identified along Majors Creek, along with several occurrences of the endangered Araluen Gum. Protection of this vegetation via weed and stock management should be a priority to enhance the stability of the creek, prevent the spread of weeds to other downstream areas. At present woody weeds are common along the wateray.

    c. Shellharbour Creek: Identified as being predominantly bedrock controlled, with erosion likely contained to outside bends and in-stream. Protecting and enhancing native vegetation along this waterway will contribute significantly to the overall stability and condition of the waterway. With scattered mature trees along the waterway and remnant vegetation upstream, fencing to exclude livestock grazing and revegetation in strategic areas should assist in overall connectivity between the escarpment and Araluen Creek.

    d. Sawmill Creek: Also identified as having large reached controlled by bedrock (ie lateral movement restricted) provides good opportunity for successful establishment of native vegetation on relatively stable streambanks. Protecting and enhancing native vegetation along this waterway via stock management will also contribute to connectivity between the escarpment and Araluen Creek.

3. Third priority will be to conitune with efforts in landholder education regarding river rehabilitation principles to enhance community acceptance of the River Rehabilitation Plan, providing information on recommended practice for the effective management of major issues within the catchment and providing guidance on acceptable activities to be carried out in various riparian environments throughout the catchment.

As with all River rehabilitation activities, opportunity to implement these projects will be limited by the interest of various private landholders in participating in the suggested activities, along with maintaining the works following their completion, access to financial incentives and labour to assist with activities such as weed control and revegetation.

More information

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Acknowledgments

Contributions by members of the Upper Deua Catchment Landcare Group

References:

Chessman, B.C. Fryirs, K.A. & Brierley, G.J. (2006). "*Linking geomorphic character, behavior and condition to fluvial biodiversity: implications for river management*." Aquatic Conservation: Marine and Freshwater Ecosystems Vol 16: 267-288 Wiley Inter Science.

Department of Environment, Climate Change & Water, 2010*, NSW Climate Change Profile,* Department of Environment Climate Change & Water.

Department of Land and Water Conservation, 1998, *Aquifer Risk Assessment Report*

Ede, F.J. and Hunt T.D. (2008) *Habitat management guide – Riparian: Weed management in riparian areas: south-eastern Australia.* CRC for Australian Weed Management, Adelaide.

GHD Pty Ltd (2012) *NSW Office of Water, SRCMA-Riverstyles Report Feb 2012 (Draft),* GHD Pty Ltd.

Goulburn Mulwaree Council (2011*) Community Strategic Plan*

Healthy Rivers Commission of NSW,(1998*) Independent Inquiry into the Shoalhaven River System, Draft Report*. Healthy Rivers Commission, Sydney

Lovett s & Edgar B, 2002, *Planning for River Restoration – Fact Sheet 8,* Land and Water Ausralia, Canberra.

NSW Department of Primary Industries (2005) *Reducing the impact of road crossings on aquatic habitat in coastal waterways – Southern Rivers, NSW.* Report to the New South Wales Environmental Trust. NSW Department of Primary Industries, Flemington, NSW.

NSW Office of Water (2013) *Draft Water Sharing Plan for the Deua River unregulated and Alluvial Water Sources – Order*, NSW Department of Primary Industries (office of water),

Parsons M, Thoms M, Capon T, Capon S & Reid M (2009) *Waterlines Report Series No. 21 – Resilience and thresholds in river ecosystems,* Australian Government National Water Commission

Pritchard S (2000) *Araluen Groundwater Investigation Water Quality Sampling Report*, Department Land and Water Conservation, Wollongong.

Radke B , 2003, Filters and Funnels – A survey of stream degradation in the Upper Shoalhaven and Upper Deua Catchments, Upper Shoalhaven Landcare Council, Braidwood.

Reichert P et. al, 2004, Concepts of Decision Support for River Rehabilitation, Swiss Federal Institute for Environmental Science and Technology (EAWAG), Switzerland

Appendix 1 – Assessment of Repair Requirements to existing structures along Araluen Creek

Introduction

The Upper Deua landcare Group are assessing existing in-stream works within Araluen Creek, evaluating their effectiveness in maintaining streambed and bank stability and seeking maintenance requirements.

The Landcare group should be aware the any earthmoving activities within a watercourse that involves disturbance to streambeds, banks and native vegetation requires consultation with and consent of:

- NSW DPI (fisheries)
- NSW DPI (office of water)
- South East Local Land Services.

In general a Review of Environmental Factors should be prepared which will consider any impact the proposed activities will have on the existing environment.

The following information is intended to be provided to the landcare group as advice only on potential activities they may wish to consider when developing their plan for further in-stream works along Araluen Creek.

Background

Upper Deua Landcare group have assessed the condition of existing in-stream strucutres, completing a creek walk in August 2014.

Surveys have been completed, by Bradley Surveying & Design in September 2014 to provide accurate reference points for the location of existing in-stream works, along with cross-sections to provide a record of the structure of the waterway and information for future planning. An additional benefit of this information provided is the ability to prepare an estimated long section of the creek, providing opportunity to compare streambed heights at the various existing structures assisting with planning of future works.

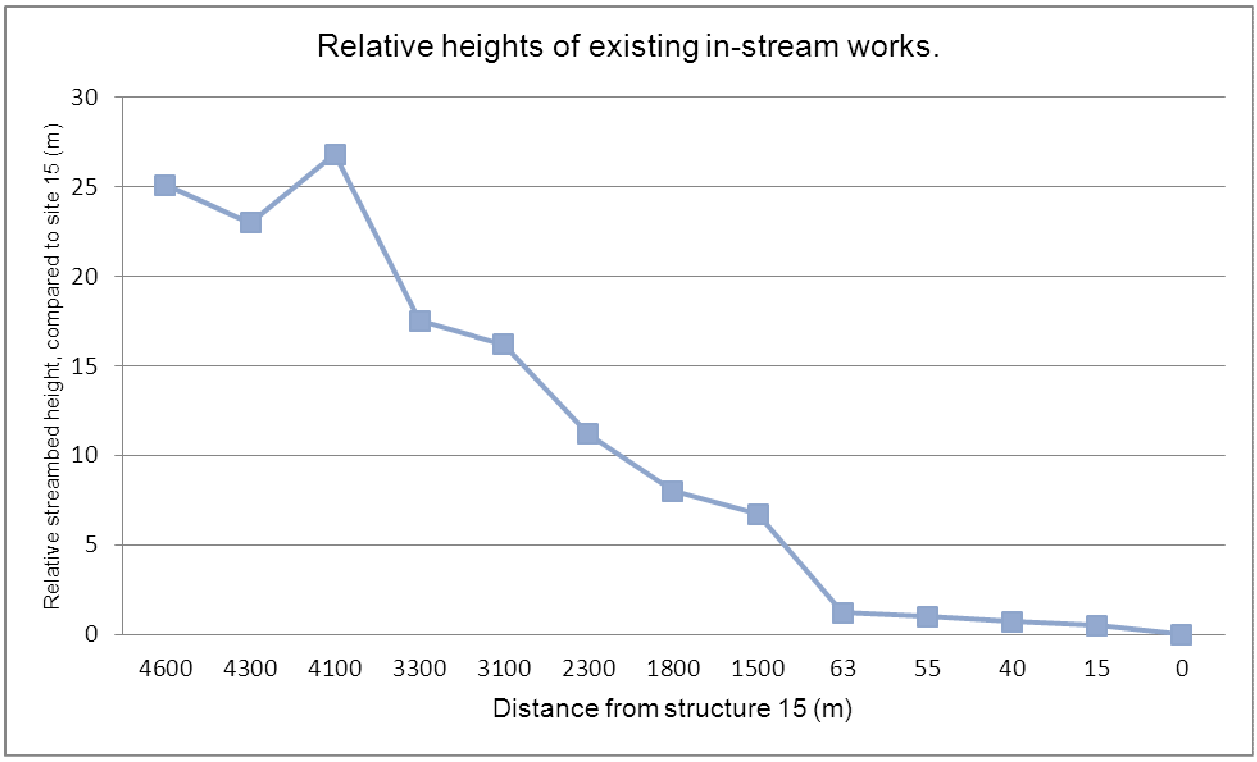

Figure 1: Graph demonstrating the long section along Araluen Creek between sites 1 – 15, above the Nerringla Road Bridge.

Recommendations to consider

Commencing with review of existing works from the Nerringla Road, working back upstream:

- Below all structures there is opportunity to build an additional streambed control structure to raise bed levels and assist trapping sediment and securing the existing works.

Figure 2: Incised stream downstream of structure 15 with mobile sediment and eroding streambank (top left of the view), would benefit from placement of an in-stream structure, raising bed levels.

- Structures 15, 14, 13 and 12 are all clustered fairly close together and functioning well to manage water flows and retain bed stability. However upstream of this area, there remains significant sand accumulation whish has the potential to travel to downstream areas as the existing structures are reaching their capacity for raising/ stabilising bed levels. There is opportunity to install an additional structure abov this cluster to assist in trapping upstream mobile sediment as structures 12 & 11 are currently level. The group may consider opportunities to raise the bed level upstream of structures 12 or 11 to assist in stabilising this mobile sediment. Minor maintenance may be required to these existing strucutres in the placement of rock in scour holes.

Figure 3: Sand beds currently between sites 10 & 11.

- The log sill at Site 10 has been effective in controlling streambed lowering. There is bed and bank erosion downstream of this site, which may benefit from the previously proposed structure, or may require an additional structure to address this. The log sill at site 10 is showing signs of decay with the top log used in the construction of the structure rotting and partly washed away. The landcare group should consider opportunity to repair this structure via placement of additional logs upstream that may also further raise bed levels to upstream areas.

Figure 4: Log sill at site 10, in need of replacement of upper log/ potential upgrade.

- I have not inspected log sills at sites 9 – 3, however the Landcare group conducted a creek walk in September 2014 and identified potential issues at sites 7 and 8 with active erosion that should be considered. Sites “6” and “8” have not been identified by recent surveys as the structures could not be located an may require additional investigation to locate.
- Log sill at site three is effective in managing streambed lowering upstream of this area, with the long section demonstrating this structure is placed higher than other upstreamworks. Streambank and bed erosion is occurring downstream of this structure and will need to be assessed.

Figure 5: area below Log sill 3.

Conclusion

While it has been identified that streambed and bank stabilisation is justified as a priority for the Landcare group in their efforts in riparian rehabilitation, the landcare group will need to complete additional investigations along the creek and consultation with various government agencies prior to undertaking any works. The recommendations are provided as a guide only.