Toorumbee Creek to Belgrave Falls Reach Plan

River Assessment and Management Plan

December 2014

Australian Government

NSW GOVERNMENT

Local Land Services North Coast

aquatic habitat rehabilitation making more fish ...naturally

Title: Toorumbee Creek to Belgrave Falls Reach Plan (River Assessment and Management Plan)

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December 2014

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Cover photo: Recording habitat data adjacent a shallow pool using hand held Trimble® device.

Disclaimer Information contained in this report is based on knowledge and understanding at the time of writing (December 2014). However, because of advances in knowledge, users are reminded of the need to ensure that information on which they rely is up to date and to check the currency of the information with the appropriate officer of the NSW Department of Primary Industries or the user’s independent advisor.

This report should be cited as:

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Executive Summary

The Aquatic Habitat Rehabilitation Unit of NSW Department of Primary Industries (NSW DPI), in collaboration with the North Coast Local Land Services (LLS) undertook detailed mapping of riverine condition from the tidal limit at Belgrave Falls for 47 km upstream to Toorooka Bridge on the Macleay River.

The study area was divided into nine ‘reaches’ of equivalent length to enable accurate comparison between those reaches. Key features of in-stream and riparian habitat were digitally recorded and then analysed by reach to identify potential locations for further enhancement. The features used for the prioritisation process included refuge pools, large woody debris (snags), native & exotic vegetation cover, erosion and stock damage. Additional features that were mapped and recorded included fencelines, pump locations, gravel extraction sites, aquatic vegetation, fauna observations, riffles and shallow pools.

A Decision Support System (DSS) was then applied to determine priority management actions and areas, ranking reaches based on their overall reach condition scores, which were standardised and weighted to account for the key features being measured at different scales and units.

The main issues revealed by the mapping process were a relative lack of large woody debris, exotic weed incursions on otherwise good condition native riparian vegetation and direct stock access to the river (even where there was existing fencing).

The main recommendations for on-ground actions include control of exotic vegetation, reintroduction of snags, adaptive control of stock grazing in the riparian zone and recovery of native vegetation. All these facets of habitat rehabilitation and land management are critical aspects of increasing local native fish populations.

If any on ground activities are to have beneficial long term effects, the local communities and landholders must be involved in those rehabilitation activities, given that the majority of riparian lands are managed by adjacent landholders. Engaging land managers and stakeholders is a vital component of continuing habitat rehabilitation into the future and this is highlighted in the reach recommendations and activities.

This project has demonstrated the value of riverine habitat mapping in terms of providing baseline information against which future changes can be benchmarked. In addition, the prioritisation process has determined the key actions for targeted areas that can secure the ongoing health of this stretch of the Macleay River. These benefits can be replicated in other reaches, catchments and river systems within the area managed by North Coast Local Land Services.

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1. Introduction

Native freshwater fish stocks have suffered alarming declines since European settlement. The 2001 Assessment of River Conditions found that 30% of NSW rivers were substantially degraded and a further 68% were moderately degraded (Norris *et al.* 2001). Many freshwater habitats for juvenile and adult fish have declined or have been completely lost through urban, industrial and agricultural development. Habitat deterioration is now widely accepted as having a major influence on the diversity and abundance of native fish. As such, aquatic habitat rehabilitation has become progressively more important in NSW as the community increasingly recognises the benefits of natural, healthy systems.

The main threats to the health, abundance and diversity of fish in NSW are the destruction of their habitat through agricultural, urban and industrial development in estuarine areas and land use in freshwater environments. In NSW rivers, fish populations have declined through the removal of vegetation from river banks, wetlands and floodplains, increased sediment, nutrients and pollutants into streams, and the removal of organic matter and snags from rivers. Many fish need to travel a long way to survive, escape predators and competitors, and breed and rear in different waters. Many are stopped from migrating by barriers, such as dams, weirs, floodgates and road crossings.

The Macleay River is known to be one of the best fishing grounds for Australian Bass, a widespread species native to the south-eastern coastal area of Australia (Greg West, *pers. comm*., 2011). The habitat for bass ranges from upland streams, floodplain wetlands and estuaries. Within this range, there is partial segregation of the sexes with females preferring the upstream locations and males the lower estuarine environments (Harris 1987). During spawning, females move into the brackish estuarine tidal reaches (Harris 1986). Habitat utilisation within this range is varied primarily based on size or age. Larvae and juveniles are dependent upon macrophyte beds such as *Vallisneria spp.* and common reeds like *Phragmites australis* while migrating upstream (Harris 1988). Adult fish prefer in-stream cover including submerged woody debris, undercut banks and overhanging vegetation (Pusey *et al.* 2004).

On behalf of the North Coast Local Land Services, the Aquatic Habitat Rehabilitation Unit of NSW Department of Primary Industries (NSW DPI) undertook extensive mapping of specific physical riverine features relating to river health along 47 km of the Macleay River, from Toorumbee Creek to Belgrave Falls, in south-eastern Australia. Habitat features were recorded, digitised and then analysed to benchmark aquatic habitat condition and provide natural resource managers with a guide for rehabilitation, protection and enhancement measures along the river.

2. Aims

- To map and assess riparian and in-stream conditions along approximately 47 km of river between Toorumbee Creek and Belgrave Falls.
- Conduct a desktop analysis of this data using an innovative prioritisation program to determine management actions and priority areas.

3. Project Scope and Objectives

3.1 Objectives

The primary objectives of the project were to:

1. Document and assess the riparian floristic condition of the reach, focusing on native vegetation, weed infestation and existing management activities;

2. Document and assess river bed morphology, including the location, length and depth of pools that may act as drought refugia, the in-stream habitat features and large woody habitat (snags) loading;

3. Identify threats and processes that may influence the extent and condition of aquatic and riparian habitat features (including erosion), and prioritise specific areas/issues that require management action; and

4. Make recommendations to protect and improve river health habitat features.

3.2 Study Area

The Macleay River rises below Blue Nobby Mountain, east of Uralla within the Great Dividing Range. The river flows in a meandering course generally east by south through the Cunnawarra National Park and Oxley Wild Rivers National Park, before reaching the Pacific Ocean near South West Rocks, NSW. The river descends 460 metres over its 298 kilometre course.

The Lower Macleay River Riparian Zone study area (hereafter known as the “study area”) comprises 47 km of the Macleay River, from just downstream of Toorooka Bridge to the tidal limit at Belgrave Falls (see Figure 1).

The study area was divided into nine Management Reaches, each exactly 5.2 km long. This step was necessary to allow each reach to be statistically compared to its counterparts.

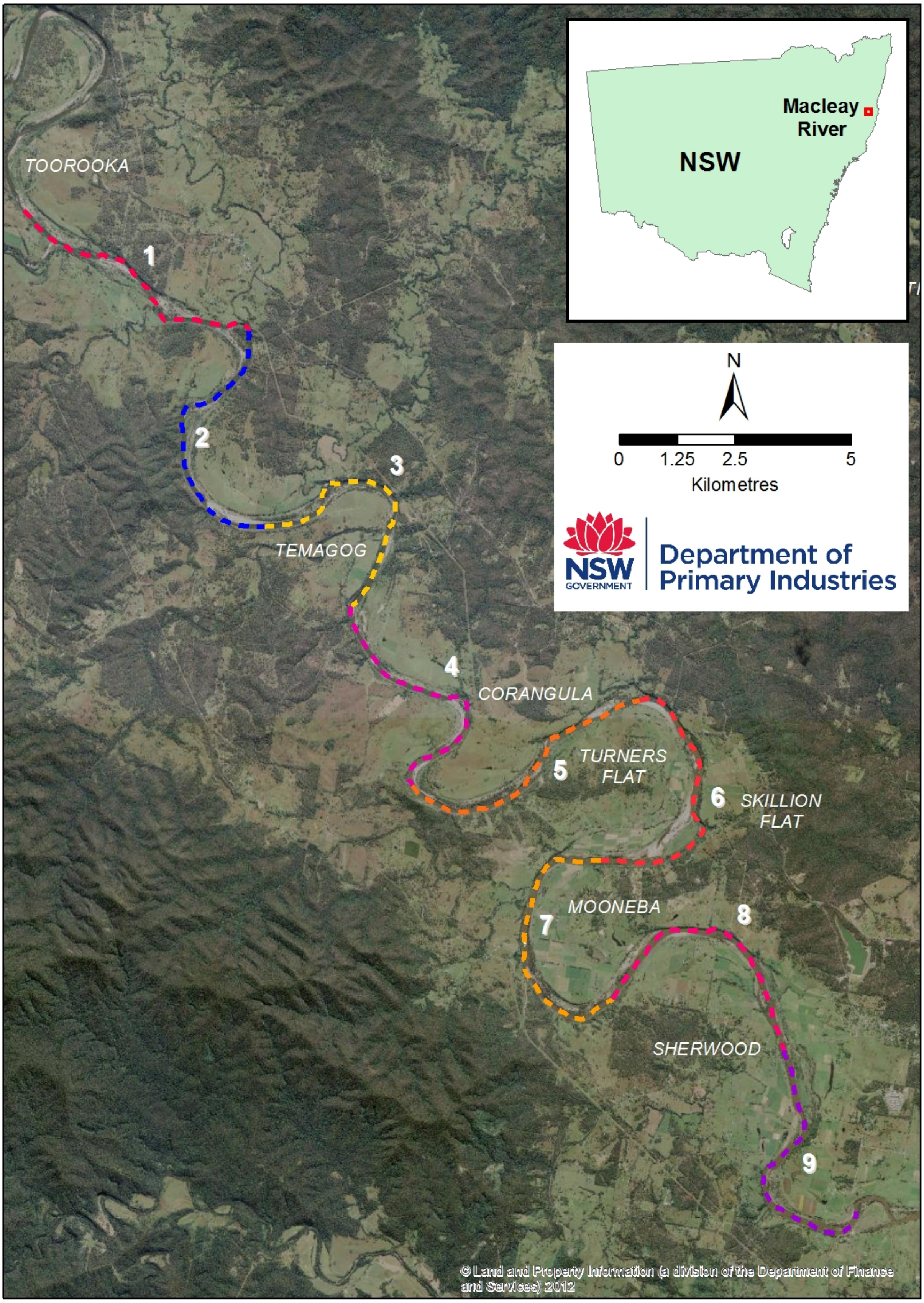


Figure 1: The Study Area incorporates nine Management Reaches.

3.2.1 Study Area Issues

Noxious weeds

Table 1: Aquatic weeds potentially found in the Macleay River project area.

Common Name	Botanical Name	Class of weed
Alligator Weed (WoNS)	*Alternanthera philoxeroides*	2
Anchored Water Hyacinth	*Eichhornia azurea*	1
Arrowhead	*Sagittaria calycina* var. *calycina*	4 *
Cabomba (WoNS)	All *Cabomba* spp. except *C. furcata*	5 *
Eurasian Water Milfoil	*Myriophyllum spicatum*	1
Horsetail	*Equisetum spp.*	1
Hydrocotyle	*Hydrocotyl ranunculoides*	1
Hygrophila (Glush Weed)	*Hygrophila costata*	2
Kidneyleaf mudplantain	*Heteranthera reniformis*	1
Lagarosiphon	*Lagarosiphon major*	1
Leafy Elodea / Dense Waterweed	*Egeria densa*	4 *
Long-Leaf Willow Primrose	*Ludwigia longifolia*	3
Sagittaria (WoNS)	*Sagittaria platyphylla*	4 *
Salvinia (WoNS)	*Salvinia molesta*	3
Senegal Tea Plant	*Gymnocoronis spilanthoides*	1
Water Caltrop	*Trapa spp.*	1
Water Hyacinth (WoNS)	*Eichhornia crassipes*	3
Water Lettuce	*Pistia stratiotes*	1
Water Soldier	*Stratiotes aloides*	1
Yellow Burrhead	*Limnocharis flava*	1

WoNS = Weed of National Significance.

* and the plant must not be sold, propagated or knowingly distributed.

Class 1 The plant must be eradicated from the land and the land must be kept free of the plant and requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with (Notifiable – State prohibited).

Class 2 The plant must be eradicated from the land and the land must be kept free of the plant and requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with (Notifiable – Regionally prohibited).

Class 3 The plant must be fully and continuously suppressed and destroyed (Regionally controlled).

Class 4 The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread (in accordance with your local Councils Class 4 weed management policy) (Locally controlled).

Class 5 Requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with (Notifiable – Sale restricted).

Weeds have been described as plants growing in the wrong place. They can cause problems for farmers, for gardeners, for public utilities and for conservation. Many weeds are a nuisance (environmental weeds), while others (noxious weeds) can cause serious losses to crop and livestock production, threaten ecological communities and harm the health of people.

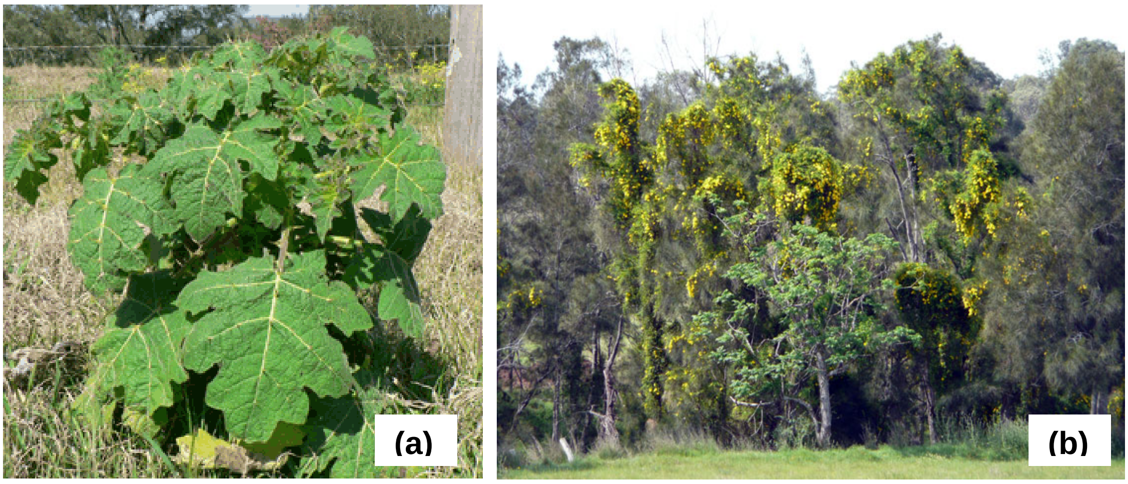


Figure 2: (a) Tropical Soda Apple (Solanum viarum) and (b) Cat's Claw Creeper (Dolichandra unguis-cati). Photos: Kempsey Shire Council and NSW DPI.

Noxious weeds are defined as weeds that all landholders have a legal obligation to control under the *Noxious Weeds Act 1993*. The Act requires all landholders in a defined area, including local government and state government agencies, to control noxious weeds on land they occupy. It also prohibits the sale of some noxious weeds and the sale of goods contaminated by those noxious weeds (see Table 1 above).

Tropical Soda Apple (*Solanum viarum*) and Cat's Claw Creeper (*Dolichandra unguis-cati*) have been identified as significant problems in the study area (Figure 2a and b).

Tropical Soda Apple (Class 1 declared noxious weed) was first identified in Australia in the upper Macleay Valley in August 2010, though it is believed to have been in this area for a number of years.

In mid-2014, reports from landholders downstream of Bellbrook confirmed that as a result of the early 2013 flood events, Tropical Soda Apple spread downstream via floodwater to at least Sherwood, with individual landholders reporting hundreds of plants germinating over just one month.

Kempsey Shire Council reported that infestations in 2014 were concentrated from the Georges Creek area to below Bellbrook (upstream of the study area).

The plant itself is unpalatable to livestock, thus reducing carrying capacity, though the fruit is readily eaten by livestock. Prickles on this plant restrict grazing by native animals and livestock and thickets can create a physical barrier for animals preventing access to shade and water. The plant is a host for many diseases and pests of cultivated crops, and it contains solasodine which is poisonous to humans (NSW DPI 2014). Major vectors of spread include cattle, feral pigs and deer as well as birds, which consume and translocate the seeds. Water movement of the fruit and seeds also contributes to downstream spread. Tropical Soda Apple is a Class 1 State Prohibited Weed across NSW under the *Noxious Weeds Act 1993* which requires that it must be eradicated.

Cat's Claw Creeper *Dolichandra unguis-cati* (Class 3 declared noxious weed, previously *Macfadyena unguis-cati*) is a woody climber with stems extending over 20 m. It is native to tropical America and a garden escape in NSW. Cat's Claw Creeper is an aggressive climber which completely smothers shrubs and trees. It is now widespread and common in coastal areas of NSW north of Sydney especially along coastal and hinterland streams in northern NSW. It has also been declared a Weed of National Significance in Australia.

Gravel extraction

When bedload (sand and gravel) removal from a section of river exceeds the amount being transported into it from upstream, there is a net sediment loss to the system. In simple terms, the river responds by eroding its bed or banks or both. Which of these actually occurs depends on the composition of the bed and banks, along with their susceptibility to erosion.

Investigations into the sand and gravel extraction in the Macleay River from Toorooka to Sherwood Bridge crossings (Telfer 2001) found that many extraction sites would be more appropriately described as mines, as there was no replenishment of the resource over a reasonable time period. Some sites were extending into floodplain and terrace deposits which were not an active part of the channel. When the investigation was concluded it also found that new resource areas were scarce and flooding was not replenishing existing sites.

Historic mining activities

There has been some concern for the level of Antimony (Sb) and Arsenic (As) in the river system due to the legacy arising from historic mining operations further upstream. The dominant source of Sb and As into the Bakers Creek – Macleay River system is from the Hillgrove mining area (Ashley *et al.* 2007) located at the headwaters of the study area (Figure 3).

The Bakers Creek–Macleay River system is contaminated by Sb and As from Hillgrove to the estuary, a distance of over 300 km. This is evident in levels of Sb and As in stream sediments, stream water, riparian vegetation and aquatic algae. There is uptake of the metalloids into aquatic invertebrates in Bakers Creek and pasture species on the Macleay River floodplain. There were large physical additions of mine waste to the Bakers Creek sub-catchment for about 90 years, and these now form a strongly contaminated slug of stream sediment for at least 50 km downstream.

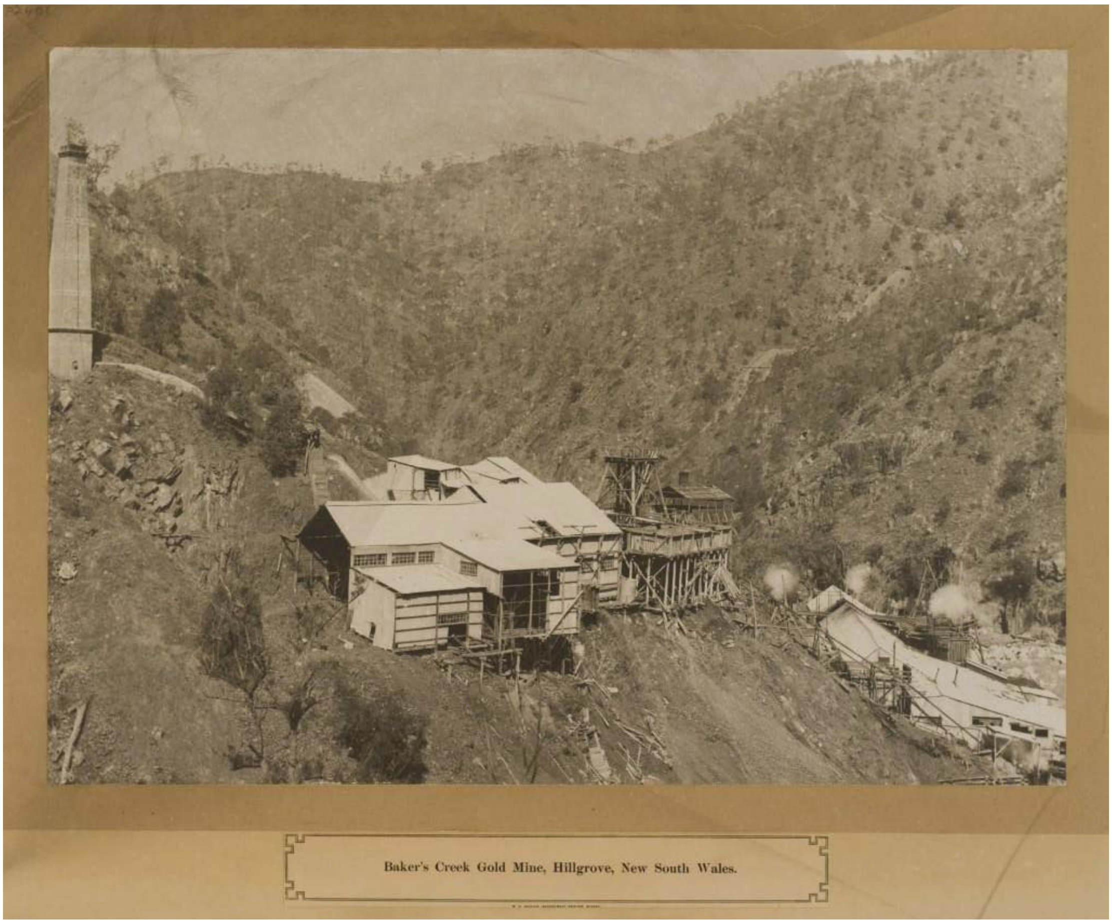


Figure 3: Bakers Creek mining operations. **Source: W.A. Gullick, Government Printer, Sydney 1906.**

Kempsey Shire Council has undertaken a number of programs to monitor heavy metals in the Macleay River at Bellbrook for water supply purposes. Drinking water is pumped from the shingle bed on the edge of the river. In 2005 to 2007, intensive metals analysis were undertaken following elevated levels of As found in the drinking water at Bellbrook. The monitoring of the river and bore water indicated that the As levels were associated with the groundwater and not the river surface water.

In 2010, a water treatment plant was constructed at Bellbrook that had the capacity to remove As from the ground water. Council's water treatment plant at Bellbrook ensures that the water is processed in accordance with the Australian Drinking Water Guidelines (ADWG), including maintaining As and Sb concentrations at below the guideline levels.

In 2013, Kempsey Shire Council and Bass Kempsey Inc. collected Australian bass for testing of heavy metal levels by the NSW Environment Protection Authority. A total of 13 bass were collected for analysis from the upper Macleay River. Each fish was analysed for metal content, with the data compared to 'maximum levels' and 'generally expected levels' set by *Foods Standard Australia New Zealand.* The results showed that the levels detected in the samples, complied with the standards set and were found to be safe for human consumption.

3.3 *Geomorphology and Hydrology*

Geomorphology

Note: The following information has been largely extracted from an unpublished Department of Land and Water Conservation report by Telfer (2001). The report was focused on sand and gravel extraction and targeted the area between Toorooka and Sherwood bridge crossings (which geographically mirrors the present day "study area").

A broad scale geomorphic assessment of the Macleay River catchment using the Riverstyles methodology (Ferguson *et al.* 1999) described the lower Macleay trunk as a gravel bed river with discontinuous floodplain exhibiting irregular and compound channel morphology. Features of the channel include long deep pools (up to several kilometres long and several meters deep) separated by low relief riffles (usually <1 m) with channel sediments ranging from large gravels to cobbles and boulders (>1.5 m b-axis), refer Figure 4.

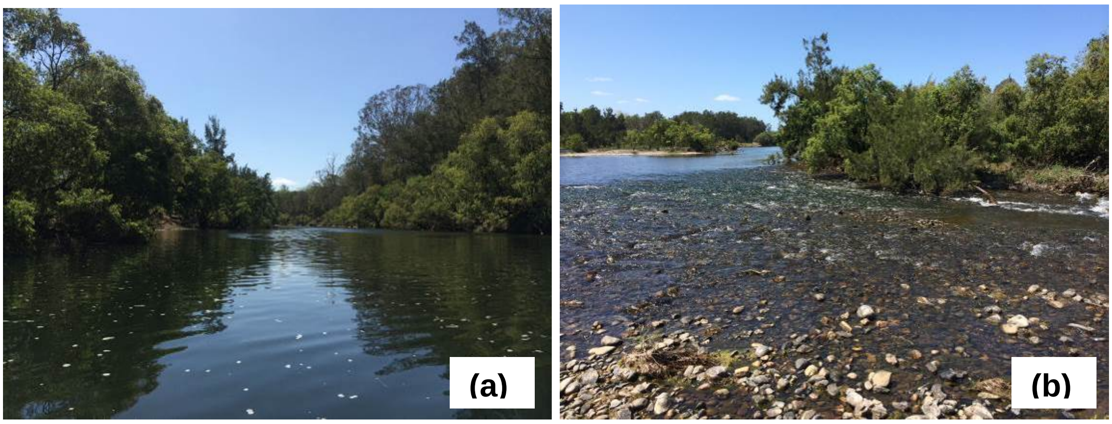


Figure 4: Examples of (a) refuge pool and (b) riffle.

The channel is regularly pinned to bedrock valley margins with inside bends characterised by gravel point benches and bar complexes, often with extensive floodchutes. In their natural state, these benches would be well vegetated with Bottlebrush, River She-Oak, Sandpaper Fig and Lomandra. However, many of the benches and low terraces are now either pasture, or bare giving a stripped appearance. Coarse woody debris loading is low relative to channel capacity.

Field investigations undertaken in 2001 allowed more intensive assessment of the river reach characteristics and found the following:

- The predominance of bedrock within the channel means lateral migration of the channel is unlikely and instead the floodchutes and low terraces form the primary mechanism for energy dissipation within the channel, along with sediment loading and vegetative roughness. Reducing the sediment load of the system (through inappropriate levels of extraction) and/or the vegetative cover on the point bar/lateral bar/bench complexes will increase the available energy within the channel for any given flood event.

- Given the lateral migration is restricted by bedrock, extra stream energy will need to be dissipated upon the streambed, within the floodchutes, or from terrace deposits by sourcing sediment (i.e. stripping). In areas of bedrock control, it could be predicted that floodchutes would lower at an accelerated rate potentially resulting in channel avulsions. In areas where bedrock does not control riverbed levels, bed lowering could occur resulting in band instability, sedimentation, loss of alluvial lands, and impacted ecological processes.

The compound channel structure is common throughout the study area. The bar/bench/floodchute complexes are important for geomorphic stability of the lower Macleay River and in many cases are important ecological units in the landscape. Floodchutes in particular often result in backwater features and may periodically hold water after flooding.

Rock bed controls occur frequently in the upper reaches of the study area and therefore there is limited opportunity for extensive bed lowering to occur.

Figure 5: Downstream of Turners Flat.

During field assessments, Toorumbee Creek appeared to be contributing significant quantities of course sediments in the Macleay trunk stream. It was also noted that Nulla Nulla Creek (upstream of the study site) was also contributing finer gravels of significant enough quantity to form a tributary mouth bar at the confluence with the Macleay.

Riffle features are generally regularly spaced and in most cases appeared stable. Notable exceptions were:

- at the downstream end of the Corangula Bend where overall channel stability was low and a large sediment slug is depositing over an existing island, and

- at the commencement of the Mooneba Bend (in the vicinity of Rose's and Mainey's extractive operations) where the channel is significantly over-wide, resulting in mid-channel island development and associated channel responses (i.e. poor channel definition and bank instability).

Flooding in 1999 resulted in limited replenishment of extracted gravel bars and benches. Few fresh gravel deposits within the Macleay trunk stream were noted with the exception of a chute upstream of Stoney Creek, a bench area upstream of Temagog Bridge, and several small dumps in the vicinity of the Corangula Bend.

A more recent report by Alluvium (2012) re-assessed the River Styles of the Macleay River and concluded that the current study area is in moderate geomorphological condition and has moderate recovery potential. This information forms an important part of the background to the current study, but does not affect the prioritisation process as the entire study area was classed as a homogenous unit.

Hydrology

The Macleay River is an unregulated waterway dominated by low flows. There is one flow gauging station being serviced on the Macleay River by the NSW Office of Water (Macleay @ Turners Flat, 206011). The gauge is located within the study area, 18 km upstream of Belgrave Falls. A flow duration curves for these gauges is shown in Figure 6.

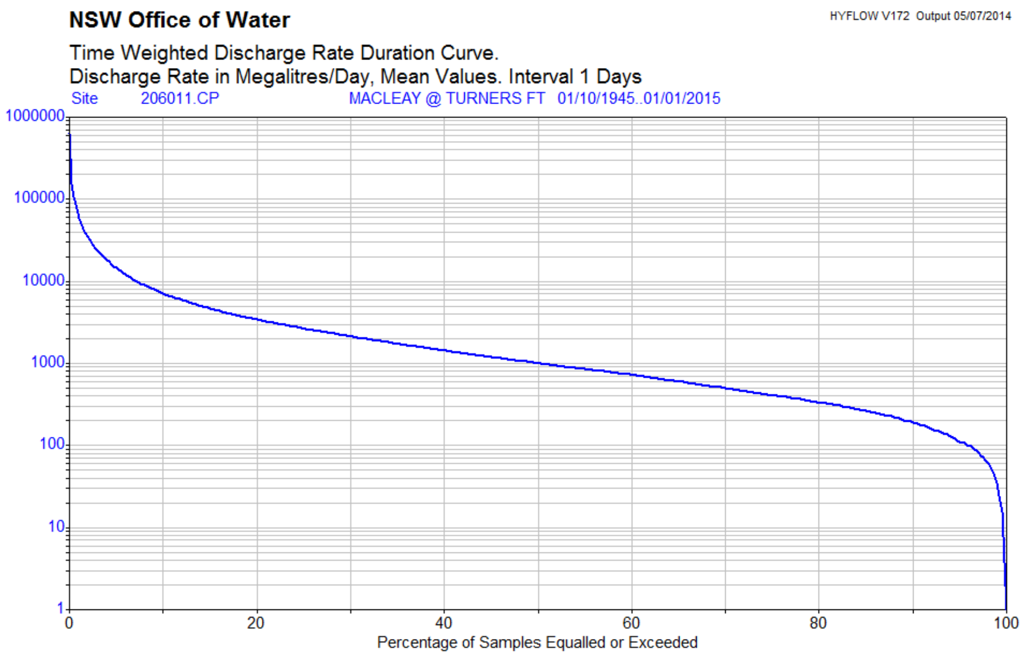


Figure 6: Flow duration curves – Macleay River, 1945 - 2013. **Source: NSW Office of Water.**

An analysis of the flow data showed that 90 per cent of all recorded daily discharge was less than 7,000 ML/day. Discharge in the Macleay tends to be summer/autumn dominant with the highest average discharge in February and March and the lowest in spring. Flood flows are characterised by steeply ascending and descending limbs and can reach discharge levels above 500,000 ML/day, reaching 750,000 ML/day in the 2001 flood (see Figure 7).

At the time of field work (29th Sept–3rd October 2014), the stream water level as recorded by NSW Office of Water at the Turners Flat gauging station was -0.21 metres and the daily discharge was 320 ML/day. Both indices continued to fall over the following month. These figures indicate that the river level in the Macleay was relatively low and discharge was within the lowest 20th percentile (see Figure 7).

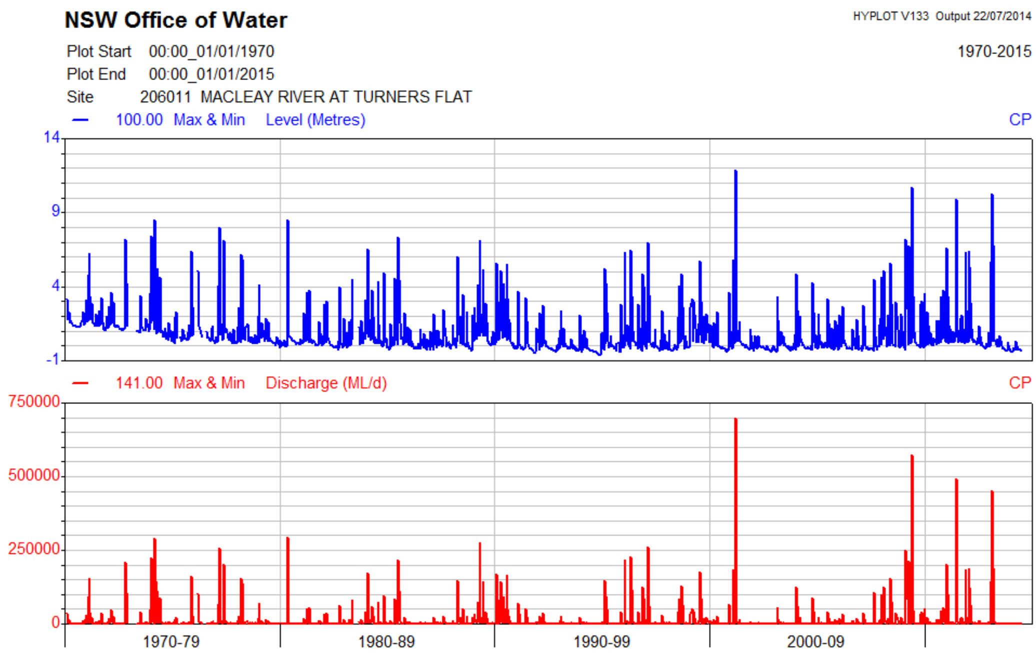


Figure 7: Peak flows in the Macleay River, 1970 - 2013. **Source: NSW Office of Water.**

Historic account

Colonial naturalist, explorer and surveyor Clement Hodgkinson travelled through the Macleay shortly after the commencement of European settlement (Hodgkinson 1844). The following description refers to the author's observations after travelling upstream from Kempsey and encountering Belgrave Falls.

"Directly the tide loses its influence in the river it ceases to be navigable any farther, even for small boats; and it now assumes the appearance of a rapid stream flowing over beds of shingles, a quarter of a mile wide, composed of pebbles of granite, limestone, beautiful crimson jasper, greenstone, basalt, quartz, &c.

The alluvial brushes on its banks are now frequently superseded by park-like forest ground, verdant rocky eminences, and luxuriant grassy flats of the greatest richness, lightly timbered with Apple trees, (<u>Angophora</u> <u>lanceolata</u>,) whose gnarled branches, and light green foliage, resembling that of the English oak, render it the most picturesque forest tree in Australia.

Several small tributary streams now begin to join the river. The first we meet, on the south side, is Dongai Creek. In the narrow valley of this stream, the land is of the richest quality possible, consisting of a narrow border of alluvial flats, covered with broad-bladed grass, growing breast high, and with a few large blue gum trees scattered so far apart as to offer no impediment to immediate tillage. All the squatters on this stream have, in consequence, brought patches of ground under cultivation.

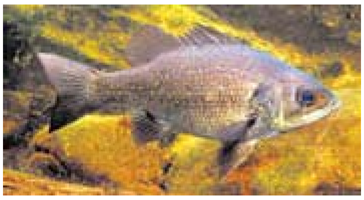
Dongai Creek is hemmed in on both sides by fertile ranges, well clothed with grass, and lightly wooded; apple trees being the predominating trees on their lower slopes. The scenery is often very pleasing; the ranges rise in smooth round cones, and their sloping sides, covered with bright green verdure, contrast strongly with the dark glistening green of the brush vegetation which occasionally invades some of the hills.

The stream itself, of crystal brightness, rushes rapidly through the glen, over a bed of large pebbles, and frequently forms diminutive cascades over opposing rocks; this, with the magnificent trees, and beautiful flowering creepers, forming natural arches, with a glimpse of distant hills, softened and blended with the deep azure of an Australian sky, cannot fail of affording gratification to anyone who can admire nature unadorned by art…

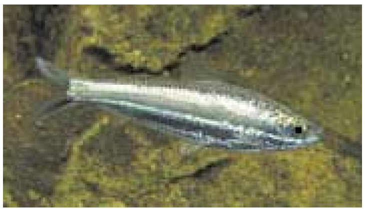
…The soft slaty ranges just mentioned, are very general in the basin of the MacLeay, especially on the south side of the river, the strata form a considerable angle with the horizon, and their edges are almost in every instance more than usually disintegrated and decomposed, forming, in consequence, a rich loose soil, on which the grass is generally comparatively better than on ranges of other formations. The clay-slate ranges rise in smooth, round, waving summits; they are not in general thickly wooded, and would be pre-eminently suitable for the growth of the vine".

3.4 Freshwater fish of the Macleay River

Native species:


Australian Bass
Macquaria novemaculeata


Cox's Gudgeon
Gobiomorphus coxii


Freshwater Herring
Potamalosa richmondia


Australian Smelt
Retropinna semoni


Dwarf Flathead Gudgeon
Philypnodon macrostomus


Freshwater Mullet
Myxus petardi


Blue Catfish
Arius graeffei


Empire Gudgeon
Hypseleotris compressa


Long-Finned Eel
Anguilla reinhardtii


Bullrout
Notesthes robusta


Flathead Gudgeon
Philypnodon grandiceps


Olive Perchlet
Ambassis agassizii


Common Jollytail
Galaxias maculatus


Freshwater Catfish
Tandanus tandanus


Oxleyan Pygmy Perch
Nannoperca oxleyana

Sea Mullet
Mugil cephalus

Southern Blue-Eye
Pseudomugil signifier

Short-Finned Eel
Anguilla australis

Striped Gudgeon
Gobiomorphus australis

Bullshark
Carcharhinus leucas

Exotic species:

Brown Trout
Salmo trutta

Gambusia
Gambusia holbrooki

Rainbow Trout
Oncorhynchus mykiss

Common Carp
Cyprinus carpio

Goldfish
Carassius auratus

The freshwater fish species of the Macleay River are multiple and diverse. The Macleay is well known to recreational fishers as offering some of the premiere sportfishing opportunities to catch Australian Bass in the country.

While Common Carp are known to inhabit the Macleay, it is of interest to note that none were observed in the study area throughout the sample period.

Bullsharks have been reported by a number of local residents as making their way well up into the freshwater reaches of the Macleay. They give birth in the freshwater and the young develop in the river before making their way downstream to the ocean. Freshwater attacks on humans have rarely been recorded.

The present conservation status of these species in NSW is listed at:
http://www.dpi.nsw.gov.au/fisheries/species-protection/conservation/what-current

4. Methodology

4.1 Habitat Mapping

Habitat mapping involved canoeing the length of the nine reaches and manually entering data using a handheld Trimble PDA (Personal Digital Assistant) with GPS/GIS interface to plot habitat features and record issues throughout the study area. Following some on-water trials, it was found that the study area was impractical to navigate in a larger boat, due to the low water levels encountered at the time of survey. Numerous riffles and emergent rocks prevented safe travel at reasonable speeds. As a result of its bulk, the side scan sonar unit was not able to be fitted to the canoe for subsurface habitat mapping and depth assessments.

At the time of mapping the visibility in the Macleay River was good (around two metres), making it possible to identify in-stream features such as snags, macrophytes and substrate type, beneath the surface of the water.

The PDA devices (Tripod Data Systems Nomad PDA with GPS and GIS interface software ArcPad) enabled the digitisation of all information necessary to record habitat features and condition in both aquatic and riparian areas along the river corridor. Table shows the typical features that were recorded during habitat mapping using three spatial feature classes: point, line and polygon.

Table 2: Data recorded on PDA.

Point Features	Line Features	Polygon Features
Woody debris (snags) – alignment, complexity, width, length	Existing fence lines	Native riparian vegetation – species, condition & extent
Pump sites	Vehicle access	Exotic riparian vegetation – species, condition & extent
General points of interest. e.g. gravel extraction, boat launch sites, recreation		Aquatic vegetation – species & extent
Fish barriers – barrier type, head loss		Bank erosion – slumping, scouring and undercutting
		In-stream features – sediment inputs, point bars, riffles, refuge pools

To improve the efficiency and standard of data collection, a unique scripting code was developed by NSW DPI technicians to provide prescribed data entry menus specific to project requirements. This enabled all essential attributes for each recorded feature to be entered into the spatial database at the time of data collection.

4.2 Decision Support System

A Decision Support System (DSS), developed by NSW DPI to determine reach scale conservation management priorities, was employed to assess individual habitat features on an individual management reach basis and was scored based on the overall health of those reaches.

4.2.1 Reach grouping and ArcMap Toolbox

The first stage of the DSS involved dividing the Macleay River study area into nine management reaches (each 5.2 kilometres in length) in ArcMap by grouping the attributes and splitting the relevant segments of the river line feature class (see Figure 1). This management reach scale limits the potential for introducing masking issues that may influence a reach condition score and allows effective, targeted threat management and habitat protection activities.

The second stage of the DSS involves a suite of tools in the ArcMap Toolbox, developed by NSW DPI, containing a series of comprehensive scripts (six in total). These tools use Python programming language to automate the interrogation of ESRI feature classes and identify and summarise individual habitat features by management reach.

The tool firstly runs through the river line feature class in ArcMap and consecutively numbers the management reaches, prompting manual correction in the event of gaps in the spatial data. All data points in each habitat feature class being interrogated are assigned the relevant reach number (involving conversion to point feature classes and/or snapping to the river line feature class), then summarised by reach and tabulated. This tabulation is then exported into a series of tab delimited text files, which in turn are manually imported into the Microsoft Excel® based Prioritisation Module. The format of data output for each habitat feature class is shown in Table 3.

Table 3: Format of data output from the ArcMap Toolbox as used in the prioritisation process.

Habitat Feature Class	Output Format
In-stream refuge holes	Number, Depth, Surface Area
Large Woody Habitat (snags)	Number, Width, Length, Complexity
Native riparian vegetation	Total area coverage
Exotic riparian vegetation	Total area coverage
Bank erosion	Number, Area
Stock damage	Number, Area

4.2.2 Prioritisation Module

The final stage of the DSS involved the development of a Microsoft Excel® based Prioritisation Module to determine conservation and management priorities. Outputs from the ArcMap tool and manual data collation were imported into the Prioritisation Module for individual habitat features for each 5.2 kilometre management reach.

The total bank area within each management reach was calculated to be 20.8 hectares, based on a 20 metre corridor along both banks of the river. The use of corridors of a uniform size enabled each individual reach to be directly compared to the other reaches for assessment and ranking purposes.

A prioritisation scheme was then developed to assist in ranking both individual habitat features and overall reach condition. The scheme helps determine priorities by ranking each reach based on the following categories:

- Refuge pools = number x pool depth x pool area
- Snags = number x length x complexity
- Native canopy species = total extent (hectares)
- Exotic plant species = total extent (hectares)
- Bank erosion = total extent (hectares)
- Stock damage = total extent (hectares).

Treatment of habitat features for prioritisation

Data for habitat features differ in terms of type and scale (that is, unit and magnitude). Variables measured at different scales will not contribute equally to the analysis For example, snag data which were collected as a function of their number, size and complexity had a score per management reach ranging from 10 to 455; these will outweigh exotic plant species, erosion and stock damage that was collected in area units, typically ranging in magnitude from 0 to 2 hectares. Standardising the data to comparable scales can alleviate this issue by equalising the range of the data.

Data were standardised in the prioritisation module to have a mean of 0 and standard deviation of 1 by the function: (value – mean)/standard deviation so that comparison of spatial trends in the parameters could be made on the same scale, then weighted according to relative influence of the habitat feature on protection and rehabilitation priorities as follows:

$$HabitatFeatureScore_{Weighted} = \frac{(habitatfeaturetotal - mean)}{StDev} \times Weight$$

where *habitat feature total* is the sum of habitat features within each management reach.

The habitat feature scores (weighted) were then combined to generate reach condition scores in terms of overall health and condition. Reach condition scores were subsequently ranked and coded into three groups - better health, moderate health and poorer health - based on the reach condition score and the number or extent of various habitat features.

5. Landholder Liaison

Letters were sent on 6 August 2014 to over 100 landholders along the study site informing them of the aims and objectives of the project and that NSW DPI staff would be in the area during the following weeks for the purpose of mapping the river (see Appendix B).

As a result, a number of landholders contacted NSW DPI expressing an interest in the project and particularly with respect to any follow-up funding for riparian fencing, tree planting and weed control.

6. Results and Discussion

The habitat feature dataset developed through the habitat mapping fieldwork was processed to identify conservation and management actions for priority reaches to assist natural resource managers and landholders to make strategic decisions about investment in on-ground works. The DSS provides a ranking of reaches based on their overall reach condition scores.

The main drivers for setting priorities included the available in-stream habitat for native fish (particularly deep holes and snags) plus other key features that impact on habitat values including riparian condition, exotic weeds, bank erosion and stock damage. In many other areas, barriers to fish passage provide another key feature for analysis; however, in our study area no artificial barriers to fish passage were encountered.

The measures necessary to protect and rehabilitate aquatic habitat condition on the priority reaches, as generated through the DSS, can be determined by interrogating the relative impact of individual habitat feature scores. These can provide natural resource managers with a clear direction on how to proceed with aquatic and riparian habitat protection and restoration initiatives.

A map of each management reach containing the main habitat feature data as recorded and assessed as part of this report is presented in Appendix A.

6.1 Riparian vegetation condition

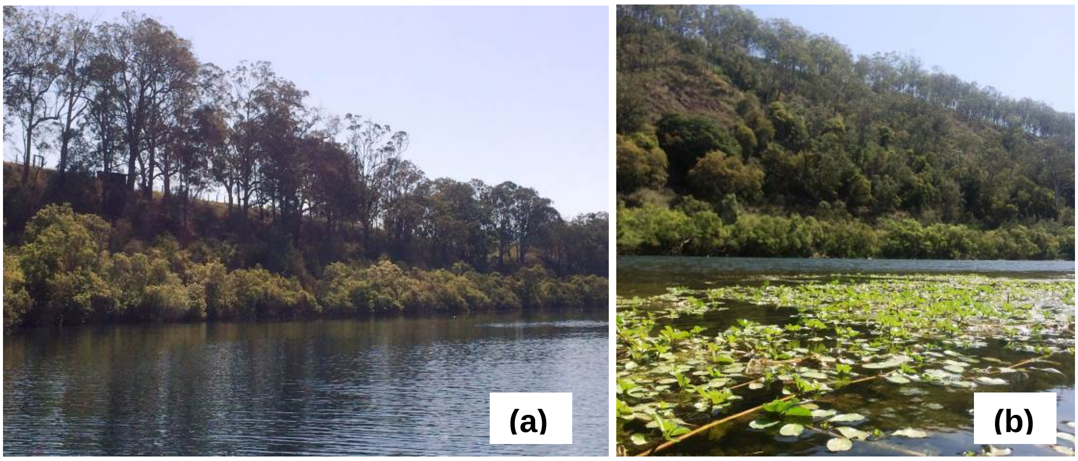


Figure 8: (a) Typical good condition riparian vegetation with Callistemon along the edge and Eucalypts set further up the bank. (b) Water primrose is visible in the left foreground.

Riparian vegetation condition was variable throughout the 20 m buffer study area ranging from healthy, intact areas to quite degraded stretches that were devoid of canopy cover combined with eroding banks and dominated by exotic plant species. Figure 8 shows examples of sites with good riparian vegetation and in-stream emergent vegetation.

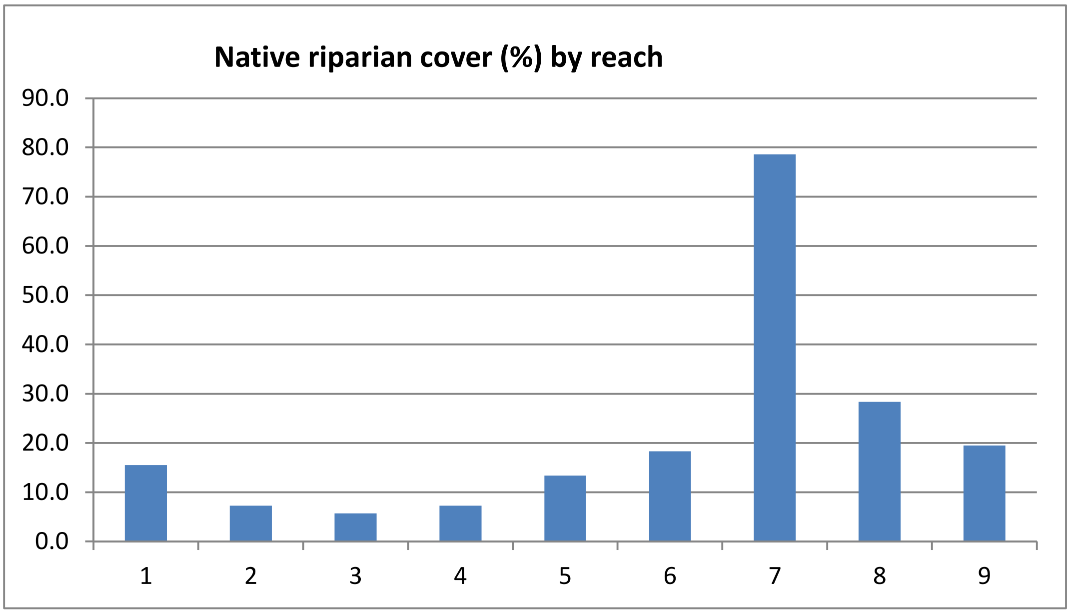


Figure 9: Percentage cover of native riparian vegetation by reach.

The presence of overhanging Callistemon along many banks provided bank stability, shading (temperature control), predator protection (amongst roots and submerged overhanging branches), as well as a food source for aquatic species. These include aquatic invertebrates feeding on the root/branch biofilms and fish which feed on these invertebrates or terrestrial insects that fall into the water from overhanging branches.

As Figure 9 indicates the average native vegetation cover across all reaches in the study area was 21.5%. Reach 7 had the largest single proportion of native riparian vegetation (78.6%); while Reach 3 had the smallest (5.7%).

It should be noted that the above figures for riparian cover are affected by some other variables associated with the mapping and prioritisation processes. Areas with native riparian cover that had scatterings of exotic vegetation were also classed as “exotic” for prioritisation purposes (however, these are shown as “native & exotic mix” on the attached maps).

For the observers undertaking the fieldwork, the condition of the river in many parts appeared to be ‘better’ than has been recorded here. The use of a 20 m buffer was critical in determining priority areas, as the use of standardised reach lengths was used to compare and contrast each reach against the others. However, this method precluded the use of the remaining visible riparian zone beyond 20 metres. Large patches of good condition vegetation that could be seen beyond the 20 metre zone were unable to be incorporated in the prioritisation, hence leading to the perceived discrepancy. For completion, these areas are also clearly detailed on the maps.

Some sections of river bank had substantial groundcover and were observed to be in a relatively stable condition with limited erosion in spite of seemingly unfettered access by livestock, mainly cattle, in those areas. This may be partly the result of the bedrock, cobble and gravel base that was commonly observed throughout the study area.

The recommendations outlined below relating to managing livestock access to the riparian zones, will provide the opportunity for native vegetation to regenerate naturally once grazing and trampling pressure is reduced in these areas. Revegetation works are not recommended for most reaches of the study area, although some opportunities may exist further downstream. This would depend upon landholder willingness to control stock movement and provide close monitoring and maintenance of any plantings through a formal management agreement or riparian grazing plan.

6.2 Exotic plant species

Figure 10: Willows present on the riverbank.

A wide variety of exotic plant species, including Willows (Figure 10) were identified throughout the study area as a result of the habitat mapping. Table 4 lists the main species of exotic plants identified and their declaration status for the Kempsey Shire Local Government Area and/or Weed of National Significance.

Table 4: Exotic plant species identified during the fieldwork.

Common name	**Scientific name**	**Kempsey Shire status**
Tobacco Bush	*Solanum mauritianum*	Not listed
Castor Oil Plant	*Ricinus communis*	Not listed
Cat's Claw Creeper	*Dolichandra unguis-cati*	Class 4
Madeira Vine	*Anredera cordifolia*	Class 4
Lantana	*Lantana camara*	Class 4
Willow (Weeping, Black)	*Salix spp.*	Class 2
Paper Mulberry	*Broussonetia papyrifera*	Class 2
Cockspur Coral Tree	*Erythrina crista-galli*	Class 3
Poplar	*Populus spp.*	Not listed
Privet (Large, Small-Leaf)	*Ligustrum spp.*	Class 4
Camphor Laurel	*Cinnamomum camphora*	Class 4
Mexican Poppy	*Argemone spp.*	Class 5

For prioritisation purposes and following consultation with North Coast Local Land Services and Kempsey Shire Council weed staff, it was decided that exotic weeds would be defined as those species that were identified as belonging to Classes 1 – 4. These are the species requiring the most attention given their recognition in the legislation.

In addition to these species, considerable effort was invested searching for Tropical Soda Apple *(Solanum viarum*). However, no plants were subsequently identified during the fieldwork. The previous season had seen considerable control efforts made along the Macleay from where it had first been identified the year previously. The timing of the fieldwork in late September may have been too early in the season to observe any emerging individuals of this Class 1 exotic weed.

Cat's Claw Creeper was distributed across the study area and was highly visible due to prolific flowering during the fieldwork (Figure 11). In addition to the (unexpected) lack of Tropical Soda Apple, no Morning Glory was observed and just a single example of Madeira Vine. There were two Black Willows (*Salix nigra*) noted and increasing occurrences of Lantana, Castor Oil Plant and Tobacco Bush in travelling further downstream.

Figure 11: Cat's Claw Creeper smothering native riparian vegetation along the Macleay River.

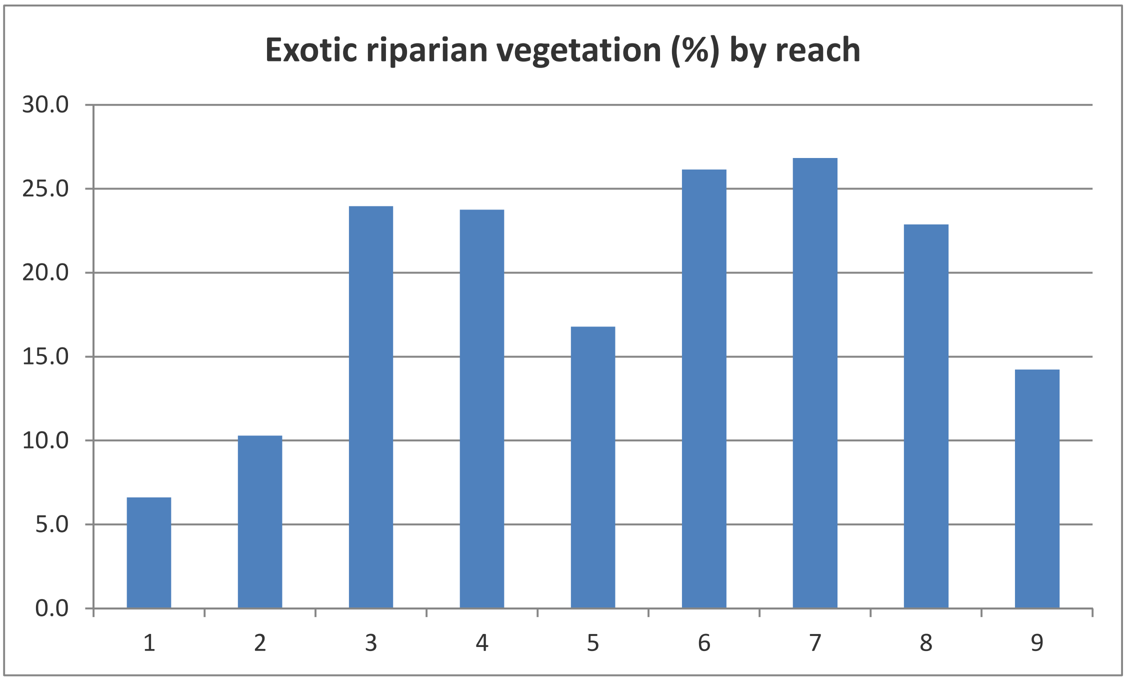


Figure 12: Percentage cover of exotic riparian vegetation by reach.

On average 19.1% of the study area had exotic vegetation cover. As mentioned previously, much of this was identified as a mixture of native & exotic species. For other projects undertaken using similar methodologies, this result can be compared to other regions such as the Macquarie River downstream of Burrendong Dam which had 33.2% exotic cover (NSW DPI 2010). The Horton River (SW of Inverell) had an even lower density with 8.75% of that study area possessing coverage of exotic weeds (NSW DPI 2013).

In general within the current study area, the percentage coverage of exotic vegetation tended to increase further downstream. Reach 1 had the lowest percentage area of exotic species with 6.6%, whereas Reach 7 had the highest with 26.8% exotic coverage. Targeted weed control programs could offer some significant benefits in these particular identified areas.

It is therefore recommended that an awareness program be conducted in collaboration with Local Government and landholders to actively treat these weeds along the length of the study area.

6.3 Large Woody Habitat (Snags)

Figure 13: In-stream snags.

Large Woody Habitat (LWH) is a major ecological and structural element of many Australian waterways and provides valuable habitat for aquatic and terrestrial species (Figure 13). In-stream LWH provides spawning sites, shelter and resting places and territorial markers for several species of native fish. In many cases, LWH assists in developing scour pools and preventing erosion through bank stabilization. As the wood breaks down it provides food for benthic algae, invertebrates and microorganisms that form the basis of the food web.

Availability

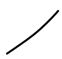
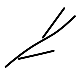
LWH loading was recorded throughout the study area to identify the availability of in-stream woody habitat to aquatic fauna. Details recorded included the number, size, complexity (the more complex the greater the fish carrying capacity) and orientation of each LWH. In the 47 km of river channel that was surveyed, a total of 76 large woody habitats were recorded, resulting in an average of 1.62 snags per kilometre. In comparison with results of assessments using similar methods elsewhere, the Horton River (western drainage NSW) had an average of 4.84 snags per kilometre and the Macquarie River had 9.75 snags per kilometre. Compared to these other two river systems, the study area is relatively poor in LWH.

Complexity

There is an ecological basis for differentiating large woody habitat based on size and complexity (Boys *et al.* 2013). More complex snags provide greater protection to aquatic fauna from predators and flow, are more useful as breeding sites and have a greater influence on the creation and maintenance of refuge habitat.

Table 5 shows examples of snags with varying complexities. The more complex a snag is the more ecological benefit it has to the aquatic environment.

Table 5: Structural complexity classes used to describe LWH (Hughes 2001).

Description	Examples		Class
A single trunk or branch: a root mass or small part of a branch may be present.			1
Double trunk or branch or single trunk with one level of branching for most of the length.			2
Trunk with multiple branches for most of length, with 2nd level of branching present			3
Complete tree with extensive branching or an accumulation of large wood in which individual pieces could not be resolved			4

This basis has been used in the prioritisation process, with a snag score calculated for each reach. This score has been based on the function of the number of snags per reach, their complexity and their overall length. The results are shown below:

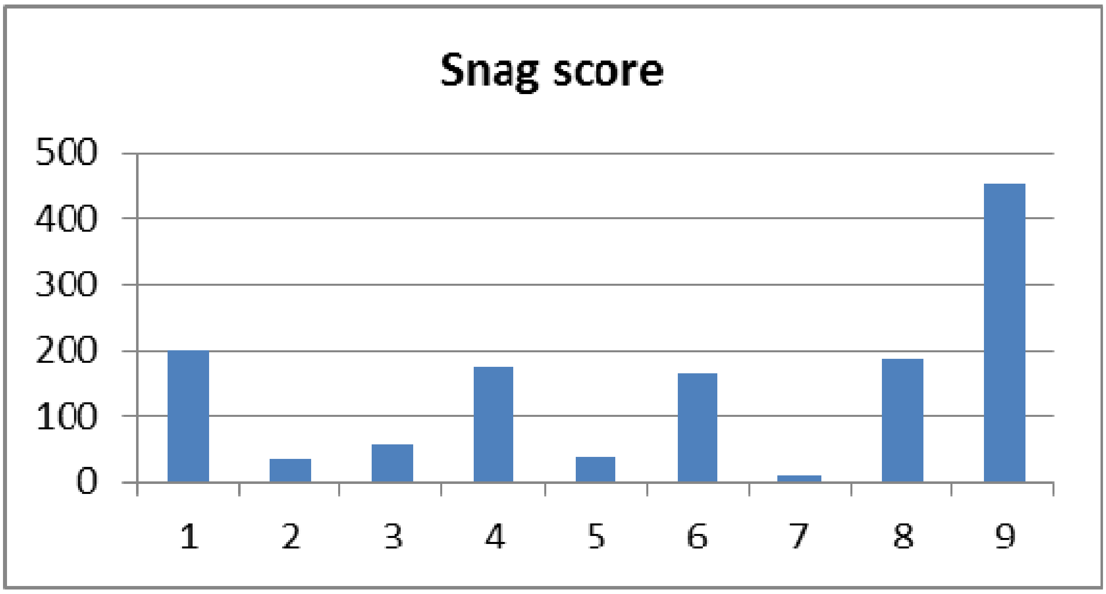


Figure 14: Snag score by reach

Figure 14 shows the generated measure of LWH value across the study area. The reach with the outstanding score is Reach 9 which had a number of large, highly complex LWH in comparison to other reaches upstream.

Reaches 1, 4, 6 and 8 formed another cluster with moderate LWH values. The remaining Reaches 2, 3, 5 and 7 all displayed relatively poor values for snag habitat features.

Table 6: Number of snags within each complexity class.

Complexity	**Class 1**	**Class 2**	**Class 3**	**Class 4**
No. of snags	45	19	7	5

Table 6 indicates that the majority of snags present throughout the project area have minimal complexity, comprising of only one or two branches and having reduced value to in-stream aquatic fauna.

6.4 Drought refuge pools

Figure 15: Drought refuge pool.

Thirty eight refuge holes were identified along the 47 km study area (Figure 15). For the project, they were defined as being those bodies of water in excess of two metres depth.

The refuge scores in Figure 16 are a function of the total number of refuge pools, the deepest depth recorded in each pool and the surface area of each pool. As the chart shows, Reach 3 had the greatest overall value as refuge habitat. This was driven by a relatively large number of pools (10, as compared to the average number per reach of 4.2) and the large cumulative surface area. Moderate values were returned by Reaches 5, 6, 7 and 9. The refuge pool values for Reaches 1, 2, 4 and 8 were relatively modest in comparison.

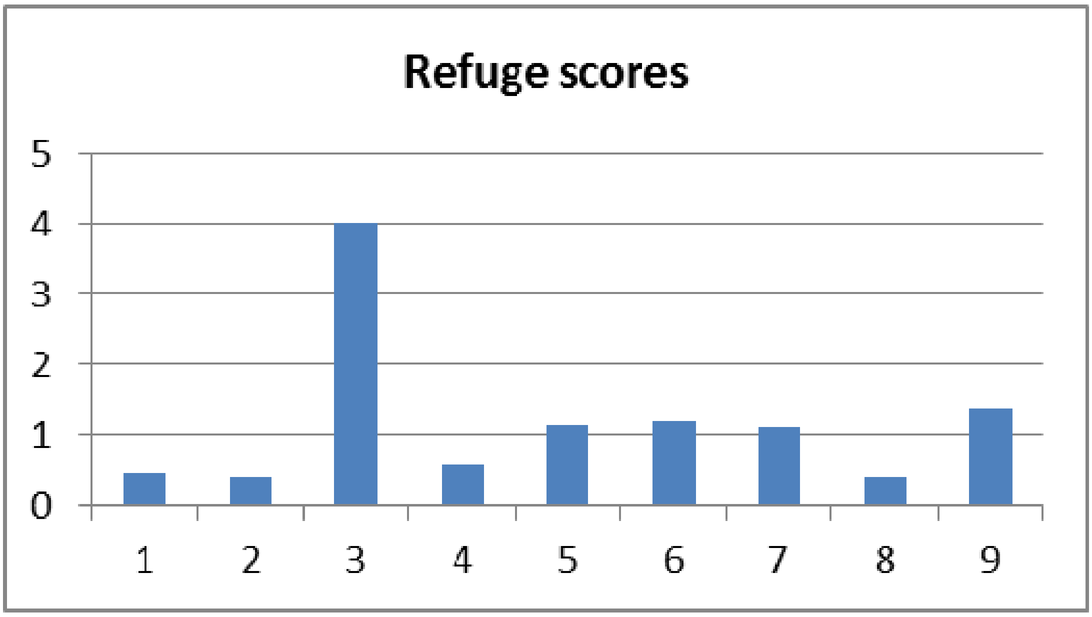


Figure 16: Refuge scores present by reach.

Drought refuge (Figures 15 and 17) is an essential habitat feature in determining protection and rehabilitation priorities and is weighted accordingly.

Resident populations of aquatic species cannot survive through extended dry periods without refuge habitat, which could lead to local extinctions of these species.

Figure 17: Drought refuge pool.

6.5 Aquatic macrophytes

Various species of floating, attached, submerged and emergent aquatic macrophytes were found throughout the study area during the course of the fieldwork including:

- Pondweed (*Potamogeton spp.* including *P. perfoliatus* and *P. crispus*)
- Water Milfoil (*Myriophyllum spp.*)
- Ribbonweed (*Vallinseria nana*)
- Filamentous Algae
- River Club Rush (*Schoeneplectus validus*)
- Water Primrose (*Ludwigia peploides ssp. montevidensis*)
- Smartweed/Slender Knotweed (*Persicaria decipiens*)
- Sedges (*Juncus spp., Bolboshoenus spp*., *Scoenoplectus spp.*)
- Spiny-headed Mat-rush (*Lomandra hystrix*)

Filamentous green algae was observed throughout the study area indicating high nutrient levels, however growth never dominated or caused smothering of other species.

Submerged macrophytes also occurred throughout the study area, the most common being *Potomogeton spp.* which was observed growing in deeper water of refuge holes up to and including shallow pools (Figure 18).

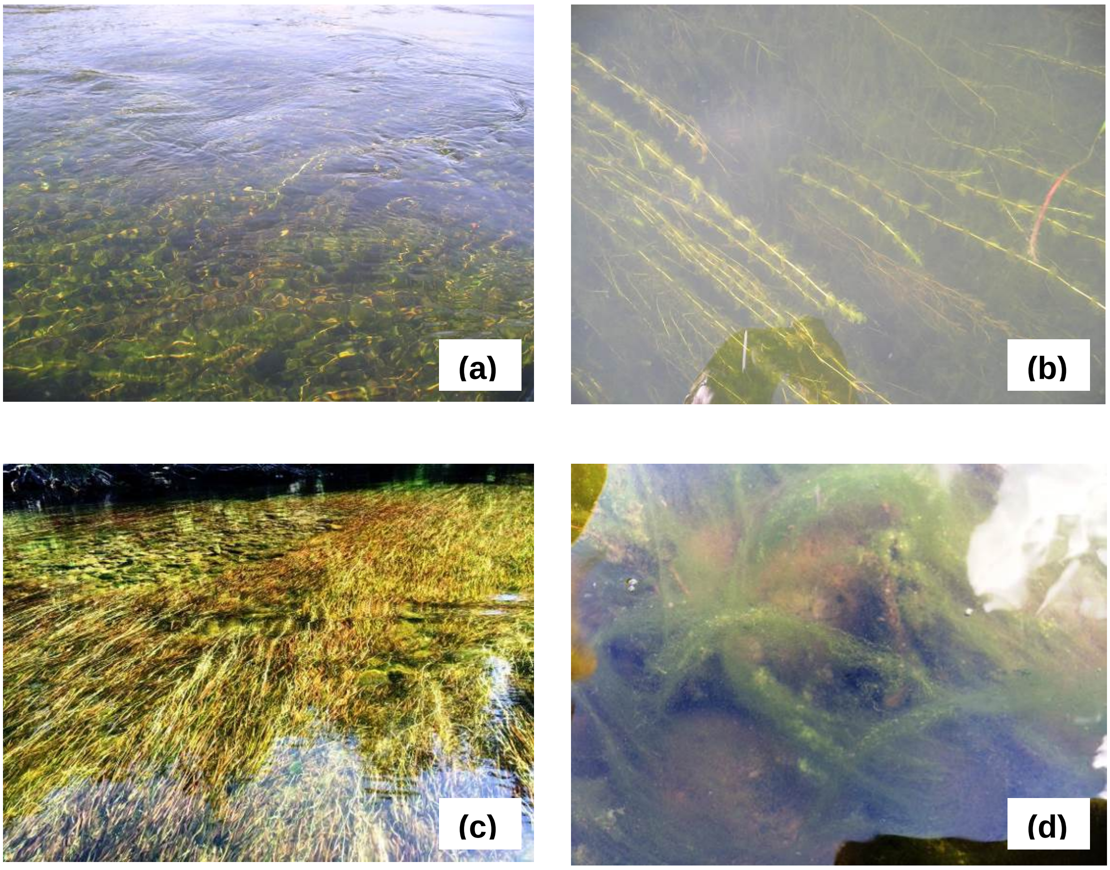


Figure 18: Submerged aquatic vegetation observed (a) likely Potomogeton perfoliatus bed, (b) mixed species including P. crispus and Myriophyllum spp., (c) Vallisneria nana bed with catfish nest in back left corner, (d) filamentous algae.

In shallower water (including within refuge holes) *Potomogeton spp*. mixed with *Myriophyllum spp*. to form dense beds, with *Myriophyllum spp.* sometimes dominating these areas.

In addition, *Myriophyllum spp*. and *Vallisneria nana* were also observed growing in and around riffle habitat where *V. nana* would often dominate.

Water Primrose was observed growing in occasional small patches. Fringe dwelling macrophytes such as rushes and sedges were observed growing along the water's edge in very small patches scattered throughout the study.

6.6 Livestock access and damage

Figure 19: Stock in the study area.

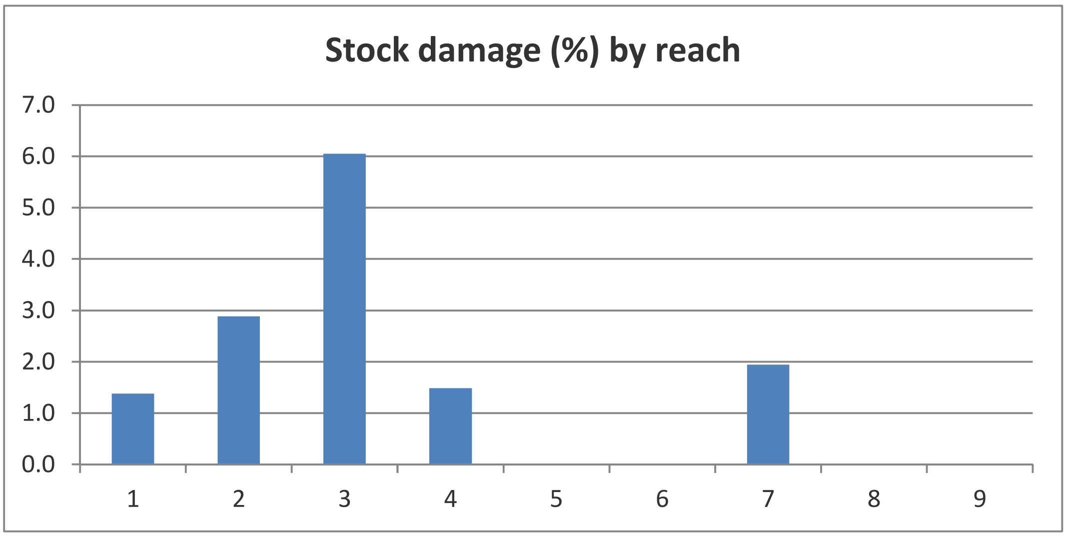


Figure 20: Percentage stock damage (erosion) by reach.

The level of visible stock damage was relatively low for most reaches with an average of 1.5% affected in some way. Reaches 5, 6, 8 and 9 had no visible stock impacts at all. Reaches 1, 2, 4 and 7 had some visible damage, but Reach 3 had the most significant impacts (6.1%) from stock being able to access the river bank (Figure 20).

In terms of stock access, it was observed that while the positive identification of stock exclusion fencing was often difficult (due to poor visibility behind vegetation or above cliff faces), even where fences were clearly present it was by no means unusual for stock to be seen in the river directly in front of the fencing, accessing riparian vegetation and the river banks (Figure 19).

Overall, the extent of bank instability and damage caused by livestock trampling throughout the study area appeared to be relatively low compared with that expected given the observed level of livestock access to the study area.

6.7 Erosion

Figure 21: Bank scour and slumping erosion with stock access tracks also present.

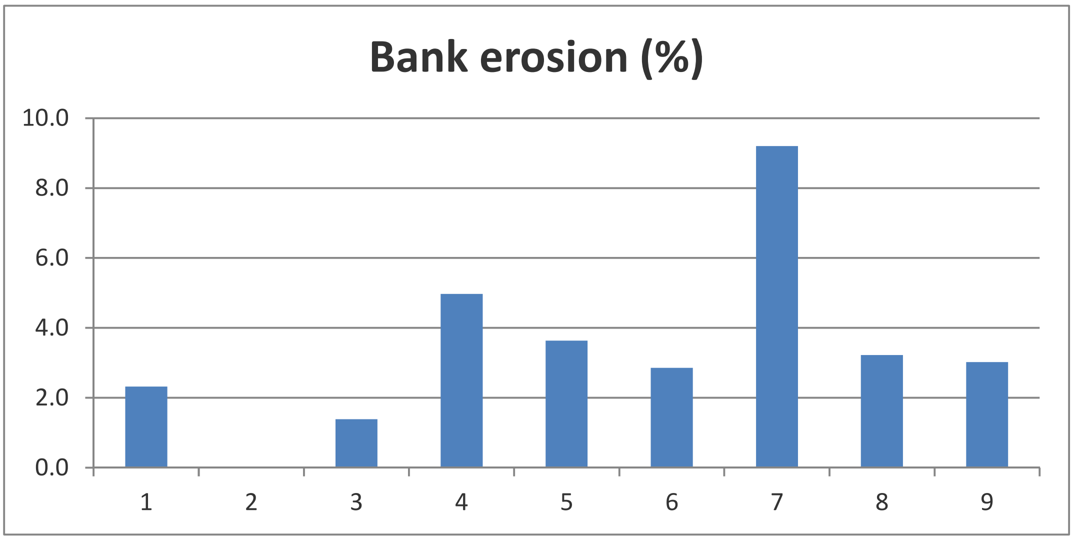


Figure 22: Percentage bank erosion by reach.

While most reaches had fairly low levels of erosion caused by factors other than stock access (an average of 3.4%), Reach 7 had 9% of its area affected by erosion (Figure 22).

In some areas, significant scouring and block failure was identified on the outside of large bends (see Figures 21 and 23). The likely causes for this type of erosion may be a combination of land clearing and changes in river morphology as a result of natural channel migration and/or induced channel migration due to changes in flow dynamics caused by artificial bed controls or flow training.

Figure 23: Erosion (slumping) on an outside bend.

6.7.1 Historic river 'improvement' works

Evidence of historic river control works were found in the form of concrete blocks (approximately 1 m^3) crossing the river or running parallel to it and connected by heavy duty steel cable (see Figure 24 a).

These were part of a river improvement works program (John Schmidt, pers. comm.) initiated after the 1950s floods, where a preferred channel width and direction were identified and then followed by removal of all impediments to that channel (including gravel bars, riparian vegetation etc). The concrete blocks and engineered cables were part of an attempt to realign the main channel at locations where flood chutes departed from it.

The cables were originally hung with bamboo mesh curtains interlaced with vegetation to divert water flows, but these washed away after their installation (Ron Kemsley, pers. comm.) (see Figure 24 b).

Figure 24 a: Concrete blocks mid-stream, an historic erosion control activity.

Figure 24 b: Configuration of concrete blocks, cables and vegetation screens.
Source: Ron Kemsley, Kempsey Shire Council

6.8 Gravel extraction

Evidence of gravel extraction was present at five locations within the study area (Reaches 1, 6, 7 and 9), however only one of these were operational at the time of the survey (Reach 1). The active gravel extraction site at Reach 1 was removing material from the floodplain of the left bank rather than from within the river channel. Water being pumped from the river channel to the work site was not resulting in sediment entering the adjacent waterway at the time of inspection.

6.9 Water extraction

Several stock and domestic pumps were observed throughout the study area, mostly related to residences adjacent the waterway. The highest number of small volume pumps were observed in Reach 6 (8 pumps), with Reaches 3 and 4 each having 5 pumps recorded; Reaches 5, 7 and 9 each having 4 pumps; Reaches 2 and 8 each having 2 pumps; and Reach 1 recording only 1 stock and domestic pump.

Only one pump was observed to be related to a commercial activity (gravel extraction, Reach 1), although this was only capable of removing relatively small volumes of water from the river (Figure 25a).

In addition, in Reach 9 at Belgrave Falls defunct large volume pipes and equipment were observed, which were the flood-damaged remains of the South Kempsey water main (Figure 25b). A new mains pipe has since been drilled to pass under the bed of the Macleay (Ron Kemsley, pers. comm.)

Figure 25: (a) Small domestic pump, (b) remnants of old water main pipe at Belgrave Falls.

6.10 Fish passage

While many other river systems are affected by blockages to fish passage (road crossings, weirs, dams and floodgates etc.), the study area was found to be unaffected by this issue.

The rest of the mainstem Macleay River is also lucky enough to lack man made fish passage barriers, however 11 road crossing barriers, 3 weirs and 11 unmodified floodgates are present on named and unnamed tributaries within its catchment (Industry & Investment, 2009). Of these barriers, one affects a tributary upstream of the project site (MACL008R), Scotchys Creek causeway. A ford road crossing on Hickeys Creek (MACL0015R) and weir on Mungay Creek (Mungay Creek Weir 6) will impact on fish movement within these tributaries. Two other barriers (Hickeys Creek Weir 2 and Mungay Creek Weir 8) are present in the upper catchment and will have less impact on fish movement compared to their downstream counterparts.

6.11 Fauna observations

Figure 26: Circular gravel nest of Freshwater Catfish (Tandanus tandanus) in a shallow pool.

Some observations from the field work that have not been documented elsewhere in this report, include the following:

- No Common Carp (*Cyprinus carpio*) were observed.
- Macquarie Freshwater Turtles (*Emydura macquarii*) were seen in every reach.
- White-Bellied Sea Eagle (*Haliaeetus leucogaster*) adults, juvenile and nesting sites were seen on each reach.
- Freshwater Catfish (*Tandanus tandanus*) nests were present in many shallower areas of reaches – particularly in shallow pools or in shallower sections of refuge holes (Figure 26).
- Water Rat (Hydro*mys chrysogaster)* evidence in the form of piles of live mussel hoards stashed on the bank near deep holes was not an unusual occurrence (Figure 27).
- Schools of Freshwater Herring (*Potamalosa richmondia*) were often seen leaping from the surface of the water.
- Black Swans (*Cygnus atratus*) and their young cygnets were noted in each reach.
- Pelicans (*Pelecanus conspicillatus*), Shags and Cormorants (Family *Phalacrocoracidae*) were often noted adjacent to shallow riffles.

Figure 27: Freshwater Mussel hoard (Family Unionidae) – indication of Water Rat activity.

7. Management reach assessments and recommendations

7.1 Priority Management Reaches

Overall the study area appeared to be in good – very good condition; based on the riparian and in-stream habitat condition that was observed within 20 metres of the riverbanks. Each reach had numerous deep refuge holes separated by riffle-run sequences, consistently large and dense areas of healthy in-stream vegetation and areas of good quality overhanging native riparian vegetation.

Each reach also had some in-stream timber snags to provide refuge for aquatic species, although the number and complexity of timber was relatively low.

Bank erosion resulting from stock and other processes occurred throughout the study area, with stock damage noted as being greater in the upstream Reaches (1-4), while bank slumping and scouring was noted as being greater in the downstream Reaches (3-9).

Low levels of filamentous algae were noted in all reaches, indicating a higher level of soluble nutrients in the water, but its growth did not appear to smother in-stream native vegetation or reduce its growth potential.

Water clarity was consistently high throughout the study area, perhaps as a result of the low flows being experienced in the waterway at the time of the survey.

Riverbanks were predominantly vegetated, with only small localised areas dominated by pasture (the largest areas being in Reaches 8 and 9).

The presence of overhanging callistemon along most banks provided bank stability, shading (temperature control), predator protection (amongst roots and submerged overhanging branches), as well as a food source for aquatic species.

Exotic species were also present throughout the study area, but generally did not form large exotic-only stands. Exotic species were often dispersed amongst native vegetation – e.g. mulberry, tobacco bush, but sometimes did comprise the majority of the understory (e.g. lantana on higher sloping ground).

Figure 28 indicates relative ranking of the nine Reaches – those which have a positive value are ranked higher than those with negative values.

Reaches 9 and 3 were identified as the two sections in the best overall condition and hence recognised as the highest priorities for future enhancements to maintain their integrity into the future. Conversely, those reaches with poorer scores are ranked less highly for rehabilitation purposes.

Reach 9 was the reach that (narrowly) scored the absolute highest result overall. It had a good number of well sized refuge pools, combined with the best single score for existing snag loadings. There were also relatively low levels of erosion and no stock damage observed within the 20m buffer zone from the river edge.

In this reach the quality of riparian vegetation is being negatively affected by exotic weed incursions from species such as lantana, mulberry, castor oil plant, tobacco bush, privet, camphor laurel and willow.

The next highest ranking was attributed to Reach 3 largely because it offered the single largest number of well-sized refuge pools, providing ample opportunities for fish habitat. This provides a sound basis for improving the remaining key variables, such as the relatively low snag score in this reach.

The reach judged to be in the poorest condition was Reach 7 (-0.67 weighted average score).

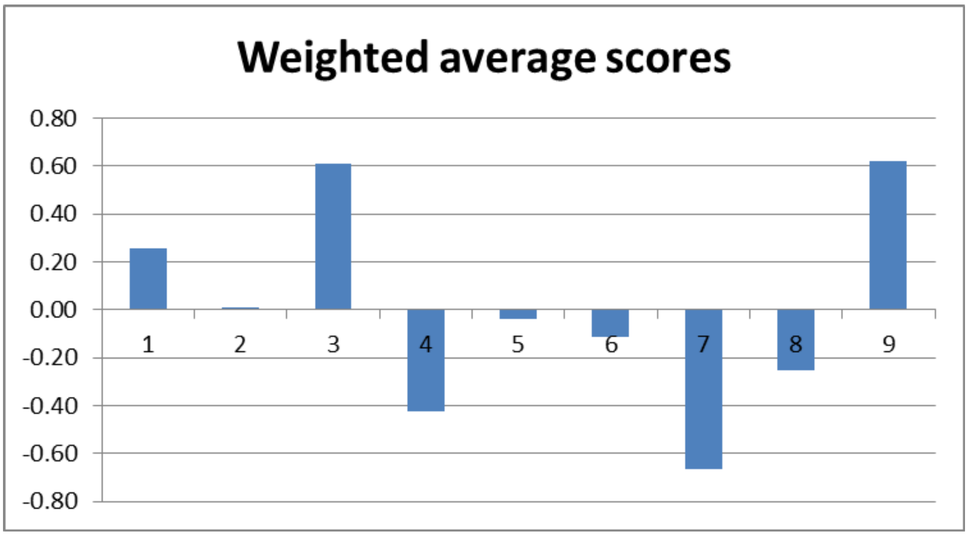


Figure 28: Weighted average scores give relative rankings for the nine reaches.

The table below shows the results of the prioritisation process for each of the nine reaches.

Table 7: Prioritisation results per reach.

Reach	Refuge pools	Snags	Native spp.	Exotic spp.	Bank Erosion	Stock Damage	Weighted average scores	Condition assessment	Priority Ranking
1	-3.16	0.76	-0.13	5.08	0.84	0.07	0.26	Moderate Health	3
2	-3.43	-1.64	-0.32	3.58	2.63	-0.68	0.01	Moderate Health	4
3	12.56	-1.28	-0.35	-2.01	1.56	-2.27	0.61	Better Health	2
4	-2.71	0.40	-0.32	-1.92	-1.22	0.02	-0.43	Poorer Health	8
5	-0.28	-1.57	-0.18	0.93	-0.18	0.77	-0.04	Moderate Health	5
6	-0.02	0.25	-0.07	-2.89	0.42	0.77	-0.11	Moderate Health	6
7	-0.38	-2.01	1.26	-3.18	-4.49	-0.21	-0.67	Poorer Health	9
8	-3.48	0.61	0.15	-1.56	0.14	0.77	-0.25	Poorer Health	7
9	0.91	4.47	-0.04	1.97	0.29	0.77	0.62	Better Health	1

Summary:

- Reaches 9 and 3 were found to be in the best overall health in comparison to the other reaches.
- Reaches 1, 2, 5 and 6 were assessed as being in a moderate condition.
- Finally, Reaches 4, 8 and 7 were ranked as being in the poorest comparative riparian / aquatic health condition.

7.2 Recommendations for Priority Management Reaches

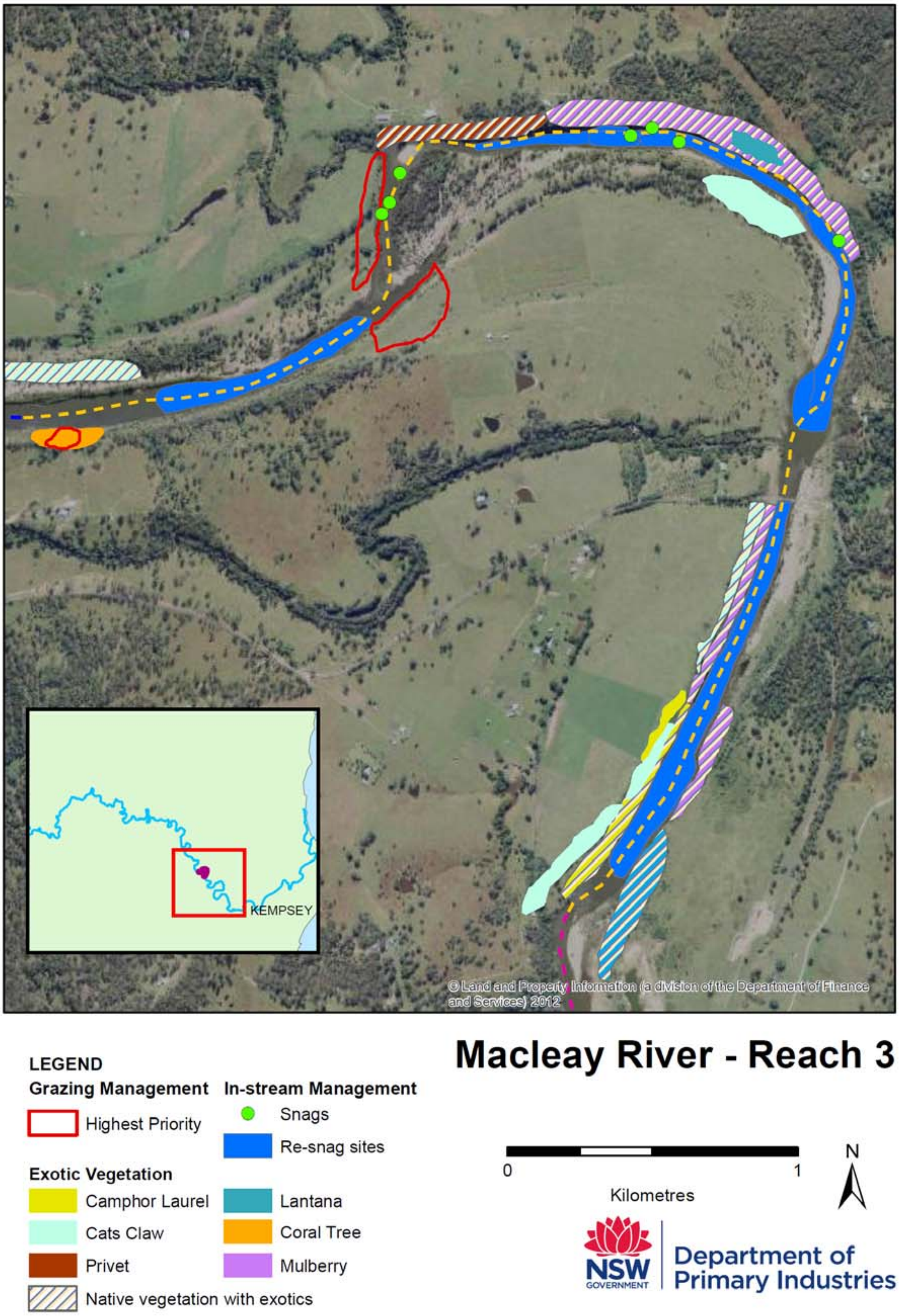


Figure 29: Recommendations for Priority Reach 3

The following recommendations are made for Priority Reach 3:

- **Control of noxious weed species to allow for natural regeneration of native species.**

Weed control will enable the unencumbered development of a well-developed native riparian cover, improving bank stability and retaining an important component of the riverine ecosystem.

There are three dense infestations of Cat’s Claw Creeper on the western bank of Reach 3 and a dense patch of lantana to the north-west of the reach. There are also single, isolated patches of Camphor Laurel and Coral Tree. Mulberry trees mixed with native vegetation are the next most dominant category of noxious weed, followed by native vegetation with scattered patches of Cat’s Claw, Mulberry and Privet.

- **Snag installation works within the numerous refuge pools could offer significant benefits for fish habitat enhancement**.

Any such works would need to be installed with due consideration for the Macleay River’s propensity to deliver high volumes and velocities of floodwaters on occasion. NSW DPI has had extensive experience undertaking re-snagging projects throughout NSW. It is recommended to seek guidance (and appropriate permits) from NSW DPI if re-snagging is identified as a potential remediation technique. Approximately 75% of Reach 3 was comprised of refuge pools, with an extremely low density of existing snag loadings. The identified refuge pools would each benefit from any increases to that current snag density.

- **Develop grazing management plans that seek to minimise the time spent by stock within the riparian zone.**

The high levels of stock damage observed in Reach 3 also lead to a recommendation for the improved control of stock. While fencing and off-stream watering may assist in some cases, in other areas the fencing is already present and a different approach is needed. This would involve targeted negotiations with the appropriate landholders.

Figure 29 identifies areas of “highest priority” for grazing management, these relate to areas that had visible stock damage present. The remainder of the reach would also benefit from discussions regarding riparian grazing management strategies with relevant landholders.

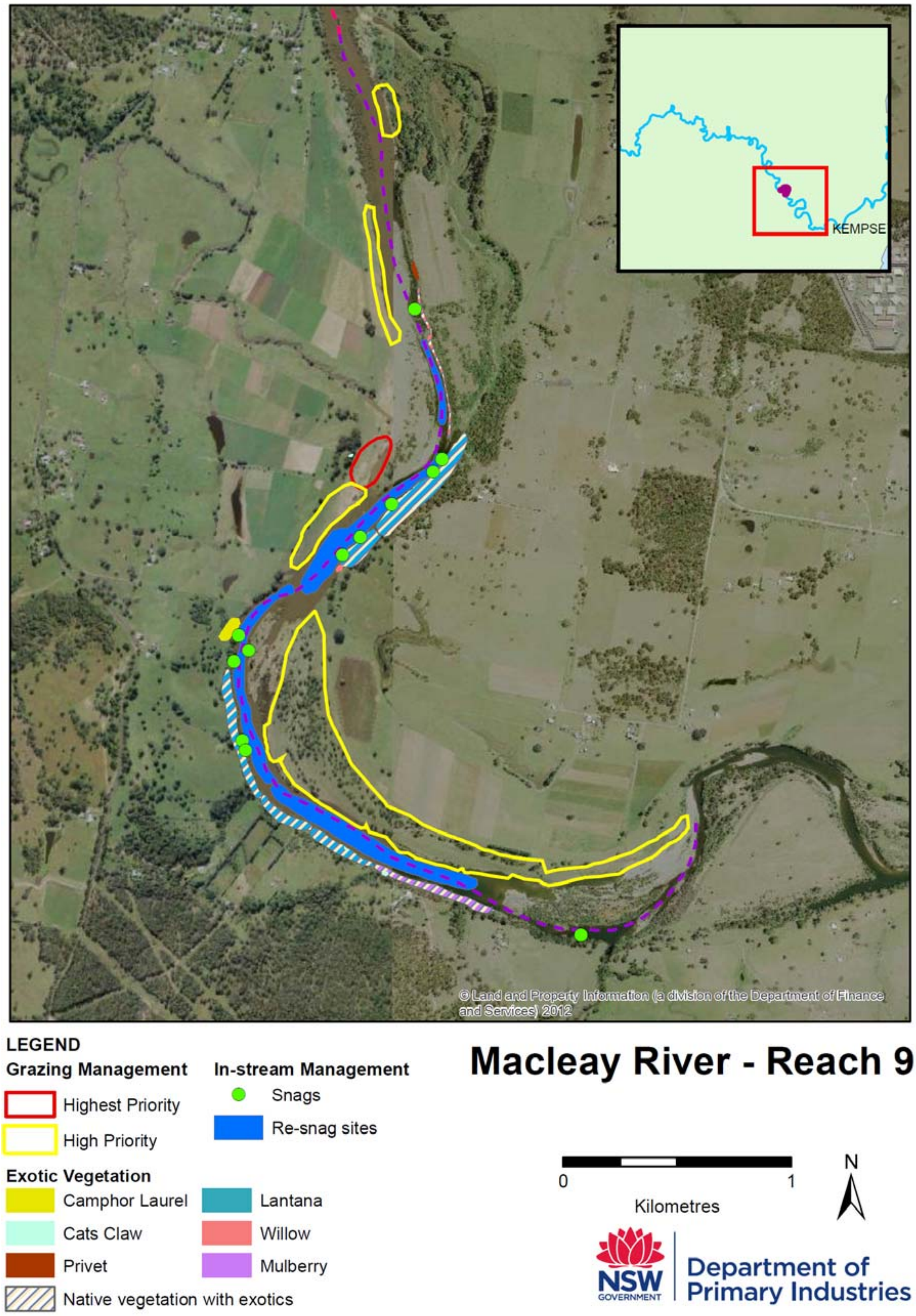


Figure 30: Recommendations for Priority Reach 9.

The following recommendations are made for Priority Reach 9:

- **Control of noxious weed species to allow for natural regeneration of native species.**

Weed control will enable the unencumbered development of a well-developed native riparian cover, improving bank stability and retaining an important component of the riverine ecosystem.

There are thin scatterings of Cat's Claw Creeper and Privet mixed with native vegetation on the banks of Reach 9. While there are some monoculture stands of other species (Camphor Laurel, Willow, Privet & Lantana), these are very small and could be targeted relatively easily.

- **Snag installation works within the numerous refuge pools could offer significant benefits for fish habitat enhancement**.

Any such works would need to be installed with due consideration for the Macleay River's propensity to deliver high volumes and velocities of floodwaters on occasion. NSW DPI has had extensive experience undertaking re-snagging projects throughout NSW. It is recommended to seek guidance (and appropriate permits) from NSW DPI if re-snagging is identified as a potential remediation technique.

Approximately 35% of Reach 9 was comprised of refuge pools, with a low density of existing snag loadings. The identified refuge pools would each benefit from increases to that current snag density.

- **Develop grazing management plans that seek to minimise the time spent by stock within the riparian zone.**

The high levels of stock damage observed in Reach 9 also lead to a recommendation for the improved control of stock. While fencing and off-stream watering may assist in some cases, in other areas the fencing is already present and a different approach is required. This would involve negotiations with the appropriate landholders.

Figure 30 identifies areas of "highest priority" for grazing management, these relate to areas that had visible stock damage present.

The "High priority" areas were located where there was a complete lack of native regeneration (characterised by no trees and pasture grasses only). Grazing management would be important here to allow for recruitment of native vegetation.

The remainder of the reach would also benefit from discussions regarding riparian grazing management strategies with relevant landholders.

7.3 Overall recommendations:

Overall, the health of the study area was found to be reasonably good, albeit with some room for improvement along similar lines as for the two high priority areas.

- **Snag installation works within the numerous refuge pools could offer significant benefits for fish habitat enhancement**.

Given the comparatively low numbers of snags present in the overall study area, it would be appropriate to strategically install snag complexes, particularly adjacent to deep refuge pools.

The current woody debris loading comprises callistemon and casuarina trunks. Installation of longer lasting hardwood timber of reasonable complexity will benefit fish fauna of the Macleay.

- **The removal of noxious weed incursions in the areas mapped as native / exotic mixtures is highly recommended.**

Incursion of exotic vegetation remains one of the biggest threats for native riparian vegetation. Removal will encourage natural regeneration of native riparian species.

- **Address the issue of stock accessing the river.**

This should occur by proactively working with landholders to develop appropriate management strategies for riparian grazing that will minimise stock presence in the waterway while also not being a great imposition on the landholder. Improved stock management will enable natural regeneration of native riparian species and reduce bank erosion, particularly at those locations comprised of grain size finer than large gravel/cobble.

8. References

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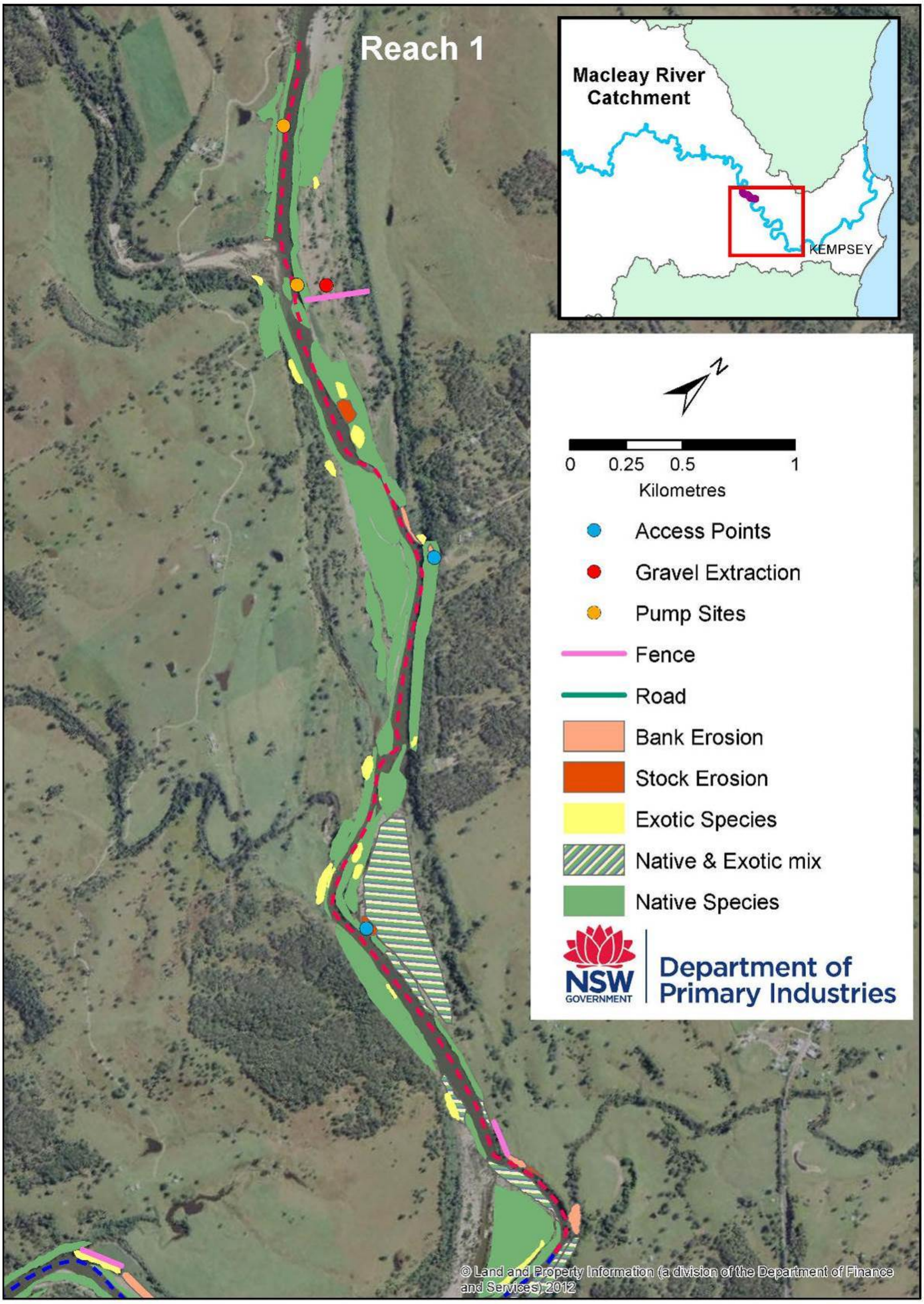
9. Appendices

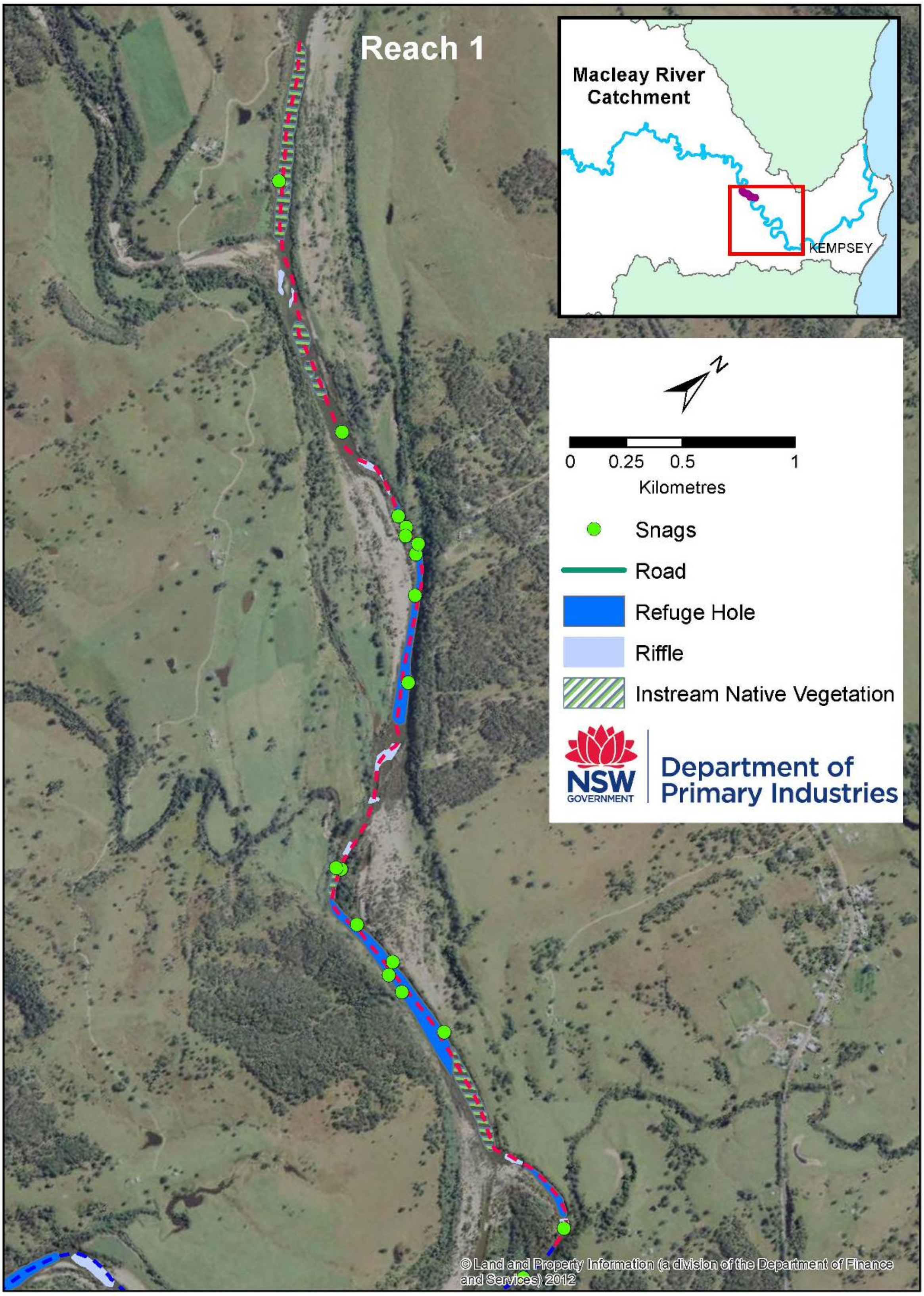
Appendix A – Management Reaches

This appendix contains the maps of the nine management reaches.

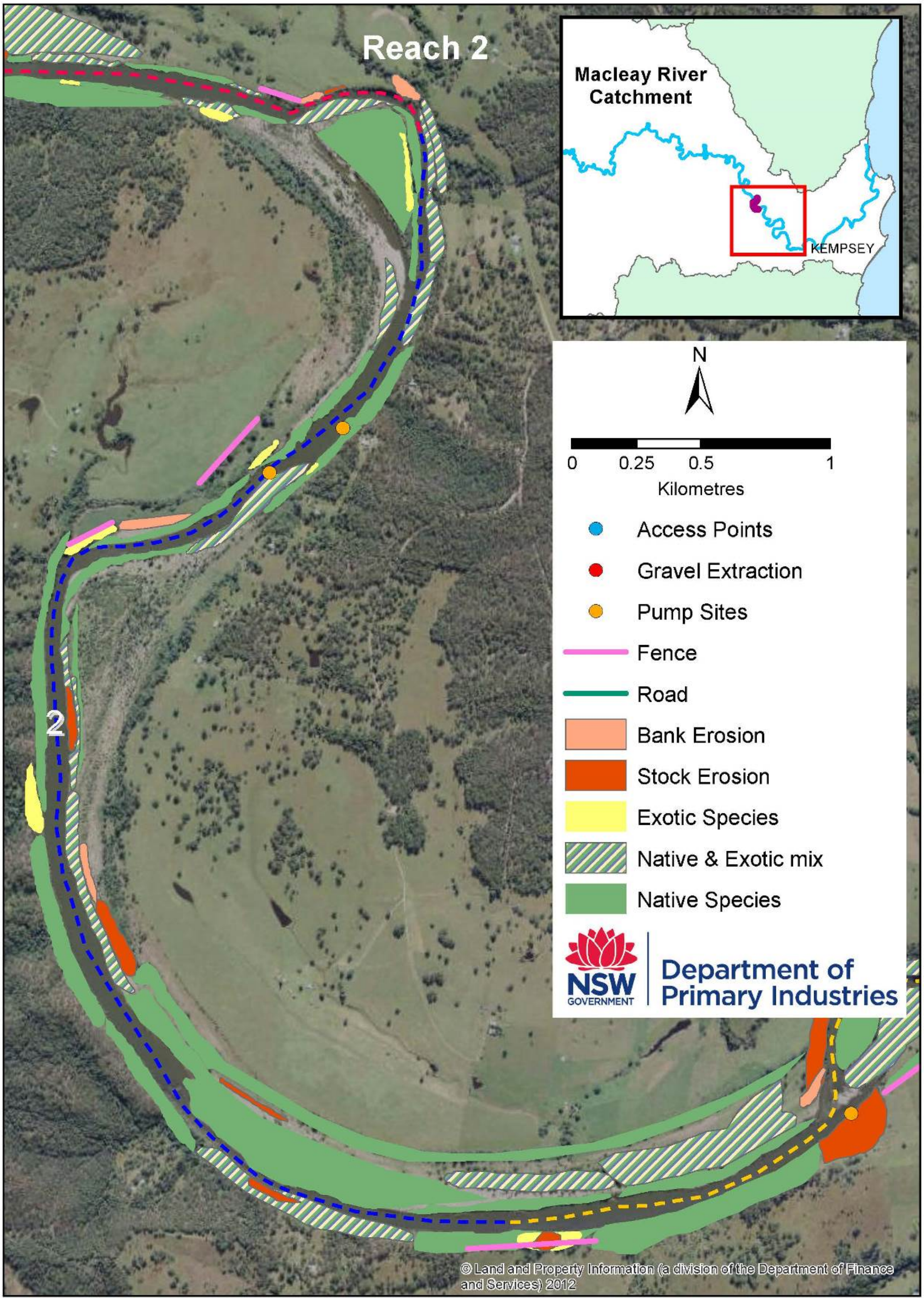
Due to the sheer volume of information collected, each reach has two separate maps – one showing the riparian features and the other displaying the in-stream habitat features that were mapped



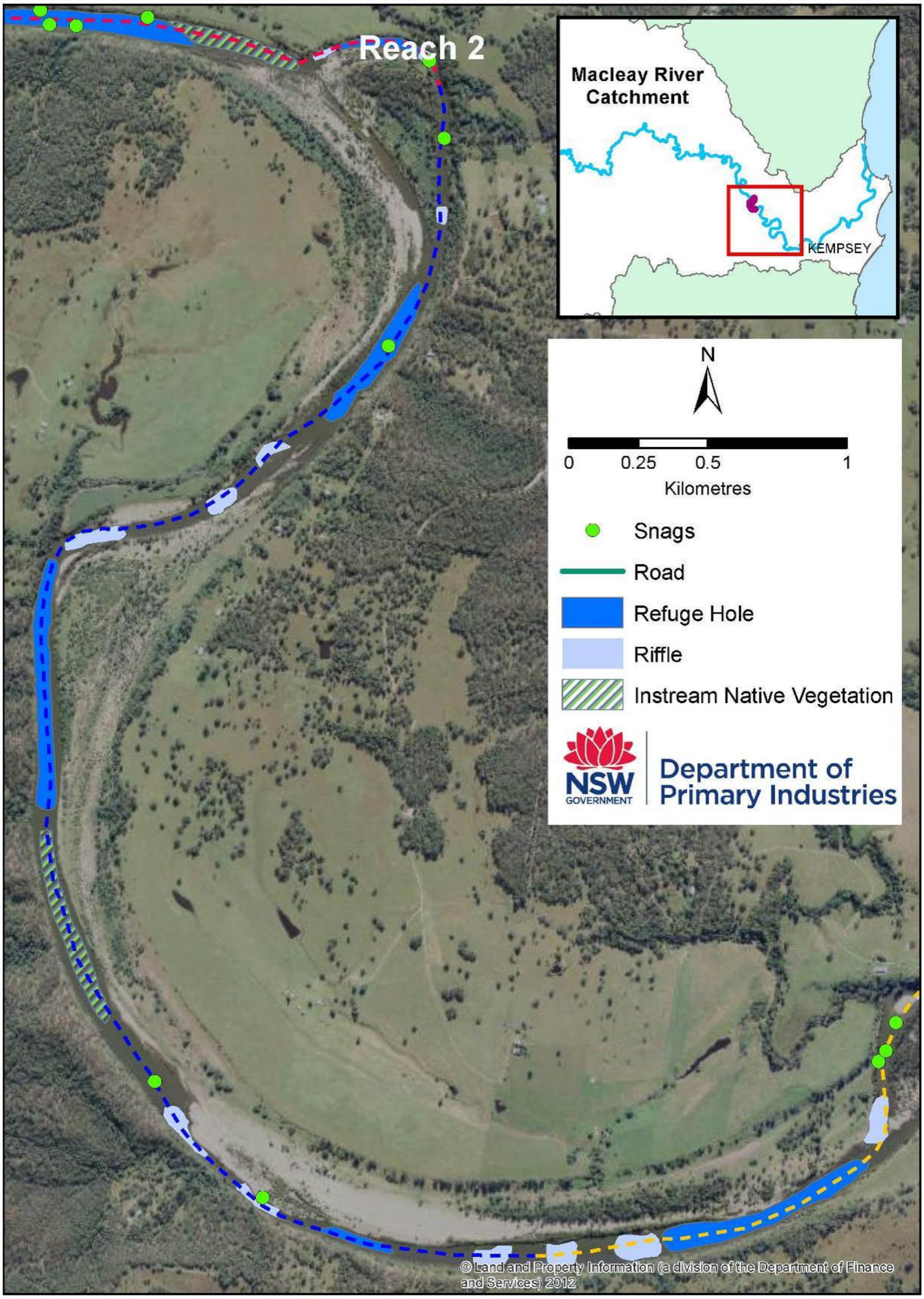
Reach 1 – Riparian features



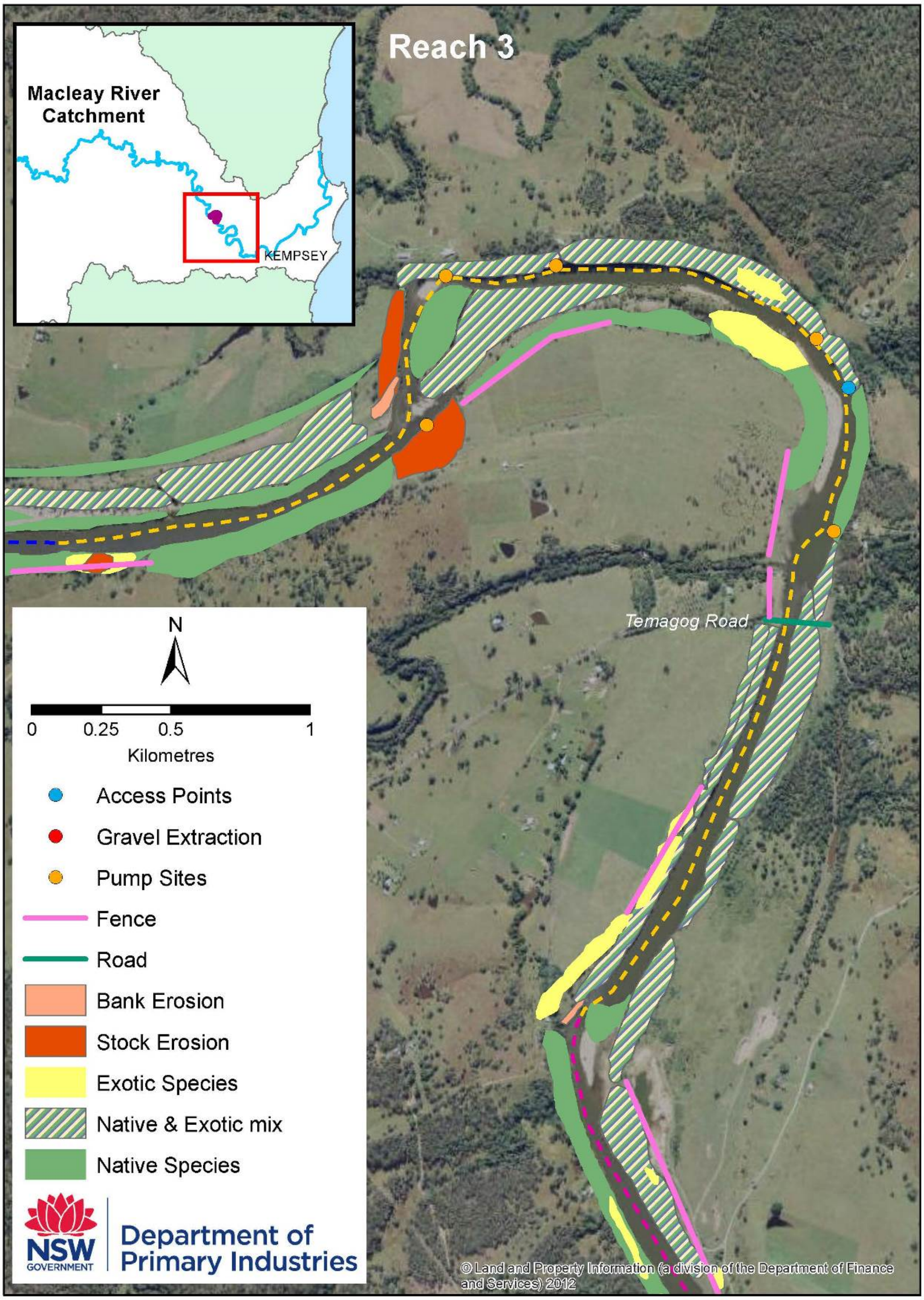
Reach 1 – In-stream features



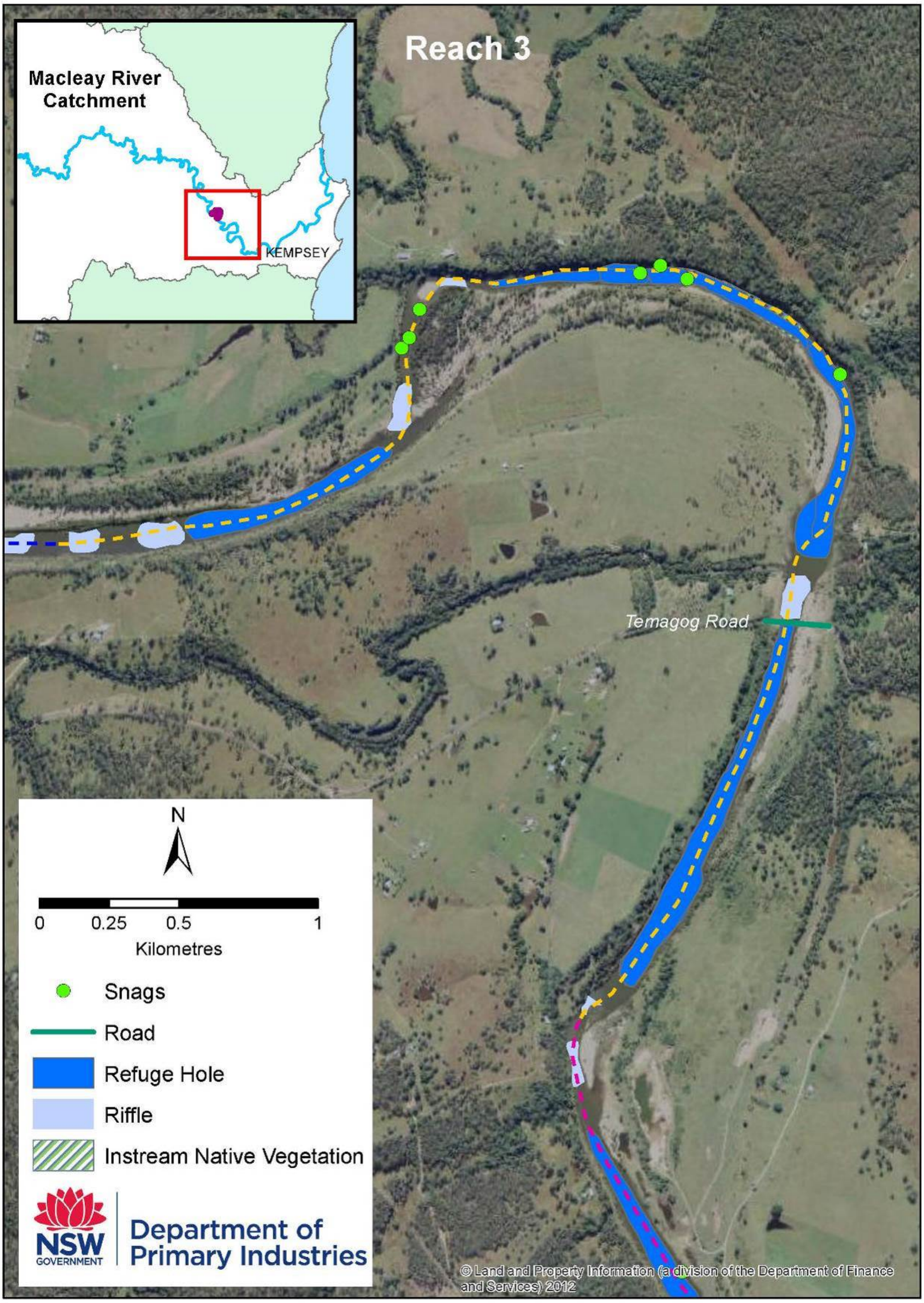
Reach 2 – Riparian features



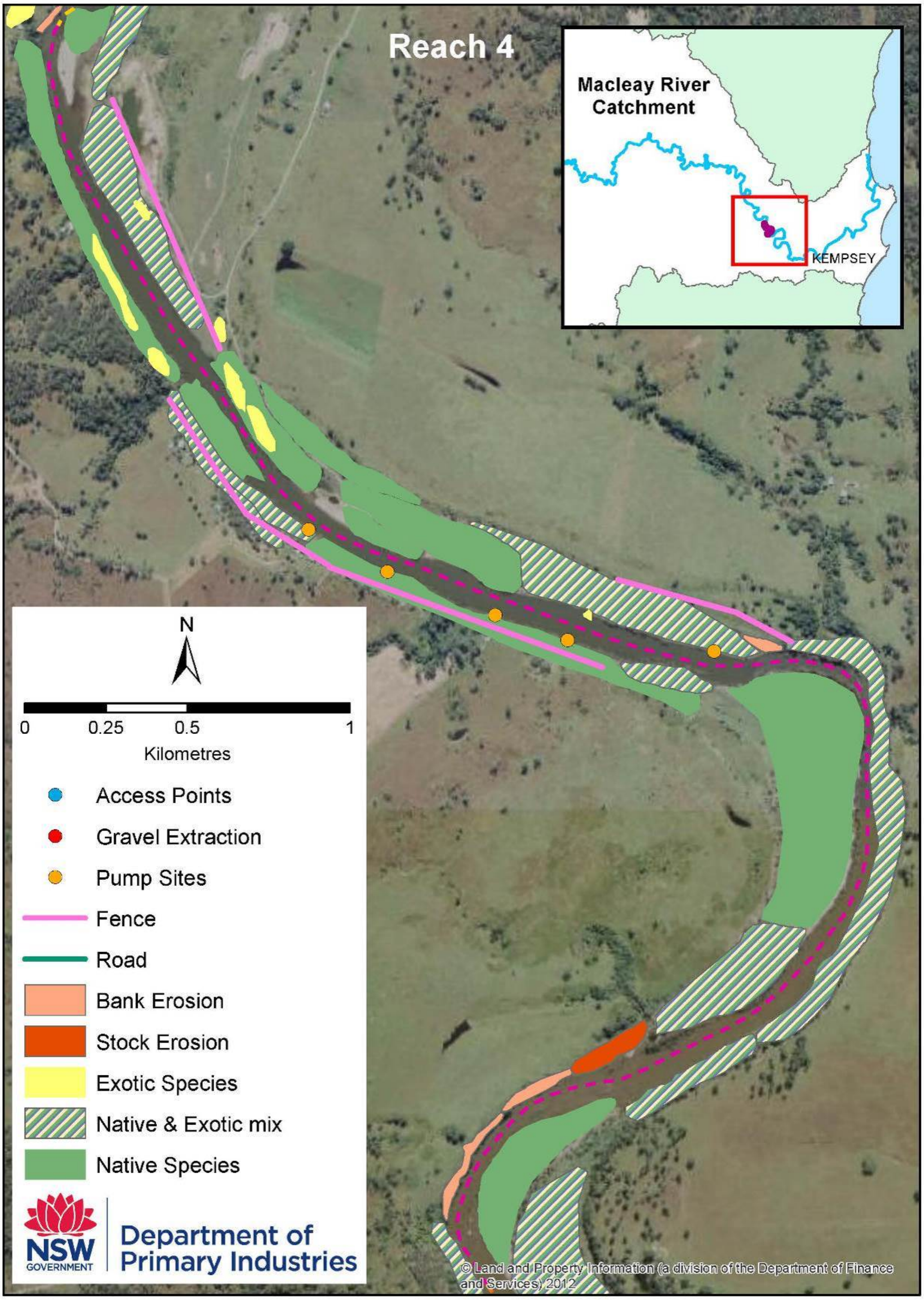
Reach 2 – In-stream features



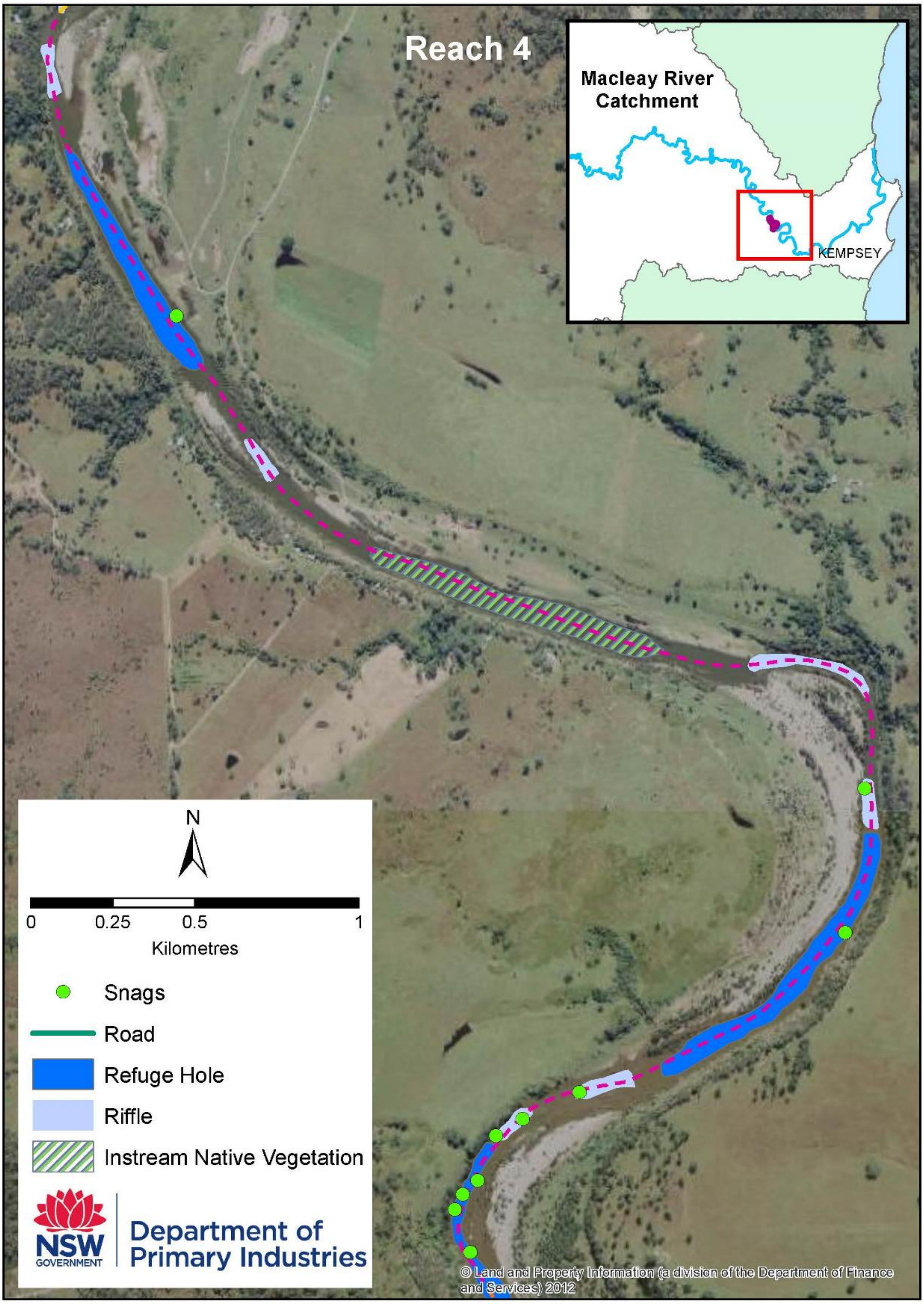
Reach 3 – Riparian features



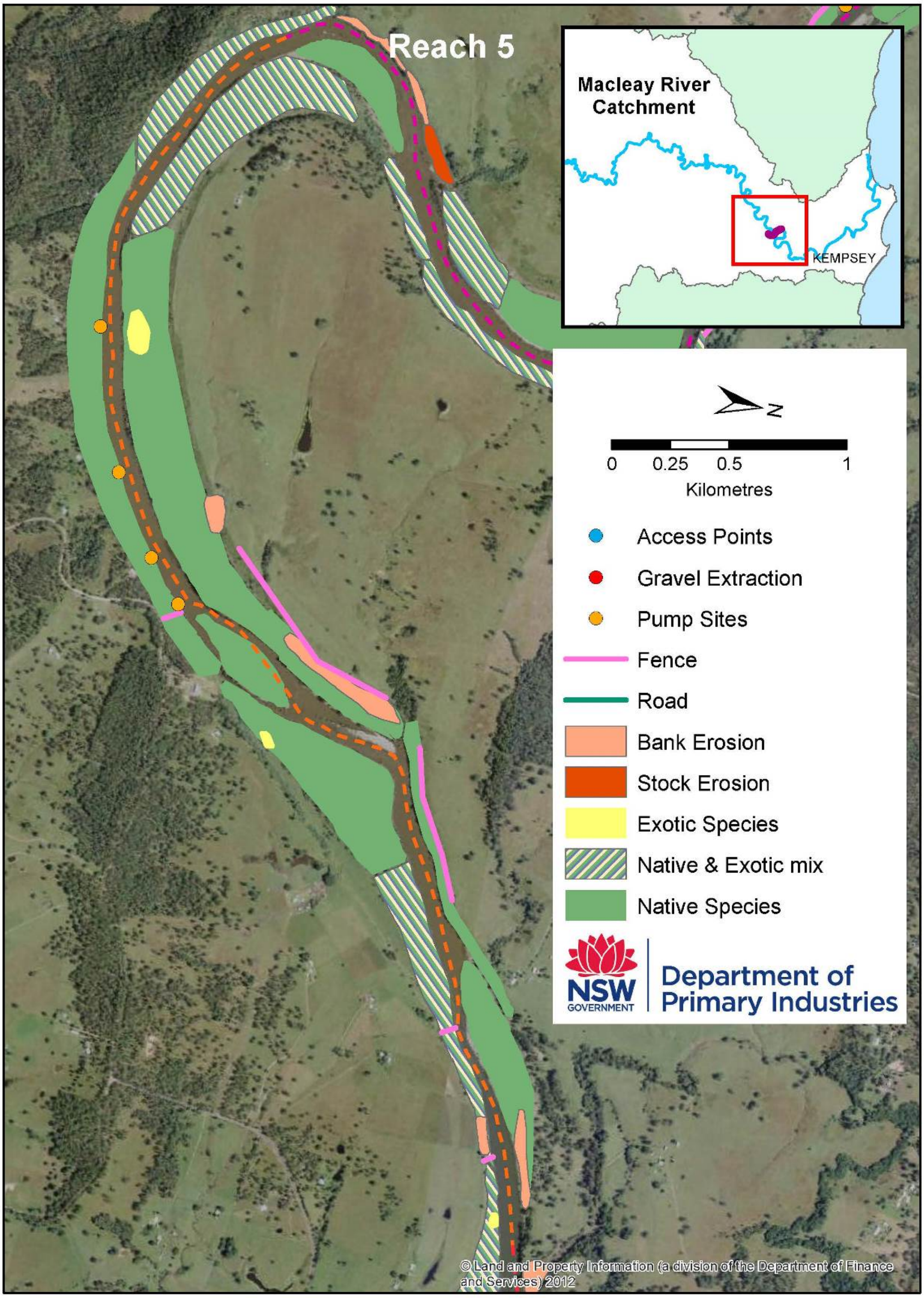
Reach 3 – In-stream features



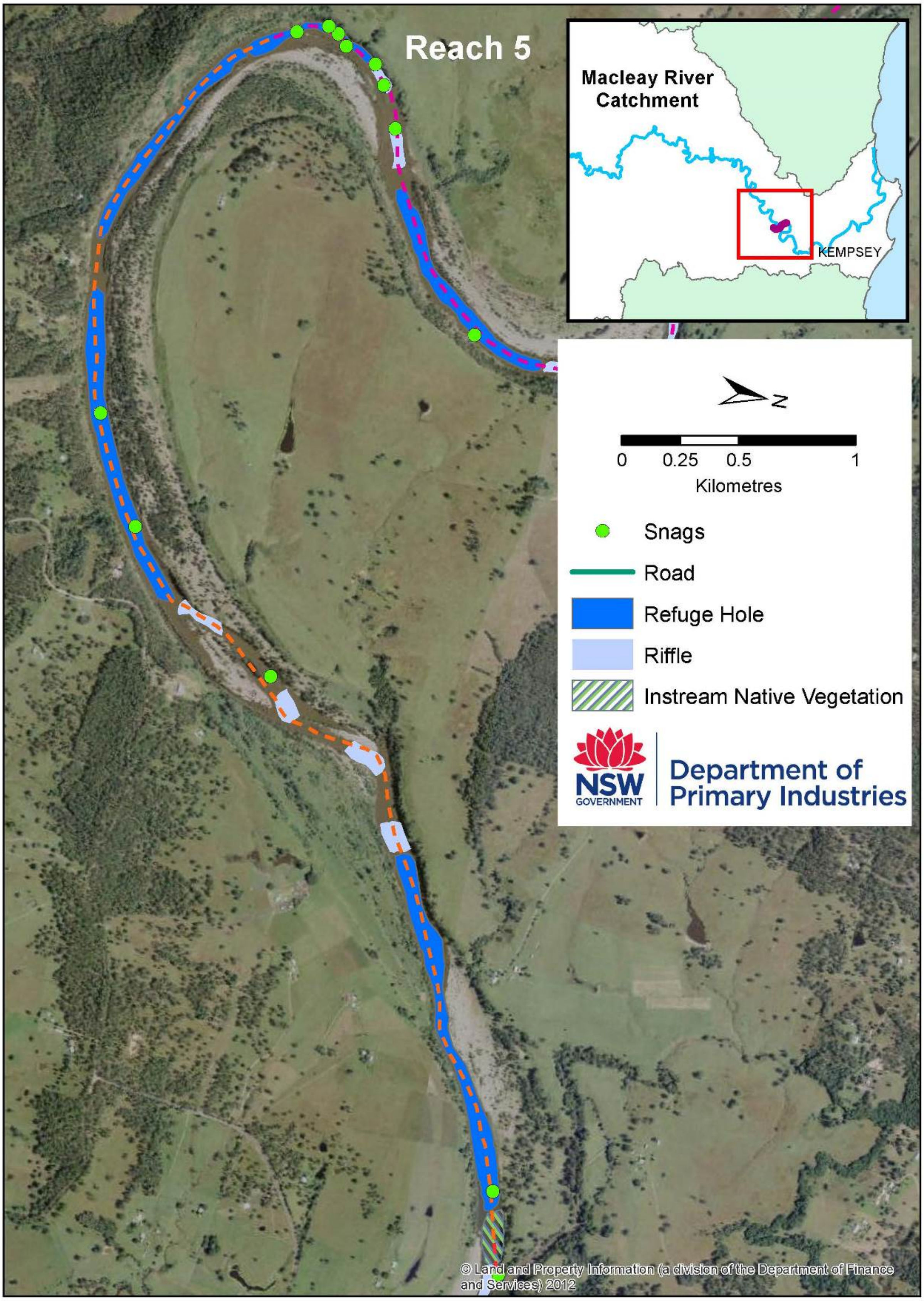
Reach 4 – Riparian features



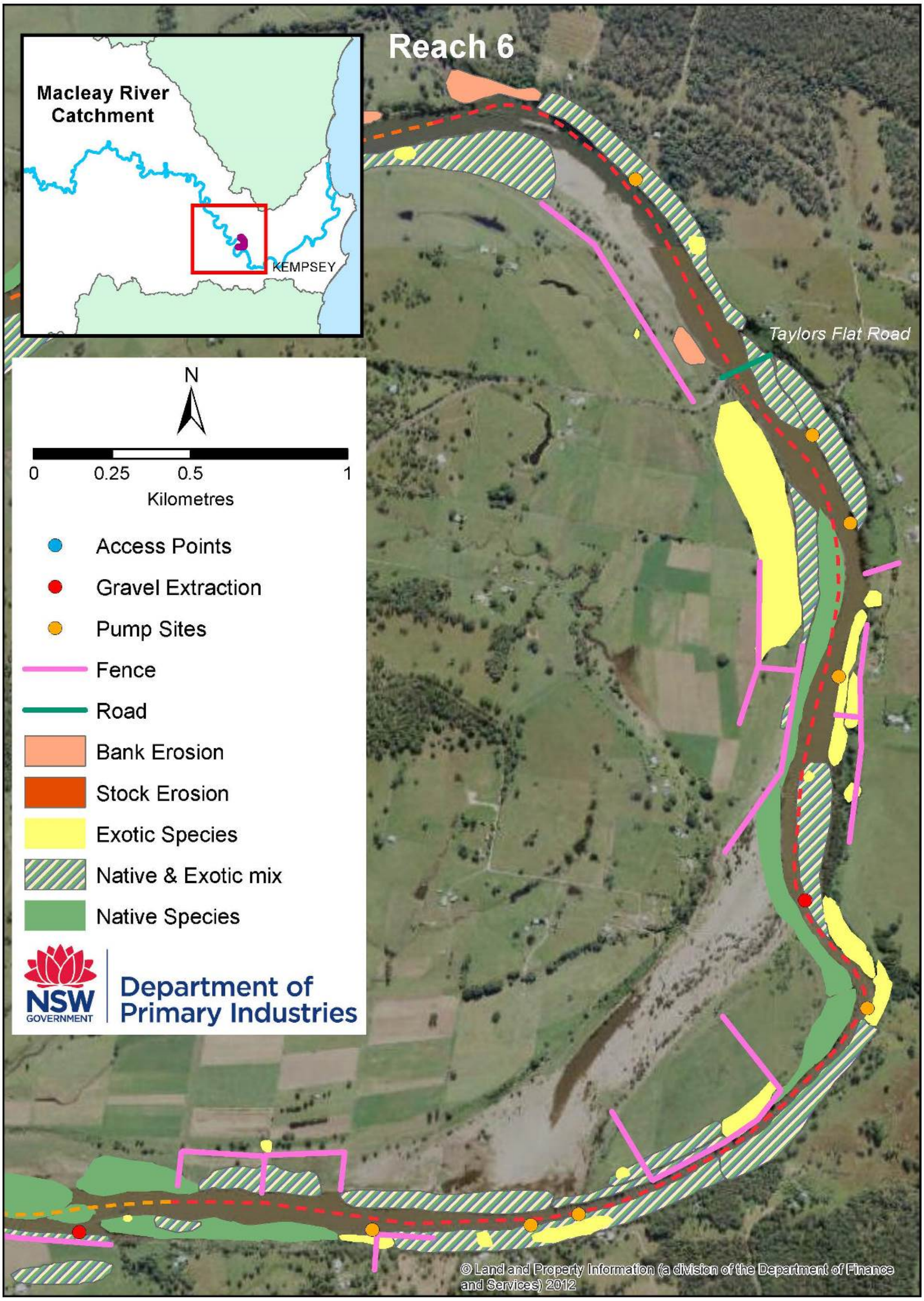
Reach 4 – In-stream features



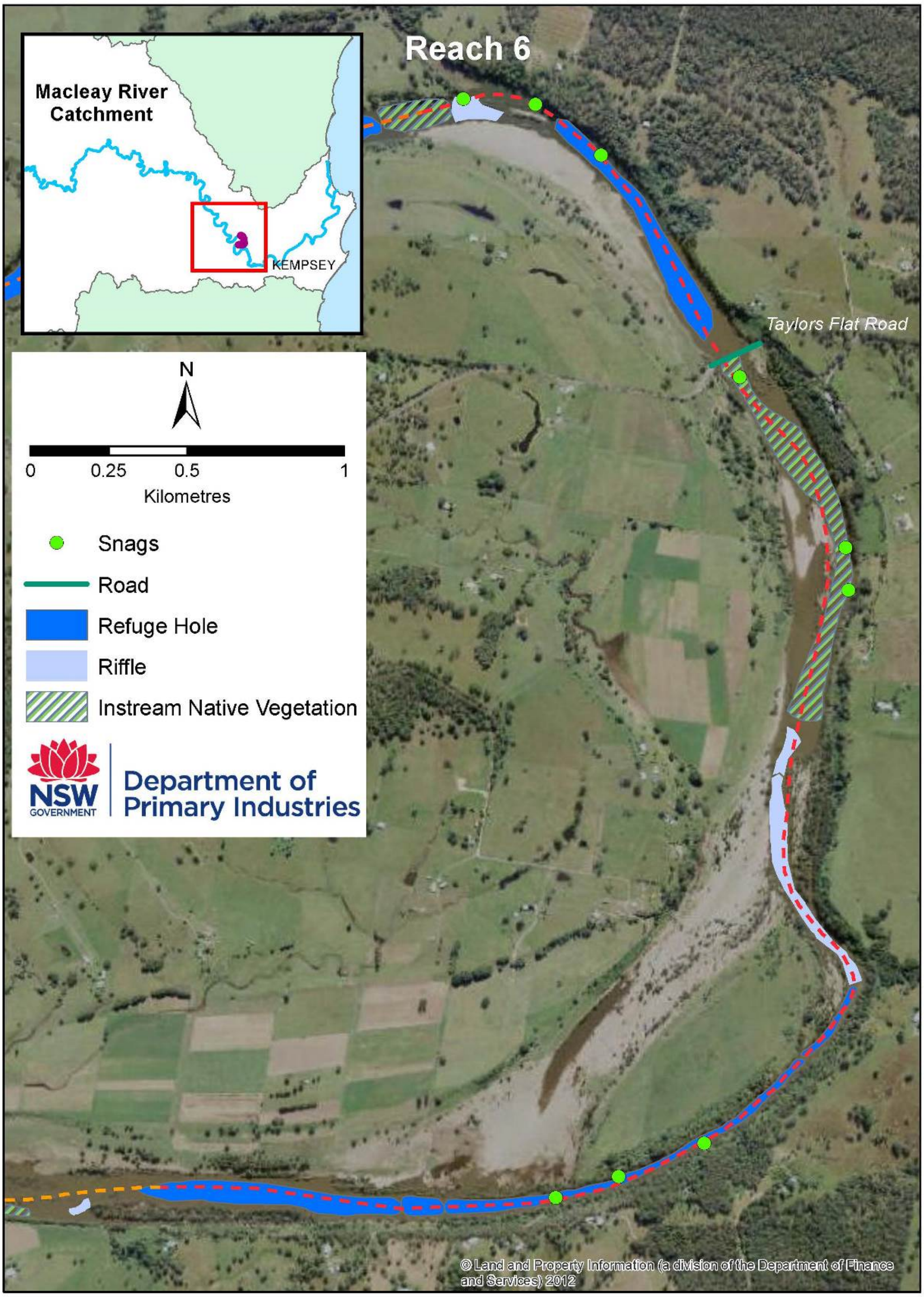
Reach 5 – Riparian features



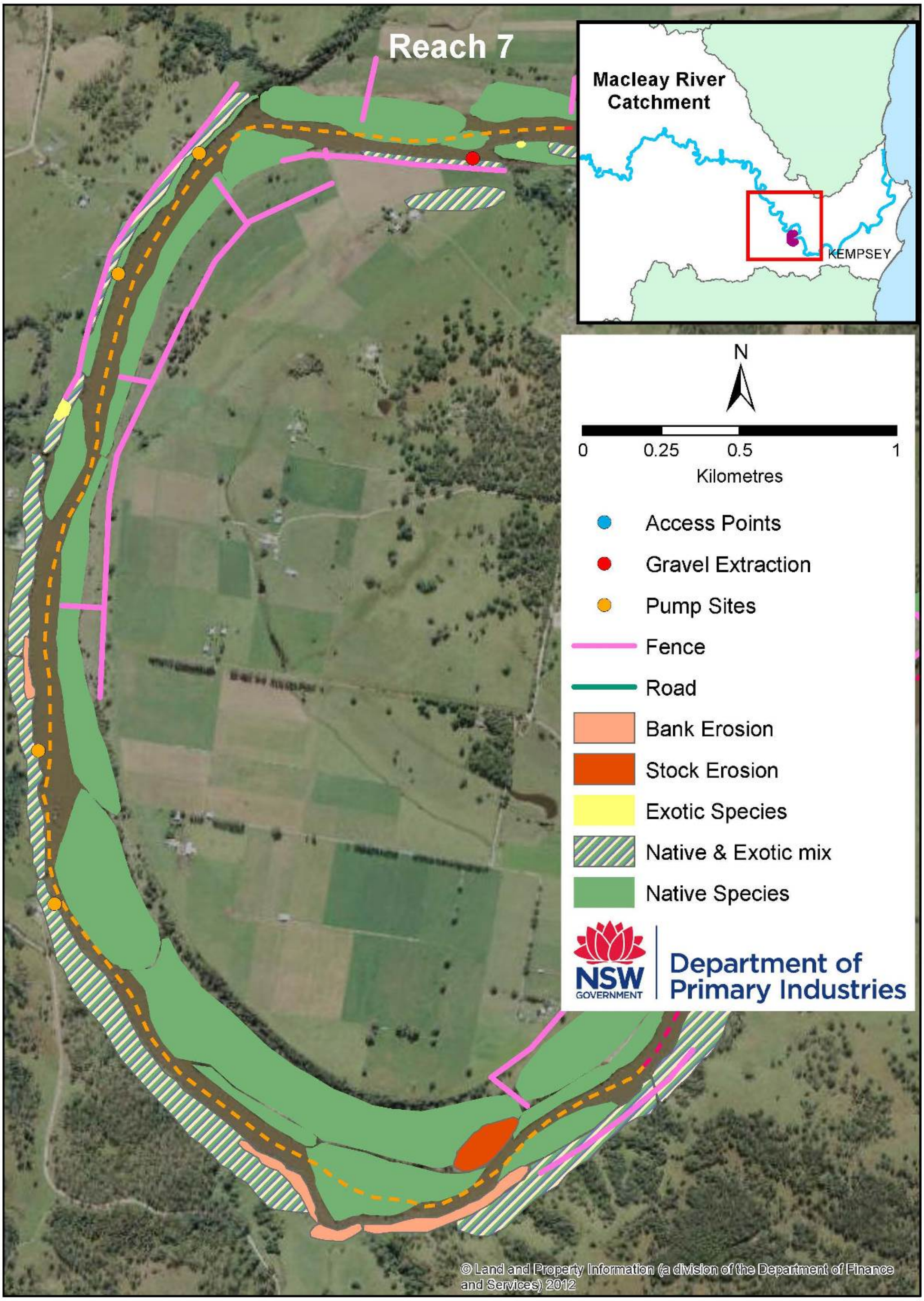
Reach 5 – In-stream features



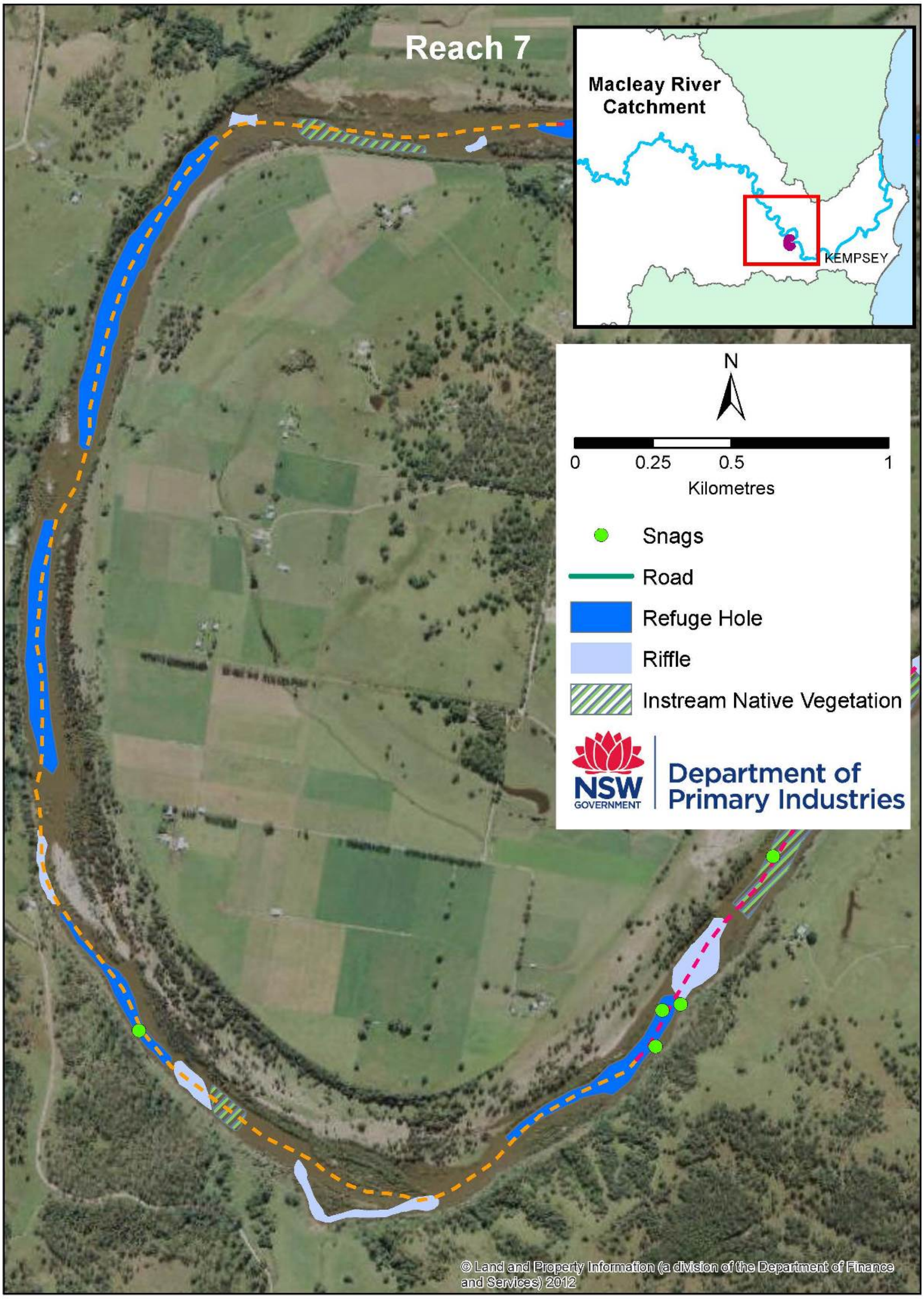
Reach 6 – Riparian features



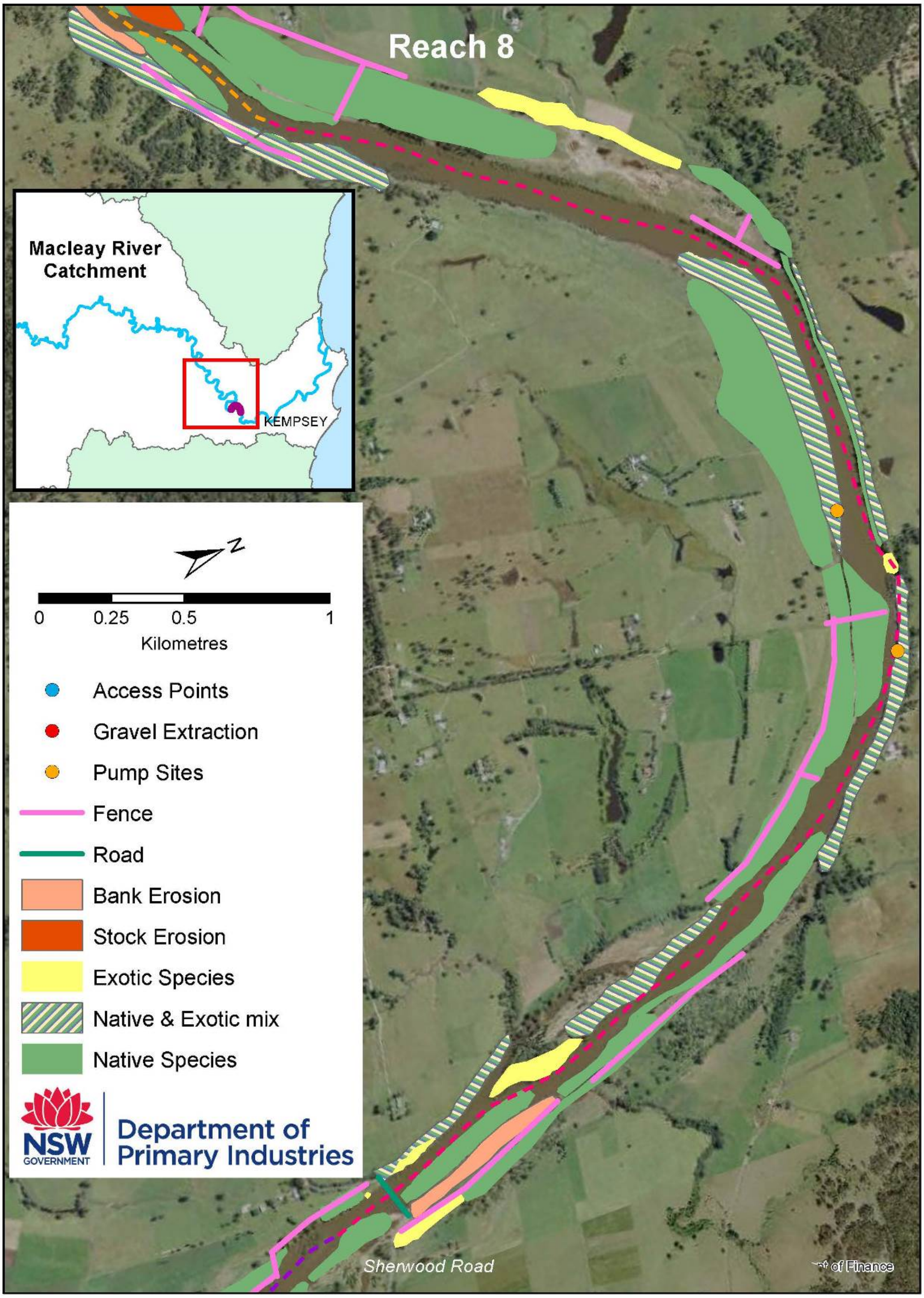
Reach 6 – In-stream features



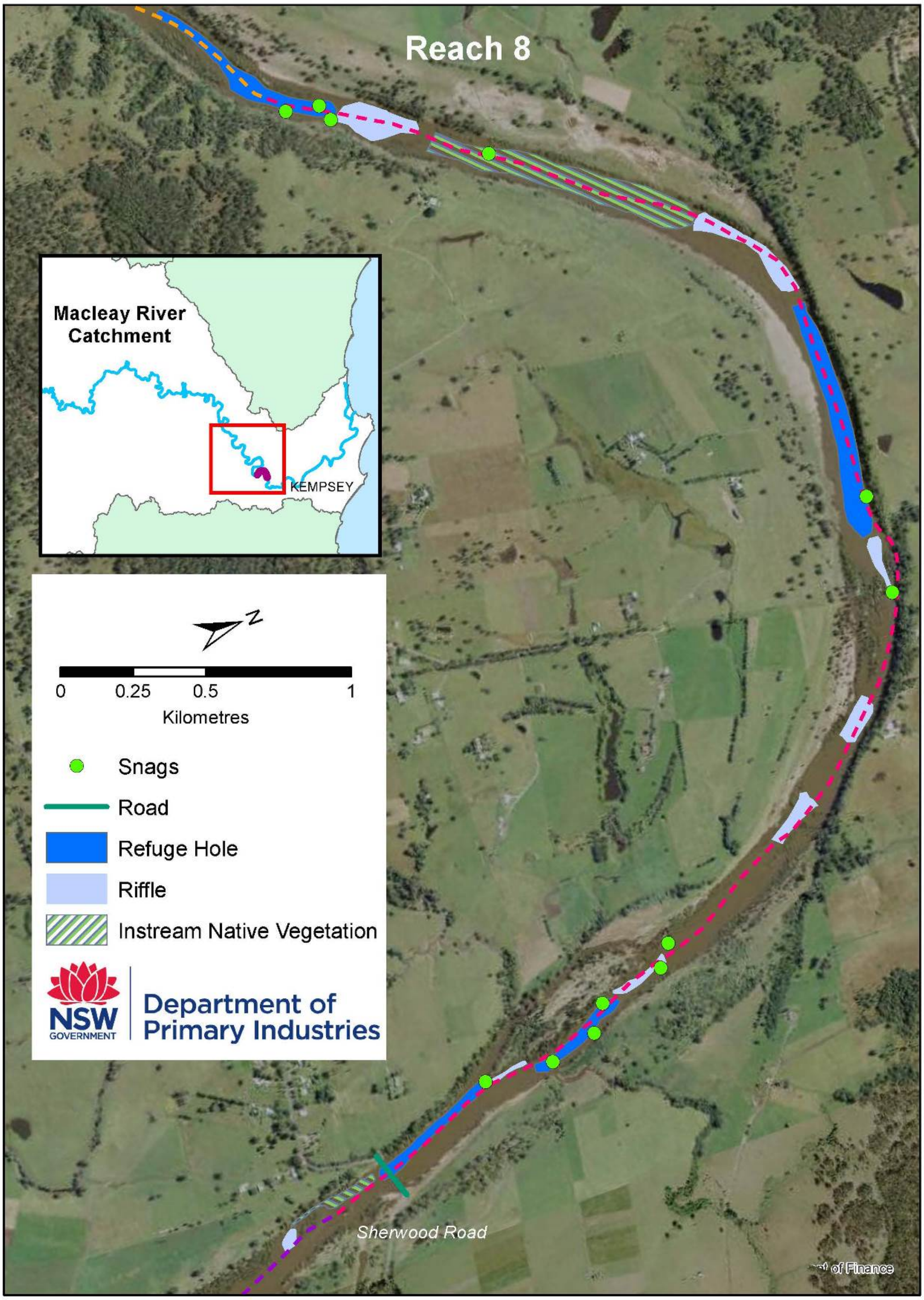
Reach 7 – Riparian features



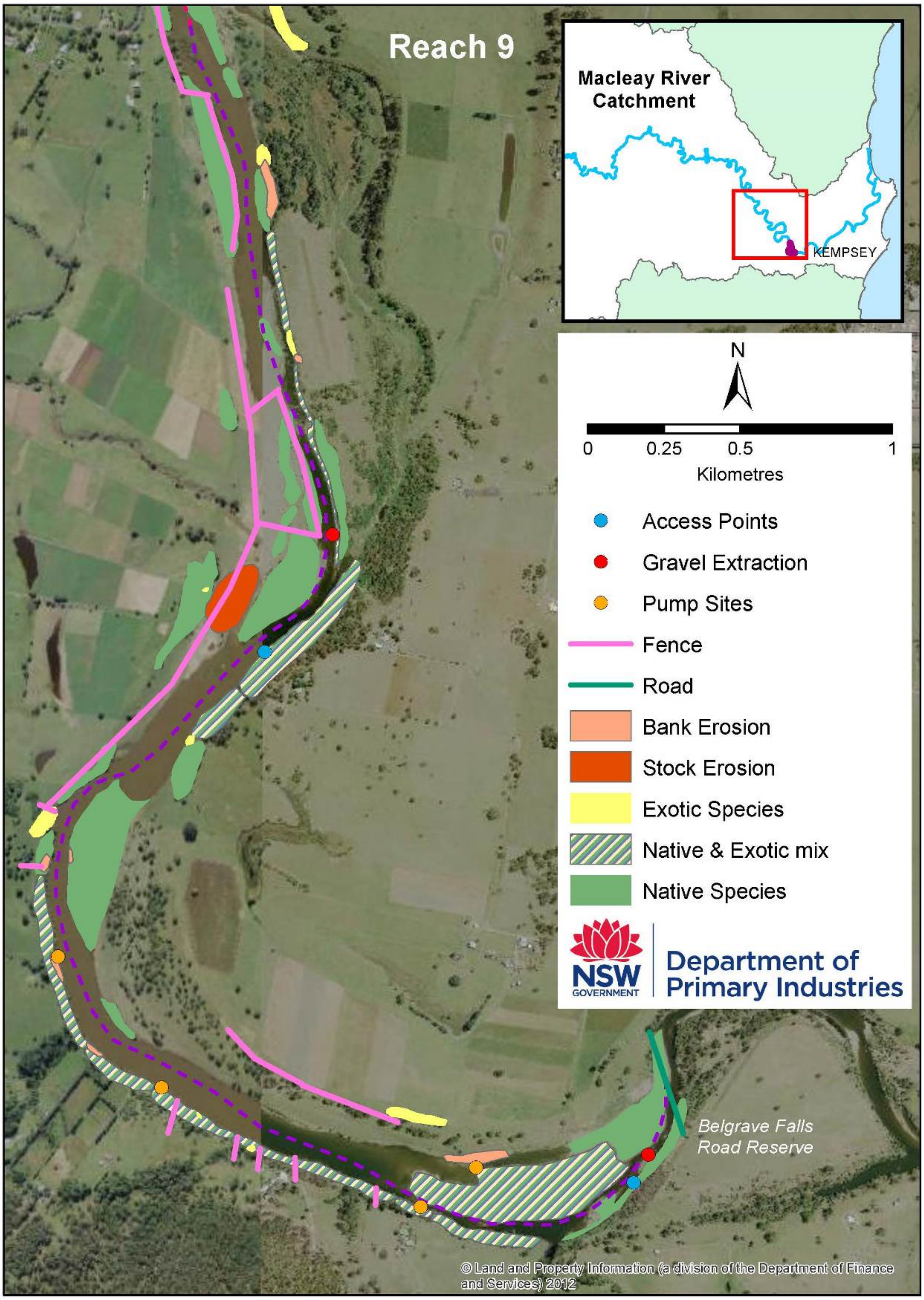
Reach 7 – In-stream features



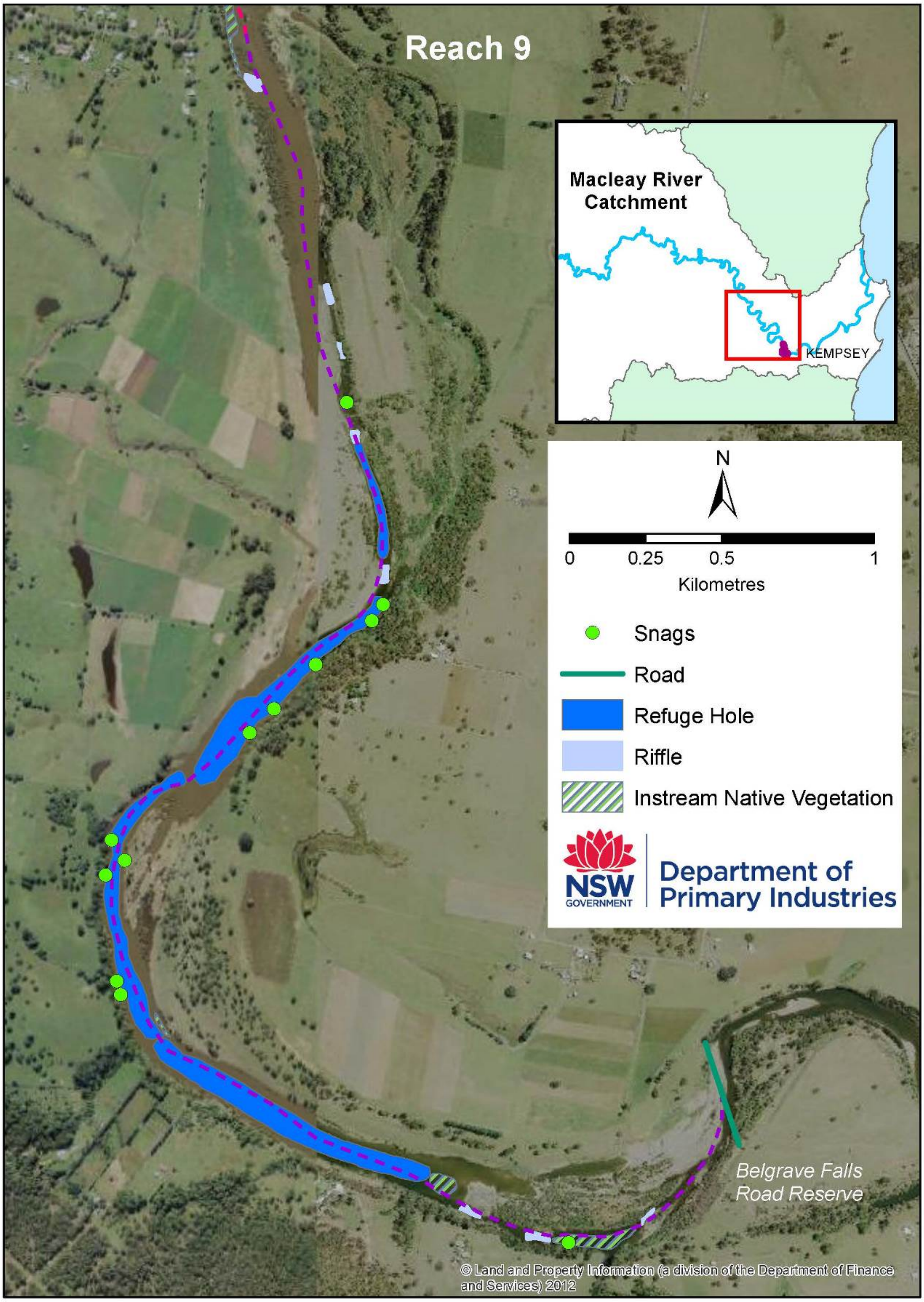
Reach 8 – Riparian features



Reach 8 – In-stream features



Reach 9 – Riparian features



Reach 9 – In-stream features

Appendix B – Landholder information letter

Letter sent to approximately 100 landholders with properties adjacent to the 47 km study area.

Department of Primary Industries

NAME
ADDRESS
TOWN STATE POSTCODE

Dear Landholder,

Re: Fish habitat mapping of the Macleay River - Toorumbee Creek to Belgrave Falls.

The Aquatic Habitat Rehabilitation unit of the NSW Department of Primary Industries (Fisheries NSW) and the North Coast Local Land Services will be undertaking a project to map and assess riparian and in-stream conditions along approximately 45km of the Macleay River between Toorumbee Creek and Belgrave Falls. The primary objectives of the project are to:

1. document and assess river bed structure, including the location, length and depth of pools that may act as drought refuges for fish, the in-stream habitat features and large woody habitat (snags);
2. document and assess the riparian condition of the reach, focussing on native vegetation, weed infestation and existing management activities;
3. identify threats and processes that may influence the extent and condition of aquatic and riparian habitat features, and prioritise specific areas/issues that require management action; and
4. make recommendations to protect and improve river health habitat features.

As a landholder adjacent to the study site we wish to inform you that the field work will be carried out by DPI staff during the month of September. It is anticipated that all work will be carried out in a small boat and access to the river will be achieved via public access points. However, should this situation change we may be in touch to request access from your property to carry out the mapping.

Once mapping has been completed and final recommendations made, we may target additional funding to carry out recommended rehabilitation works in or adjacent to the river to improve fish habitat in conjunction with supportive landholders. Should you like to discuss any aspects of the project please do not hesitate to contact me on 6626 1256.

Yours sincerely

Simon Walsh
Resource Officer – Aquatic Habitat Rehabilitation

06/08/14