



Hutt River Foreshore Assessment

HUTT RIVER FORESHORE ASSESSMENT

Prepared by
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We welcome your feedback

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Cover photograph: Waterfall within sandstone rapid section of the Hutt River

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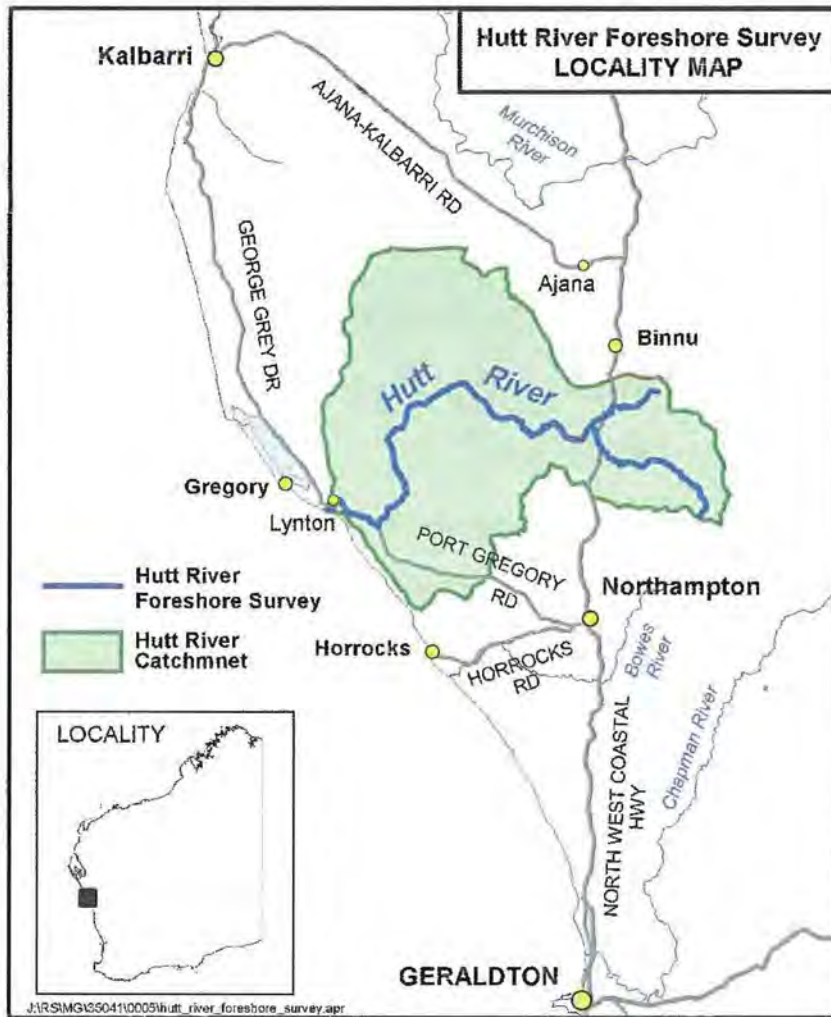


Figure 1: Locality map

Summary

The Hutt River is located on the Northampton Block in the northern part of the Mid West region of Western Australia. The Hutt River commences to the east of the North West Coastal Highway between Northampton and Binu and meanders through a diverse landscape to the river mouth located to the south of Port Gregory. The Hutt River has been identified as a priority waterway for the Northern Agricultural Region, however there has been a lack of information about the health of the river.

The aim of this Foreshore Assessment was to assess and document the current uses, disturbances and health conditions of the Hutt River and one of its major tributaries, Kennedy Creek. The survey was conducted in June and July 2003 based on the method developed by Pen and Scott (1995), *Stream and Foreshore Assessment in Farming Areas*, with some variations included to meet the specific needs of this assessment.

As a result of development pressures and various landuses, many sections of the study area are under threat from degradation. A wide range of management issues, such as stock and vehicle access, erosion, feral animals and salinisation of the land and water, have been identified through field surveys and consultation with landholders along the waterway.

Management recommendations have been included to suggest ways in which the foreshore and channel conditions along the length of the river can be improved to provide environmental, economic and social benefit to landholders and community members throughout the area.

Although the main channels of the Hutt River and Kennedy Creek were surveyed in isolation, the long-term management of the riverine environment depends on an integrated catchment approach, whereby landholders within the whole catchment are encouraged to work together to improve the condition of the waterways. Many of the issues require all landholders to work collectively in order to make a difference. The importance of catchment groups in raising awareness, providing technical and on-ground support and encouraging all landholders to become involved, cannot be stressed enough.

Table 1: Summary of foreshore condition of Hutt River and Kennedy Creek surveyed.

Condition Rating	Total Length	Total %
A (Very Good)	10.7km	11%
B (Good)	22.7km	23%
C (Moderate)	57.9km	60%
D (Poor)	5.8km	6%
Total	97.1km	100%

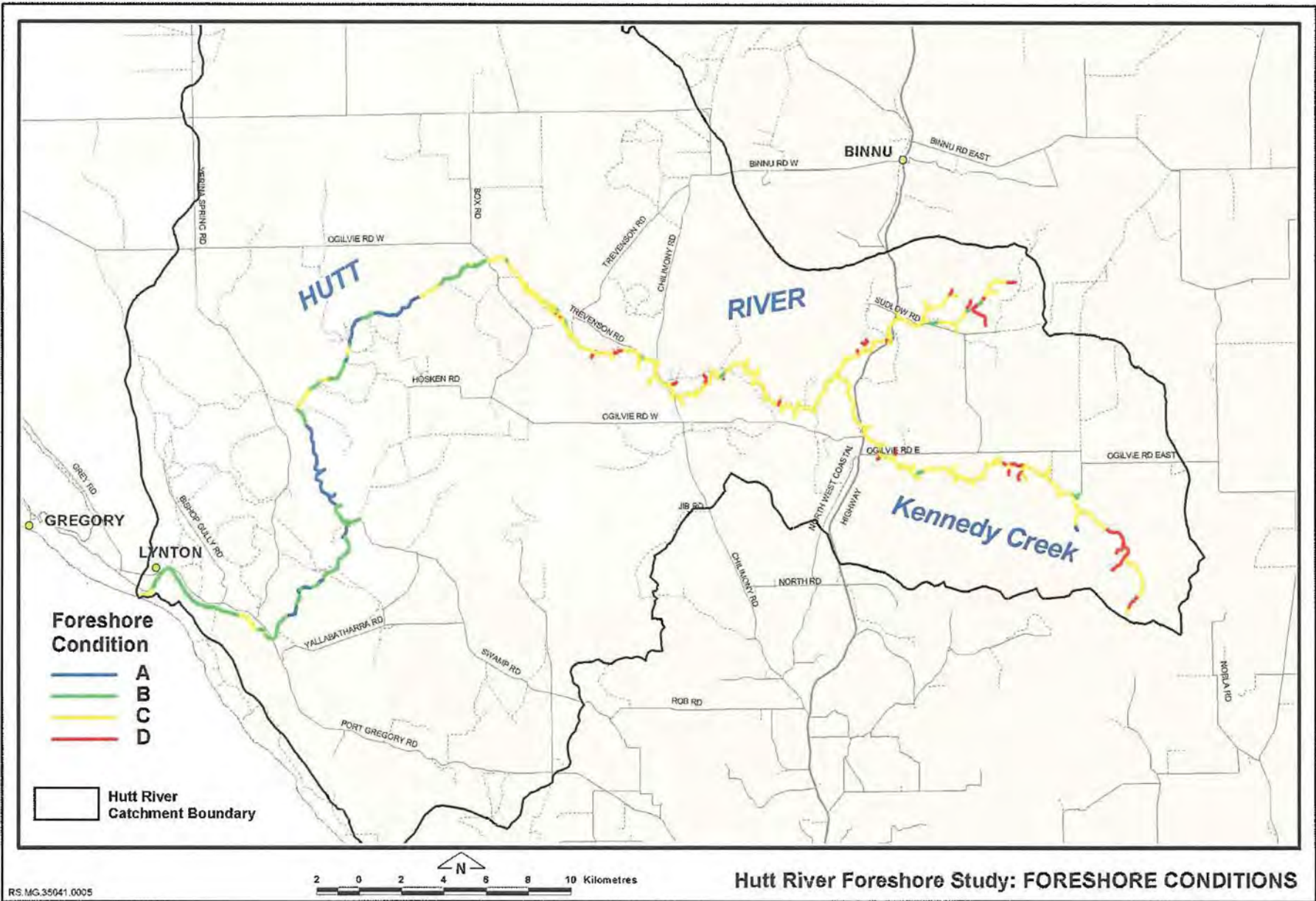


Figure 2: Summary of Foreshore Condition

1 Introduction

1.1 Purpose of the Survey

The Hutt River has been identified as a priority waterway for the Northern Agricultural Region. However there is a lack of information about the health of the river.

The Hutt River is unique as the only non-saline perennial river in the northern Midwest of Western Australia. The water quality of the river is maintained by freshwater tributaries fed by sandplain seeps. The flow from these seeps appears to be increasing, probably as a consequence of clearing in the catchment and the resultant increased groundwater recharge. The Hutt River retains significant amounts of riparian vegetation and linkages to large areas of remnant vegetation in some sections. Although lacking along the majority of the length of the river, this vegetation is significant in comparison with other Midwest rivers.

The Hutt River contains the most northern population of wild marron in Western Australia and although initially introduced is a significant social asset for family marroning parties. This healthy population of marron is unusual in that it lives in conjunction with a large introduced yabbie population.

This survey aims to assess and document the current uses, disturbances and health conditions of the Hutt River and one of its major tributaries, Kennedy Creek. By promoting awareness of the need and knowledge for the implementation of an integrated approach to the management of the river and surrounding lands, landholders will be encouraged to undertake management strategies which will improve and maintain the health of the waterway.

Specific objectives of this project can be summarised as follows:

- To establish the current foreshore condition and management practices along the Hutt River and Kennedy Creek;
- To highlight areas needing future rehabilitation, conservation and/or management;
- To provide a benchmark against which landholders and surrounding communities can monitor future river health and management activities;
- To enhance landholder and community awareness and knowledge about the causes of waterway degradation; and
- To provide a sound technical basis for future funding or project submissions.

1.2 Study Area

The Hutt River commences approximately 50 kilometres east of Port Gregory in the Waterloo Range. The main channel of the Hutt River is approximately 60 kilometres in length with a catchment area of 1240 square kilometres. Sixty per cent of the catchment is cleared for agricultural land use. Kennedy Creek, located approximately 70 kilometres north north east of Geraldton and extending east of the North

West Coastal Highway and along the East Ogilvie Road, forms one of the main southern tributaries of the Hutt River.

1.2.1 Climate

The Kalbarri area of the Mid West region in which the Hutt River and Kennedy Creek are located has a dry warm Mediterranean climate with mild wet winters, warm dry summers and thunderstorm activity causing localised flooding. Median temperatures range from 19°C in winter (May to August) to 32°C in summer (November to March). The average rainfall for the Hutt catchment is 360 mm, received on an average of 65 days in the year, falling mainly during the winter season (May to August).

1.2.2 Hydrology

Annual rainfall and groundwater dynamics influence the hydrology of the Hutt River. The estuarine reach of the Hutt River is also subject to the hydrodynamics of tidal exchange.

Flow of the Hutt River is mainly dependent on rainfall events, with a mean annual flow of 13,000 megalitres. The upper reaches of the river are ephemeral with mainly saline flows. Tributaries of the middle and lower reaches are mostly perennial, with flow maintained by sand plain seeps. These tributaries include Yerina Springs, Yarder Gully, Swamp Gully, the creek on which Harry Spring is located, Simkin Creek and Bishop Gully. A series of permanent pools are located on the main channel, some of which are maintained by groundwater influence.

1.2.3 Water Quality

Surface water quality data of the Hutt River and tributaries is limited. Water quality data is collected by a stream gauging station located approximately 10 kilometres upstream from the mouth of the Hutt River. From the data collected, the median Total Dissolved Salts (TDS) is 2900 mg/L which is brackish. The median concentration of the samples collected by the auto-sampler for Total Nitrogen is 1.6 mg/L and for Total Phosphorus, 0.06 mg/L. The pH of the Hutt River is neutral (median concentration 7.8), with a highly turbid median of 56 NTU sedimentation. Also see Appendix 1 for flow, rainfall and TDS plots.

From observation, the tributaries of the Hutt vary in salinity and turbidity. The Department of Environment intends to conduct a water quality snapshot of the catchment area to better understand the surface water hydrology of the Hutt River.



Photograph 1: Department of Environment Stream Gauging Station

2 Survey Methods

2.1 Community Awareness and Involvement

A letter of introduction was sent to landholders along the Hutt River and Kennedy Creek explaining the purpose of this survey. Arrangements were then made by phone for access onto properties to survey the river and when possible to meet with landholders to discuss management issues, anecdotal and historical information. Rivercare Officers spent time talking to individual landholders to learn about their current management practices and to gauge their interest in taking part in activities for the protection and enhancement of the Hutt River and Kennedy Creek.

2.2 Assessment Technique

The assessment was based on the assessment techniques developed by Pen and Scott (1995), *Stream and Foreshore Assessment in Farming Areas*, with some variations included to meet the specific needs of this assessment.

The foreshore areas were divided into sections corresponding to property boundaries where possible. A survey was conducted for each of these sections, and the condition of the foreshore parameters determined. Finally the overall Stream Condition Index was determined.

Scaled baseline maps were prepared by the Department of Environment with aerial photo-mosaics overlain by cadastral boundaries, topography and the waterway. The maps used in the survey were plotted at 1:7 000 scale with the topography information from 1:50 000 based data and the Air Photography from 1:25 000 data. As the condition of the foreshore was assessed the information was sketched onto these baseline maps. Other information such as the location of native vegetation along the verge, the location and extent of predominant weeds and the presence of erosion, sedimentation and secondary channels were detailed on each map. Fences and remedial works were also noted. Global Positioning System (GPS) was used to record most of the point data to improve the accuracy and speed of mapping. This data is presented on the maps contained within this report.

The primary focus of this assessment was the foreshore and channel areas of the River. The area studied included the riverbed, channel embankments, floodway, verge, foreshore and land use adjacent to the waterway.

Foreshore and channel assessments were conducted by walking the length of each river section. Landholders were asked about changes in waterway condition and health, fauna, past landuse and management of the waterway.

Although the survey did not propose to identify all of the plant species present along the river the dominant vegetation was described. Where vegetation was not identified during field assessments, samples were taken for later identification. Books such as *Western Weeds* (Hussey et al, 1997) as well as the expertise of consultant, Nicole Seimon from Nicole Seimon and Associates, were used to identify these specimens. A *Licence for Scientific or other Prescribed Purposes* was obtained from the

Department of Conservation and Land Management giving permission to collect flora for scientific and identification purposes subject to certain conditions.

2.3 Environmental Parameters of Foreshore Condition

Principal environmental parameters were used as indicators of foreshore condition and were assessed during the foreshore survey to determine overall Stream Condition Index. These parameters are:

- Bank stability;
- Foreshore vegetation;
- Stream cover;
- Habitat diversity; and
- Verge vegetation.

During this survey verge vegetation extent was described and mapped for each river section to highlight this issue, however the overall foreshore condition ratings do not include this rating. The decision to exclude the presence of verge vegetation in the overall ratings was made because along much of the river the overall lack of verge vegetation would downgrade most ratings.

2.4 River Zone Assessment

The survey used a rating system to assess the health of the foreshore based on a method developed by Pen and Scott (1995). This system was developed for rivers in the southwest land division, and therefore required some amendments to improve the descriptions for rivers in the semi-arid zone, such as the downgrading of rivers due to lack of permanent water and the presence of salinity.

The Stream Condition Index is a summary of the foreshore environmental parameters and is an indication of the overall stream condition (Table 2).

Table 2: Stream Condition Index Colour Parameter Description Code Rating

Blue	A (Very Good)	All parameters rated Blue.
Green	B (Good)	Three to four parameters rated Green or better with only one parameter rated Yellow and no Red ratings.
Yellow	C (Moderate)	Three parameters rated Yellow or better with no more than one Red.
Red	D (Poor)	Three to all parameters rated Red.

A brief overview of the foreshore environmental parameters and the grading system follows in Table 3. This document provides ratings for the four key levels (A, B, C, and D).

2.5 Collating the Results

The results compiled from the foreshore surveys of each section were collated and a series of maps produced. These maps were digitised and the GPS data downloaded to enable presentation of the foreshore information in a visual format with corresponding text.

The summary codes of the condition of environmental parameters and the Stream Condition Index are included on the summary map for each site.

This report also contains a detailed description of the key findings for the five environmental parameters assessed for each survey section. Suggested action for each section, regional management priorities and overall management recommendations are also outlined. Note that in this document the left and right sides of the main channel are defined by looking upstream.



Photograph 2: Carrying out the survey

Table 3: The summary conditions of the environmental parameters assessed to determine foreshore health

	Bank Stability	Foreshore vegetation	Stream cover	Habitat Diversity	Verge vegetation
Blue (A) Excellent	No significant erosion, slumping or sediment deposits in floodway or on lower banks; good native vegetation cover; only isolated areas of exposed soil or thinning vegetation.	Vegetation structure dominated by native plants that comprise 80-100% of the total number of species; weeds only scattered or rarely evident in small clusters; nil or minor signs of disturbance (i.e. tracks, rubbish dumping).	Abundant shade from overhanging vegetation; occasional instream cover from patches of aquatic vegetation and isolated heaps of leaf litter or rocks and logs.	Good water quality and some permanent water; at least three aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for each terrestrial vertebrate category (frogs, reptiles and birds).	Relatively intact shrubland and woodlands adjoining the riparian zone. Structure dominated by native plants with minimal weed invasion and few signs of disturbance.
Green (B) Good	Some localised erosion, slumping and sediment deposits; native vegetation cover on verges may be patchy and interspersed with patches of exposed soil.	Some changes in vegetation structure, native plants comprising 50-80% of the total species composition; little revegetation of trees and shrubs; weeds occurring occasionally; moderate levels of disturbance.	Stream channel mainly clear; fringing vegetation almost absent providing very little permanent shade; instream cover almost absent with generally no instream vegetation and very infrequent rocks and logs.	No apparent problems with water quality (i.e. muddy or cloudy in winter); at least two aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for any two of the terrestrial vertebrate categories.	Vegetation patchy but comprises mostly native species. Native vegetation covers more than 50% of the section. Moderate levels of disturbance.
Yellow (C) Moderate	Extensive active erosion, slumping and sediment deposition particularly during peak flows; bare banks and verges common.	Modified vegetation structure with native plants comprising only 20-50% of the total species composition. Tress remain with only scattered shrubs and an understorey dominated by weeds; high prevalence of disturbance.	Stream channel mainly clear; fringing vegetation almost absent providing very little permanent shade; instream cover almost absent with generally no instream vegetation and very infrequent rocks and logs.	Possible seasonal problems with water quality and no permanent water; at least one aquatic habitat type; at least one habitat type for terrestrial invertebrates; at least one habitat type for one of the terrestrial vertebrates.	Verge vegetation minimal with occasional individual plants or small groups of plants. Usually shrubs and occasional trees with a dense understorey of weeds. Numerous signs of disturbance and minimal regeneration of native seedlings.
Red (D) Poor	Almost continuous erosion; over 50% of banks slumping; sediment heaps line or fill much of the floodway; little or no vegetation cover.	Insufficient vegetation to control erosion; natural vegetation structure absent with occasional native trees and shrubs comprising less than 20% of the total species composition; weeds abundant; very high prevalence of disturbance and extensive areas of exposed soil.	Zero or minimal stream cover with no permanently shaded areas and no instream cover.	Poor water quality; almost no healthy habitats available for aquatic and terrestrial organisms.	Vegetation adjoining the riparian zone is minimal or absent. disturbance is conspicuous.

Source: Water and Rivers Commission (2001), WRM 23.

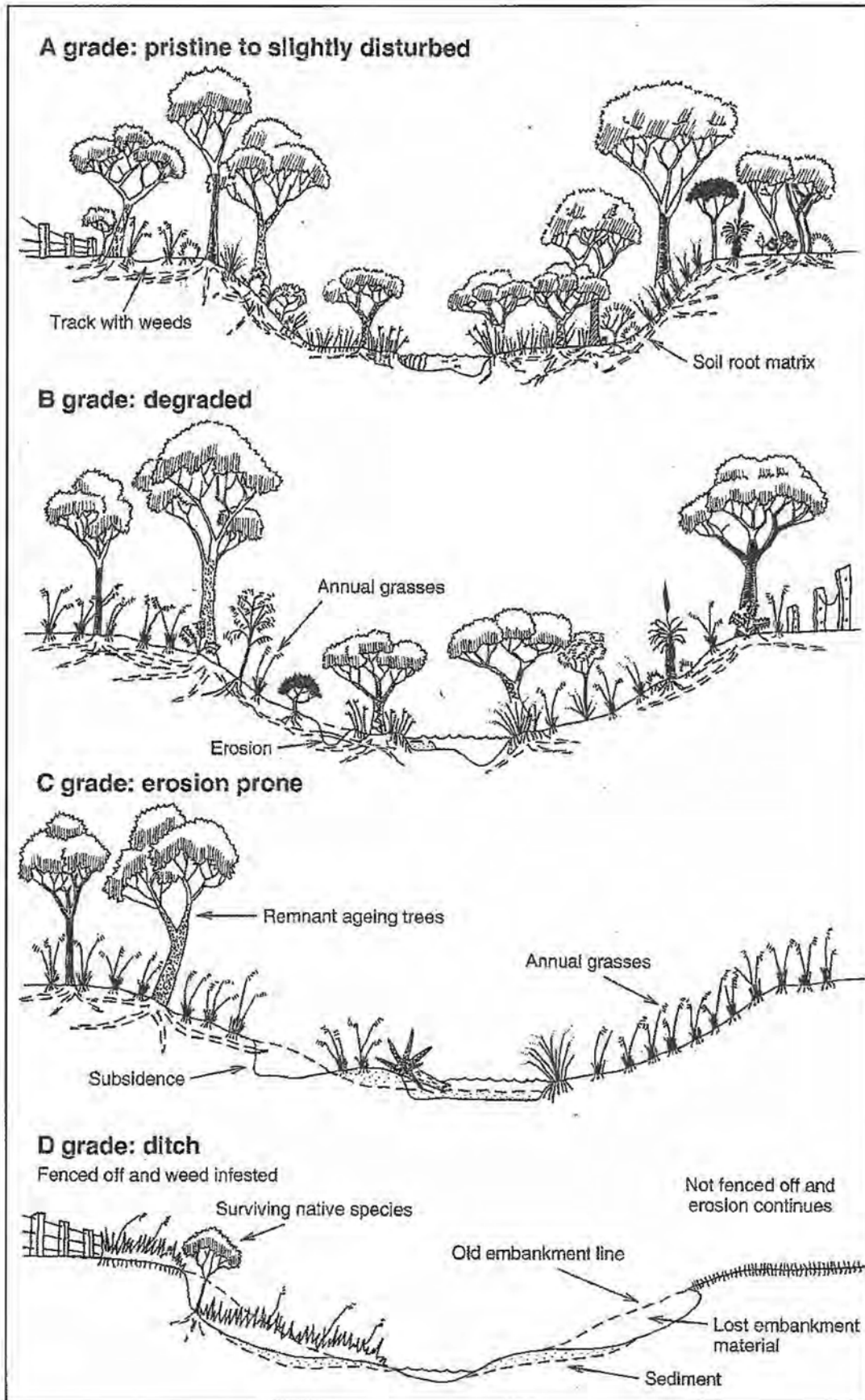
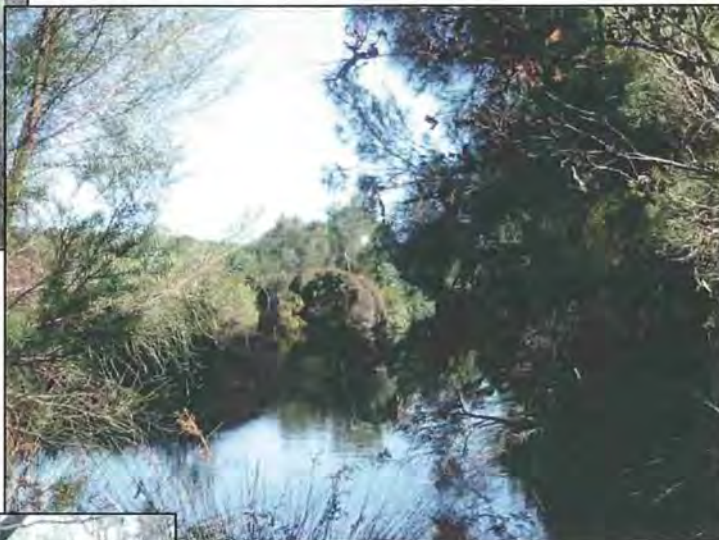


Figure 3: Foreshore Condition Ratings

Source: Water and Rivers Commission, 1999

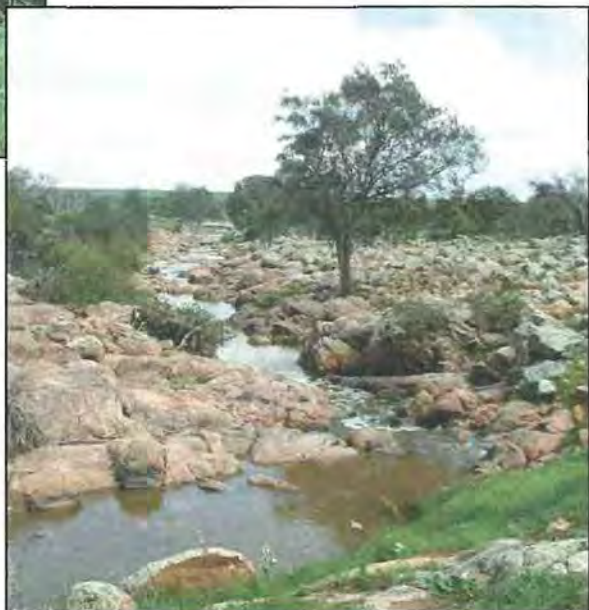


A grade foreshore: Fringing vegetation provides habitat, shade and leaf litter, important elements of a healthy river system.



A grade foreshore: Native fringing vegetation protects the banks from erosion, as well as trapping sediment and organic matter before it reaches the river.

B grade foreshore: Although sedges are abundant, weeds have become a significant component of the understorey vegetation.



B grade foreshore: Rocky areas exhibit excellent bank stability.



C grade foreshore: Trees remain though there is little evidence of regeneration. The shallow-rooted weedy understorey provides no support to the soil, making the banks vulnerable to erosion.



C grade foreshore: Soil is being washed away from between tree roots and the undermined trees are at risk of falling into the river. This will cause ongoing erosion problems.



D grade foreshore: Deposits of sediment are accumulating along the river and the river channel is widening and eroding back into farmland.



D grade foreshore: The waterlogged area is wide due to the lack of vegetation to confine and take up water.

3 Section reports

This part of the report provides a series of descriptions of river sections. Many of the river sections correspond with property boundaries at the time of the survey as these often corresponded to a management entity. However, due to separate titles on different sides of the river and the presence of some small holdings, not all of the sections equate to properties.

A description is given for each of the four parameters used to determine the stream condition index rating along the section. Although some dominant native and introduced plant species are included, the survey was not intended to examine the vegetation in detail. The suggestions in the report are intended to help landholders meet their land management objectives while protecting and potentially improving the natural values of the river and its tributaries. General management suggestions and further information is located in Section 4 of this report.

The Hutt River Foreshore Study Maps, located in the back of this report, provide a visual complement to the descriptions. The maps are a tool for each landholder to use to continue to document changes to their river section, and to monitor the health of their river section. Each landholder should feel free to add information to the map for their section, to monitor weed control success for example. The foreshore assessment process was based on a profoma, which can be obtained from the Department of Environment, to reassess the condition of the river to see how management actions have affected the condition.

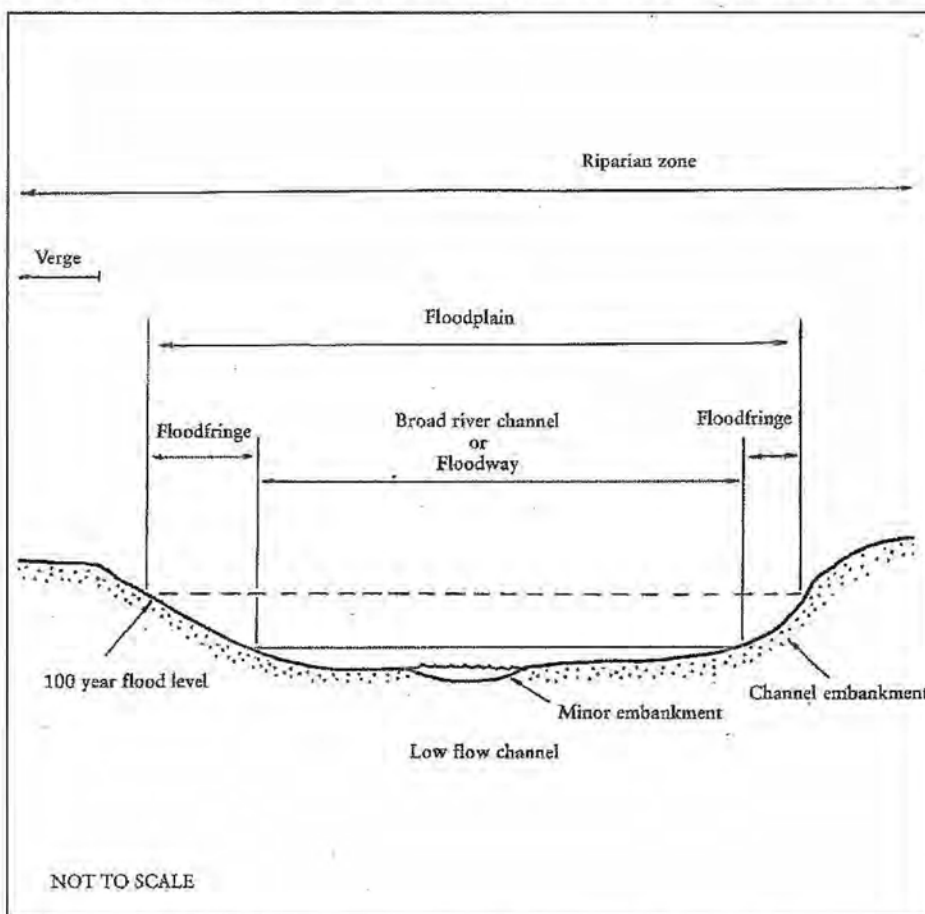


Figure 4: Typical river valley form and the riparian zone. The terminology from this diagram is used throughout the specific site reports.

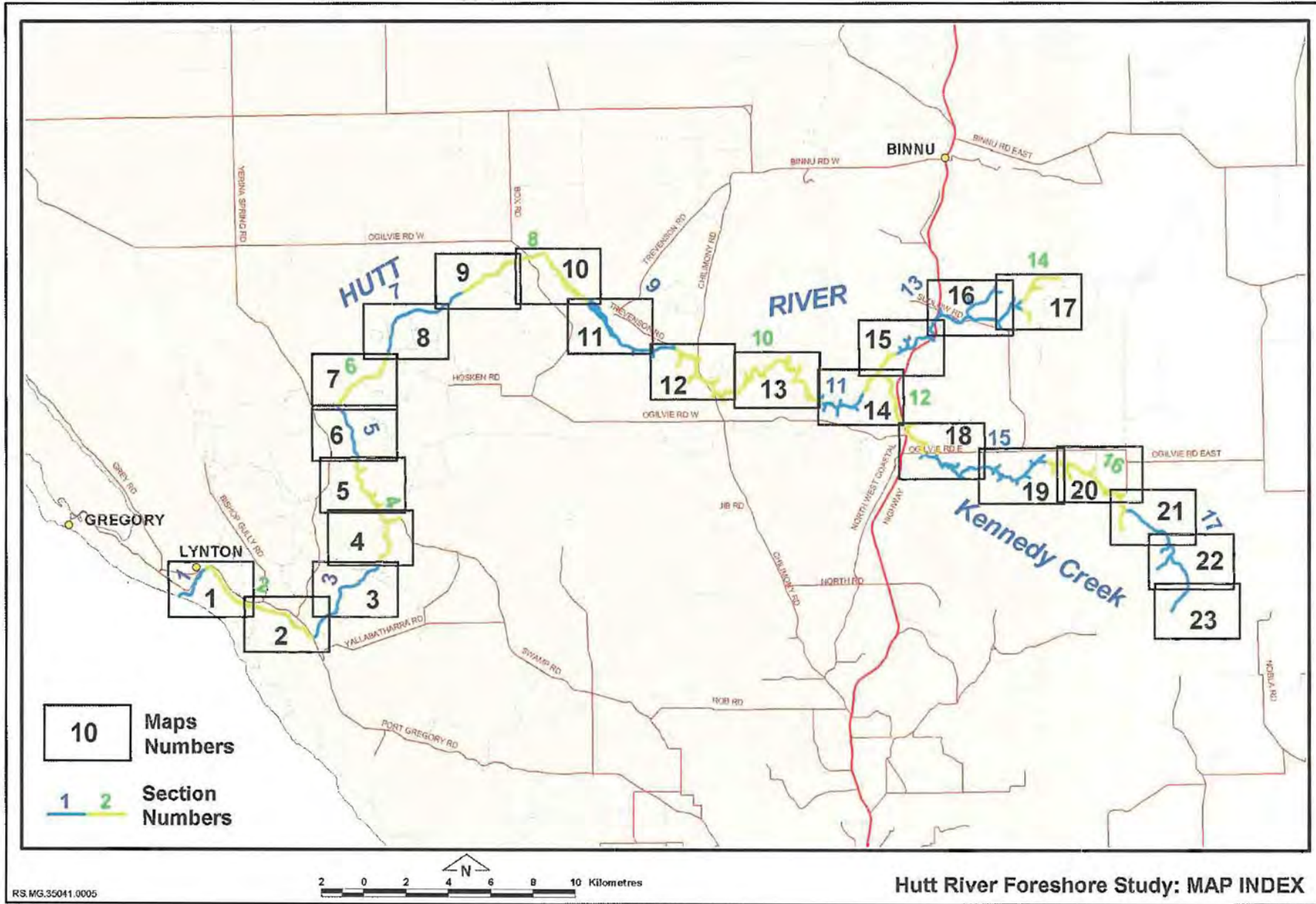


Figure 5: Index map for locating sections of the Hutt River

Specific Site Reports

Section 1

Map 1

Length of section: 2 026 metres

Date surveyed: 24/07/03

A grade	B grade	C grade	D grade
	968 metres	1 058 metres	

Bank stability

Bank stability at the mouth of the river is moderate. Large flows appear to have caused significant erosion along the banks and sand dunes and there is little vegetation stabilising the dunes. The river, previously meandering to the north just before reaching the ocean, has changed course recently during a large flow event. Much of the flow now bypasses its original path and flows straight to the ocean.

There is no significant erosion immediately upstream of the river mouth where sedges and trees hold the banks together providing good bank stability.

Vegetation

Vegetation is good along most of this section. The overstorey is characterised by *Casuarina obesa* (Swamp sheoak) and *Eucalyptus camaldulensis* (River red gum) with *Melaleuca raphiophylla* (Swamp paperbark) offering the equivalent of a middlestorey. Dodder, an unidentified climber, is abundant growing over the *M. raphiophylla*.

The understorey comprises *Cyperus gymnocaulos* (Spiny flat sedge), *Juncus kraussii* (Sea rush) and weeds including annual grasses, Wild radish (*Raphanus raphanistrum*) and Patterson's curse (*Echium plantagineum*).

One Prickly pear (*Opuntia stricta*) and two Castor oil (*Ricinus communis*) plants were observed growing in the road reserve adjacent to the river.

At the downstream end, towards the river mouth, the vegetation is characterised by coastal species.

Stream cover

Stream cover is mainly good with many overhanging sedges and *Melaleuca raphiophylla* providing shade and cover. The larger canopy trees also offer shade.

Habitat diversity

Habitat diversity is good. Many sedges and overhanging trees provide cover and food for aquatic animals, whilst the thick vegetation on the right bank provides good habitat for terrestrial animals. At the time of the survey, many water birds were observed roosting in the larger trees along the river.

Main Issues	Suggested Actions
<p>Estuary management requires full integration of catchment and marine management. Pressures include catchment development, increased terrestrial runoff and nutrient supply, sediment deposition, habitat loss and resource exploitation.</p>	<p><i>Encourage good land and waterway management within the catchment to minimise adverse impacts on the estuary. Prevent onsite degradation of the estuary and coastal environment.</i></p>
<p>Although evidence of pigs and rabbits was not observed along this section they are present and disturbing the bed and banks on nearby properties. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>The estuarine and coastal areas of the Hutt River are located on Unallocated Crown Land. This area requires management to prevent further degradation and to enhance the area for environmental and recreational value.</p>	<p><i>Establish vesting and management responsibility of the Hutt River estuarine and coastal areas. Develop an estuarine and coastal management plan for the area.</i></p>
<p>There is opportunity for interested group of locals to work with the Shire of Northampton to protect and enhance the Hutt River Estuary area.</p>	<p><i>Explore opportunities for forming a coastal community group and/or inviting a group to adopt the Hutt River Estuary area to protect and enhance environmental, cultural and recreational values of the estuary area.</i></p>
<p>Vegetation is lacking along the 800 metres of where the estuary meets the ocean. A large denuded sand dune makes up the southern bank and flow events have eroded the northern bank to a vertical cliff of greater than one metre high.</p>	<p><i>Explore options to decrease the danger posed to visitors by the eroding vertical cliff and reintroduce riparian and coastal vegetation to the downstream part of the estuary.</i></p>
<p>There are many four-wheel drive tracks in the sand dunes near the Hutt River estuary. Vehicles in dunes, and above the high tide mark on the beach can cause significant damage, including loss of vegetation, soil disturbance, and the creation of blowouts and sand sheets.</p>	<p><i>Monitor 4WD tracks and close any unnecessary tracks.</i></p>
<p>Castor oil (<i>Ricinus communis</i>) and Prickly pear (<i>Opuntia stricta</i>) are present in only this section along the Hutt River. Castor oil is a problem along other rivers in the region and can threaten native vegetation if allowed to spread.</p>	<p><i>Remove Castor oil and Prickly pear. Monitor for re-occurrence and remove plants when sighted. See Appendix 3 for pictures and removal methods.</i></p>
<p>Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sited remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>

Section 2

Maps 1 & 2

Length of section: 6 829 metres

Date surveyed: 24/07/03

A grade	B grade	C grade	D grade
	5 494 metres	1 335 metres	

Bank stability

Bank stability along this section is generally moderate. Stability is enhanced immediately downstream of the Port Gregory Road bridge, due to the presence of many rocks in the channel and sedges growing along the banks. There are signs of damage from high flows along this section with many secondary channels and washouts in the floodway. This section also exhibits some areas of steep eroding banks on the floodway margins. For example, there is a vertical face of about 10 metres along the outer floodway of a one hundred metre stretch. Some undermining of trees and exposed roots are present within the channel. Some large woody debris accumulations may block flow in medium to high flow events.

There is evidence that sheep and pigs have access to the floodway. These animals disturb banks, contribute to erosion and disrupt the nutrient balance of waterways.

Vegetation

The vegetation along this section ranges from moderate to good. There is good regeneration of native plants however much of this is under stress as a result of grazing by stock. The dominant overstorey alternates between *Casuarina obesa* (Swamp sheoak) and *Eucalyptus camaldulensis* (Red river gum).

Melaleuca raphiophylla (Swamp paperbark), as well as forming part of the overstorey, dominate the middlestorey. *Pimelea microcephala* (Shrubby rice flower), *Acacia* spp. (wattles) and *Labichea lanceolata* (Tall labichea) are also abundant in the middlestorey.

There is a range of sedges in the understorey including *Juncus kraussii* (Shore rush), *Cyperus gymnocaulos* (Spiny twig sedge), *Baumea juncea* (Bare twig rush) and some *Isolepis* sp. and *Lepidosperma* sp.. There is also some *Cotula* sp., *Lobelia* sp. and abundant *Gahnia* sp. (Saw sedge) at the beginning of the section. There are many weeds in the understorey, mainly annual grasses, Soursob (*Oxalis pes caprae*) and some other pasture weeds. There are a few stands of *Typha domingensis* (Cumbungi) and *Baumea articulata* (Joint twig sedge) in the channel.

Stream cover

Stream cover is good. Much of the channel is permanently shaded and sedges overhang the banks. The many rocks along this section, woody debris and leaf litter provide stream cover.

Habitat diversity

Habitat diversity is good. Many pools and riffles are present as well as woody debris, all of which provide habitat. A good overstorey, middlestorey and understorey and extensive verge vegetation for much of the right bank (looking upstream), provide good habitat for terrestrial animals. Instream woody debris and litter provide good habitat for aquatic animals. Tadpoles and small fish are present in the pools and frogs can be heard. There is some evidence of kangaroos in the floodway.

Main Issues	Suggested Actions
Anecdotal evidence and field observations suggest that feral pigs, foxes and feral cats are present. These animals can undermine bank stability and threaten native fauna. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
Stock access is currently having a negative impact on the floodway. Sheep are exacerbating erosion and large gullies have formed along sheep tracks down steep banks. Grazing is reducing successful regeneration of floodway vegetation.	<i>Fence the river to permit management of stock access to prevent exacerbation of erosion gullies and allow regeneration of riparian vegetation.</i>
Being located on the lower reaches of the river means that in high flows large volumes of water move through this section. Thus, to prevent erosion damage, a thick band of vegetation needs to exist within the floodway.	<i>Ensure fences for allowing monitored stock access are located well out of the floodway. Manage stock to ensure thick vegetation and sedge cover exists.</i>
Trees are required on the flat ground above the valley. This enables trees on the upper part of the embankment and those above the river valley to anchor each other and the adjacent land, preventing subsidence and widening of the valley, see <i>Figure 8A</i> .	<i>Encourage growth of trees on the flat ground above the valley edge, allowing their roots to interlock with those growing on the steep slope.</i>
Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).	<i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i>



Photograph 3: The old Port Gregory Road crossing although slowly eroding away is still obstructing small to medium flows



Photograph 4: The new Port Gregory Road bridge minimised disturbance to flow.

Section 3

Maps 2 & 3

Length of section: 5 371 metres

Date surveyed: 18/7/03

A grade	B grade	C grade	D grade
1 401 metres	3 970 metres		

Bank stability

The bank stability is good to excellent as rock forms the bed and banks for most this of section and sedges stabilise the banks where rocks are absent. In this section, the main channel of the Hutt River is well defined ranging in width from 3 – 8 metres for the most part but spreading to 20 metres over a flat rocky bed just downstream of the stream gauging station. Many large washouts have developed during high flow events and are being colonised by dominant vegetation species.

Pig diggings in sandy areas of the floodway may cause erosion and washouts in medium to large flows. Stock access to the river and is adversely affecting bank stability in the upstream part of this section.

Vegetation

The vegetation along this section is good. Sections graded 'A' have less than 20% weed cover present. Regeneration is abundant along the length of this section. The dominant overstorey species is *Casuarina obesa* (Swamp Sheoak), with the occasional *Eucalyptus camaldulensis* (River Red Gum) and some larger *Melaleuca raphiophylla* (Swamp paperbark).

The middlestorey is dominated by *Melaleuca raphiophylla* (Swamp paperbark), *Acacia* spp (Wattles), *Labichea lanceolata* (Tall labichea) and *Melaleuca viminea* (Mohan).

The understorey consists of the native herb *Lobelia* sp., *Cyperus gymnocaulos* (Spiny flat-sedge), *Juncus kraussii* (Shore rush), *Isolepis* sp., *Cotula* sp., *Lepidosperma gladiatum* (Coast sword-sedge) and *Baumea juncea* (Bare twig rush) with occasional *Gahnia* sp. (Saw sedge). Weeds present include annual grasses, Soursob (*Oxalis pes-caprae*) and some pasture weeds, with isolated Black berry nightshade (*Solanum nigrum*) and patches of couch (*Cynodon dactylon*).

Verge vegetation is extensive along most of this section however for half of the length it is not continuous with the riparian vegetation. This leaves the areas in the floodway lacking perennial vegetation between the riparian zone and verge vegetation exposed to scouring during flood events.

Stream cover

Stream cover is excellent along this section. *Melaleuca* and sedges overhang the water and provide continuous shade. Woody debris, snags and rocks provide stream cover.

Habitat diversity

Habitat diversity is good to excellent. Pool and riffle sequences provide good habitat for aquatic animals along with instream and overhanging vegetation and woody debris. Good verge vegetation, leaf litter and the rocky verge provide habitat for birds, reptiles and other animals. Many birds and frogs were heard during the survey and tadpoles, a bobtail lizard and kangaroo tracks were observed.

Main Issues	Suggested Actions
Anecdotal evidence and field observations suggest that feral pigs foxes and feral cats are present. These animals can undermine bank stability and threaten native fauna. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
Stock exclusion from the downstream part of this section is reflected in its good to excellent condition. There is evidence of a fence along the upstream of this section lost in a large flow event. To prevent the loss of fences they need to be located above the floodway.	<i>Exclude or manage stock access to upstream floodway sections. Ensure fences are located above the floodway.</i>
All washouts present are associated with areas lacking vegetation cover or where no verge vegetation exists along the riparian vegetation.	<i>Ensure adequate vegetation cover in the floodplain.</i>
Removal of fences across the river or the use of plain wire fences reduce or prevent debris accumulation on the wire. Debris accumulation impacts on river flow, which can cause deflection of water and erosion of banks.	<i>If fences must cross the river, the use of temporary or plain wire fences is recommended.</i>
Black berry nightshade (<i>Solanum nigrum</i>) has become a nuisance along other waterways in the Northern Agricultural Region. It has also been known to host agricultural pests such as bacteria and fungus.	<i>Eradicate Black berry nightshade while in small numbers to reduce the threat of it becoming a significant management issue. Monitor for reoccurrence. See Appendix 3 for a picture and control methods.</i>
Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).	<i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i>

Section 4

Maps 4 & 5

Length of section: 5 857 metres

Date surveyed: 30/06/03

A grade	B grade	C grade	D grade
3 049 metres	2 808 metres		

*Note: due to limited access along the river of this section some assumptions have been made.

Bank stability

Along this section of the Hutt River, the channel is well defined ranging in width from 3 to 10 metres with occasional braided sections. The bank stability along this section is excellent in the portion graded 'A', with rocky outcrops present along the left bank (looking upstream), and dense vegetation, including sedges, stabilising the right bank. There is no evidence of erosion along the 'A' grade section.

Bank stability in the portion graded 'B' is moderate to good. The rocky left bank is still present, however there is less fringing vegetation and sedge cover than the 'A' graded section. There are several large washouts and substantial accumulations of large woody debris occur frequently. These accumulations may have contributed to erosion by deflecting the river flow.

Where the grade changes from 'A' to 'B' bank stability is reduced. Access by cattle to this part of the river may be contributing to the reduction in bank stability due to loss of vegetation as a result of grazing and trampling. There is also some evidence of feral pigs along this section, with tracks and diggings noted in the riparian zone and verge vegetation. Pigs are a threat to bank stability.

Vegetation

Vegetation is good to excellent in this section, with good representation of native vegetation in the overstorey, middlestorey, and understorey. The dominant overstorey alternates between *Casuarina obesa* (Swamp sheoak) and *Eucalyptus camaldulensis* (River red gum). *Melaleuca raphiophylla* (Swamp paperbark) is present along the entire length of this section.

The middlestorey consists of a variety of species from the following genera: *Acacia*, *Melaleuca*, *Labichea*, *Jacksonia* and *Alyogyne* (Native hibiscus).

The understorey is characterised by several different types of sedges and rushes including *Juncus kraussii* (Shore rush), *Isolepis* spp. (Club rushes), *Lepidosperma* spp. (Sword-sedges) and occasional *Cyperus gymnocaulos* (Spiny twig sedge). There are few weeds in the 'A' grade section whilst the 'B' grade area has less sedge cover and more pasture weeds, mainly annual grasses. *Baumea articulata* (Joint twig sedge) present in swampy areas and along the main channel is indicative of semi-permanent to permanent water. At one location, the native *Typha domingensis* (Cumbungi) and *Persicaria* sp. co-occur with the *B. articulata*. The introduced *Cyperus involucratus* was observed in Yarder Gully near the confluence with Hutt River.

Verge vegetation is excellent along much of this section, especially fringing the 'A' grade section, where the vegetation extends for up to 700 metres either side of the river.

Stream cover

Stream cover is excellent along most of this section, due to the continuous canopy cover and fringing sedges. Overhanging vegetation provides shade and cover. Frequent instream rocks and woody debris also provide stream cover and shade.

Habitat diversity

The habitat diversity in the 'A' grade section is excellent due to its almost pristine state. There is continuous, diverse native vegetation with few weeds as well as extensive verge vegetation and leaf litter providing excellent habitat for

birds, reptiles and other terrestrial animals. The 'B' grade section also has good habitat diversity provided by the fringing and verge vegetation.

There are many riffles, large woody debris instream and the water is well shaded, providing a good environment for aquatic animals. There appears to be some permanent or semi-permanent pools and wetland areas, indicated by dark tannin stained water and *Baumea articulata*. A permanent spring feeding into the river provides year round habitat for aquatic animals. During the survey, many frogs and shrubland birds were heard along this section and waterbirds were seen along the river.

Main Issues	Suggested Actions
Actual conversations and field observations have determined that feral pigs and rabbits are present and disturbing the bed and banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
Where large woody debris accumulations are blocking flow or directing it into banks and causing erosion they should be realigned or removed. In most cases large woody debris can be moved manually. However in this section there is one accumulation in particular that may require mechanical assistance to move or controlled burning of the offending material may be an option.	<i>Realign or remove if necessary, large woody debris accumulations where they are deflecting or blocking flow. See Box 1 or contact the Department of Environment for information.</i>
Where stock do not have access to the river it is in excellent condition. However, where stock freely graze the floodway, regeneration of native plants is limited and bank erosion is present along with many washouts in the floodway.	<i>Exclude or manage stock access and grazing in the floodway.</i>
Currently stock cross and water in many locations along the river. Controlling this access minimises damage to the bed and banks and reduces fouling of the water. Areas where the channel is flatter and rocky are ideal for controlled stock crossing and watering points.	<i>Establish controlled stock crossings and watering points.</i>
The introduced weed <i>Cyperus involucratus</i> was observed in Yarder Gully near its confluence with Hutt River. It is widely cultivated as a decorative plant, will persist almost indefinitely once planted, establishes vegetatively from garden refuse and has the potential to become a weed in some situations.	<i>Monitor to ensure <i>Cyperus involucratus</i> is not spreading. If so remove the parent plant, being careful of disposal site, and continue to remove regrowth to prevent spreading downstream.</i>
Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).	<i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i>

Section 5

Maps 6

Length of section: 2 994 metres

Date surveyed: 17/07/03

A grade	B grade	C grade	D grade
2 002 metres	992 metres		

Bank stability

Generally the bank stability along this section is excellent due to rocky banks and continuous sedge cover along the banks. For most of this section the channel width is about 3 – 5 metres wide and about 0.5 – 1.5 metres deep. One area however, about half a kilometre from the upstream end of the section and of about 400-500 metres in length, has very steep banks and significant erosion, probably the result of a large flood. In places along this length the channel appears to have eroded to bedrock. Here the channel is approximately 4 metres deep and up to 10 metres in width. Many large trees have fallen into and across the river due to the undermining of banks. Whilst some of these fallen trees are well aligned with the bank and are acting to protect the bank from further erosion, others may act to impede high flow and result in further bank erosion. In several places the natural accumulation of large woody debris during flood has created dams across the channel which may cause erosion of banks on either side. This problem is also evident where a fire break has been put in and the resulting trees and wood bulldozed into the river, causing severe erosion directly downstream.

There are many pig diggings along this section especially on the flood fringe towards the downstream end of the section. These make the soil vulnerable to erosion and washouts in higher flows.

Vegetation

Vegetation in this section is good to excellent. There is good regeneration of all native species. The continuous canopy fringing the river is dominated by *Melaleuca raphiophylla* (Swamp paperbark) and *Eucalyptus camaldulensis* (River Red Gum) with the occasional *Casuarina obesa* (Swamp sheoak). An isolated stand of a bamboo-like plant was observed during the survey.

The middlestorey is excellent for the most part and includes *Melaleuca raphiophylla*, *Melaleuca viminea* (Mohan), *Acacia saligna* (Orange wattle), *Acacia rostellifera* (Summer-scented wattle), *Alyogyne huegelii* (Native hibiscus), *Labichea lanceolata* (Tall Labichea). The middlestorey is sparse to absent in the 'B grade' area at the upstream end of this section in comparison to the 'A grade' areas.

The understorey is comprised of mostly native species, including *Cyperus gymnocaulos* (Spiny flat-sedge), the native herb *Lobelia* sp., *Juncus kraussii* (Shore rush), *Baumea juncea* (Bare twig rush), *Lepidosperma gladirtum* (Coast sword-sedge), *Gahnia* sp. (Saw sedge) and patches of *Bolboschoenus caldwellii* (Marsh club-rush) and *Baumea articulata* (Jointed rush). Weeds present are mainly annual grasses with occasional other pasture weeds, Black berry nightshade (*Solanum nigrum*) and small patches of Couch (*Cynodon dactylon*). Weeds are more common in the 'B' grade section.

There is extensive, diverse verge vegetation along much of this section. The verge vegetation extends from 75 to 600 metres on each side of the river with the larger expanses in the downstream half of the section.

Stream cover

Stream cover is excellent, with tree canopy shading the entire length of this section. Sedges, *Lobelia* sp. and middlestorey species are present instream and overhang the water. Rocks, woody debris and leaf litter also provide stream cover.

Habitat diversity

This section provides excellent habitat for birds, reptiles, other terrestrial and aquatic animals. Varying water velocities, riffles, pools, leaf litter, woody debris, rocks and instream vegetation provide excellent aquatic habitats. Good vegetation present in the overstorey, middlestorey and understorey in addition to extensive verge vegetation for much of

the length provides good habitat for terrestrial animals. Many frogs and birds were heard during the survey and evidence of kangaroos observed.

Main Issues	Suggested Actions
Actual conversations and field observations have determined that feral pigs are present and disturbing the banks of the river. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
During the time of survey a freshly made firebreak had slightly decreased the width of the thin band of verge vegetation fringing the riparian vegetation along part of this section. The woody debris formed during this exercise had been pushed into the river channel. This blockage is obstructing river flow and causing significant erosion immediately downstream.	<i>Firebreaks maintain the existing extent of the verge vegetation. The large woody debris blocking the river should be removed to prevent further erosion downstream. Care should be taken to ensure nothing goes into the river that interferes with flow.</i>
Where large woody debris accumulations are blocking flow or directing it into banks and causing erosion, they should be realigned or removed. In most cases large woody debris can be moved manually. However in this section there is one accumulation in particular that may require mechanical assistance to move or controlled burning of the offending material may be a option. Many logs along this section were actually aligned to protect the banks.	<i>Realign, or remove if necessary, large woody debris accumulations where they are deflecting or blocking flow. See Box 1 or contact the Department of Environment for information.</i>
A stand of a bamboo-like plant is present on the edge of a tall vertical bank. These types of plants can help bank stability or can be aggressive weeds threatening the native riparian vegetation.	<i>Check the identity of the bamboo-like plant and monitor to ensure that it is not spreading. If it is an aggressive weed or is spreading, removal should be a long term goal once other vegetation has been established to maintain bank stability.</i>
At present this section is in good to excellent condition. However conditions can deteriorate rapidly especially if stock have uncontrolled access or management practices change.	<i>Monitor condition to ensure good to excellent condition is maintained. If condition starts to deteriorate, management may need to be altered.</i>
Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).	<i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i>

Section 6

Maps 7

Length of section: 3 813 metres

Date surveyed: 16/07/03

A grade	B grade	C grade	D grade
164 metres	1 923 metres	1 726 metres	

Bank stability

The bank stability is good to excellent along most of this section of the Hutt River. A rocky channel bed is common and rocks along the banks increase the bank stability. Many large trees line the channel embankment and dense shrubland in the floodway provides bank stability for much of the length. Good sedge cover in many places also increases bank stability. The downstream half of this section appears to have suffered more during large flood events, indicated by large washouts in the outer floodway and accumulated large woody debris. Most of this downstream half lacks the dense shrubland that is present in the floodway of the upstream half of the section.

Evidence of feral pigs was noted during the surveys. Together with sheep that have access to the river, pigs can undermine bank stability and contribute to erosion.

Vegetation

The vegetation along this section ranges from moderate to excellent. The dominant overstorey alternates between *Melaleuca raphiophylla* (Swamp paperbark) and *Eucalyptus* spp. with isolated patches of *Casuarina obesa* (Swamp sheoak). Dodder, an unidentified climber, is abundant growing over the *M. raphiophylla*.

The middlestorey is dominated by *Alyogyne* sp. (Native hibiscus) and *Acacia saligna* (Coojong) with *Melaleuca viminea* (Mohan) and *Labichea lanceolata* (Tall labichea).

There is an abundance of native understorey species along this section including *Juncus kraussii* (Shore rush), *Baumea juncea* (Bare twig rush), *Lepidosperma gladiatum* (Coast sword sedge), *Lepidosperma* sp. (Sword sedge), *Cyperus gymnocaulos* (Spiny twig sedge), *Gahnia* sp (Saw sedge), *Lobelia* sp. and *Cotula* sp. However, weeds are still common in the understorey, mainly annual grasses but include Soursob (*Oxalis pes-caprae*), Wild radish (*Raphanus raphanistrum*), Capeweed (*Arctotheca calendula*), Paterson's curse (*Echium plantagineum*), one Spiny rush (*Juncus acutus*) and some Black berry nightshade (*Solanum nigrum*). There are also stands of native *Typha domingensis* (Cumbungi) and *Baumea articulata* (Joint twig sedge) near a permanent spring along with two mature date palm trees.

Verge vegetation along much of this section is good containing an extremely diverse range of species.

Stream cover

The continuous shading, the presence of instream rocks, woody debris and leaf litter, together with overhanging sedges and *Lobelia* sp., provide good to excellent stream cover along this section.

Habitat diversity

The good vegetation structure in the 'A' and 'B' grade sections as well as the presence of rocks and diverse verge vegetation, provide good to excellent habitat for terrestrial animals. The overhanging vegetation and instream rocks, logs, woody debris, pools and riffles provide habitat for aquatic animals. There were many frogs and birds present during the survey, as was evidence of kangaroos.

Habitat diversity is reduced in the 'C' grade section due to the lack of middlestorey and understorey.

Main Issues	Suggested Actions
Anecdotal evidence and field observations have determined that feral pigs are present and disturbing the banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
The areas graded C appear to coincide with greater stock access and have proved to be more prone to damage during large flows. Limiting the stock access to these areas would allow greater regeneration of the riparian vegetation and increased bank stability.	<i>Alter grazing regime, exclude stock from C grade areas to allow for regeneration of riparian vegetation.</i>
Fencing across rivers is not encouraged however it is sometimes necessary. These fences can catch debris flowing down the river causing damage to the fence as well as the riverbanks by impeding flow. Temporary fences can be removed in flow events or release when the force of flow hits them. Plain wire fences tend to catch less debris than ringlock fences.	<i>Ensure fences across the river do not catch debris and impede river flow. If fences must cross the river the use of temporary or plain wire fences are recommended.</i>
In several places within this section Dodder, an unidentified climber, is abundant. Often such climbers are not a problem however in some cases if left unchecked it can strangle the supporting vegetation.	<i>Monitor dodder and if it appears to be strangling the supporting vegetation take action to remove. Contact the Department of Agriculture or Department of Environment for further information</i>
A heavy infestation of Spiny rush (<i>Juncus acutus</i>) occurs upstream of this section and although only one stand was observed on this property it could quickly spread and become a significant problem. Spiny rush is an aggressive weed that is not readily eaten by grazing animals. Once established it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.	<i>Eradicate and monitor Spiny rush removing plants observed. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i>
Two mature Date palms (<i>Phoenix dactylifera</i>) are present in Date Palm Reserve within this section. This exotic species has been planted at settlements throughout arid Western Australia and can become a serious weed.	<i>As the Date palms have heritage value removal is not recommended. However surrounding and downstream areas should be monitored for the appearance of Date palms and any suckers and seedlings removed.</i>
Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>) and White cedar (<i>Melia azedarach</i>).	<i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sited remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i>

Section 7

Maps 8 & 9

Length of section: 5 377 metres

Date surveyed: 14/07/03

A grade	B grade	C grade	D grade
4 047 metres	887 metres	443 metres	

*Note: due to limited access along the river of this section some assumptions have been made.

Bank stability

Of the few places the river was accessed along this property, there were no areas of significant erosion. In places, exposed rock provided excellent stability. Secondary channels were formed during the 1999/2000 floods. Good vegetation cover provides stability along the banks.

Evidence of feral pigs was noted. Pigs can undermine bank stability and contribute to erosion.

Vegetation

This section exhibited excellent vegetation quality across all strata. A consistent canopy of *Eucalyptus* spp. including *Eucalyptus camaldulensis* (Red river gum) is present along the length of this section.

The middlestorey includes *Melaleuca raphiophylla* (Swamp paperbark), *Acacia* species, *Labichea lanceolata* (Tall labichea), *Jacksonia* spp. and *Alyogyne* (Native hibiscus).

The understorey is good, characterised by *Juncus kraussii* (Sea rush), *Lobelia* sp., *Baumea juncea* (Bare twig rush) as well as some *Lepidosperma* sp. (Sword sedge) and *Isolepis* sp. Small patches of weeds are present in the understorey, these are mainly Soursob (*Oxalis pes-caprae*) and annual grasses. Spiny rush (*Juncus acutus*) is an aggressive weed observed in the tributaries, but not seen in the main channel.

Verge vegetation ranges from thin bands to more extensive areas and contains a diverse range of species. The verge vegetation provides a good buffer on either side of the channel for much of this section.

Stream cover

Stream cover is excellent along this section. Continuous overhanging canopy provides shade to the water. Sedges and the native herb *Lobelia* sp. overhang the water and provide cover along the edges of the channel. Logs and rocks also provide instream cover.

Habitat diversity

Instream rocks and logs create pools and riffles. Together with leaf litter and overhanging sedges these provide good habitat for aquatic animals. Permanent springs feeding into the river along this section provide year round aquatic habitat. Good verge vegetation and fringing middle and understorey vegetation provide habitat for terrestrial animals. Kangaroos were observed during the survey.

Main Issues	Suggested Actions
<p>Conversations with landholders have determined that feral pigs are present. Along a length of river that is in good condition, feral pigs can be one of the biggest threats as they can undermine bank stability and contribute to erosion. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information</i></p>
<p>The main crossing of the river is currently creating a pool and has altered the river flow where it is located. Fortunately, because of the rocky river bed and banks at the choice of location for the crossing, little to no erosion is occurring as a result.</p>	<p><i>In the event of the crossing needing replacement, design options that allow a smooth basal flow should be explored. Contact the Department of Environment for further information and advice.</i></p>
<p>Spiny rush (<i>Juncus acutus</i>) was present in many tributaries in this section. It could quickly spread to become a significant problem in the main channel, degrading pristine areas. Spiny rush is an aggressive weed that is not readily eaten by grazing animals. Once established, it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.</p>	<p><i>Take all reasonable steps to eradicate Spiny rush and monitor to prevent re-occurrence. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Although not observed in this section, African boxthorn (<i>Lycium ferocissimum</i>) is present in upstream sections. African boxthorn is an invasive weed that can become dense under trees where their seeds are dropped by birds. This denies shelter to stock and damages the eyes of grazing animals, especially during dry times when stock is chasing feed under the plants. African boxthorn is also the perfect harbour for rabbits, foxes, feral cats and pigs.</p>	<p><i>Monitor the occurrence of African boxthorn and remove when sighted. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>

Section 8

Maps 9 & 10

Length of section: 7 610 metres

Date surveyed: 20/6/03 & 15/7/03

A grade	B grade	C grade	D grade
	3 041 metres	4569 metres	

Bank stability

The bank stability along this section of the Hutt River is moderate to good. The channel is braided with up to four braids, secondary channels and washouts in the upstream part of this section. The channel becomes more defined further downstream with occasional braids. Toward the downstream end of the section the channel has insized to about two to three metres deep and about eight metres wide, with steeply eroded sandy banks. Undermining and slumping here has caused the collapse of large trees into the channel.

Much evidence of feral pigs was observed in this section. Feral pig presence and digging behaviour can undermine bank stability and contribute to erosion.

Vegetation

The vegetation within this section is moderate to good. There is good, continuous canopy cover along the length of this section. The overstorey is characterised by *Melaleuca raphiophylla* (Swamp paperbark), with intermittent *Eucalyptus camaldulensis* (River red gum) and occasional *Casuarina obesa* (Swamp sheoak).

There is a moderate cover of middlestorey with mainly *Acacia* spp., *Labichea lanceolata* (Tall labichea), *Alyogyne huegelii* (Native hibiscus). Middlestorey weeds include African boxthorn (*Lycium ferocissimum*) scattered throughout the section and two patches of Brazilian pepper (*Schinus terebinthifolia*).

The understorey is moderate to poor and comprises *Cyperus gymnocaulos* (Spiny flat sedge), *Juncus kraussii* (Shore rush), *Baumea juncea* (Bare twig rush) and the native herb *Lobelia* sp. with some instream *Cotula* sp. The density of sedge cover increases in some parts of the floodway. *Baumea articulata* (Jointed twig rush) is found around a wetland and a soak that are likely to retain permanent water. Many understorey weeds are present with pasture weeds prolific. There is one stand of the vicious weed Spiny rush (*Juncus acutus*) and the occasional Black berry nightshade (*Solanum nigrum*).

Much of this section of the river is buffered by extensive verge vegetation continuing out for up to two kilometres from the riparian vegetation.

Stream cover

Stream cover is good with continuous shade offered by canopy trees, instream woody debris, overhanging sedges and the native herb *Lobelia* sp.

Habitat diversity

The habitat diversity for this section is good. There are many small waterfalls aerating the water, different depths of water, pools and woody debris. Aquatic habitat diversity is increased by the presence of a wetland within the floodway. This wetland contained black, tannin stained water and *Baumea articulata* (Joint twig rush) both of which are indicators of semi-permanent to permanent water. Small fish were observed during the survey and frogs heard. Leaf litter, riparian vegetation and extensive verge vegetation along much of the section provides habitat for terrestrial animals.

Main Issues	Suggested Actions
<p>Conversations with landholders and field observations have determined that feral pigs are present and disturbing the bed and banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>A heavy infestation of Spiny rush (<i>Juncus acutus</i>) occurs upstream of this section and although only one stand was observed on this property it could quickly spread and become a significant problem. Spiny rush is a aggressive weed that is not readily eaten by grazing animals. Once established it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.</p>	<p><i>Eradicate and monitor Spiny rush. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>The only two occurrences of Brazilian pepper (<i>Schinus terebinthifolia</i>) observed along the river were within this section. Brazilian pepper is a weed that can form dense thickets excluding other plants by shading out and smothering them or poisoning the soil with fallen leaves and berries. They are most invasive in moist situations and have become a major problem along other rivers in the Northern Agricultural Region.</p>	<p><i>Remove Brazilian pepper while only a few plants are present. Monitor for re-occurrence and remove plants when sighted. See Appendix 3 or contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Although presently uncommon along the Hutt River, the invasive African boxthorn (<i>Lycium ferocissimum</i>) is scattered throughout this section. African boxthorn is an invasive weed that can become dense under trees where their seeds are dropped by birds. This denies shelter to stock and damages the eyes of grazing animals, especially during dry times when stock is chasing feed under the plants. African boxthorn is also the perfect harbour for rabbits, foxes, feral cats and pigs.</p>	<p><i>Work to eradicate African boxthorn while in a relatively small area before it spreads further and becomes a major problem. Replace African boxthorn with native middlestorey plants to ensure habitat for shrubland birds. See Appendix 3 or contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Although extensive verge vegetation is present along most of this section, there is a lack of vegetation within much of the floodway to protect it against scour and erosion during flood events.</p>	<p><i>Ensure adequate vegetation cover to protect the floodway from erosion during larger flows. Revegetation may be necessary if managing stock access to allow natural regeneration does not achieve sufficient vegetation cover.</i></p>
<p>A large palm was observed downstream of the Box Road crossing. Some introduced palm species can spread along waterways and become serious management problems.</p>	<p><i>Identify the palm and determine if it could become a problem and therefore should be removed.</i></p>
<p>Several aggressive weeds, although not located within this section, are present along the Hutt River and Kennedy Creek. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>) and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>

Section 9

Maps 11 & 12

Length of section: 5 479 metres

Date surveyed: 17/06/03 & 18/06/03

A grade	B grade	C grade	D grade
	731 metres	3 955 metres	793 metres

Bank stability

The bank stability of this section of the Hutt River is moderate. The channel is braided along most of the section, with up to 5 braids in the downstream reaches, anecdotal evidence suggests the channel changed course and became braided during the 1960s. Washouts, erosion and secondary channels are common along this stretch of the river. Erosion is worst in a number of areas such as on power bends, where large woody debris accumulations deflect flow, popular stock crossings and where larger flows have gone around the narrow strip of vegetation along the main channel. There is minimal washout damage where good sedge cover exists. Loose mobile sediment is present throughout the channel and has been deposited periodically to form large plumes. These sediment plumes accumulate upstream of where river flow is impeded. The floodplain ranges between 50 and 250 metres in width and the channel depth from approximately 0.5 to 2 metres. In much of the upstream section where the channel is more defined, the riverbed has eroded to bedrock.

Feral pigs were seen by the river, together with sheep that have access to the river. The impacts of these animals can undermine bank stability and contribute to erosion.

Vegetation

The remnant vegetation is moderate in this section. Some regeneration of native species was noted, however these are under continuous pressure from stock grazing along this section. Characteristic canopy species are *Casuarina obesa* (Swamp sheoak), *Eucalyptus camaldulensis* (River red gum) and *Melaleuca raphiophylla* (Swamp paperbark).

The extent of the middlestorey is limited and is mostly found on the flood fringe, and consists of *Acacia* spp. including *A. rostellifera* (Summer scented wattle), *A. acuminata* (Jam) and *A. tetragonophylla* (Kurara). Other shrubs present include *Hakea preissii* (Needle tree), *Hakea recurva* (Djarnokmurd) *Labichea lanceolata* (Tall labichea) and *Alyogyne* sp. (Native hibiscus). The introduced African Boxthorn (*Lycium ferocissimum*) occurs throughout the floodway.

The understorey is dominated by pasture weeds with occasional small stands of sedges. Remnant native understorey species include *Cyperus gymnocaulos* (Spiny twig sedge), *Lepidosperma gladiatum* (Coast sword sedge) with *Isolepis* sp. noted in one area. *Lobelia*, *Maireana* sp. and *Cotula* are also present in the channel.

Two small isolated patches of verge vegetation are present and are continuous with the riparian vegetation.

Stream cover

Stream cover in this section is rated as moderate to good, due to the continuous canopy providing shade to the water. Sedges, woody debris and occasional rocks also provide instream cover.

Habitat diversity

Habitat diversity is moderate along this section. Some pools provide habitat for aquatic animals and there is a swampy area with dense sedge cover providing habitat for frogs and aquatic invertebrates. The overstorey vegetation provides suitable roosting and nesting sites for birds. A flock of Red tailed black cockatoos were observed in this section.

Main Issues	Suggested Actions
Field observations have determined that feral pigs are present and disturbing the bed and banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
Although the thin band of mature trees lining the river provides a good seed bank there was little to no regeneration of riparian vegetation observed along this section. Continuous grazing pressure is the most likely cause.	<i>Fence the river to permit management of stock access to allow regeneration of the riparian vegetation. Some areas may also benefit from planting or direct seeding along the flood fringe.</i>
The impact of uncontrolled stock access has resulted in erosion and scouring of the banks and in the floodway, especially along popular trails.	<i>By fencing and treating the river as a sensitive paddock, erosion, scour and sedimentation can be minimised.</i>
In some areas floodwaters have evaded the thin strip of vegetation where it can move more quickly and cause more severe erosion.	<i>Expand the buffer of vegetation on each side of the channel. Ensure that fences are located far enough from the banks to allow the buffer to prevent further erosion, washouts, widening of the channel, and fence loss.</i>
In part of this section the floodplain is extremely wide. This allows floodwaters to spread out, leave the channel and cause large washouts. One way to prevent this is to extensively vegetate the area with trees, shrubs and sedges. This would also act to slow the water and decrease the volume of water in the channel downstream of this area. Decreasing the velocity and volume of water in the channel decreases the amount of damage a flood can cause.	<i>Investigate possibility of flood attenuation works. Seek advice from the Department of Environment.</i>
Although presently uncommon along the Hutt River, the invasive African boxthorn (<i>Lycium ferocissimum</i>) is present in this section. African boxthorn is an invasive weed that can become dense under trees where their seeds are dropped by birds. This denies shelter to stock and damages the eyes of grazing animals, especially during dry times when stock is chasing feed under the plants. African boxthorn is also the perfect harbour for rabbits, foxes, feral cats and pigs.	<i>Work to eradicate African boxthorn before it spreads further and becomes a major problem. Replace African boxthorn with native middlestorey plants to ensure habitat for shrubland birds. See Appendix 3 or contact the Department of Agriculture or Department of Environment for further information.</i>
A heavy infestation of Spiny rush (<i>Juncus acutus</i>) occurs upstream of this section and although only one stand was observed in this section, it could quickly spread and become a significant problem. Spiny rush is a vicious weed that is not readily eaten by grazing animals. Once established it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.	<i>Eradicate and monitor Spiny rush. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i>
Saffron thistle (<i>Carthamus lanatus</i>) is a declared plant (noxious weed) throughout Western Australia and was observed only within this and two other sections. Saffron thistle competes with crops and useful pasture plants for light, nutrients and moisture. Its stiff, spiny leaves discourage grazing and may injure the mouths and eyes of livestock.	<i>Eliminate Saffron thistle to prevent spreading. Monitor for re-occurrence and remove plants when sighted. See Appendix 3 or contact the Department of Agriculture or Department of Environment for information.</i>

<p>Along this section, as with many other sections of the Hutt River, there are several examples of discarded farm materials in the main channel and its tributaries. These can include old pieces of machinery, old fences, chemical drums and general rubbish. Many of these items can be detrimental to the health of the river, the health of flora and fauna and are generally unsightly as they move downstream onto neighbouring properties.</p>	<p><i>Remove discarded farm material from the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i></p>
<p>Remnant patches of native sedges occur in this section. Native rushes and sedges are extremely important in the floodway to prevent bank erosion and washouts during both small and large flows. Sedges burn less readily than dry weeds and act as fire suppressants. Native sedge cover can also prevent nuisance weeds from becoming established.</p>	<p><i>Protect current remnants and encourage native rushes and sedges to spread along the banks. See references in section 4.3.4 or contact the Department of Environment for information.</i></p>
<p>Several aggressive weeds, although not all located within this section, are present along the Hutt River. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>



Photograph 5: Hutt River Estuary



Photograph 6: Much of the Hutt River has a stable rock bed



Photograph 7: Source of the Hutt River

Section 10

Maps 12, 13 & 14

Length of section: 11 548 metres

Date surveyed: 3/07/03 & 4/07/03

A grade	B grade	C grade	D grade
	631 metres	10 917 metres	

Bank stability

Bank stability along this section of the river is moderate. Several large secondary channels are present with associated washouts and erosion. Many of the banks along this section are eroding and slumping however, stability improves where rocks and vegetation stabilise the banks. There is evidence of sediment being deposited on some banks and these appear to be associated with secondary channels and pool areas. The channel is braided in several places, resulting in two channels of about 5 metres wide and 2 metres deep. Where the channel is more defined it often expands to up to 30 - 40 metres wide. This section of the river has many meanders and a few power bends with steep, rocky banks up to 10 metres high.

Vegetation

The vegetation along this section of the river ranges from moderate to good. The overstorey consists of *Melaleuca raphiophylla* (Swamp paperbark), *Eucalyptus camaldulensis* (River red gum) and *Casuarina obesa* (Swamp sheoak) with good regeneration of each of these species observed.

The middlestorey is limited and comprises *Acacia rostellifera* (Summer scented wattle), *A.saligna* (Coojong) and *Labichea lanceolata* (Tall labichea) colonising areas of sediment deposition. Also present is the occasional *Hakea preissii* (Needle tree) and *Hakea recurva* (Djarnokmurd) on the flood fringe.

The understorey is dominated by pasture weeds including many annual grasses, Soursob (*Oxalis pes-caprae*), Wild radish (*Raphanus raphanistrum*) and Capeweed (*Arctotheca calendula*). Small stands of the native *Cyperus gymnocaulos* (Spiny twig sedge) persist along the length. The native *Typha domingensis* (Cumbungi) and *Isolepis* species are present along the main channel downstream of a tributary that appears to have semi permanent or permanent flow. The most upstream occurrence of the weed Spiny rush (*Juncus acutus*) is in this section where it is prolific in many of the tributaries and along much of the main channel.

There is a small (100–150 metre) area that rates as 'B' grade towards the downstream end of this section. This area exhibits native overstorey with much regeneration and *Cyperus gymnocaulos* equalling weed presence in the understorey.

Small nodes of verge vegetation are present along parts of this section.

Stream cover

Stream cover in this section is good due to the continuous overstorey providing moderate to good shading. The presence of many instream rocks and some sedges as well as woody debris offers good stream cover. The native herb *Cotula* sp. provides instream cover in the moderate flow channel in many areas.

Habitat diversity

Habitat diversity is moderate to good. The continuous overstorey and understorey, together with some verge vegetation and rocky outcrops, provides habitat for terrestrial animals. Pool and riffle sequences, as well as some long pools present at time of survey, provide habitat for aquatic animals. Instream rocks, woody debris and a spring on one tributary offer additional habitat diversity. At the time of survey an echidna was seen alongside the river.

Other

The occurrence of the highly invasive Spiny rush is a major management concern. The populations present in this section will enable the spread of this serious weed downstream.

Main Issues	Suggested Actions
<p>Conversations with landholders and field observations have determined that feral pigs and rabbits are present and disturbing the bed and banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>A heavy infestation of Spiny rush (<i>Juncus acutus</i>) occurs along much of this section and many tributaries. This is the major infestation observed along the Hutt River during the survey. Spiny rush is an aggressive weed that is not readily eaten by grazing animals. Once established it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.</p>	<p><i>Target spiny rush in this section with a weed eradication program to prevent further infestation downstream. See Appendix 3 for picture and removal methods. Contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Saffron thistle (<i>Carthamus lanatus</i>) is a declared plant (noxious weed) throughout Western Australia and was observed only within this and two other sections. Saffron thistle competes with crops and useful pasture plants for light, nutrients and moisture. Its stiff, spiny leaves discourage grazing and may injure the mouths and eyes of livestock.</p>	<p><i>Eliminate Saffron thistle to prevent spreading. Monitor for re-occurrence and remove plants when sighted. See Appendix 3 or contact the Department of Agriculture or Department of Environment for further information.</i></p>
<p>Within this section the band of vegetation along the river is generally thin. In many places this has caused floodwaters to go around the vegetation where it can move more quickly and form secondary channels and washouts. This erosion has undermined many fences along the section.</p>	<p><i>Expand the buffer of vegetation on each side of the channel. Ensure that fences are located far enough from the banks to allow the buffer to prevent further erosion, washouts, widening of the channel and fence loss.</i></p>
<p>Almost no regeneration of riparian vegetation was observed in this section. Riparian vegetation is extremely important in preventing erosion, washouts and soil loss as well as acting as a filter to soil and nutrients washed off adjoining paddocks.</p>	<p><i>Fence the river to permit management of stock access to allow regeneration of native vegetation.</i></p>
<p>Remnant patches of native sedges occur in this section. Native rushes and sedges are extremely important in the floodway to prevent bank erosion and washouts during both small and large flows. Native sedge cover can also prevent nuisance weeds from becoming established.</p>	<p><i>Protect current remnants and encourage native rushes and sedges to spread along the banks. See references in section 4.3.4 or contact the Department of Environment for information.</i></p>
<p>Several aggressive weeds, although not all located within this section, are present along the Hutt River. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>

Section 11

Map 14

Length of section: 2 441 metres

Date surveyed: 2/11/03

A grade	B grade	C grade	D grade
		2 441 metres	

Bank stability

The overall bank stability for this section of the Hutt River is moderate. The channel varies between 0.5 and 1.5 metres deep and 4 and 8 metres wide. In areas where rocks are present stability is increased, however where rocks are absent much of the bank has suffered slumping. Many pool and riffle sequences act to slow water flow, reducing the erosive force of water. In some places woody debris has been snagged and is exacerbating the erosion of banks. Several secondary channels and washouts have formed during moderate to high flows.

Vegetation

Vegetation along this section is moderate to good. The overstorey consists of a continuous canopy of *Eucalyptus camaldulensis* (River Red Gum), *Casuarina obesa* (Swamp sheoak) and *Melaleuca raphiophylla* (Swamp paperbark). Regeneration of each of these species was observed.

Weeds dominate the understorey and include Wild radish (*Raphanus raphanistrum*), Lupins (*Lupinus* sp.), Annual grasses and Soursob (*Oxalis pes-caprae*). The native *Cotula* sp. is growing in the streambed. *Cyperus gymnocaulos* (Spiny flat sedge) is sparse but continuous along the length of this section, although it is out-competed by weeds in many places.

A thin band of verge vegetation occurs along most of channel in addition to two larger nodes. Good riparian vegetation occurs along the four main tributaries that flow into this section.

Stream cover

Stream cover in this section is moderate to good. The continuous canopy provides shade. Instream rocks and some woody debris provide stream cover while overhanging sedges provide infrequent cover.

Habitat diversity

The habitat diversity along this section is moderate to good. Pool and riffle sequences provide good habitat for aquatic animals. Canopy and verge vegetation provide habitat for bird life and terrestrial animals.

Main Issues	Suggested Actions
<p>Although evidence of pigs and rabbits was not observed along this section they are present and disturbing the bed and banks on nearby properties. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>Significant regeneration was observed along this section. This may have resulted from lack stock present during the change of hands of the property.</p>	<p><i>Ensure this new regeneration is allowed to mature and regeneration continues in order to improve the quality of this river section. If the property becomes continually stocked this may involve fencing the river to permit management of stock access.</i></p>
<p>Along much of this section sedges are present, however they are being smothered by weeds. Native rushes and sedges are extremely important in the floodway to prevent bank erosion and washouts during both small and large flows. Sedges burn less readily than dry weeds and act as fire suppressants. Native sedge cover can also prevent nuisance weeds from becoming established.</p>	<p><i>Protect current remnants and encourage native rushes and sedges to spread along the banks. See references in section 4.3.4 or contact the Department of Environment for information.</i></p>
<p>In this section there are several large woody debris accumulations that are directing flow into the bank and causing erosion.</p>	<p><i>Realign woody debris to protect the bank and direct flow into the centre of the channel. See Box 1 or contact the Department of Environment for further information.</i></p>
<p>Along this section, as with many other sections of the Hutt River, there are several examples of discarded farm materials in the main channel and its tributaries. These can include old pieces of machinery, old fences, chemical drums and general rubbish. Many of these items can be detrimental to the health of the river, the health of flora and fauna and are generally unsightly as they move downstream onto neighbouring properties.</p>	<p><i>Remove discarded farm material from the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i></p>
<p>Several aggressive weeds, although not all located within this section, are present along the Hutt River. Water flowing down a river provides an effective means of transport for the seeds of these invasive weeds. It is far more cost effective to target these weeds while in isolated patches. Some weeds present that have become problems along other waterways in the region include: African boxthorn (<i>Lycium ferocissimum</i>), Athel tree (<i>Tamarix aphylla</i>), Black berry nightshade (<i>Solanum nigrum</i>), Brazilian pepper (<i>Schinus terebinthifolius</i>), Caster oil (<i>Ricinus communis</i>), Fountain grass (<i>Pennisetum setaceum</i>), Saffron thistle (<i>Carthamus lanatus</i>), Spiny rush (<i>Juncus acutus</i>) and White cedar (<i>Melia azedarach</i>).</p>	<p><i>Become familiar with and monitor the occurrence of aggressive and invasive weeds that are currently uncommon within the Hutt River catchment. When sighted remove or take action to eradicate immediately. See Appendix 3 for pictures and removal methods of some weeds. Contact the Department of Agriculture or Department of Environment for further information.</i></p>

Section 12

Maps 14, 15 & 18

Length of section: 8 049 metres

Date surveyed: 1/07/03

A grade	B grade	C grade	D grade
		8 049 metres	

Bank stability

The overall bank stability for this section is moderate to poor. Whilst there are some areas where rocky banks improve stability, most of the channel is suffering from erosion and slumping. Sparse stands of sedges and an intermittent overstorey provide some stability, generally however there is little vegetation supporting bank structure. Several washouts are present along the channel and there are many areas where sediment has been deposited. Severe erosion is present on power bends where fast flowing water has scoured the bank and resulted in almost vertical banks of up to 2.5 metres high.

Anecdotal evidence suggests that foxes are a problem in this area. Fox warrens observed in the banks compromise bank stability.

Vegetation

Vegetation cover is moderate to poor. The overstorey consists of *Casuarina obesa* (Swamp sheoak), *Melaleuca raphiophylla* (Swamp paperbark) and *Eucalyptus camaldulensis* (River red gum). This is the first consistent occurrence of the latter two species along both Kennedy Creek and Hutt River.

Weeds dominate the understorey. Capeweed (*Arctotheca canlendula*) is prevalent with the occasional isolated patch of the native *Cyperus gymnocaulos* (Spiny twig sedge). There is almost no regeneration of native riparian vegetation due to continuous grazing pressure along the entire length of this section.

Little verge vegetation is present along this section. Several small isolated patches occur along the flood fringe and verge. These patches show signs of stress from continuous grazing and limited regeneration was observed.

Stream cover

Stream cover throughout this section is moderate to poor. The overstorey is patchy providing limited shading. Some areas of sedge cover are present but provide limited stream cover due to grazing pressure and there is a noticeable lack of leaf litter. Intermittent rocky areas provide some stream cover.

Habitat diversity

Habitat diversity is moderate along this section. Riffle areas and subsequent pools along with some woody debris provide habitat for aquatic animals. There is however little habitat for terrestrial animals due to reduced leaf litter, and lack of understorey and middlestorey vegetation.

Other

There is a rubbish dumping area present in the floodway.

Main Issues	Suggested Actions
<p>Field observations have determined that foxes and rabbits are present and are disturbing the bed and banks. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>Regeneration of native vegetation was not observed along this section. Continuous grazing pressure means new plants are grazed before they can become established. Sedges cannot reproduce by seed because the seeds, which are formed at the tips of the stems, are removed through grazing. Verge vegetation is also important for habitat of native birds and animals, as well as providing shade and shelter for stock.</p>	<p><i>Fence the river to manage stock access to allow regeneration of riparian vegetation and management as a sensitive river paddock. The patches of verge vegetation should be incorporated within this fence where practical. Stock should be excluded during the sedges active growing and reproductive season (spring to summer).</i></p>
<p>Riparian vegetation and sedge cover is important for bank stability. If the lack of regeneration of riparian vegetation continues, this section of river will be quickly downgraded as the aged vegetation dies and the river channel becomes a freely eroding ditch.</p>	<p><i>Ensure regeneration of riparian vegetation occurs to prevent downgrading of this section.</i></p>
<p>Along this section, as with many other sections of the Hutt River, a disposal site of discarded farm materials was observed in the floodplain. Discarded farm materials can include old pieces of machinery, old fences, chemical drums and general rubbish. Many of these items can be detrimental to the health of the river, the health of flora and fauna or generally unsightly as they move downstream onto neighbouring properties.</p>	<p><i>Remove discarded farm material and rubbish from the floodplain of the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i></p>

Section 13

Maps 15, 16 & 17

Length of section: 8 044 metres

Date surveyed: 19/06/03 & 24/06/03

A grade	B grade	C grade	D grade
	689 metres	6 927 metres	428 metres

Bank stability

For about the first half kilometre of the upstream end of this section the channel is wide (about 40m) and shallow. Here bank stability is very poor with mobile sediment and almost no instream or fringing vegetation.

The river channel becomes defined as the water flows through a large area of granite. As a result, stability is excellent and not likely to be compromised. The step in the riverbed has a gradient of 6 - 7 metres over a distance of 150 metres.

At the base of the granite the channel stability is poor, with large areas of erosion and sedimentation continuing along its length. Occasional rocky areas and patches of sedges provide some improvement to bank stability.

Vegetation

The vegetation along this section is mainly moderate with almost no regeneration. The riparian vegetation is dominated by *Casuarina obesa* (Swamp sheoak), with *Melaleuca* spp. interspersed among the *Casuarina* along the last 2.4 kilometres of this section. Overstorey weeds are limited to a single mature Cape Lilac (*Melia azerdarach*) and a stand of Tamarisk (*Tamarix aphylla*) near a pool.

Middlestorey on the flood fringe include *Hakea preissii* (Needle tree), *Hakea recurva* (Djarnokmurd), *Acacia acuminata* (Jam), *A. tetragonophylla* (Kurara) and *A. rostellifera* (Summer scented wattle). *Pimelea* sp. and occasional *Alyogyne* (Native hibiscus) are also present.

The understorey includes patches of *Cyperus gymnocaulos* (Spiny flat-sedge), occasional unidentified bluebush, *Cotula* sp. and an unidentified species of Samphire. Weeds characteristic of this section include annual grasses, Capeweed (*Arctotheca calendula*) and Wild radish (*Raphanus raphanistrum*).

Thin bands of verge vegetation occur along the river for about half of this section, with an extensive area along one 800 metre stretch.

Stream cover

In the moderate sections stream cover gradually increases in the downstream direction as *Casuarina obesa* (Swamp sheoak) become more continuous and provide shade. Occasional rocks and patches of sedges provide some instream cover. There was no stream cover in the section of this property rated as poor ('D' grade).

Habitat diversity

The habitat along most of this section is moderate. Rocky spillways provide pools for aquatic invertebrates and frogs. In some places native sedges provide cover and habitat. The riparian overstorey and remnant verge vegetation provide habitat for birds and other terrestrial fauna. Kangaroos were observed during the survey. There was no habitat provided in the section rated as 'D' grade.

Other

The invasive Fountain grass (*Pennisetum setaceum*) was noted spreading downstream of the highway. Other weeds not present elsewhere along the river were also observed along the old highway that crosses the river in this section.

When the new alignment of the North West Coastal Highway was completed, a small creek diversion was made to prevent the creek crossing the road three times. The straight diversion was cut through solid rock and its high banks appear stable.

Several dead sheep were present in the riverbed. At one location the decomposing body had turned a river pool green. This is a management issue as decomposition will result in localised increases in nutrients and thus instream algae. Disease is also of concern.

Main Issues	Suggested Actions
Although evidence of pigs and rabbits were not observed along this section they are present and disturb the bed and banks on nearby properties. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information</i>
Vehicle crossings should be reinforced along the curve of the river and bridges constructed to allow uninterrupted flow. In this section the designs of the old highway crossing and Sudlow Road crossing are inadequate and have resulted in localised erosion and sedimentation.	<i>Explore opportunities to replace road crossings to minimise disruption to flow. Rocks stockpiled near the river in the upper third of this section could be used to reinforce vehicle crossings to minimise erosion. See section 4.3.11 or contact the Department of Environment for further information.</i>
Almost no regeneration of riparian vegetation was observed in this section. Riparian vegetation is extremely important in preventing erosion, washouts and soil loss as well as acting as a filter to soil and nutrients washed off adjoining paddocks.	<i>Fence the river and manage stock access to allow regeneration of native vegetation.</i>
The 'D grade' area is denuded and prone to water and wind erosion. The channel here appears to be widening and contributing significantly to the sediment load of the river. Although a seedbank for natural regeneration exists upstream it would take a long period of time for this area to regenerate without the planting of tube stock or direct seeding.	<i>Fence and revegetate 'D grade' section. Plant or direct seed a diverse range of native species including understorey species.</i>
Fountain grass (<i>Pennisetum setaceum</i>) is an invasive weed widespread along roadsides and railway lines. Along the Hutt River Fountain grass is present only in this section where it is spreading downstream from the old and new North West Coastal Highways.	<i>Eradicate Fountain grass where it has spread along the river while plants are in manageable numbers. Control along roadsides to prevent further spreading and monitor for re-occurrence, see Appendix 3.</i>
Along this section as with many other sections of the Hutt River there are several pieces of discarded farm materials in the main channel or its tributaries. These can include old pieces of machinery, old fences, chemical drums and general rubbish. Many these items can be detrimental to the health of the river, the health of flora and fauna or generally unsightly as they move downstream onto neighbouring properties.	<i>Remove discarded farm material from the floodplain of the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i>
Three sheep carcasses were observed within the river channel in this section. One was in the dry bed while two others were in a green pool next to a clear pool containing no carcasses. Decomposing carcasses contribute nutrients to river, illustrated by the algal bloom in the pool.	<i>Ensure that animal carcasses are not left within the floodplain of the river and its tributaries.</i>
This section was involved in the development of the <i>Kennedy Creek Catchment Management Report</i> , which was published in 1993 by the Department of Agriculture for the Binnu Land Conservation District. Individual property maps showing soil types, land management hazards and existing and proposed works complimented this report.	<i>Continue to implement recommendations and works proposed in the Kennedy Creek Catchment Management Report. See section 4.2 or contact the Department of Agriculture for further information.</i>

Section 14

Map 17

Length of section: 2 348 metres

Date surveyed: 19/06/03

A grade	B grade	C grade	D grade
	185 metres	1 427 metres	736 metres

Bank stability

Bank stability is moderate to poor with a wide, flat channel that is not well defined. There is very little vegetation to hold the bank together and define the channel.

In the part graded 'B', the bank stability was better due to increased stream cover in the form of samphire protecting the banks from further erosion.

Channel width ranged from approximately 10 – 60 metres.

Vegetation

Vegetation along this section is mostly poor. Much of the section has little to no instream or fringing vegetation.

Where overstorey is present, it comprises *Casuarina obesa* (Swamp sheoak), *Hakea spp.* and occasional *Acacia tetragonaphylla* (Kurara).

With the exception of the 'B' grade section, the understorey vegetation comprises entirely weed species, the dominant being Capeweed (*Arctotheca calendula*).

A small section where stock have been excluded is graded 'B'. Vegetation here consists of samphire instream and good fringing vegetation with a well developed overstorey dominated by *Casuarina obesa* (Swamp sheoak) and *Eucalyptus loxophleba* (York Gum).

Excellent verge vegetation exists along one third of this section, exhibiting a diverse range of native species.

Stream cover

Stream cover along most of this section is poor with little to no cover. The sparse overstorey provides some stream cover and shade but there is little understorey with the exception of weeds to provide stream cover. In the 'B' graded section, samphire provides good stream cover.

Habitat diversity

Habitat is fragmented and generally poor along this section. The verge vegetation provides good habitat for terrestrial fauna. In places, woody debris and rocks provide some habitat and in the 'B' grade areas, samphire provides cover and habitat.

Other

There is a large area of dead trees in a salt pan. Anecdotal evidence suggests that they have been dead for well over 30 years.

Feral animals known to be present include foxes, cats and rabbits. Weeds present include Afghan melon (*Citrullus lanatus*), Prickly paddy melon (*Cucumis myriocarpus*) and Doublegee (*Emex australis*).

Main Issues	Suggested Actions
Although evidence of feral pigs and rabbits was not observed along this section they are present and disturbing the bed and banks on nearby properties. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.	<i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i>
No regeneration was observed in this section except in one small area where stock had been excluded. This small section appears to be part of a branch of the river that has been protected from stock trampling and grazing and was also the only reach where significant vegetation cover was present in stream.	<i>Fence the river and manage stock access to allow regeneration of native vegetation and instream cover to protect soil structure. Where practical include areas of verge vegetation within the fence.</i>
Some areas may require revegetation to initiate or speed up the process of reintroducing vegetation cover.	<i>Plant a diverse range of species including upper, middle and understorey species on the margins. Direct seeding of salt tolerant species may be trialed within the channel.</i>
This section was involved in the development of the <i>Kennedy Creek Catchment Management Report</i> , which was published in 1993 by the Department of Agriculture for the Binnu Land Conservation District. Individual property maps showing soil types, land management hazards and existing and proposed works complimented this report.	<i>Continue to implement recommendations and works proposed in the Kennedy Creek Catchment Management Report. See section 4.2 or contact the Department of Agriculture for further information.</i>



Photograph 8: Where stock has been excluded the foreshore is graded B. Here the stream cover and fringing vegetation slows evaporation and provides habitat.

Section 15

Maps 18 & 19

Length of section: 7 357 metres

Date surveyed: 28/ 06/ 03

A grade	B grade	C grade	D grade
	388 metres	6 969 metres	

Bank stability

The bank stability is consistently moderate with erosion, undercutting and exposed tree roots along most of the channel, with the exception of an area of 'B' grade, where granite provides increased stability. There is consistent stream width of approximately 7 metres along the length of the section with the channel bank height ranging from 0.5 metres to 3 metres on some power bends. The floodway width varies greatly and ranges between 40 and 200 metres, exhibiting frequent washouts and secondary channels that appear to have formed during high flows.

The winding nature of Kennedy Creek in this section has resulted in power bends with vertical faces up to 3 metres. Two of these appear to have eroded to a stable rock cliff. In several places, large woody debris accumulations are deflecting flow and causing the channel to widen. Accumulation of sediment around the trunks of the remnant *Casuarina obesa* is common.

Vegetation

The vegetation along this section of Kennedy Creek is moderate. Regeneration of natives plants is present but is under stress due to grazing pressure. As a result, there are few juvenile trees present. There is a consistent overstorey of *Casuarina obesa* (Swamp sheoak) with occasional *Eucalyptus loxophleba* (York gum) and one isolated patch of *Eucalyptus camaldulensis* (River red gum).

The middlestorey comprises occasional *Hakea preissii* (Needle tree) and *Hakea recurva* (Djarnokmurd), *Acacia tetragonaphylla* (Kurara), *Acacia rostellifera* (Summer scented wattle) and *Acacia saligna* (Coojong).

Although the understorey is dominated by weed species, some unidentified salt and blue bushes were noted along with isolated patches of *Cyperus gymnocaulos* (Spiny twig sedge). These plants are helping to stabilise some banks, washouts and secondary channels. Weeds include Capeweed (*Arctotheca calendula*), Wild Radish (*Raphanus raphanistrum*) and some Doublegee (*Emex australis*). There are several patches of Couch (*Cynodon* sp.) and Paterson's curse (*Echium plantagineum*) about half way along the section.

The few nodes of verge vegetation present are in small, isolated patches and mostly disjointed from the riparian vegetation. The many tributaries feeding into this section of Kennedy Creek appear to be well vegetated.

Stream cover

Moderate shading is provided by the consistent overstorey of *Casuarina obesa* (Swamp sheoak). Intermittent rocks, logs, branches and occasional patches of sedges in the river channel provide localised areas of cover.

Habitat diversity

Habitat diversity is moderate to poor. The continuous overstorey and patchy verge vegetation provide habitat for birds and terrestrial animals but habitat is limited by the lack of understorey. Occasional rocks, woody debris and sedges provide some habitat. The instream boulders and rocks in the 'B' grade section create pools and act as riffle zones, aerating the water and providing habitat for aquatic animals. Many shrubland and wading birds and two foxes were observed along this section during the survey.

Other

It would appear that one tributary may be a permanent source of water, due to the dark tannin-stained water and algae presence, both of which can indicate permanent or semi-permanent water.

Erosion is present upstream and the channel widens downstream of the Ogilvie East Road crossing. Evidence that the design of the crossing is not adequate for minimising damage caused by flow disruption.

Main Issues	Suggested Actions
<p>Conversations with landholders have determined feral pigs and rabbits are present in the area. Activities of these animals can undermine bank stability and contribute to erosion. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>Much of the native regeneration observed along this section is struggling to survive due to grazing pressure. If regeneration does not occur this section will quickly be downgraded to an eroding ditch as the old trees die.</p>	<p><i>Fence the river and manage stock access to allow regeneration of native plants. By fencing and treating the river as a sensitive paddock erosion, scour and sedimentation can be minimised.</i></p>
<p>Along this section as with many other sections of the Hutt River there are several pieces of discarded farm materials in the main channel and its tributaries. These can include old pieces of machinery, old fences, chemical drums and general rubbish. Many these items can be detrimental to the health of the river, the health of flora and fauna or generally unsightly as they move downstream onto neighbouring properties.</p>	<p><i>Remove discarded farm material from the floodplain of the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i></p>
<p>The creek crossing on Ogilvie Road is almost entirely solid with four small culverts. These culverts do not allow enough water to flow through them and have resulted in erosion upstream and widened the channel downstream of the crossing To avoid damage to the stream the space beneath a bridge needs to allow low to moderate flow volumes to pass beneath with minimal disruption.</p>	<p><i>Investigate opportunities to modify the creek crossing on Ogilvie Road to minimise disturbance to flow dynamics.</i></p>
<p>This section was involved in the development of the <i>Kennedy Creek Catchment Management Report</i>, which was published in 1993 by the Department of Agriculture for the Binu Land Conservation District. Individual property maps showing soil types, land management hazards and existing and proposed works complimented this report.</p>	<p><i>Continue to implement recommendations and works proposed in the Kennedy Creek Catchment Management Report. See section 4.2 or contact the Department of Agriculture for further information.</i></p>

Section 16

Maps 19, 20 & 21

Length of section: 5 147 metres

Date surveyed: 26/06/03 & 27/06/03

A grade	B grade	C grade	D grade
		4 033 metres	1 114 metres

Bank stability

Much of the main channel in this section has poor bank stability. Most of the banks have been eroded and undermined. Tree roots are exposed and in many places trees have fallen as a result. A couple of large sediment plumes are present and the channel braids into two in several places.

Bank stability problems and erosion is of a lesser extent along sections where stock has been excluded and vegetation allowed to regenerate. Channel width ranged from 5-10 metres where stock has been excluded and from 15-30 metres where channel was unfenced and accessible to stock. Along the 'D' grade section there are several erosion gullies created by water running off paddocks into the main channel.

Vegetation

The downstream part of the main channel is unfenced and riparian vegetation consists of an overstorey of *Casuarina obesa*, and *Melaleuca* spp. (Paperbarks). Some patches of *Acacia saligna* (Orange wattle) and *Labichea lanceolata* (Tall labichea) were noted colonising large sediment deposits. The understorey is comprised of almost entirely weeds with occasional small stands of *Cyperus gymnocaulos* (Spiny flat sedge). Some regeneration is present in 'D' grade areas but are unlikely to survive due to continuous grazing pressure.

Where the channel has been fenced and stock excluded (approximately 1.5 kilometres) there is an overstorey of *Casuarina obesa* (Swamp sheoak) with a stand of *Eucalyptus sargentii* (Salt river gum). Shrubs on the floodfringe include *Acacia tetragonophylla* (Kurara) and *Hakea preissii* (Needle tree) with the occasional *Acacia acuminata* (Jam). The understorey includes samphire, *Cotula* sp., unidentified saltbush and bluebush along with weed species including Wild radish (*Raphanus raphanistrum*), Capeweed (*Arctotheca calendula*), Flatweed (*Hypochaeris* sp.), annual grasses and occasional Doublegee (*Emex australis*). All of the native species are regenerating well and with time, providing stock access continues to be well managed, both the overstorey and understorey will increase and further improve the grade of this section.

The verge vegetation consists of thin bands present along less than half of the channel in this section with a few larger remnants present adjacent to the riparian vegetation. Many of the tributaries flowing into this section are well vegetated especially where they have been fenced and stock excluded.

Stream cover

The upstream section has good stream cover due to shade provided by the continuous overstorey. Cover is also provided by samphire and some woody debris in the floodway. Stream cover declines further downstream as there is a less continuous overstorey and no understorey.

Habitat diversity

Habitat diversity is limited due to minimal middle and understorey cover. One pool of about 100 metres long provides good habitat for aquatic fauna. Verge vegetation and overstorey provides habitat for shrubland birds. Kangaroos were observed during the survey.

Other

Whilst tributaries were not considered in the grading of the river foreshore condition it is worth noting that a number of permanent springs arise on surrounding tributaries. Excellent habitat was observed on the most upstream tributary flowing into this section. This tributary has been fenced and the exclusion of stock has allowed it to regenerate. The area is characterised by an overstorey of *Casuarina obesa* (Swamp sheoak), some *Acacia* spp. a large stand of *Typha*

domingensis (Native cumbungi), extensive *Cyperus gymnocaulos* (Spiny flat-sedge) and *Cotula* sp. cover. At least three species of frog were heard here and dragonflies, dependant on fresh water for part of their lifecycle, were observed.

Main Issues	Suggested Actions
<p>Conversations with landholders have determined feral pigs and rabbits are present in the area. Activities of these animals can undermine bank stability and contribute to erosion. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>Much work has been done over the last decade or so to fence tributaries and areas of the channel within this section to exclude stock and allow regeneration. The success of these actions can be seen on Map 21 where previously degraded tributaries were rated as 'A' grade and 'B' grade during the survey.</p>	<p><i>Continue to fence the main channel and its tributaries to manage stock access. Include areas of verge vegetation within the fence where practical.</i></p>
<p>In 'D Grade' sections regeneration alone may not be sufficient to control erosion and sedimentation. Some revegetation may be required to initiate or speed up the process.</p>	<p><i>Use revegetation techniques to speed up the recovery of degraded parts of the creek. See Appendix 4 for details of different techniques.</i></p>
<p>Although the overstorey has regenerated well in the main channel where stock has been excluded, there has been no regeneration of sedges. These are important to provide understorey and improve bank stability especially where the roots of some of the <i>Casuarina obesa</i> (Swamp sheoak) are exposed or the overstorey is sparse. There is a good seedbank of <i>Cyperus gymnocaulos</i> (Spiny flat-sedge) on the most upstream tributary in this section. However, if these do not do well, seed may be collected from <i>Juncus kraussii</i> (Sea rush) on properties further downstream. This species is more tolerant to saline conditions.</p>	<p><i>Reintroduce a seedbank of sedges into the main channel. See references in section 4.3.4 or contact the Department of Environment for information.</i></p>
<p>Fallen trees (large woody debris) can direct water into banks causing erosion. They can be aligned to direct flow into the centre of the channel and protect banks from undercutting and erosion.</p>	<p><i>Ensure woody debris is not directing flow into banks. Use large woody debris to protect bare and eroding banks. See Box 1 or contact the Department of Environment for further information.</i></p>
<p>Along this section, as with many other sections of the Hutt River, there are several examples of discarded farm materials in the main channel and its tributaries. These can include old pieces of machinery, old fences, chemical drums and general rubbish. Many of these items can be detrimental to the health of the river, the health of flora and fauna and are generally unsightly as they move downstream onto neighbouring properties.</p>	<p><i>Remove discarded farm material from the floodplain of the river and its tributaries. Prevent further dumping within the floodplain of waterways.</i></p>
<p>This section was involved in the development of the <i>Kennedy Creek Catchment Management Report</i>, which was published in 1993 by the Department of Agriculture for the Binnu Land Conservation District. Individual property maps showing soil types, land management hazards and existing and proposed works complimented this report.</p>	<p><i>Continue to implement recommendations and works proposed in the Kennedy Creek Catchment Management Report. See section 4.2 or contact the Department of Agriculture for further information.</i></p>

Section 17

Maps 21, 22 & 23

Length of section: 6 721 metres

Date surveyed: 25/06/03

A grade	B grade	C grade	D grade
		4 014 metres	2 707 metres

Bank stability

This section contains the source of Kennedy Creek. For much of this section the channel banks are poorly defined and the water is able to spread across a wide, shallow, flat floodplain. The channel width ranges from 3 – 150 metres and the channel depth from 0 – 0.75 metres. About two and a half kilometres from the upstream end of this section the channel becomes more defined through a valley for about half a kilometre, downstream of this the floodway widens for about one and a half kilometres before continuing on a more defined path.

Vegetation

In sections graded 'D', there is little to no instream or riparian vegetation present.

The remaining riparian vegetation in sections graded 'C' is dominated by *Melaleuca uncinata* (Broom bush) and *Melaleuca adnata* with an understorey of annual grasses and occasional Capeweed (*Arctotheca calendula*) and Doublegee (*Emex australis*). *Casuarina obesa* (Swamp sheok) is common in the overstorey in the most downstream 'C' Grade length where the channel becomes more defined (map 21).

Good continuous patches of verge vegetation exist adjacent to more than half of the riparian vegetation along this section. The verge vegetation contains a diverse range of native species.

Stream cover

In sections graded 'D' there is no stream cover. The majority of sections graded 'C' retain moderate to good stream cover due to the density of the canopy species as well as the presence of some woody debris. Stream cover is reduced to poor in the areas graded 'C' with few trees occurring occasionally along the channel. These sections are tending towards a 'D' rating.

Habitat diversity

There is no instream or riparian habitat in sections rated 'D'. Those areas graded 'C' have moderate habitat diversity for terrestrial organisms. The verge vegetation provides good habitat for birds and other terrestrial animals. A kangaroo and a bobtail lizard were observed during the survey.

Other

At the headwaters of the creek there is a stand of dead trees. This may be due to waterlogging and indicate a change in hydrological balance.

Much of the vegetation along the creek in this section appears to be affected by salinity or waterlogging. There are many dead trees instream. The verge vegetation located on higher ground appears relatively unaffected.

There is evidence of localised revegetation works along this section with a single to double row of riparian vegetation planted along the bank.

Main Issues	Suggested Actions
<p>Conversations with landholders have determined feral pigs and rabbits are present in the area. Activities of these animals can undermine bank stability and contribute to erosion. In order for feral animal control to be effective it is imperative that all landholders in the region participate in a regional approach.</p>	<p><i>Initiate and participate in a Co-ordinated Community Control Program. Contact the Department of Agriculture in Geraldton for information.</i></p>
<p>Although there are large amounts of verge vegetation along much of this section, lengths of the creek are exposed and in poor condition. Here the banks are freely eroding, the channel is widening and waterlogging is present.</p>	<p><i>Fence the creek to permit management of stock access to allow regeneration of native plants and protection of revegetation efforts. A large buffer on each side of the channel may be required to increase the survival rate. Areas of verge vegetation should be included inside the fence where practical.</i></p>
<p>Some revegetation works have been done in one place however many plants in the two rows of trees are struggling to survive.</p>	<p><i>Plant a diverse range of species including upper, middle and understorey species on the margins. Direct seeding of salt tolerant species may be trialed within the channel.</i></p>
<p>This section contains good areas of verge vegetation with a diverse range of native species.</p>	<p><i>Maintain quality of verge vegetation by excluding stock or carefully monitoring grazing.</i></p>
<p>This section was involved in the development of the <i>Kennedy Creek Catchment Management Report</i>, which was published in 1993 by the Department of Agriculture for the Binu Land Conservation District. Individual property maps showing soil types, land management hazards and existing and proposed works complimented this report.</p>	<p><i>Continue to implement recommendations and works proposed in the Kennedy Creek Catchment Management Report. See section 4.2 or contact the Department of Agriculture for further information.</i></p>

4 Waterways Management

4.1 Catchment Focus

The concept of this foreshore and channel survey is to encourage management activities as well as provide a condition report on the river. The successful management of a waterway entails the inclusion of the surrounding landscape. It is important to understand that the landscape components within the Hutt river catchment are interrelated and hence need to be managed as a whole.

The river should not be managed as an entity on its own, as there are many issues throughout the catchment that contribute to the current condition. Managing the waterway on its own can be likened to treating the problem but not the cause. A catchment-wide approach should be employed with a range of objectives to improve the health of the riverine environment. There are many smaller tributaries feeding into Hutt River that impact on the water quality, sediment loads, and channel and foreshore condition.

Efforts should be made to maintain and enhance the condition and quality of the water in Hutt River and adjoining tributaries, in order to conserve ecological systems and meet the needs of present and future generations.

4.2 Kennedy Creek Catchment Management Report

The 'Kennedy Creek Catchment Management Report' was prepared in the early 1990s and printed in 1993 by the Department of Agriculture for the Binnu Land Conservation District. Along with the report, each landholder received property maps showing soil types, land management hazards and existing and proposed works. The area of the Management Report covered the catchment of the Hutt River and all of its tributaries to east of the North West Coastal Highway.

The project was designed to develop management strategies for land management hazards in the catchment. These include strategies for:

- Salinity
- Water erosion
- Wind erosion
- Soil acidification
- Soil structure decline
- Water logging
- Remnant vegetation decline
- Unstable drainage lines
- Non wetting sands

The report also set out to identify the major soil types and land classes in the catchment and develop sustainable management strategies for them, as well as support farmers in developing individual property plans to facilitate the recommended management strategies. This was achieved through a series of farm planning workshops and property visits.

From field observations during the foreshore assessment survey of the upper Hutt River and Kennedy Creek, works have begun in some areas but many of the above issues still exist within the catchment.

The recommendations made in the catchment management report address catchment issues in far greater depth than this report. Implementation of the solutions found in the preparation of the Kennedy Creek Catchment Management Report is important to protect the long term condition of the Hutt River and viability of the land within the catchment.

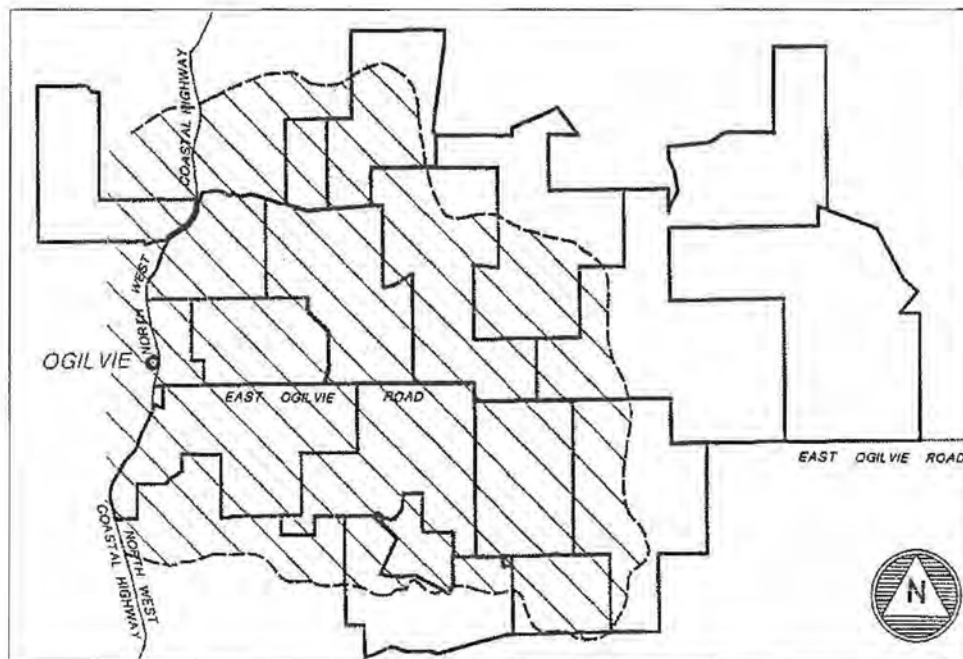


Figure 6: Area covered by the Kennedy Creek Catchment Management Report (1993)

4.3 Management Issues and Advice

4.3.1 Where to start?

The main principles for river management are to conserve the best pieces first, move on to those reaches showing signs of recovery, and then treat the more degraded parts of the system. This advice applies to both individual properties and the river system as a whole.

It is cost effective to protect areas still retaining native fringing vegetation. These areas are the most stable and the most likely to regenerate naturally. Assisting natural regeneration is a lot cheaper and easier than undertaking revegetation and erosion control works.

Work on the more degraded parts will be easier if the river upstream is in good condition, as erosion and weed infestations impact on areas downstream.

4.3.2 Water quality and sediment deposition

Poor water quality and high sediment loads can significantly affect the health of a river and its surrounding ecosystems. Some land use practices and decrease in stream bank vegetation has increased erosion rates from catchments. Combined with increasing salinity levels and increasing runoff to the river and its tributaries this can adversely affect the health of a riverine system.

Water quality can be affected by contaminants, excessive nutrients, salinity and turbidity levels. Increased turbidity from excessive suspended solids prevents light penetration. This can limit plant growth, effect the food chain, and block the gills of fish and aquatic macroinvertebrates. Sediments comprise sand (the heavy, coarse fraction which is mostly moved along the bed), and silt (the finer fraction which is carried in-suspension). Both are moved down the river channels to be deposited when the river velocity is slowed, either by natural pools, an obstruction or as the flow decreases. Excess sedimentation fills pools and channels reducing summer refuge waterholes for aquatic and terrestrial wildlife and reducing the flow-carrying capacity of a channel which increases the risk of flooding and subsequent out of channel erosion.

Maintaining a buffer of vegetation, including trees, shrubs and groundcovers, along the length of the river and its tributaries is the best way to protect it. Vegetation, especially native sedges, filters runoff from adjacent paddocks, limiting nutrients and sediment entering the river. The roots of riparian vegetation hold banks together and slow water velocity, thereby reducing the erosive force of the water and the movement of sediment downstream.

Restricting stock access from the river will help to improve water quality and reduce erosion. Stock mobilise plant nutrients which they distribute via their faeces. Controlled access will minimise the amount of manure within the waterway and limit nutrient enrichment. Restricted access also limits stock movement breaking down the bed and banks, which promotes erosion.

A riffle, a designed low rock and log structure or some other form of engineered structure, placed across the river at a strategic point can slow the flow rate causing sediment to be deposited thereby reducing sediment movement. Riffle-like structures can also double as stable stock and vehicle crossings.

Useful references for protecting water quality and minimising sediment deposition

Price P. and Lovett S. (eds) (1999) Using buffers to reduce sediment and nutrient delivery to streams. In: *Riparian Land Management Technical Guidelines: Volume Two: On-ground Management Tools and Techniques*, LWRRDC, Canberra.

Water and Rivers Commission (1997) *River and Estuary Pollution*, Water Facts 3.

Water and Rivers Commission (2000) *Sediment in Streams*, Water Note WN 17.

Also see references for bank stability and erosion control.



Photograph 9: Stock movement in the river adversely affects water quality. Stock mobilise plant nutrients via their faeces, limit growth of understorey plants that are important to good water quality and promote erosion by breaking down the bed and banks.

4.3.3 Bank stability

The banks along much of the Hutt River are eroding and slumping. Many banks have been undercut and trees undermined. Washouts are common in the floodway along most of the river. Washouts occur where the river at peak levels locates a weakness in the soil and causes erosion. The soil weakness often corresponds with areas lacking good vegetation cover or have been disturbed by pig diggings, animal tracks parallel to the river channel or where soil has been cultivated too closely to the river.

Bank stability along the Hutt River is best where there is either abundant vegetation cover in both the overstorey and understorey, ample rock in the bed and banks, or both. Bank stability is poorest where there is little to no vegetation cover or rock, or where there is no perennial understorey and trees have been undermined and are falling into the river.

Banks sometimes naturally erode on bends, however when vegetation is cleared, they can become unstable causing extensive erosion along the floodway and the build up of sediment downstream. While some level of erosion and deposition is natural within any riverine system, the acceleration of these processes can cause management problems.

Issues associated with erosion problems include:

- Loss of valuable soil
- Loss of fences as the river course deviates
- Poor water quality resulting from increased turbidity and nutrients
- Increased flood potential due to the silting up of the channel
- Filling of summer pools
- Increased channel width and loss of agricultural land
- Reduced visual amenity associated with the river
- Further loss of native riparian vegetation as severe erosion problems cause subsidence.

4.3.3.1 Points on bank stability

- Feral pigs and other feral animals can undermine bank stability and are the direct cause of many washouts seen along the Hutt River.
- Farm stock and native animals also impact on the stability of sediment.
- Native animals, particularly kangaroos and emus, do less damage to waterholes than domestic stock and feral animals because they have evolved to cope with these conditions.

Useful information on erosion control

Pen, L.J. (1999) *Managing Our Rivers*, Water and Rivers Commission, Perth.

Raine, A.W & Gardiner, J.N. (1995) *Rivercare – Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. Land and Water Research and Development Corporation. Canberra.

Water and Rivers Commission (2000) Importance of Large Woody Debris, Water Note WN 21.

Water and Rivers Commission (2001) *Stream Stabilisation*. River Restoration Report No. RR 10.

Box 1: Large Woody Debris

Large woody debris (also known as snags) are branches, large limbs or whole trees which fall into the watercourse and either remain in place or move downstream where they come to rest. It is common for smaller debris and leaf litter washed downstream to become accumulated at these points, providing an important habitat for many aquatic organisms.

Contrary to common belief, the removal of large woody debris does not reduce flood risk and will actually lead to bank and channel erosion caused by an increased flow velocity. The increased movement of sediment through the system will be deposited in pools and along floodplains and may lead to a decline in habitat, raised channel beds and increased threat to infrastructure such as low bridges.

Occasionally accumulations of large woody debris create a large dam across all or part of the river or divert flow into the bank impeding flow or causing erosion in areas lacking support from native vegetation. On these occasions it is beneficial to remove the accumulation or reposition logs at an angle of 20°- 40° to the stream bank (Figure 7). Large woody debris can also be added to streams to deflect flows from unstable areas, further advice can be sought from the Department of Environment.

Frequent burning of the fringing vegetation encourages trees to drop more branches. Therefore realignment or manual removal of large and fine woody debris is by far the most effective management technique. Often there are only small numbers of blockages that are causing problems, and burning may not target the sections that require treatment. Woody debris that is suspended between one and two and a half metres above the main channel is commonly the material that contributes to damage during peak flow events. The material on the ground helps to slow water movement on the margins of the floodway and focus the flow into the main channel.



Figure 7: Large woody debris bank protection.

4.3.4 Vegetation

The health of the bank and foreshore vegetation along a waterway is indicative of the health of the waterway. The vegetation along the Hutt River is in variable condition, ranging from totally denuded to almost pristine with trees and shrubs of all ages with dense perennial sedge cover. Loss of perennial vegetation cover is a significant step towards facilitating erosion during any flow event. As the Hutt River may respond to substantial rainfall events in any season it is critical that there is vegetation cover on the river foreshore all year round.

Vegetation along waterways should be managed with a view to improving waterway health. Ways in which riparian vegetation improves waterway health include:

- Stabilising the channel bed, banks and verge.
- Providing habitat and wildlife corridors for native fauna.
- Providing shade over the waterway, thus providing a more favourable habitat, slowing evaporation of pools and decreasing the likelihood of algal blooms.
- Providing woody debris for habitat and bank stabilisation.
- Filtering runoff from surrounding land to decrease nutrient and sediment input into the waterway.
- Protecting soils from wind and water erosion (Olsen and Skitmore, 1991).

Management works should be prioritised to gain the greatest benefit from the available resources. Protecting areas of good riparian vegetation and working towards more degraded areas is more economically viable. It is more costly to rehabilitate a degraded area than to protect it before it becomes degraded.

Most of the Hutt River and Kennedy Creek surveyed was determined to be 'C Grade' due to the lack of perennial middle and understorey vegetation. Native rushes and sedges tend to be tall cylindrical plants with dense underground stems that are important for holding the soil down. These plants also trap leaf litter and other material that provide habitat for native animals. In comparison, plants like introduced couches provide perennial cover but have limited habitat value. During peak flow events, the height and shape of the rushes and sedges enables them to lie down in the stream and allow the water, fully loaded with sand, to pass through. However where the dominant plant in the floodway is couch, sediment will accumulate, building up the height of the floodway which can increase the occurrence of flooding.

Of concern along the Hutt River is that in many sections there is little to no regeneration of native species. Without regeneration of perennial vegetation the condition of river will soon deteriorate when the older trees die. Much of the problem appears to be caused by continuous uncontrolled grazing of the riparian zone.

If revegetation of riparian areas takes place, it is important that stock do not have access to these areas of fringing vegetation. It is recommended that stock be excluded from the planted area for at least three years to allow plants to grow and recolonise the area (Piggott et al, 1995). After this period the plants should be established and stock access, if allowed, should be controlled and properly managed.

Total exclusion of stock is ideal, however where grazing of the riparian zone is necessary, the following rules should be followed to minimise disturbance and limit the environmental and economic losses associated with an unhealthy river system:

- Only graze the riparian zone in Autumn when the weed germination is sufficient to provide opportunistic feeding to stock and help to reduce the potential fire risk. Avoid grazing in Spring and Summer during the germination and growing times of native plants.
- Do not overstock the riparian zone. This will minimise the negative impact that grazing and trampling have on the productivity of this area, as well as the water quality in the river.
- Adjust stocking rates and the frequency of grazing within this zone to suit the carrying capacity of the land. Aim to remove stock before they start to graze the native perennial vegetation and their seedlings.

Useful references on natural regeneration and revegetation

Scheltema, M (1993) *Direct seeding of Trees and Shrubs*. Greening Western Australia, Perth.

Water and Rivers Commission (1999) *Revegetation: Revegetating riparian zones in south-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR 4.

Water and Rivers Commission (1999) *Revegetation: Case studies from south-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR 5.

Water and Rivers Commission (1999) *Using rushes and sedges in revegetation of wetland areas in the south-west of WA*. Water and Rivers Commission River Restoration Report No. RR 8.

Water and Rivers Commission (2000) *Rushes and Sedges*, Water Note WN20.

Wilcox D.G., Lefroy E.C., Stoneman T.C., Schoknecht N.R. and Griffin E.A., (1996), *Trees and Shrubs for the Midlands and Northern Wheatbelt*, Bulletin 4324, Agriculture Western Australia, South Perth, Western Australia.

Box 2: Regeneration and Revegetation

In areas that still retain native trees and understorey natural regeneration is the cheapest and easiest option. Control of stock access and invasive weeds is essential to this approach. Smoke water can be applied to encourage germination. Brushing is another technique to assist regeneration and involves laying the seed bearing parts of native plants directly onto the ground, allowing seeds to fall from them.

Sections of the rivers that have been heavily grazed and cleared generally contain more weeds and have a diminished seedbank. Options for these areas include: direct seeding, brushing with woody natives that contain seed, pre-seeded matting and planting of tube stock (See Appendix 4 for a description of these revegetation techniques). The riparian zone should be planted in a wide band with a diverse suite of local provenance species including deep-rooted trees and shrubs, along with sedges, rushes, and other native groundcovers. This not only improves the habitat value of the foreshore, but also provides a matrix of different root structures to improve bank stability and assist in erosion control.

Good site preparation is often crucial to successful revegetation. Consideration of weed removal and preparation of the soil surface for direct seeding or planting are important, along with ongoing control of pests and weeds. Planting and sowing at the right time of year and at the appropriate depth also influence the success of the revegetation effort.

Although the foreshore assessment lists the dominant plant species for each section this is not a comprehensive list. A project could be developed to conduct a flora survey to determine the diversity along the Hutt River and to compile a list of species for seed collecting and those suitable for revegetation that are readily available from nurseries.

4.3.5 Weeds

Weeds have many negative impacts on the riverine environment. They degrade the bushland along the waterway, and increase fire hazard. Introduced species replace native vegetation, or prevent the regeneration of native vegetation, and are often visually unattractive. They compete with native vegetation for space and water. The resulting loss of native species may lead to a change in the food and habitat source for native fauna, hence altering the food chain.

The cost of weed control within cropped land is massive within Australia. Weeds affect crop values, can poison stock and reduce the values of animal products such as wool and leather. Managing weeds before they become a significant problem is critical as the cost of not controlling weeds when present in small numbers will be significantly greater in future years.

In foreshore areas, removal or control of weeds must be completed with care. In the riparian zone the erosive power of water requires consideration when planning a weed management strategy. Clearing weeds in an unplanned manner could result in erosion in the river channel.

Weed control principals to keep in mind include:

- An integrated management approach is the best way to deal with weeds. Weed control needs to focus on the immediate area as well as upstream areas where seeds can be easily transported downstream to susceptible areas. Information should be sought from the Environmental Weeds Action Network to develop a catchment-wide weed control strategy.
- Weed control should target the best areas and work towards the worst weed infested areas. Focusing on invasive species as well as declared and pest plants will give a more productive outcome to weed control.
- Weeds thrive in disturbed areas and areas of bare ground. If weed control is carried out, revegetate to prevent water erosion of the area and further weed invasion in the bare soil.

- Fire promotes weeds. Burning a weed infested remnant only make the weeds worse unless there is follow-up weed control and revegetation. Native plants cannot compete with the rapid growth of weeds, which then become a greater fire hazard.
- Aggressive perennial weeds that spread readily along riparian corridors are important to eradicate, for example, Spiny rush, African boxthorn, Black berry nightshade, Brazilian pepper and Fountain grass.
- Some native plants look and act like weeds. Do not begin weed control until you are sure a plant is a weed.
- Chemical control of weeds on waterways requires consideration of the effects of the herbicides on native flora and fauna and the impact on water quality. The use of Roundup Biactive is recommended.
- Some introduced species perform a useful role in rehabilitation and riverbank stabilisation. For example, Saltwater couch colonises bare areas along banks and verges and is often useful in stabilising areas that would otherwise be susceptible to erosion and undercutting. These species should be tolerated in the short term, but in the longer term they will need to be controlled before spreading too far. When undertaking weed management, weeds should only be removed from areas susceptible to erosion when revegetation is about to begin. Planting of native species to replace weed species should be considered as an option when planning for revegetation. For example, Native couch (*Sporabolous virginicus*) can be used to replace Saltwater couch.
- Weeds growing along road verges that run in close proximity to the waterway and its tributaries should be controlled, so as to reduce the risk of spreading into surrounding riparian zones.

In some cases it may be appropriate to use restricted grazing to control weeds. Where banks are steep and sandy or prone to collapse, or where the objective is to maintain high quality riparian habitat, grazing should be avoided. However, where the riparian zone has a history of grazing and the exclusion of stock would lead to an explosion of weeds, maintenance of the zone by light grazing is an option. The landholder needs to keep a watchful eye on the riparian zone to see that it has an adequate cover of a mixture of native and weed species and erosion is not occurring. Troublesome major weeds should be identified at an early stage and eradicated immediately (Pen, 1999).

Tables of weed distribution along the area surveyed and a summary of control methods can be found in Appendix 3.



Photograph 10: Spiny rush (*Juncus acutus*) infestation along a tributary of the Hutt River. Spiny rush is an aggressive weed that is not readily eaten by grazing animals. Once established it covers an area and eliminates almost all other vegetation. Stands can become impenetrable to livestock and humans and the sharp spikes are a danger to animals' eyes.

Useful references for weed identification and methods of control

Brown K. and Brooks K., (2002) *Bushland Weeds: A Practical guide to their management*, Environmental Weeds Action Network Inc, Greenwood, Western Australia.

Hussey B.M.J., Keighery G.J., Cousens R.D., Dodd J. and Lloyd S.G., (1997), *Western Weeds – A guide to the weeds of Western Australia*, The Plant Protection Society of Western Australia, Victoria Park, Western Australia.

Water and Rivers Commission (1999) *Revegetation: Revegetating riparian zones in south-west Western Australia*. Water and Rivers Commission River Restoration Report No. RR 4.

Water and Rivers Commission (2001) *Herbicide use in wetlands*, Water Note WN22.

Water and Rivers Commission (2000) *Weeds in Waterways* Water Note WN15.

4.3.6 Stock access and grazing

Stock access and grazing within the channel and riparian zone are major causes of degradation and erosion in the Hutt River. While periodic low level grazing can be an effective weed management tool, long term stock access or stocking with large numbers of animals is detrimental to river health.

Problems related to unrestricted stock access include:

- Loss of native fringing vegetation
- Weed invasion
- Compacted soils
- Erosion
- Poor water quality

River paddocks are important components of many farms. The onus is on landholders to manage the foreshore in order to protect the integrity of the river system and minimise adverse impacts on those downstream.

Treating the river foreshore as a sensitive paddock and monitoring stock impacts are essential components towards protecting the river's form and function. Some inappropriate stock management practices observed during the foreshore assessment include overgrazing and not providing shade or shelter for stock elsewhere on the property. These have a significant impact on foreshore health and reflect poor farm management practices.

4.3.6.1 General suggestions

- Develop river paddocks and manage them as 'sensitive areas' when determining stock rotation.
- Design river paddocks to minimise the chance of stock walking parallel with the riverbanks by ensuring fences are not located too close to the river channel.
- Monitor the impact of stock on the vegetation and aim to restore or maintain at least 70% perennial vegetation cover at all times of the year.

- Ensure that farm management plans include grazing schedules, recognise surface and groundwater issues and aim to invest in improving the land when times are good.

4.3.7 Fence alignment

The control of livestock access is the most important management tool in the protection and restoration of waterways and fencing is the best method to achieve this.

There are many examples of undermined fences along the length of the Hutt River. Fences located within the floodway have an increased risk of being washed with river flow while only gaining a small area of land. If the fence is at risk, so too is the top soil because it means that should the water level reach the areas prepared for cropping, it will have limited resistance to water erosion. See Photographs on page 74.

It is important to weigh up the value of locating a fence above peak events and loss of potentially productive land. *Figure 8* illustrates the correct placement of fences in relation to the river valley. Areas of adjoining verge vegetation should be included within fencelines controlling stock access to the river foreshore where possible.

Where property boundaries cross the river it is difficult to manage the fence during flow events. It may be useful to consider using temporary fences, either electric or ringlock, which are reasonably quick to install and remove in the event of flow. Hanging fences which allow water to flow underneath are ideal. Sacrificial fencing is also used widely throughout the Northern Agricultural Region. If permanent fencing is required, plain wire is less likely to catch debris than ringlock type fencing. Regardless of the type of fencing used regular maintenance to clear away any caught debris is important.

Under the *Rights in Water and Irrigation Act 1914* it is illegal to disrupt the flow of any waterbody. This means that if fencing is used across the river and traps debris, which impacts on water flow, it contravenes the Act. Common sense needs to apply, however fencing across waterways is not generally recommended.

Useful references on stock access and fencing

Water and Rivers Commission (2000) *Livestock Management: Fence location and grazing control*, Water Note WN 18.

Water and Rivers Commission (2000) *Livestock Management: Construction of Livestock Crossings*, Water Note WN 6.

Water and Rivers Commission (2000) *Livestock Management: Watering Points and Pumps*, Water Note WN 7.

Water and Rivers Commission (2000) *Flood proofing fencing for waterways*, Water Note WN19.

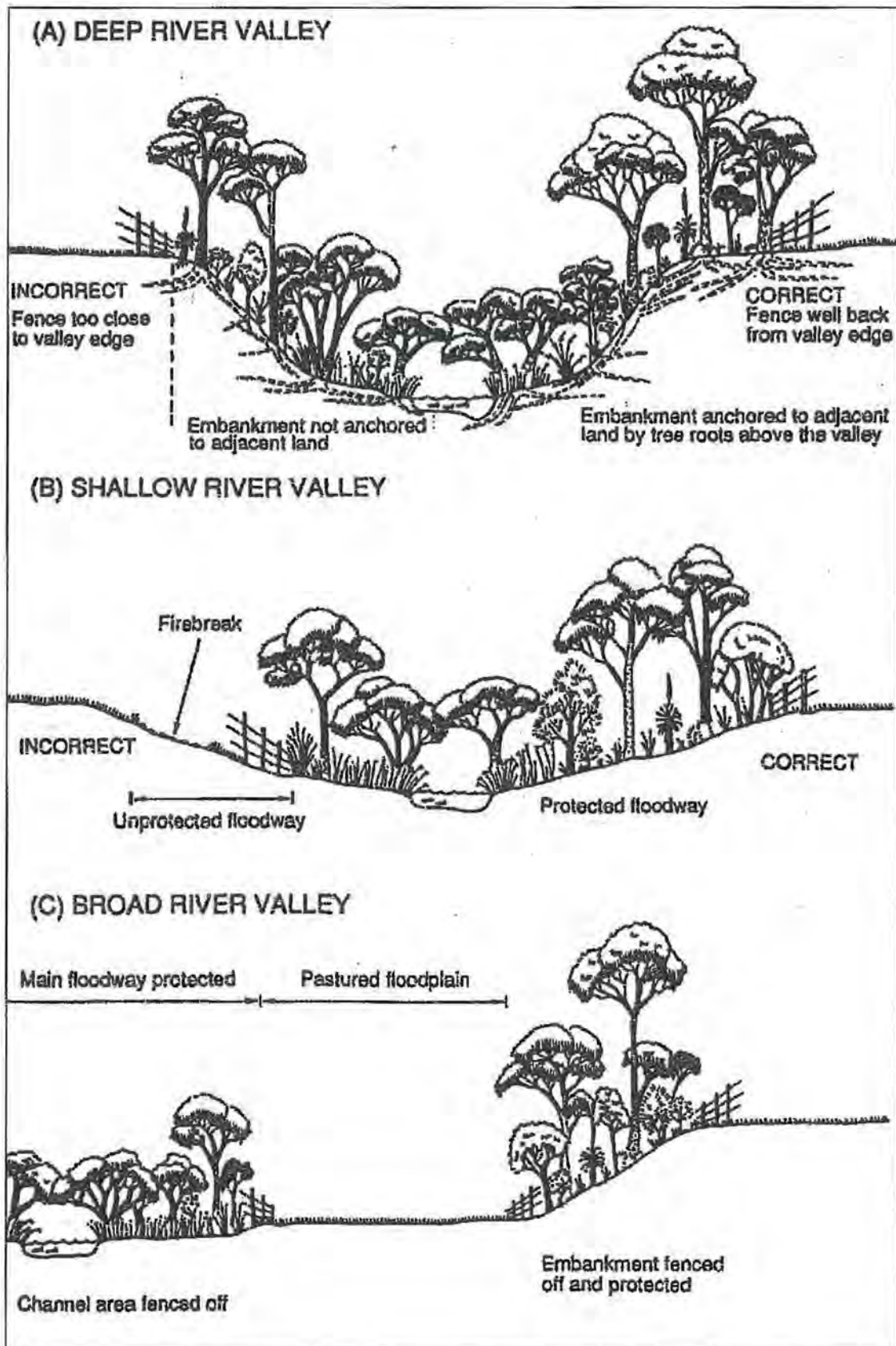


Figure 8: The correct and incorrect placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad flood-plain

Source: WRC, 2000, WN 18

Main Management Issues on the Hutt River



Erosion: Erosion leads to widening of the river, loss of adjacent land, disturbance of vegetation and increased sediment. Sediment then causes the river to get shallower, fills pools and covers rocks, vegetation and other habitat.



Lack of vegetation: Riparian vegetation protects the banks from erosion, provides shade and habitat and prevents nutrient and sediment runoff from adjacent paddocks reaching the river. Verge vegetation protects soil in the floodway from being washed away during large flow events.



Stock Access: Stock movement in the floodway limits regeneration, disturbs the banks making them prone to erosion and mobilises nutrients.

4.3.8 Rising groundwater and salinity

Of the two contributing headwaters surveyed, one arose in a salt pan and the other in a waterlogged area. The upper tributaries of the Hutt River have become increasingly saline from the impacts of clearing. As a result the increased secondary salinity along the upper tributaries can increase the rate at which salt enters or accumulates in the riparian zone, with resultant adverse effects on the riverine system.

In 1993 4.5% (1260 ha) of Hutt River catchment area examined in the Kennedy Creek Catchment Management Report (1993) (Figure 6) was salt affected. Many of the drainage lines and valley floors were affected by secondary salinity and most were considered susceptible. The majority of landowners reported significant increases in the salt affected area in the five years to 1993. Virtually all drainage lines were degraded to some degree, although some of them appeared to be suffering more from over-clearing, over-grazing and the impact of stock than salinity.

Anecdotal evidence and observations throughout the Hutt River catchment indicate that rising groundwater tables have increased the contribution of some springs. Rising groundwater is certainly an issue and is difficult to address. It is important to remember, however, that rivers reflect the way in which the catchment is managed. There is a risk that as the river is expected to cope with increased salt and water loads it will degrade and ultimately function as an unstable drain rather than a river. Improving land management in the catchment is critical to prevent further impact on this issue.

Where the rising watertable is carrying salt to the surface, investigations need to be made into what management options may be viable to prevent further degradation of the streamline and minimise downstream effects. Engineering or drainage works can be an option in some soil and slope conditions. In many situations the only way to alleviate the problem is to minimise additions to the watertable by planting perennial vegetation in areas of recharge. Excluding stock from salt affected creeklines is the first step to recovery, however, often saline areas need to be planted to prevent further erosion and trap overland flows carrying silt and nutrients as the saline conditions can limit natural regeneration.

Increased discharge from fresh springs due to rising groundwater levels can affect the river as the channel and vegetation adapt to the changing conditions. The channel may erode and become larger to accommodate the increased flow and vegetation may be drowned. Opportunities should be explored to use the excess freshwater from these springs to maintain natural flows and alleviate waterlogging.

4.3.8.1 General suggestions

- Work with Department of Agriculture and Department of Environment to implement recommendations of the Kennedy Creek Catchment Management Report (1993), considering advances made in the last ten years. Develop new projects to expand the area covered and to fill in any gaps identified.
- Obtain approval from the Department of Environment for engineering works to address salinity and waterlogging to ensure they do not adversely affect the creek and river systems.
- Seek advice from the Department of Environment before undertaking any works that impact on the bed or banks of a waterway.

4.3.9 Pest fauna

Field observations and conversations with landholders along the Hutt River and Kennedy Creek suggested that there are a high number of feral animals within the district. Feral pigs and foxes are the

most problematic although feral cats and rabbits are present in smaller numbers. Feral pigs can cause serious damage to the environment, especially along river systems with their habit of wallowing and rooting for food. Foxes and rabbits can undermine bank stability as they build their warrens in the sides of the banks. Pigs, foxes and rabbits, in addition to feral cats, can threaten the survival of native wildlife.

There are a number of legal requirements associated with owning rural and special rural lands in relation to pest fauna. Owners are responsible for the control of all Declared Animals on their land. The majority of the landowners along Hutt River and Kennedy Creek currently perform some form of feral animal control on their properties. Management of feral animals should be approached as a whole throughout the catchment. There is no use in working to rid one property of pest animals to have them migrate from surrounding properties. Controlling weeds and rubbish dumping will also help to deter pest animals due to a lack of food and breeding sites.

Anecdotal evidence suggests that current rabbit numbers are not high. These should be monitored as if the numbers of foxes and feral cats drops significantly due to diligent control, rabbit numbers may increase. If this occurs there will be a need to control these species together to prevent the control of predators causing rabbit numbers to increase or alternatively rabbit control leading to foxes and cats preying on stock and native animals.

The Department of Agriculture can provide specific advice on pest fauna control and assist in developing a co-ordinated community control program to target fauna pests on a catchment or regional scale.

4.3.10 Fire

Fires occur in the riparian zone following paddock fire escapes, deliberate lighting or uncommonly as the result of lightning strikes. Historically fire has been used as a management tool along the middle reaches of the Hutt River.

Fires usually result in loss of vegetation and debris that slow big flows, resulting in washouts and loss of arable land within the floodplain. Fire creates bare open ground which is ideal for the germination of weed species, and if fires become too frequent it is easy for weeds to out-compete native plants. Annual weeds dry out during the summer months and can pose a serious fire risk if not kept under control. Native groundcovers such as sedges, which are green all year round, do not burn readily and can act as fire suppressants.

While fire can be a useful tool, it is also a serious threat to the integrity of riparian vegetation. In most instances, fire exclusion rather than use, will be the management aim. Fire should only be used in riparian land under special circumstances. Its use should be carefully managed and its reason for use carefully considered, as there may be more appropriate options available. When fire occurs on too frequent a basis it may lead to a loss of habitat, loss of seed, increased tree branch loss, an increased susceptibility to erosion and weed invasion and can hinder management works if rehabilitation plantings and fences are burnt.

Firebreaks along foreshore verges are important to protect the fragile vegetation from unintentional fires that may result from crop and pasture burning in surrounding paddocks. To maintain effective fire control for the riparian zone, firebreaks and fencing should be maintained along verge areas of the foreshore. When fencing for protection of riparian, vegetation the firebreak should be located on the river side of the fence, as far away from the bank as possible. A firebreak on the river side of the fence will allow easy access to this zone, and prevent stock from pushing on the fence to graze on the river side. However, care

must be taken not to locate the fire break too close to the floodway as larger flows may find this an easy path to flow down causing washouts or an additional channel along the firebreak.

4.3.11 Crossing design

It is important that all river and creek crossings are designed in a way to minimise impacts on the waterway. Poorly designed crossings can significantly change the flow pattern and velocities. This can cause scour of the bed, erosion of the banks, mobilisation of large amounts of sediment, especially in sandy areas, and loss of fringing vegetation. Many crossings were present throughout the Hutt River catchment and some were observed to be causing problems both upstream and downstream.

The impacts of bridge, culvert and ford crossings can include:

- Alteration to the stream's natural flow pattern;
- Reduction in the volume of water the stream can carry without causing problems;
- Increase in erosion due to concentration of flow through culverts and under bridges;
- Increased risk of blockage or damage due to debris;
- Reduced capacity for aquatic fauna movement;
- Reduction in flora and fauna habitat in the vicinity of the crossing;
- Increased extent of flooding upstream;
- Increased sediment load input during construction;
- Toxicant inputs from highly trafficked bitumen roads;
- Removal of riparian and in-stream vegetation;

The type of crossing best suited will depend on the purpose of the crossing, i.e. for public road or internal farm access. As well as the characteristics of the stream in which it is installed, e.g. whether it is permanently flowing or only flows during rain events and whether it is a known fish habitat or not.

Table 4: Minimum Preferred Structures for Fish Passage

Classification	Stream Characteristics	Minimum Preferred Structure
Class 1 - Major fish habitat	Large named permanently flowing stream. Aquatic vegetation present. Known fish habitat.	Bridge
Class 2 - Moderate fish habitat	Smaller named permanently or intermittent flowing stream. Aquatic vegetation present. Known fish habitat.	Large box culvert or Bridge
Class 3 - Minimal fish habitat	Named or unnamed watercourse with intermittent flow.	Box / pipe culverts
Class 4 - Unlikely fish habitat	Named or unnamed stream with flow during rain events only.	Ford or culverts

Source: Goulburn Broken Catchment Management Authority

Many examples of suitable crossings were observed during the survey, for example where farm crossings are located on naturally hard rocky sites. Crossings causing problems should be upgraded to minimise waterway degradation. Ford crossings can be designed to create a pool and riffle to provide habitat and slow the flow, thus minimising the water's destructive force. Poorly designed crossings that are causing problems should be redesigned to minimise impacts when an opportunity arises.

Contact the Department of Environment for information and advice before undertaking any works that impact on the bed and/or banks of a waterway.

Useful References for Crossing Design

Goulburn Broken Catchment Management Authority, Works on Waterways: Bridge, Culvert and Ford. Available: <http://www.gbcm.vic.gov.au/default.asp?ID=164>

Water and Rivers Commission Water Note 6, *Livestock Management: Construction of Livestock Crossings*.

Further information can be obtained from the Department of Environment.

4.3.12 Waste disposal

Field observations determined that along some sections of the river it has been and still is commonplace to dispose of household and other waste, unwanted farm machinery, cars and chemical containers along the banks of the waterway or within tributaries. Refuse can cause pollution of the river when oils, fuel, chemicals and organic substances leach into the waterway and waste is moved downstream during periods of flow.

4.3.13 Farm plans

Farms, as with any other business, should have a plan. Farm management plans are important to ensure that the land is managed in a way that protects the sustainability of environmental, financial and social values.

Managing water movement across, through and beneath the land surface is one critical component of such plans. Land that is unproductive or difficult to farm, often in the floodplain, could be written off to help restore river function. By restoring vegetation to the floodplain, peak flows can be slowed more consistently and can reduce flood damage. Cropping within the floodplain is a gamble as productive land can be lost and the damage downstream considerable. The offsite impacts of rivers are rarely recognised as many landholders rarely see other properties located on the same river.

4.3.14 Education and awareness

For the long-term benefit of the riverine ecosystem, measures should be taken to promote a wider understanding and awareness of the significance of waterways and their management for future use. Waterways need to be managed as a continuum on a catchment scale. People all along the river need to communicate so that those at the top of the catchment are aware of the issues faced by those downstream and vice versa. In addition, education of young people and visitors is needed to protect the river for the future generations.

Catchment management and community action require awareness of the issues, education and information, technical advice and practical support. Local Government Authorities, as well as relevant government and non-government agencies need to provide support to these groups, while banding together to promote issues such as waterways management, integrated catchment management and land management to community.



Photograph 11: It is important that the next generation learns the values and secrets of our rivers.

[Photo by Mike Johnson]



Photograph 12: Hands on River Recovery workshops allow sharing of ideas and experiences.

[Photo by Stephanie Cobb]



Photograph 13: Rock riffle structures and logs placed instream can arrest erosion and get a river on the road to recovery.

[Photo by David Gibb]

4.4 General Recommendations

It is recommended that landholders consider the following:

1. Make a commitment to protect the Hutt River and its tributaries, and restrict stock access.
2. Fence the river to exclude stock permanently, or to achieve management that allows for bank stability and native vegetation establishment and protection. Utilise funding to fence the river and its tributaries.
3. Control feral animals primarily pigs, foxes, cats and rabbits.
4. Work to eradicate weeds, particularly invasive weeds, dominating the riparian zone.
5. Consider widening the riparian zone in various ways; options aside from indigenous vegetation could include commercial trees, fodder trees, commercial plantings of native shrubs for seed, flower production, dried foliage etc.
6. Use management techniques that will minimise soil erosion and nutrient loss to waterways, such as establishing a vegetation buffer and realigning large woody debris.
7. Monitor and remove invasive weeds spreading from properties upstream and downstream.



Photograph 14: Fence too close to the floodway which was not protected from washouts in large flows



Photograph 15: Thin band of riparian vegetation along the river has allowed large flows to go around and cause a large washout of vulnerable unprotected land. Resulting in a greater loss of cropping land.

It is recommended that the catchment as a whole consider the following:

1. Work closely with neighbours to protect the Hutt River and its tributaries and take an interest in the river as an entity. Consider the downstream and future effects of management and actions.
2. Explore the possibility of establishing a catchment group or number of sub-catchment groups to make co-operation and cross property boundary management easier.
3. Develop an implementation plan for works throughout the catchment. Detail actions, responsibilities, costs and timelines.
4. Assist in the implementation of the recommendations in the 'Kennedy Creek Catchment Management Report', consider expansion of the area covered and update some of the information contained within it.
5. Endeavour to obtain funds from outside sources to assist groups and private landholders who are willing to implement rehabilitation activities.
6. As a priority, protect areas of the river still retaining native fringing vegetation. It is more cost effective to protect these areas now than to restore them later after further degradation has occurred.
7. Extend the focus to include the rehabilitation of tributaries to achieve the greatest impact on stripping sediments and nutrients before they reach the river channel.
8. Promote management techniques that minimise soil erosion and nutrient loss to waterways, such as buffer strips, soil testing and maximising vegetation cover on the soil.
9. Seek advice from the Department of Environment (formally Water and Rivers Commission) regarding erosion problems that require remedial action.
10. Encourage landholders to ensure all strata of vegetation, including understorey, middlestorey and overstorey species, are included in revegetation works to reinforce bank stability.
11. Conduct a flora survey to obtain an extensive list of revegetation species to be used as base data for diversity in future years.
12. Investigate ways of coordinating weed control efforts on a catchment scale. A regional weed management plan for selected weeds could be developed.
13. Undertake coordinated feral animal control along the river and within the catchment.
14. If fire is deemed a necessary management tool to be used, contact the Department of Environment for advice.
15. Evaluate all public road crossings in the Hutt River Catchment to assess whether they are causing problems for the waterway. Target those that are due for replacement and ensure the design of all future crossings and repairs of existing crossings minimise adverse impacts.
16. Ensure discarded farm materials are removed from the river and rubbish dumps are located outside of the floodplain.

17. Ensure current and future aquaculture ventures do not threaten the river and its wildlife due to increased nutrients or introduced species.
18. Monitor the effectiveness and relative benefits of different management techniques utilised and update management techniques accordingly.
19. Monitor the effectiveness of sustaining interest within restoration projects at both the management and implementation level. Develop techniques to support community groups and individuals in undertaking this work.
20. Investigate possibilities for management and vesting of sections of the rivers contained in unvested Crown land.
21. Ensure plans for a substantial foreshore reserve to protect the Hutt River is included in any future subdivision plans and that no development occurs that will adversely affect the river system.
22. Signpost the Hutt River and all the named tributaries and the catchment boundary where roads intersect them to increase ownership and awareness for locals and visitors.
23. Collect and make known all of the studies that have been done and all of the information that has been collected from within the Hutt River catchment. This could be compiled as a list of available information and where to find it or as a catchment compendium report.
24. Continue to use the foreshore assessment proforma (available from the Department of Environment) to assess changes to foreshore health over time and to assess tributaries of the Hutt River.
25. Conduct a flood attenuation and mitigation study to explore options to reduce damage during flood events.
26. Create a herbarium of native and weed species to teach group members and other interested parties to distinguish between native and introduced plants in the riparian zone. This could include seedlings.
27. Learn more about the Hutt River and its catchment by conducting aquatic and terrestrial fauna surveys for both native and introduced species.
28. Conduct a frog survey by distributing tapes of frog calls for residents to identify the types of frogs calling on their property.
29. Promote awareness and knowledge of the Hutt River, its catchment, threats and waterways management through a series of brochures.
30. Investigate ways in which land management within the entire catchment can protect the Hutt River for future generations.

4.5 General management suggestions for each foreshore rating

A - Near pristine (Very good)

River sections achieving this rating require minimal maintenance effort including:

- Removal or realignment of large and suspended woody debris where it is causing localised erosion.
- Eradication of isolated occurrences of weeds.
- Maintenance of fencing to exclude livestock and feral animals.
- Establishment and maintenance of fire access tracks.

B - Moderate

Management effort required is greater than in A grade foreshore sections and generally relates to:

- Eradication of minor weed infestations and ongoing maintenance control of more widespread weeds. The weed control effort should be focussed on establishing buffers around native plants to encourage regeneration.
- Monitoring and realignment of woody debris to ensure that natural dams that are exacerbating erosion are realigned to improve flow. Any debris that is not resulting in erosion needs to be left as habitat.
- Close stock management is necessary to achieve effective weed control without reducing the values of the persisting native vegetation or the creation of clearly defined tracks.

C - Poor

Management activities are becoming more difficult as the degradation has stepped up an order of magnitude. Potential management activities include:

- Order of magnitude. Potential management activities include:
- Using woody debris to direct peak flows back to the main river channel and working to slow flows across the floodway.
- Revegetating using a combination of direct seeding and tubestock planting on the floodway margins. Planting close to the main channel is unlikely to be successful due to the volumes of mobile sediment and instability of the channel.
- Controlling stock access until there is sufficient groundcover to improve bank and floodway stability.

D - Very poor

It is very costly to restore river systems once they degrade to this level. Priorities include:

- Re-establishing nodes of vegetation using fast growing species initially then infilling with slower growing plants. All plants need to be protected from peak flow events.
- Developing and implementing strategies to slow water flow - possibly using instream large woody debris or riffles/causeways.
- Undertaking localised weed control around revegetation works only.
- Excluding stock until there is sufficient vegetation cover to protect the channel banks and floodway.

Source: Water and Rivers Commission (2001), WRM 23.

Appendix 1: Flow, Rainfall and Water Quality Data from Gauging Station

The Department of Environment Hutt River Gauging Station (Photograph 1) records rainfall, river flow, conductivity and water temperature data. The Gauging Station is located approximately 10km upstream of the mouth of the river (see map 3) and records data for most of the flow from the catchment.

Below are three plots from data collected from the Stream Gauging Station. The first plot shows the river level height in metres (m). The stage height starts at a base of ten, therefore actual river levels above zero flow are the figures in the plot minus ten. Rainfall is measured by a pluviograph or automated rain gauge near the gauging station and is plotted as mean daily rainfall in millimetres (mm). The mean daily total dissolved salts (TDS) are calculated from the conductivity and temperature data and plotted in milligrams per litre (mg/l). Gaps in the plot correspond with lost or faulty data. This information can be accessed on the internet at <http://riverdata.environment.wa.gov.au> where the data is updated daily.

The river level data below indicates that the Hutt river catchment is rainfall reactive. There is a general base flow for both summer and winter, with peaks directly following rainfall events. Salt levels are higher in winter than summer, due to the flow from saline ephemeral parts of the catchment following rainfall. The general downward trend in salt levels over the last twelve years results primarily from increased fresher discharge from sandplain seeps rather than salinity management in the catchment.

Department of Environment - Geraldton

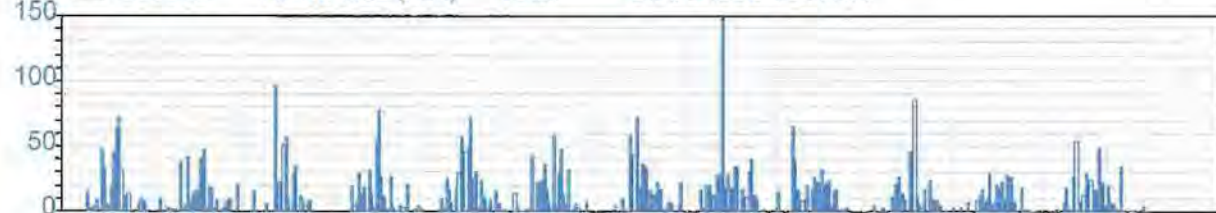
HYMPLOT V57 Output

Period 13 Year Interval 10 Day

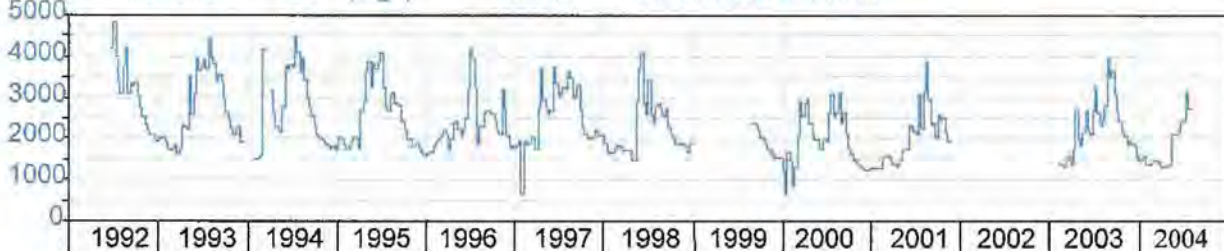
Stn	Var	Type	Start	Name
701010	STAGE (M)	Max & Min	01/01/1992	YERINA



Stn	Var	Type	Start	Name
508036	RAINFALL (mm)	Total	01/01/1992	YERINA



Stn	Var	Type	Start	Name
701010	TDS - (mg/l)	Mean	01/01/1992	YERINA



Appendix 2: Habitats Found Along Waterways

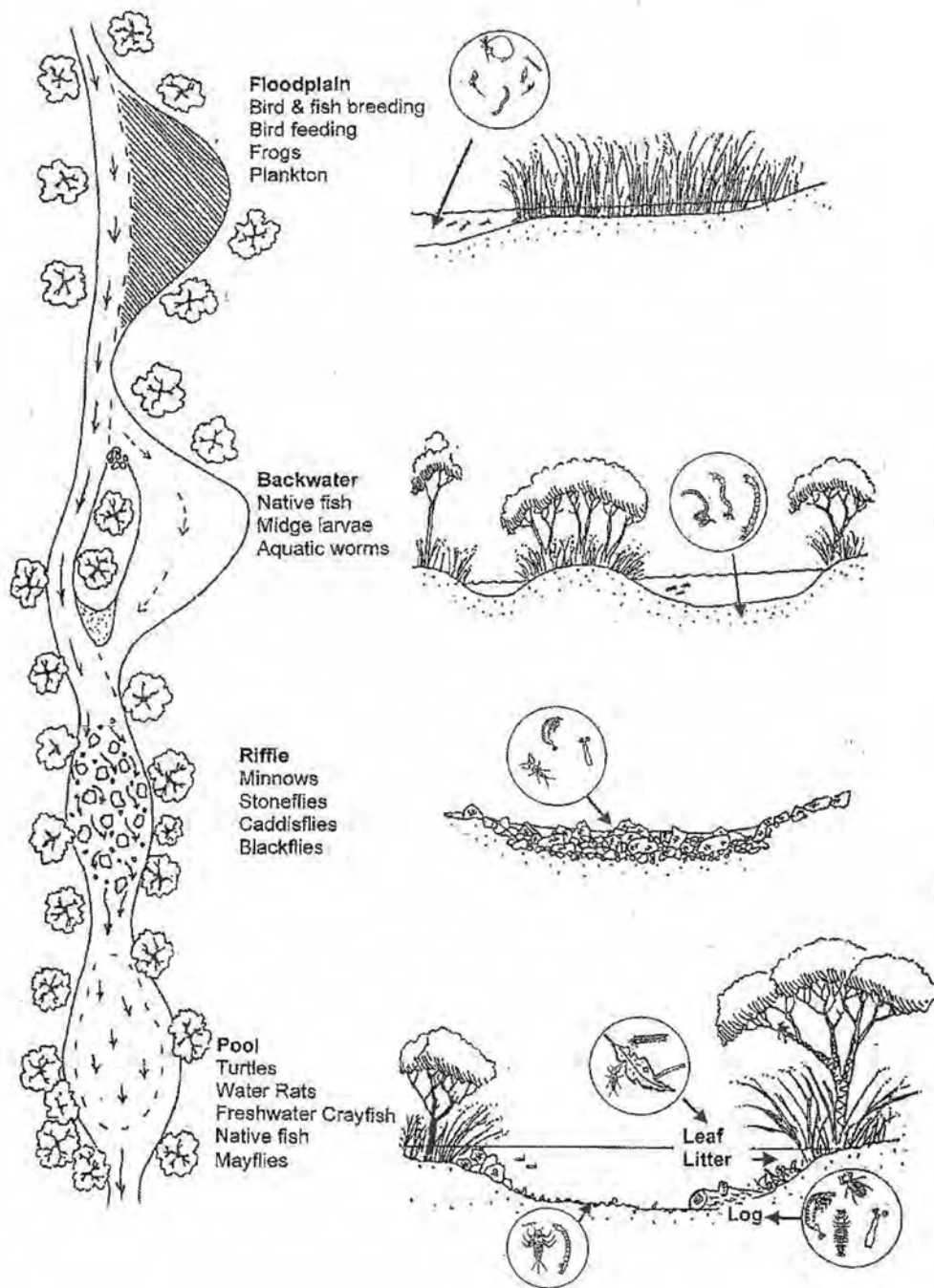


Figure 9: Important habitats in waterways and some of the animals that occur there.

Appendix 3: Weeds and their Control

Table 5: Uncommon and aggressive weeds of the Hutt River











Common name (Species)	<ul style="list-style-type: none"> • Lifeform • Reproduction • Dispersal agent • Seedbank persistence 	Suggested methods of management and control	Summer	Autumn	Winter	Spring
African boxthorn <i>Lycium ferocissimum</i> 	<ul style="list-style-type: none"> • Shrub • Seed, s, r, l • Bird, mammal, water (skinks) • Short 	Injection – neat glyphosate; or basal bark with triclopyr/picloram (Feb-May); foliar spray regrowth with 10% glyphosate or 1% Grazon® + Pluse®.		Flowering (Apr-May)		Flowering (Aug-Dec)
African lovegrass <i>Eragrostis curvula</i> 	<ul style="list-style-type: none"> • Perennial grass • Seed • Water, wind, mammal, slash 	Cut out small plants; spray with 1% glyphosate; utilise unplanned fires and spray regrowth at 5-10cm. Always requires follow-up treatment. Control when actively growing before flowering.	Opportunistic flowering	Begins active growth and requires control following rains		Begins active growth and requires control following rains
Athel tree (Tamarisk) <i>Tamarix aphylla</i> 	<ul style="list-style-type: none"> • Tree • Seed, s, r • Wind, bird, mammal • Short 	Injection into root crown – neat glyphosate; cut and paint – 30% triclopyr; basal bark or spray regrowth (autumn).		Spray regrowth		
Black berry nightshade <i>Solanum nigrum</i> 	<ul style="list-style-type: none"> • Herb • Seed • birds, water, soil, machinery • 5+ years 	Weeds of disturbed sites. Shade reduces seed production. Hand weed small infestations. Control before seed set.	Flowering (Jan-Dec)	Flowering (Jan-Dec)	Flowering (Jan-Dec)	Flowering (Jan-Dec)
Brazilian pepper <i>Schinus terebinthifolius</i> 	<ul style="list-style-type: none"> • Tree • Seed, s, r • Bird, water • Short 	Hand pull seedlings; injection – 50% glyphosate; basal bark – triclopyr/picloram.	Flowering (Jan-Mar) Herbicide control best now			

Table 5 continued

Common name (Species)	<ul style="list-style-type: none"> • Lifeform • Reproduction • Dispersal agent • Seedbank persistence 	Suggested methods of management and control	Summer	Autumn	Winter	Spring
Castor oil <i>Ricinus communis</i> 	<ul style="list-style-type: none"> • Shrub • Seed, r • Water, mammal, explosive • Medium 	Hand pull seedlings; cut or scrape and paint – 50% glyphosate; basal bark – triclopyr or Garlon® (spr-sum).	Herbicide control best now		Flowering (Jul-Sep)	Herbicide control best now
Fountain grass <i>Pennisetum setaceum</i> 	<ul style="list-style-type: none"> • Perennial grass • Seed • Wind, water, mammal, slash • 6+ years 	Dig out small infestations; slash winter and/or spray with glyphosate 1% + penetrant in spring to autumn. Follow-up treatment until regrowth ceases follow-up seedling control.				
Saffron Thistle <i>Carthamus lanatus</i> 	<ul style="list-style-type: none"> • Annual herb • Seed • Water, adhesion • 8 years 	Seedlings establish in bare open ground so establish desirable vegetation cover. Hand remove isolated plants throughout spring and early summer. Glyphosate applied with a rope wick provides good control or spot spray Lontrel® 10ml in 10ml water + 25ml wetting agent. Control at rosette stage.		Seed Germination	Herbicide control at early rosette stage	Flowering (Oct-Dec) Try hand removal now
Spiny rush <i>Juncus acutus</i> 	<ul style="list-style-type: none"> • Sedge • Seed, crown fragments • Water, machinery 	Establish native vegetation cover; dig out isolated plants; spray 2% glyphosate-repeat application six weeks later. Burning plants after they have been knocked back by herbicide increases kill rate. Consider possibility of erosion.			Flowering (Oct-Dec)	
White cedar (Cape lilac) <i>Melia azedarach</i> ** 	<ul style="list-style-type: none"> • Tree • Seed, s, r, l • Bird, water • Short/medium 	Hand pull seedlings; injection – neat glyphosate; basal bark – 10% triclopyr (summer).				

Reproduction: (r, l, n, s) = regeneration strategy: r = coppices/resprouts, l = stem layering, n = not sprouting or suckering, s = suckers (parentheses indicate occasional occurrence has been observed).

Dispersal: mode of seed dispersal.

Seedbank: main storage of seed (canopy or soil), and length of seed viability.

Management and control: injection = drill and fill or frilling [details in Brown and Brooks (2003)].

** Western Australian native that have become weedy when planted outside their natural range.

Information taken from Brown and Brooks (2003).

Table 6: Distribution of some weed species observed during the survey along the Hutt River

Weeds			Location at which species was observed during survey																
Common Name	Scientific Name *		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Afghan melon	<i>Citrullus lanatus</i>	PP										x		x				x	
African boxthorn	<i>Lycium ferocissimum</i>	PP								x	x								
Athel tree (Tamarisk)	<i>Tamarix aphylla</i>																		
Black berry nightshade	<i>Solanum nigrum</i>				x		x	x		x									
Brazilian pepper	<i>Schinus terebinthifolius</i>									x									
Cape weed	<i>Arctotheca canledula</i>		x	x	x	x	x	x		x		x	x	x		x	x	x	x
Castor oil	<i>Ricinus communis</i>		x																
Couch	<i>Cynodon dactylon</i>			x	x	x	x			x		x		x	x			x	
Doublegee	<i>Emex australis</i>	DP, PP		x								x		x	x			x	x
Fountain grass	<i>Pennisetum setaceum</i>														x				
Lupins	<i>Lupinus</i> spp			x		x	x	x				x	x						
Small flowered mallow (Marshmallow weed)	<i>Malva parviflora</i>										x			x				x	
Paterson's curse	<i>Echium plantagineum</i>	DP		x	x			x	x	x	x	x		x				x	
Prickly paddy melon	<i>Cucumis myriocarpus</i>	PP									x								
Prickly pear	<i>Opuntia stricta</i>	DP, PP	x																
Safron thistle	<i>Carthamus lanatus</i>	DP									x	x							
Spiny rush	<i>Juncus acutus</i>							x	x	x	x	x							
Soursob	<i>Oxalis pes-caprae</i>	DP	x	x	x		x	x	x	x	x	x	x	x					
Roly poly	<i>Salsola tragus</i>										x							x	x
Wild radish	<i>Raphanus raphanistrum</i>			x	x	x	x	x		x	x	x	x		x			x	x
White cedar (Cape lilac)	<i>Melia azedarach</i>														x				
Other weeds			* Some high priority weeds that are, or may become, a problem to agriculture or the environment can be formally 'declared' under the Agriculture and related Resources Protection Act, administered by the Department of Agriculture Western Australia. When it is declared, a plant is placed in one or more categories according to the control strategies considered appropriate. The declaration may be for the whole of Western Australia or a smaller area. Declared plants are marked with a 'DP'.																
African lovegrass	<i>Eragrostic curvula</i>		Landholders with declared plants on their property are obliged to control them at their property are obliged to control them at their own expense. Contact the Department of Agriculture Western Australia for advice.																
Blue pimpernel	<i>Anagallis arvensis</i>																		
Flat weed	<i>Hypochaeris</i> sp																		
Oats	<i>Avena</i> sp																		
Barley grass	<i>Hordeum</i> sp																		
Bushy starwort	<i>Aster subulatus</i>																		
Ryegrass	<i>Lolium</i> sp																		
Goosefoot	<i>Chenopodium</i> sp																		
Fat hen	<i>Chenopodium album</i>																		
Storksbill	<i>Erodium</i> sp																		
Barbgrass	<i>Ploypogon</i> sp		Local Government Authorities are responsible for administering the pest plant provisions of the Agriculture and Related Resources Protection Act. If declared as a pest plant the Shire Council is authorised to enforce control of that plant within its boundaries. Pest plants are marked with 'PP'. NB: although declared in other Local Government Authority areas in Western Australia none of the species included in the table are declared as pest plants in the Shire of Northampton.																

Information from Hussey *et al.* (1997)

Appendix 4: Revegetation Techniques

Direct seeding

Direct seeding has a few distinct advantages over other methods:

- it is less time consuming and requires less labour than planting tube stock;
- a mixture of trees, shrubs, sedges and ground covers can be planted at the same time, resulting in a plant community with a natural look;
- it is less expensive than providing tube stock, and there are many areas along the Hutt River that have good potential for the collection of local provenance seed;
- the natural root development of seedlings grown from seed usually results in plants developing deep taproots, requiring less follow-up care.

However, direct seeding can be less reliable than planting, due to predation, specific germination requirements not being met, and poor conditions for direct seeding. Direct seeding may not be possible when high winds or strong water flow is present.

Planting

Planting is the appropriate technique for embankment and in-stream revegetation, and where direct seeding is difficult due to insufficient seed, excessive weed competition etc. In these cases nursery tube stock is ideally supplied from local provenance seed. A rule of thumb guide for planting densities is 500:50:5 herb/sedges to shrubs to trees. Sedges and rushes should be planted in spring, when the water table is beginning to fall and the soil is still moist. Other seedlings should be planted when they are actively growing; the surrounding soil is moist and follow-up rain is likely.

Brush

The use of brush is an excellent technique in all zones apart from the channel bed. This technique can be used to spread seed and assist with erosion control simultaneously. Brush should be harvested from plants at seed maturity and laid immediately on to the revegetation site. Brush along the embankment should be secured in place. Species suitable for this technique are those which retain seed on the plant, but shed it when the plant dries out.

Pre-seeded matting

Pre-seeded matting involves spreading seeds onto an appropriate fibremulch, and laying the mat on-site in early winter after germination. This technique is excellent for steep embankments, since it provides erosion control and revegetation in a single stage. It is only suitable for seeding with rushes and sedges, since matting usually requires rolling for transport to site.

Glossary

Aquatic	Living in, growing in, or frequenting water.
Bank	The steeper part of a waterway channel cross-section, which is usually considered to lie above the usual water level.
Biodiversity	The number, relative abundance and genetic diversity of life forms within an ecosystem.
Braided channel	Where the river displays numerous interlaced channels that divide and rejoin around unstable bars and small islands.
Carrying capacity	The maximum population of organisms or the maximum pressure that an environment can support on a sustainable basis over a given period of time.
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Channelisation	The straightening of the river channel by erosional processes or human intervention.
Confluence	Running together, flowing together or intermingling e.g where a tributary joins a river.
Contour farming	Ploughing and planting across the changing slope of land, rather than in straight lines, to help retain water and reduce soil erosion.
Conservation	The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.
Debris	Loose and unconsolidated material resulting from the disintegration of rocks, soil, vegetation or other material transported and deposited during streamflow.
Declared plant (DP)	Plants that are classified as high priority and which may become a major problem to the environment or to agricultural activities.
Discarded farm material (DFM)	Old machinery, containers and rubbish from farming activities.
DoE	Department of Environment (formerly Waters and Rivers Commission).
Environment	All the biological and non-biological factors that affect an organism's life.
Environmental degradation	Depletion or destruction of a potentially renewable resource such as soil, grassland, forest, or wildlife by using it at a faster rate than it is naturally replenished.
Erosion	The subsequent removal of soil or rock particles from one location and their deposition in another location.
Eutrophication	Occurs naturally with increasing age of a waterbody, but much more rapidly as a by-product of human activity.
Evaporation	A physical change in which liquid changes into a vapour or gas.

Exotic vegetation	Introduced species of vegetation from other countries or from other regions of Australia (ie. not indigenous to the region).
Flood fringe	The area of the floodplain, outside the floodway, which is affected by flooding. This area is generally covered by still or very slow moving waters during the 100 year flood.
Floodplain	The portion of a river valley next to the river channel which is or has been periodically covered with water during flooding. See <i>Figure 4</i> .
Floodway	The river channel and portion of the floodplain which forms the main flow path of flood waters once the main channel has overflowed. See <i>Figure 4</i> .
Foreshore	Area of land next to a waterway.
Habitat	The specific region in which an organism or population of organisms live.
Headcut	Sharp step or small waterfall at the head of a stream.
Headwaters	The upper tributaries of a river.
Hydrology	The study of water, its properties, distribution and utilisation above, on and below the earth's surface.
Integrated catchment management (ICM)	The coordinated planning, use and management of water, land, vegetation and other natural resources on a river or groundwater catchment basis. ICM is based on cooperation between community groups and government agencies at all levels to consider all aspects of catchment management.
Large woody debris (LWD)	A branch, tree or root system that has fallen into or is immersed (totally or partially) in a stream.
Leaf litter	The uppermost layer of organic material in a soil, consisting of freshly fallen or slightly decomposed organic materials which have accumulated at the ground surface.
Left bank	The river bank on the left-hand side when looking upstream.
Mass failure	A form of bank erosion caused by blocks of material sliding or toppling into the water.
Meander	The turn of a stream channel, a bend, often associated with a distinct loop.
Middlestorey vegetation	The middle strata of vegetation, i.e. smaller than the canopy and larger than groundcovers; esp. shrubs.
Monitoring	The regular gathering and analysing of information to observe and document changes through time and space.
NACC	Northern Agricultural Catchments Council.
Native species	Species that normally live and thrive in a particular ecosystem.
NRM	Natural Resource Management.
NTU	Nephelometric Turbidity Units. A common measure of turbidity because they are on a logarithmic scale, every unit increase represents a ten-fold increase in turbidity.
Overgrazing	Destruction of vegetation when too many animals feed too long and exceed the carrying capacity of an area.

Overstorey vegetation	The tallest strata of vegetation or canopy; esp. trees.
Pasture weeds	Annual weeds associated with agriculture; e.g. Annual grasses, Wild oats, Barley grass and Cape weed.
Pest plant (PP)	Weed species that are seen as being a nuisance to the existing landuse. Local Government Authorities can enforce the control of such a species.
Pollution	Any physical, chemical or biological alteration of air, water or land that is harmful to living organisms.
Power bend	Sharp turn in the river course. The bank on the outer side of the curve is often steep to vertical and the inside bank often has a very gentle slope. This results from flow being fast on the outer bend and having power to erode the outer bank and the water moving slowly on the inside sediment is able to deposit.
Reach	A continuous section of river channel, especially exhibiting similar characteristics.
Regeneration	Vegetation that has grown from natural sources of seed, from vegetative growth, or has been artificially planted.
Rehabilitation	The return (as much as possible) of the original characteristics of a waterway or wetland, including the physical structure and stability, functionality, water quality, flow regime, and plant and animal communities. Ideally, improvements made to the waterway or wetland during rehabilitation should be self-sustaining.
Remnant vegetation	The parts of the natural vegetation still existing after major change to the environment.
Restoration	<p>The return of a degraded waterway or wetland to the original (pre-European) state in regard to physical structure and stability, functionality, water quality, flow regime, and plant and animal communities.</p> <p>Although complete 'restoration' of a river is a goal that is rarely achieved, the term is often used to describe the complete return of a component that was once part of the river ecosystem such as a species, feature or function. For example, it may be possible to restore a population of flooded gums in a river's riparian zone despite not being able to fully restore the entire plant community.</p>
Riffle	The high point in the bed of the stream (accumulation of coarse bed materials), where upstream of accumulations a shallow pool is formed. Downstream from the crest of the accumulation the water is often shallow and fast flowing.
Right bank	The river bank on the right-hand side when looking upstream.
Rill erosion	Small, often short-lived channels that form in cropland and unsealed roads after intense rains.
Riparian vegetation	Vegetation growing along banks of rivers, including the brackish upstream reaches of an estuary.
Riparian zone	Refers to the zone directly adjoining a waterway. Any land that adjoins, directly influences, or is influenced by a body of water.
Runoff	Water that flows over the surface from a catchment area, including streams.
Salinisation	The accumulation of salts in soil and water which causes degradation of vegetation and land.

Scour	A form of bank erosion caused by sediment being removed from stream banks particle by particle. Scour occurs when the force applied to the bed, bank or soil surface by flowing water exceeds the resistance of the bank surface to withstand those forces
Sediment	Soil particles, sand and other mineral matter eroded from land and carried in surface waters.
Sedimentation	The accumulation of soil particles within a waterway, which leads to a decline in water quality.
Sediment plume	A mound of deposited sediment.
Sheet erosion	Erosion on hillslopes by dispersed overland flow.
Slumping	The mass failure of part of a stream bank.
Snags	Large woody debris such as logs and branches that fall into rivers.
Stream condition index	A rating system used in south-west Western Australia to evaluate the condition of the riparian zone based upon assessments of bank stability, foreshore/ riparian vegetation, stream cover and habitat diversity.
Stream gauging station	Stations set up and used by the Department of Environment to measure and collect stream quality and quantity data.
Subsidence	The sinking of parts of the ground which are not slope related.
Suspended solids	Particles of earth within the water in a stream. Can be coarse sand, fine clay or colloidal.
Terrestrial	Relating to land.
Tributary	A stream, creek or small river which flows into a larger stream, river or lake.
Turbidity	Muddiness or opaqueness of water due to suspended particles in the water causing a reduction in the transmission of light.
Undercutting	The undermining or erosion of soil by water from underneath an existing landform (ie. riverbank), structure (ie. fence post) or vegetation (ie. tree).
Understorey vegetation	The lowest strata of vegetation; esp. grasses, herbs and sedges.
Vegetation structure or strata	Often, but not always, in natural conditions three layers are generally represented: the canopy or over-storey; middlestorey; and understorey or groundcover.
Verge	The area extending from the top of the bank to the next major vegetation or land use change.
Verge vegetation	The strip of land up to 20m from the immediate river or creek valley.
Washout	Scour in the floodplain.
Waterlogging	Saturation of soil with irrigation water or excessive rainfall, so that the water table rises close to the surface.
Waterways	All streams, creeks, rivers, estuaries, coastal lagoons, inlets and harbours.
Weed	A plant growing where it is not wanted.

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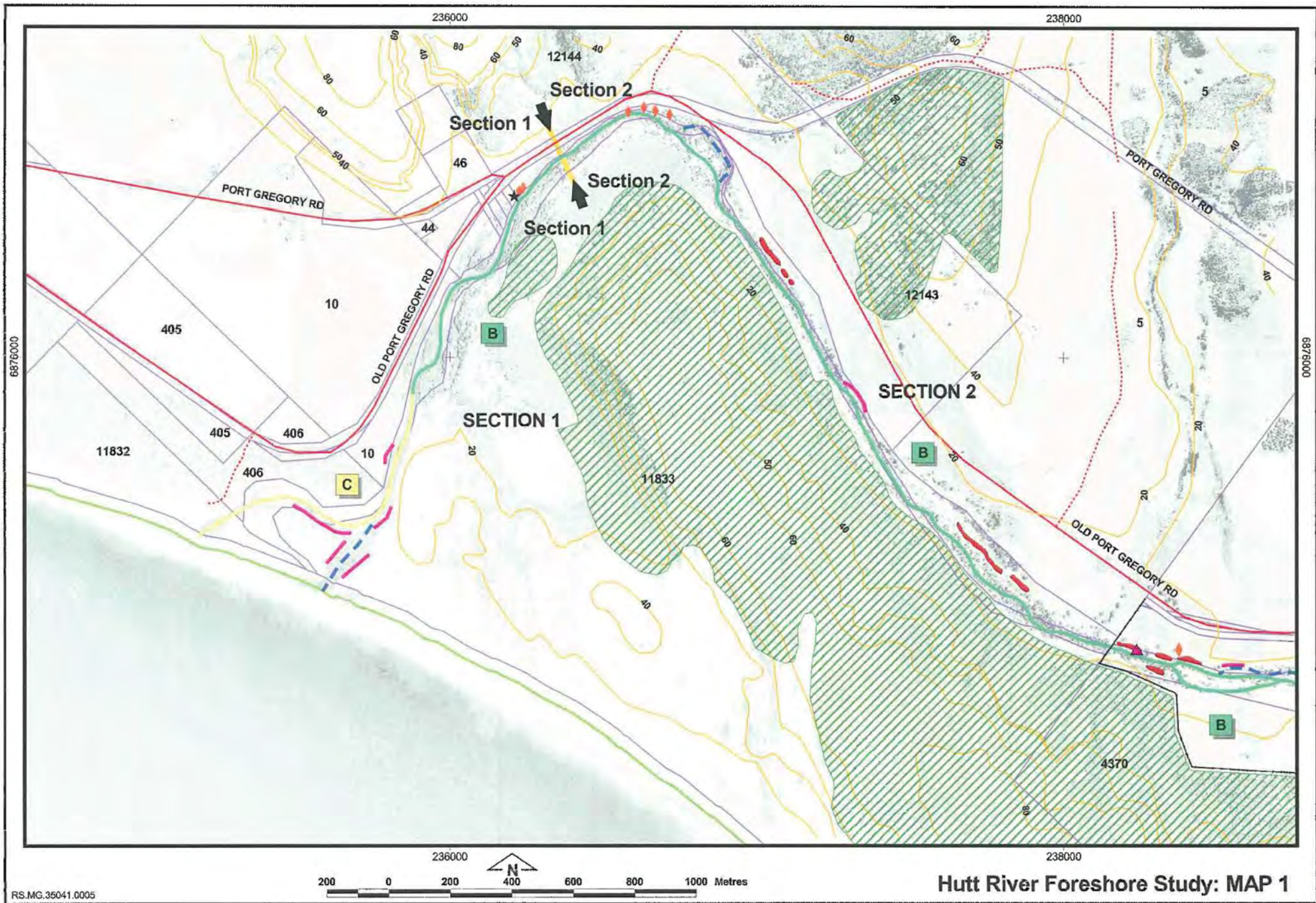
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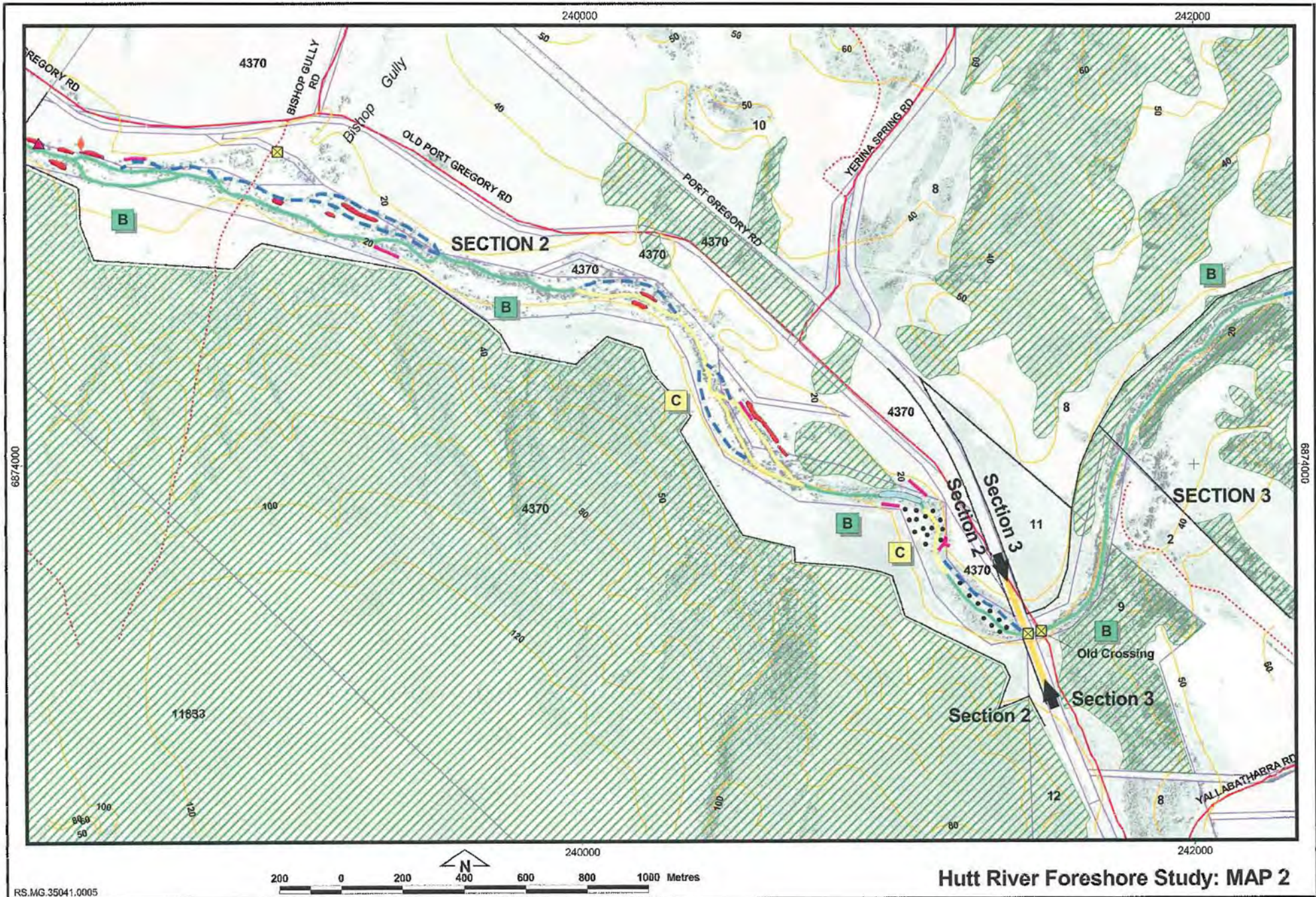
Hutt River Foreshore Assessment Maps

The Hutt River Foreshore Assessment Maps provide a visual accompaniment to the specific site reports in Section 3 of the report. Please remove the maps for ease of reference.

See Figure 5 on Page 19 for an index of where sections and maps are located along the river.

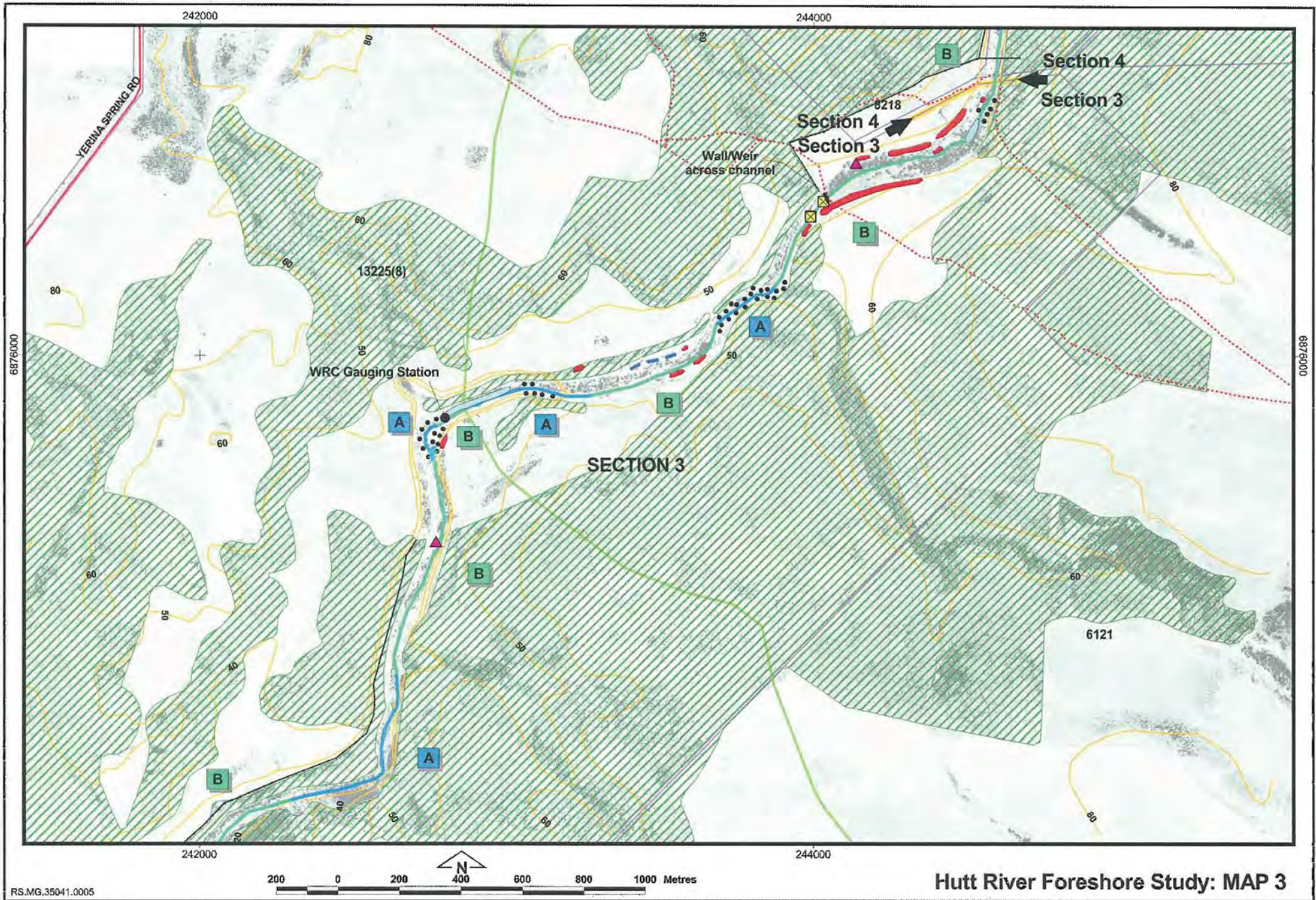
HUTT RIVER FORESHORE STUDY LEGEND			
Foreshore Condition	Features	Features	Weeds
A Grade	Fences - Existing	Building	African boxthorn
B Grade	Erosion	Dam	Brazillian pepper
C Grade	Secondary Channel	Discarded farm material	Castor oil
D Grade	Other	Large woody debris	Saffron thistle
Section Marker	Pool	Rocks	Spiny rush
Drainage Catchment Boundary	Revegetation	Soak	Prickly pear
Contours	Riparian vegetation	Spring	White cedar (Cape lilac)
Highway	Sediment Deposits	Step in river channel	Fountain grass
Local Road	Verge vegetation	Stock watering point	Athel tree (Tamarisk)
Track	Washout	Vehicle/Stock crossing	
Cadastre	Other	Windmill	
		Other	



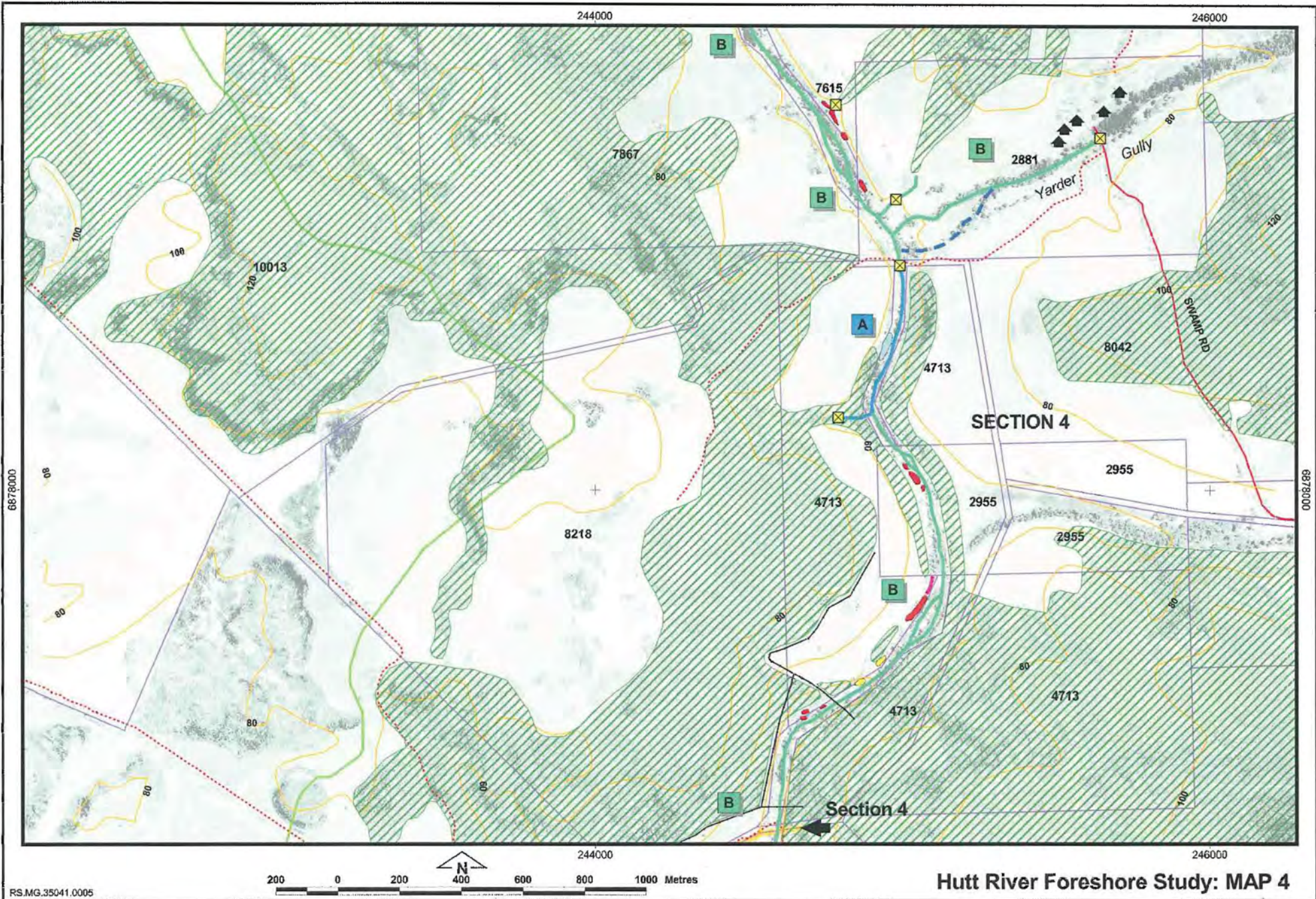


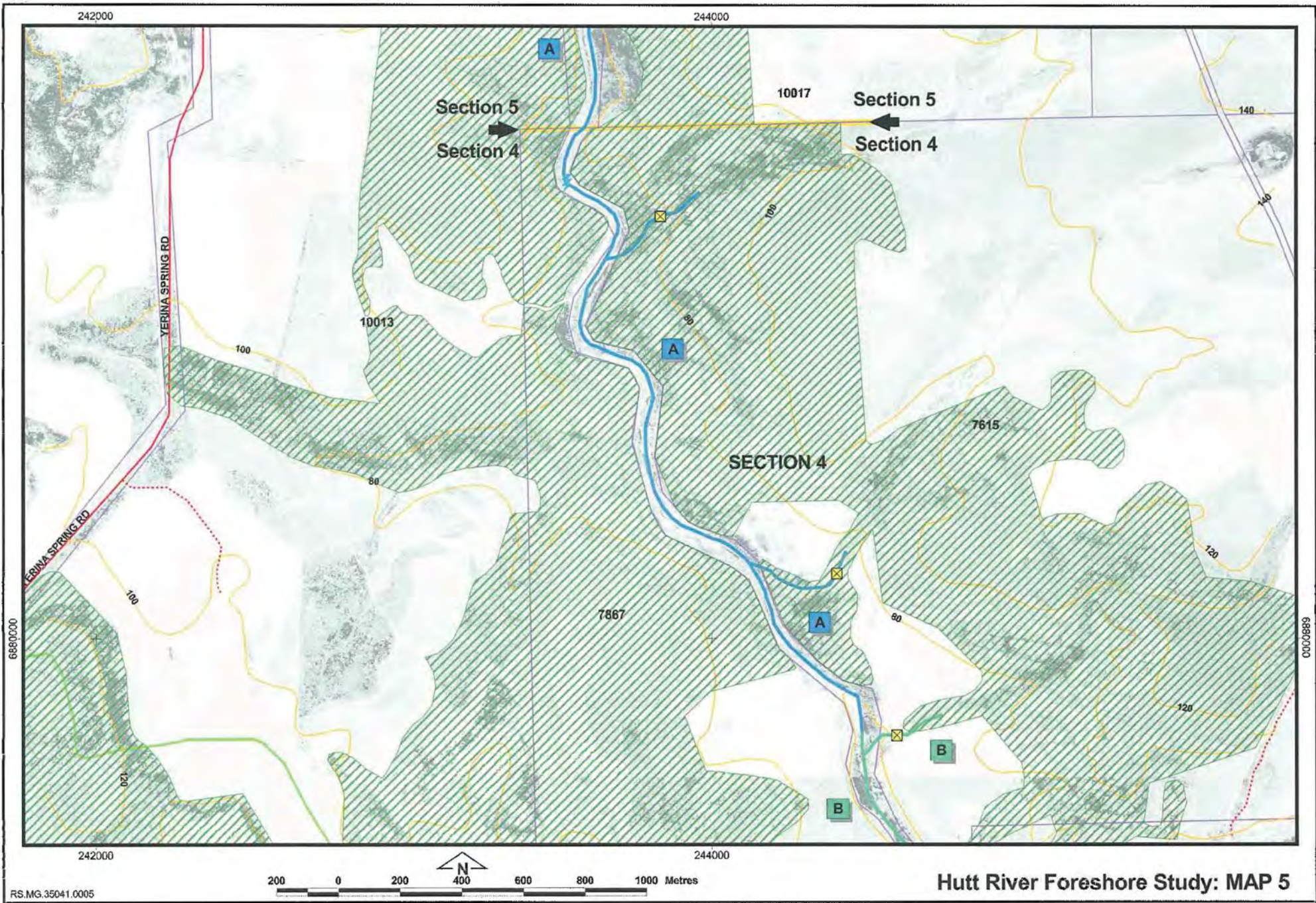
Hutt River Foreshore Study: MAP 2

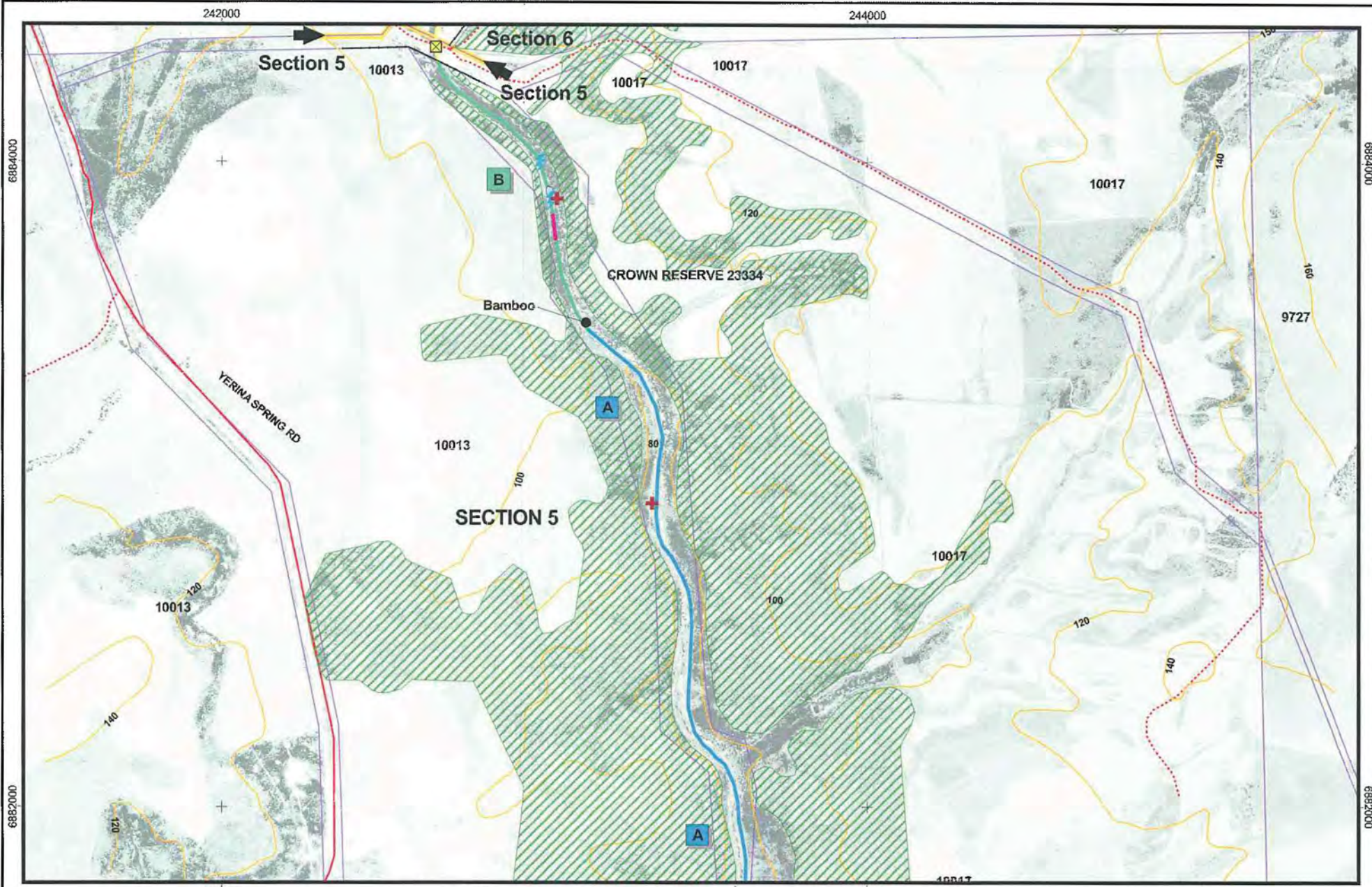
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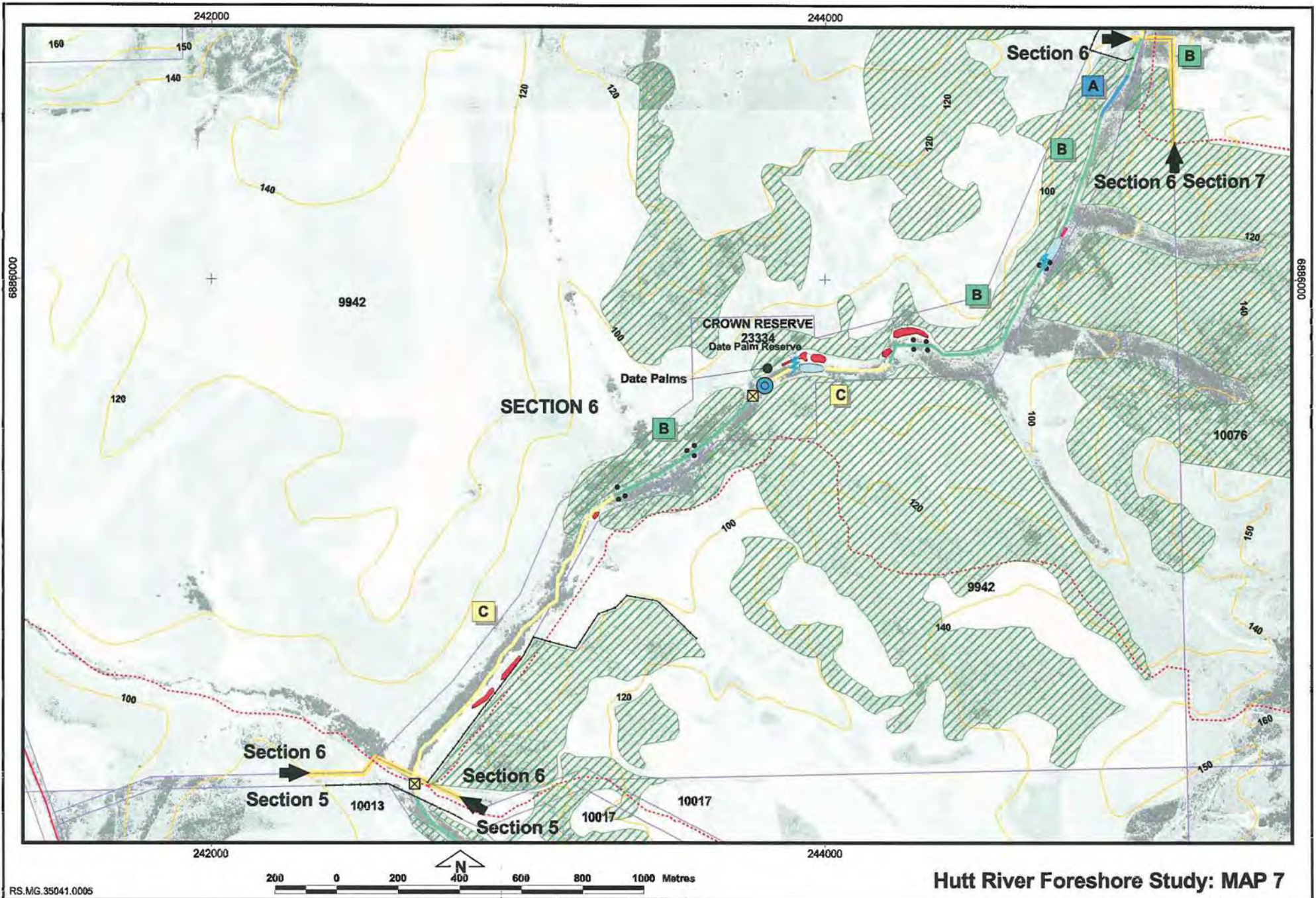


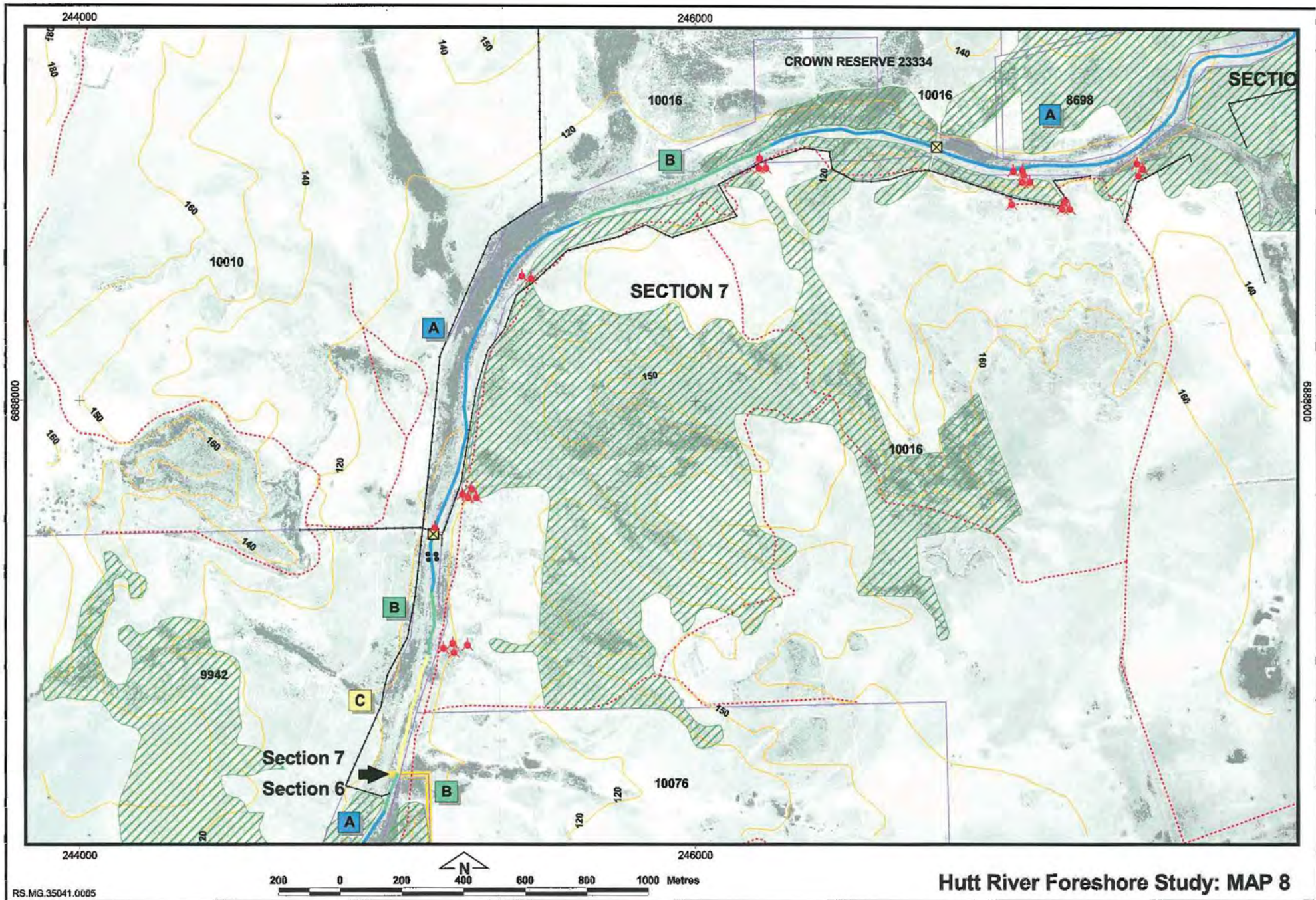
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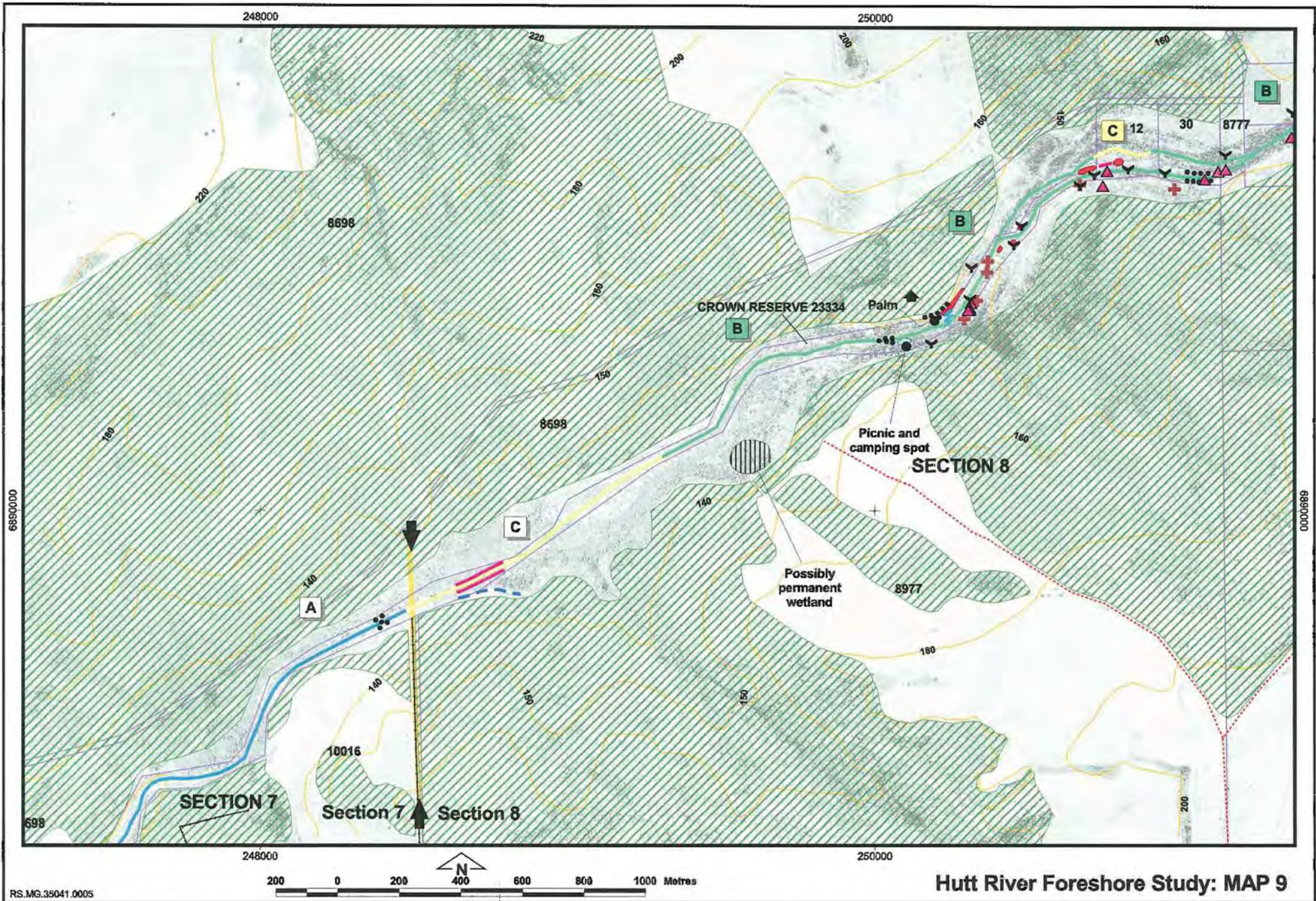




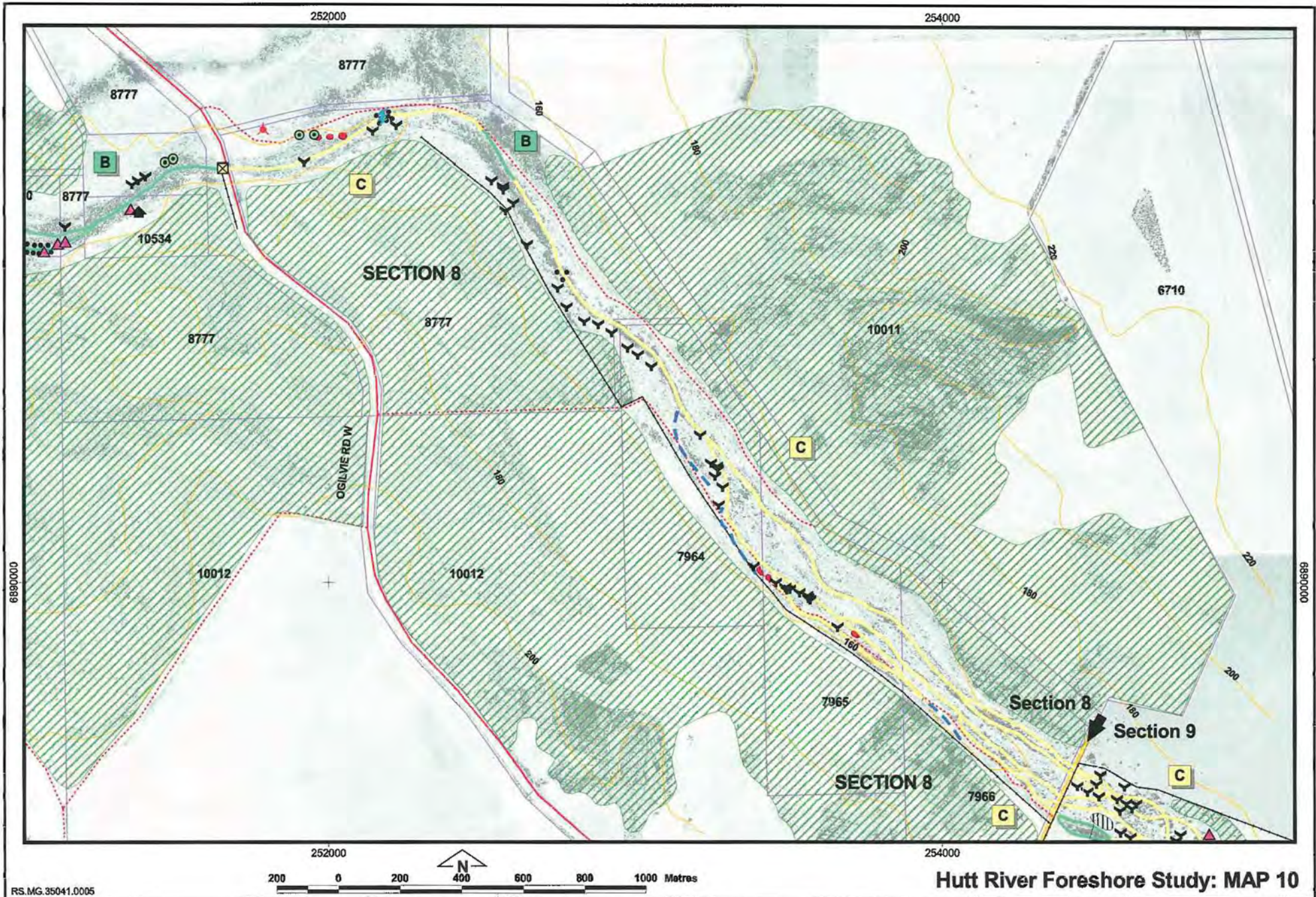


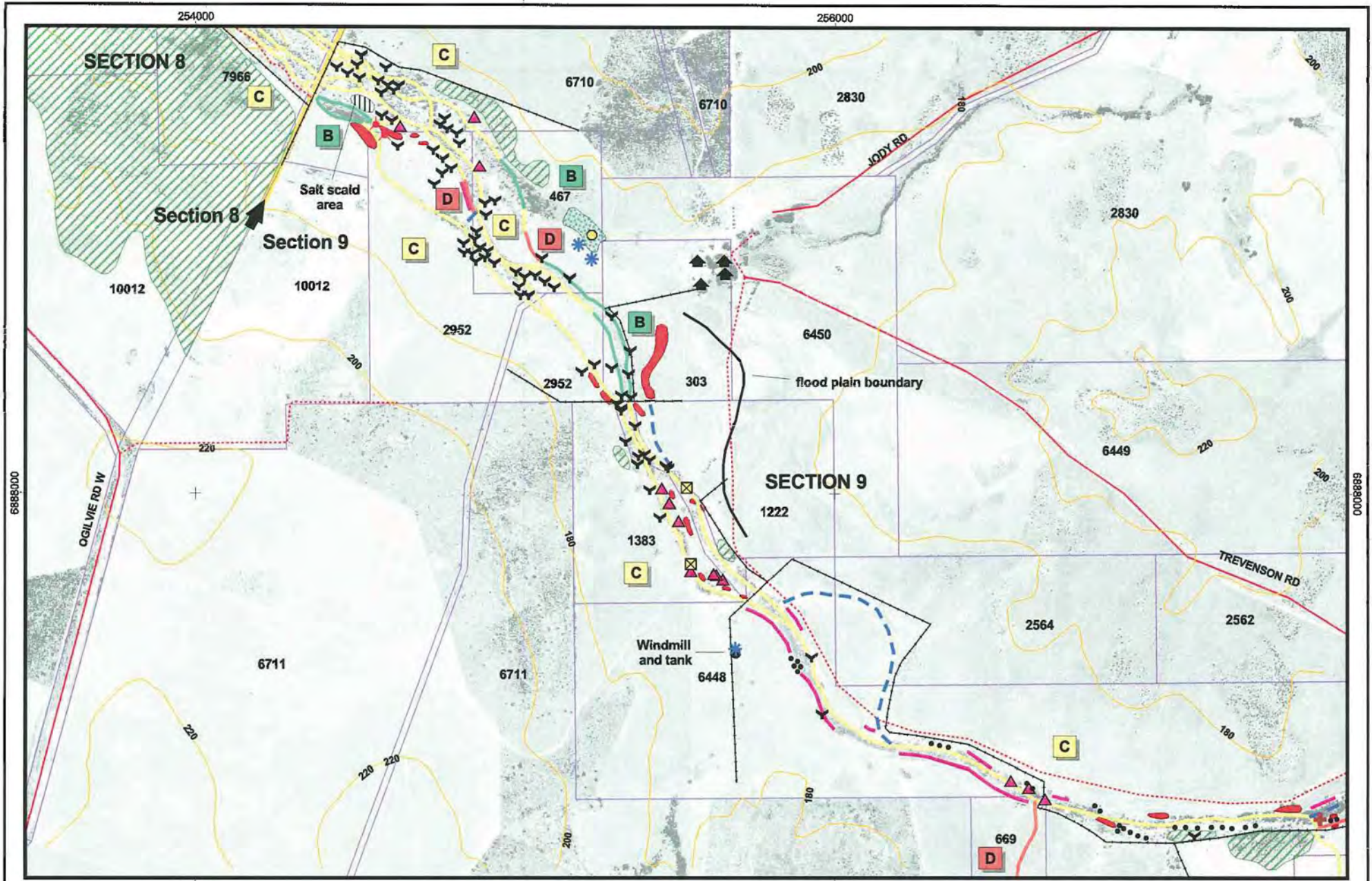


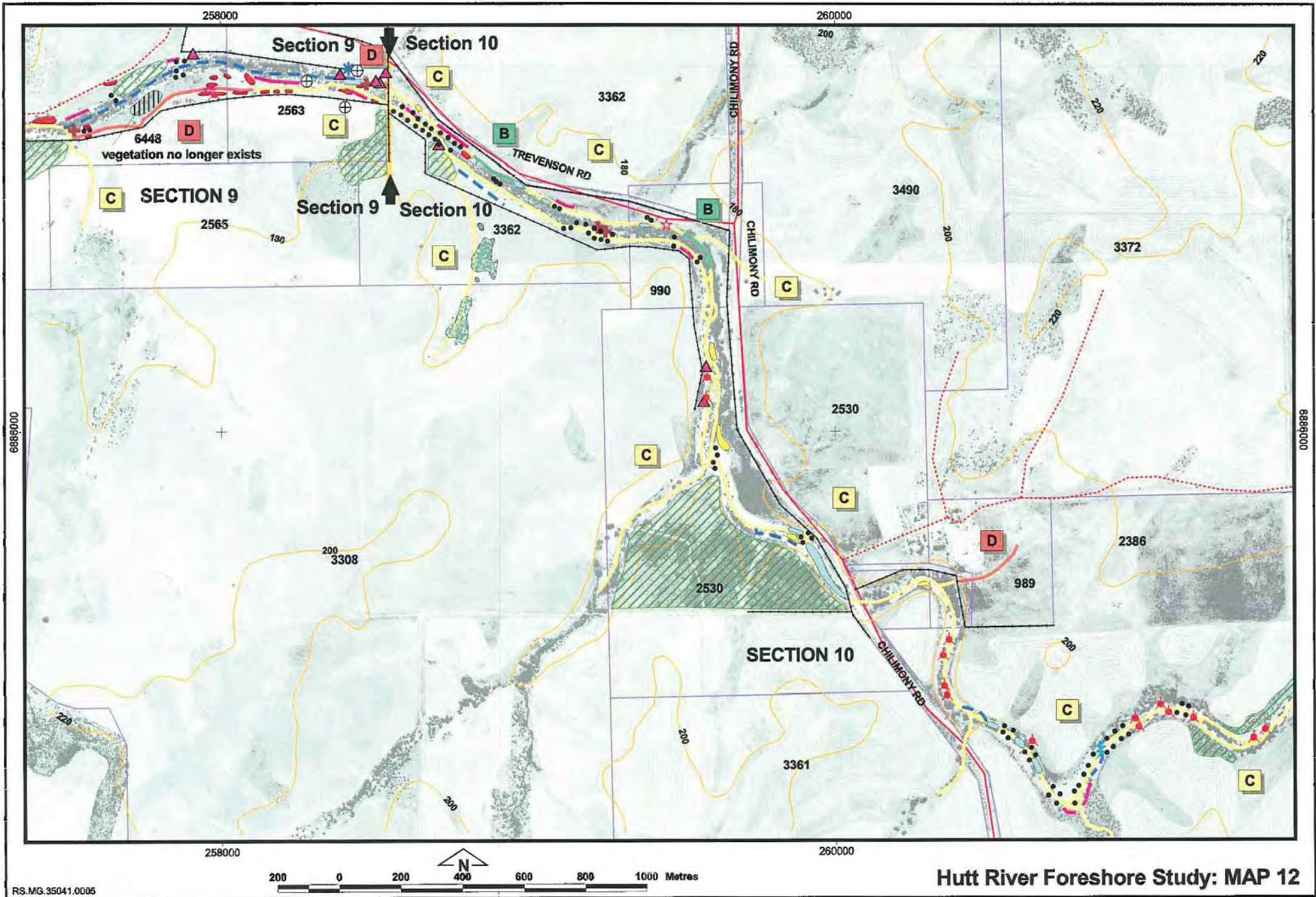


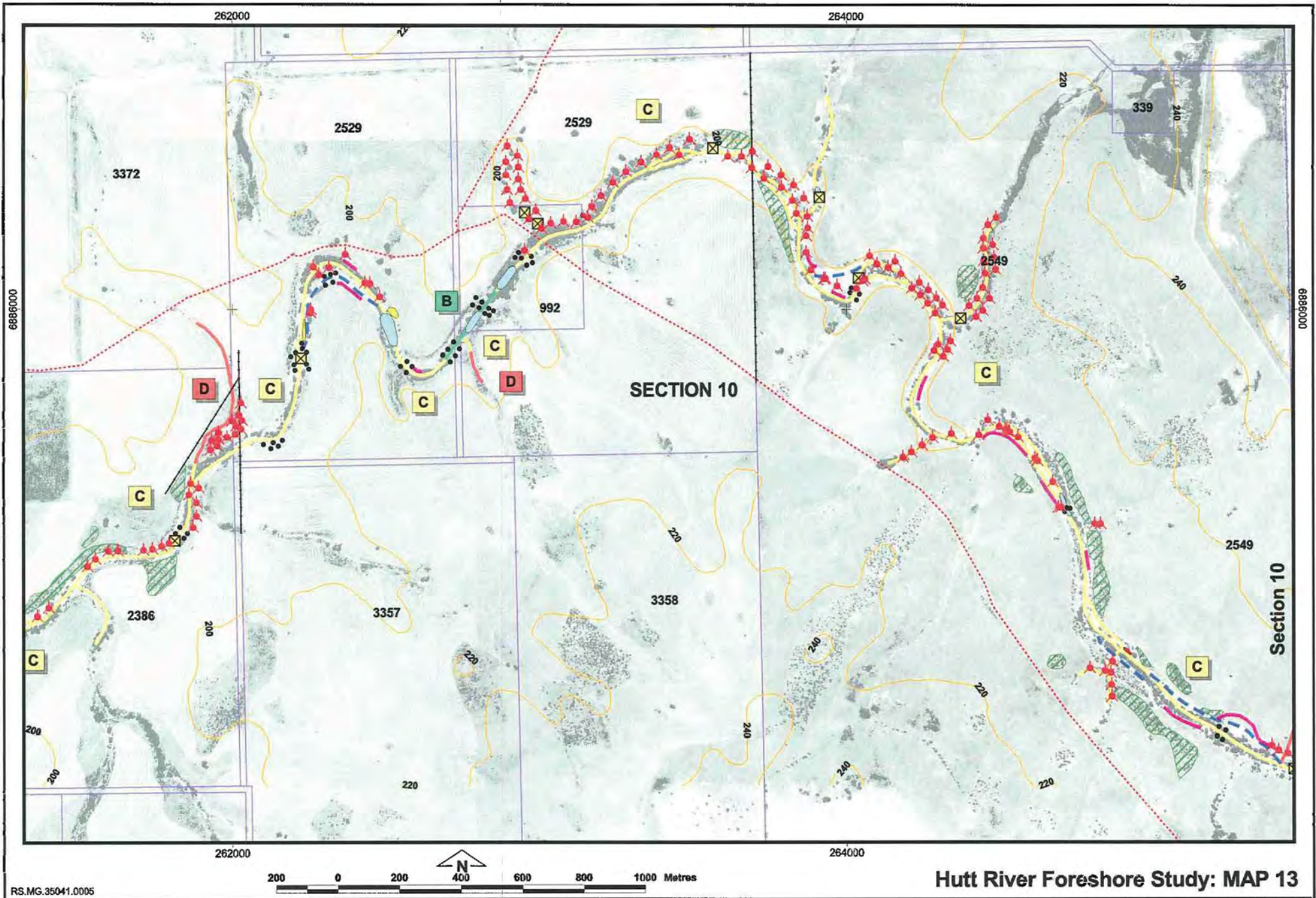


Hutt River Foreshore Study: MAP 9

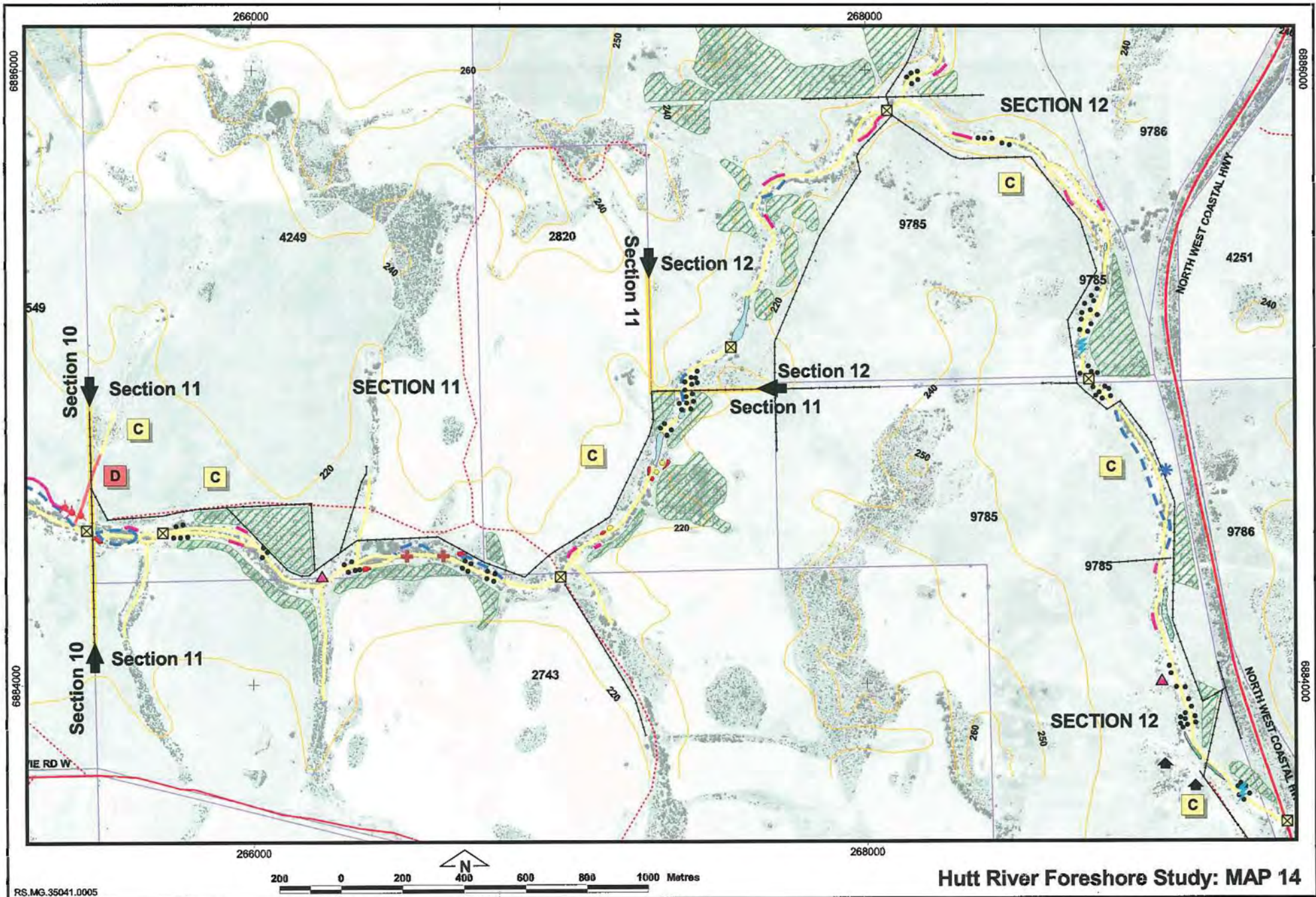




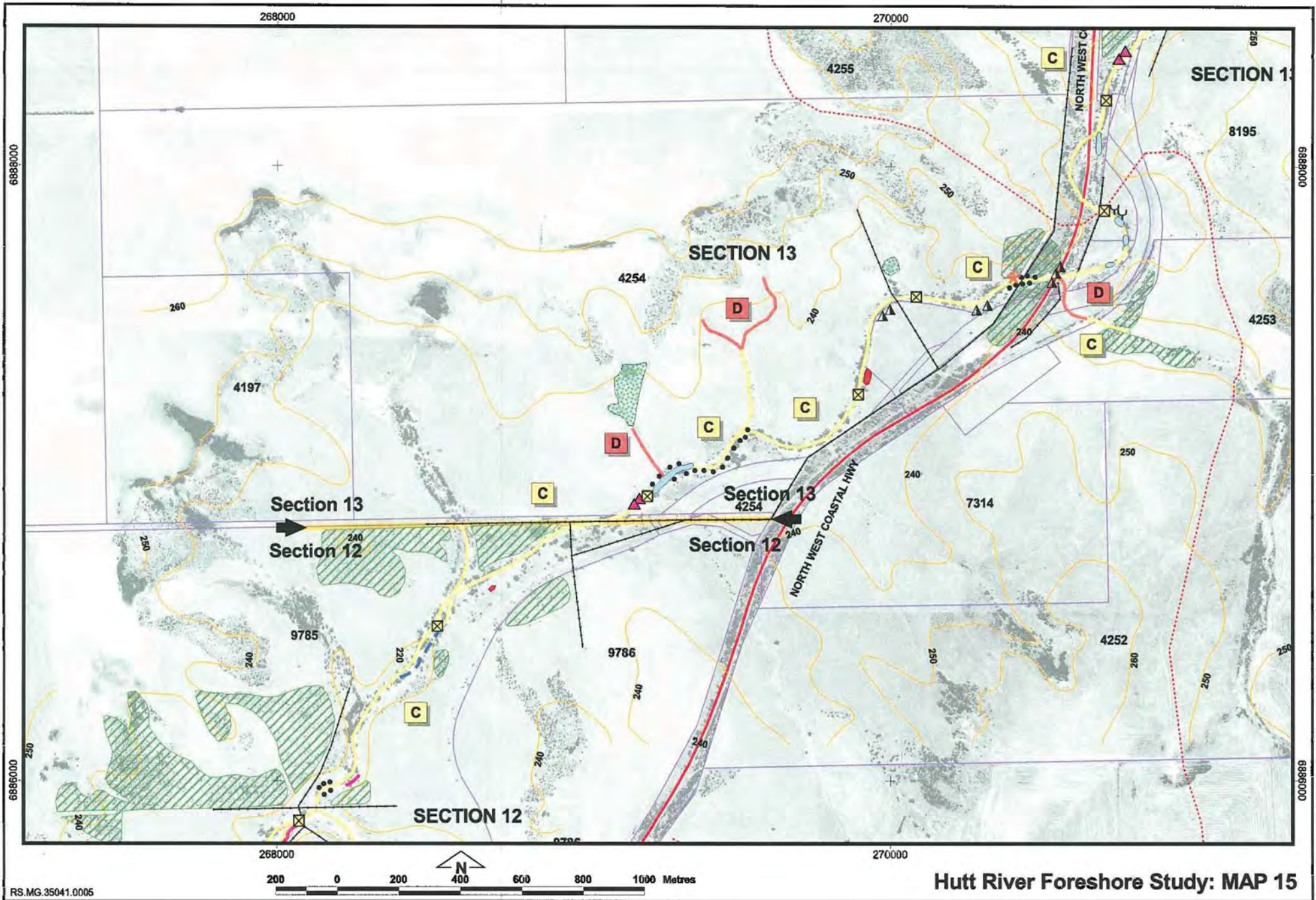


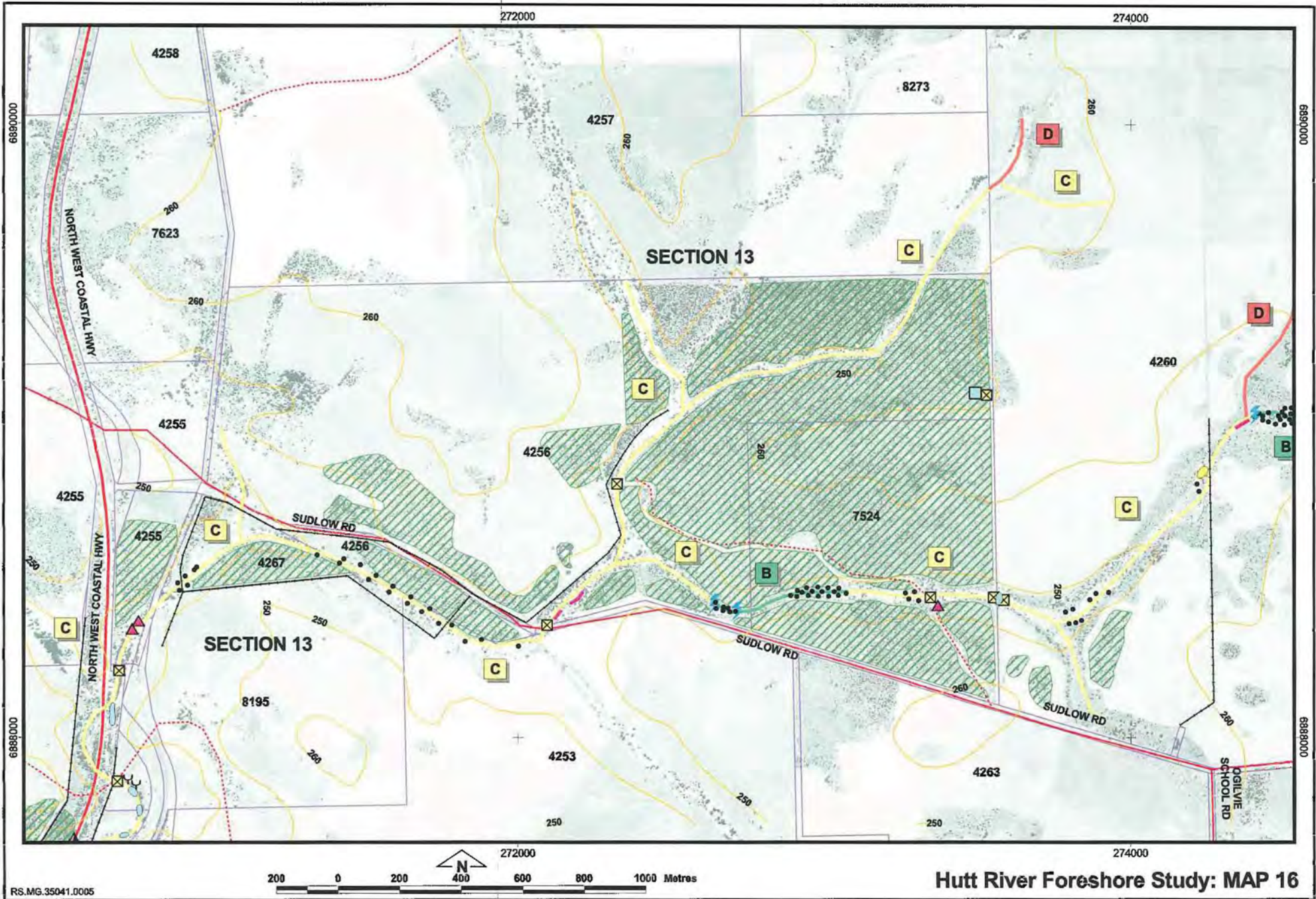


Hutt River Foreshore Study: MAP 13

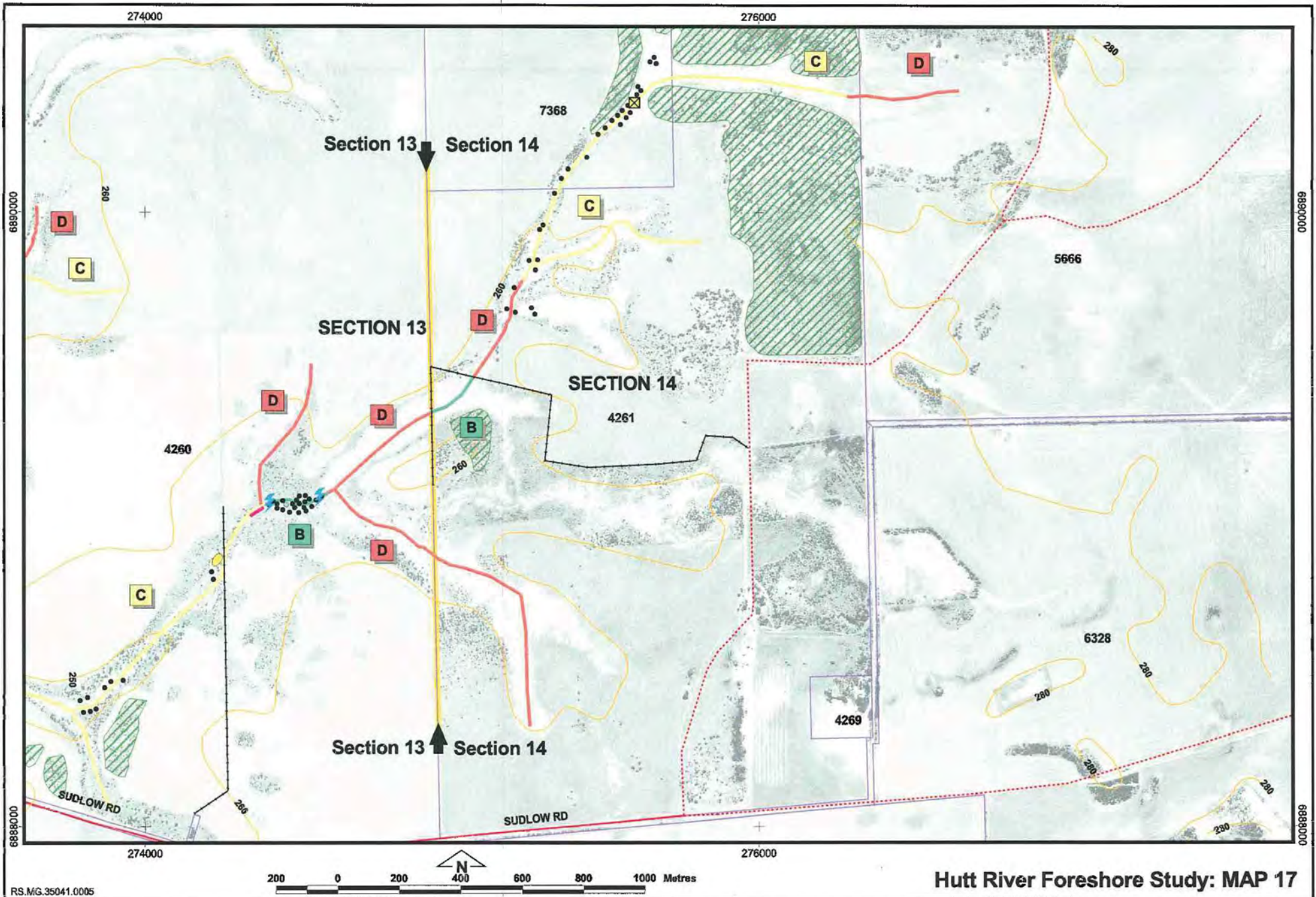


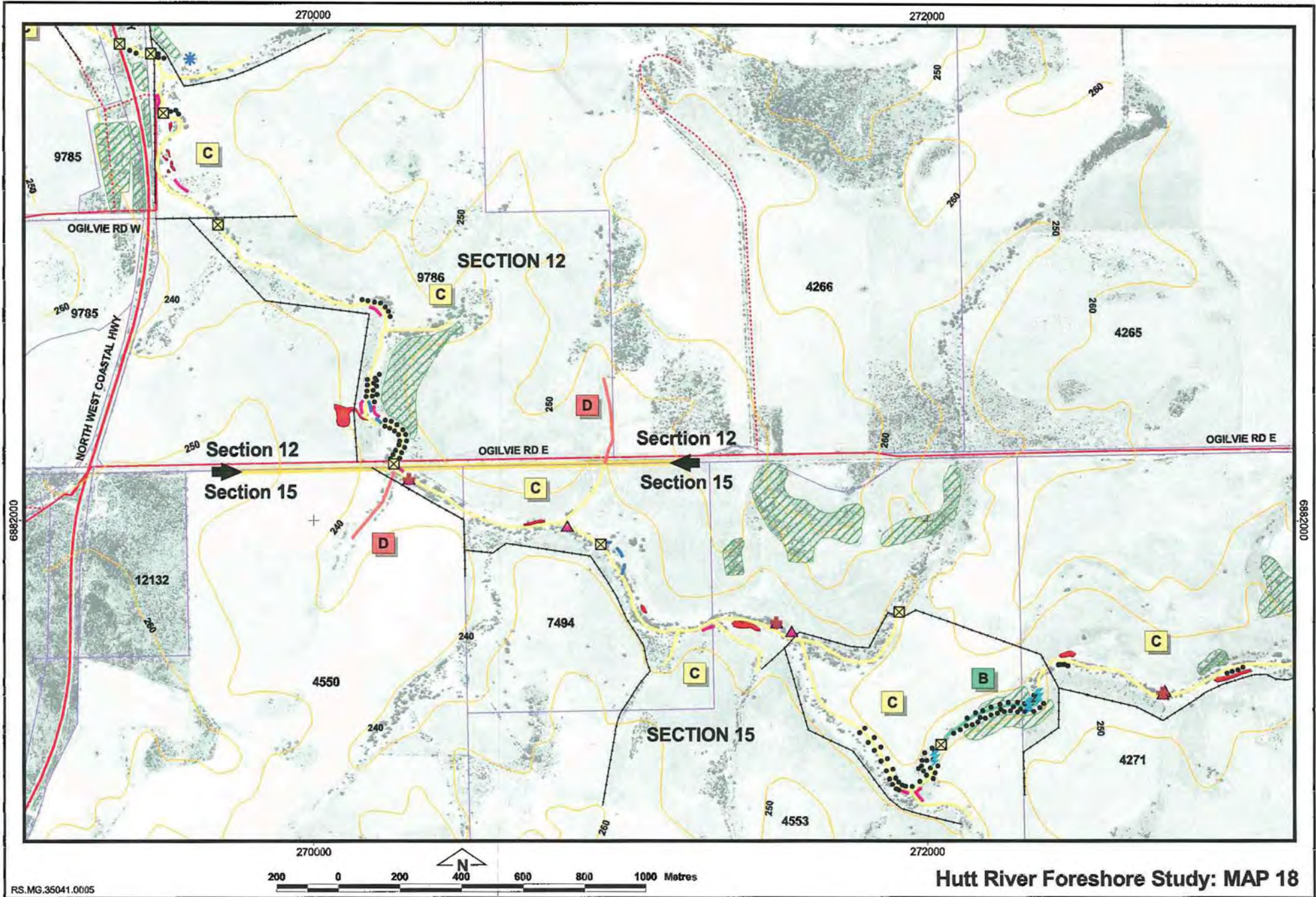
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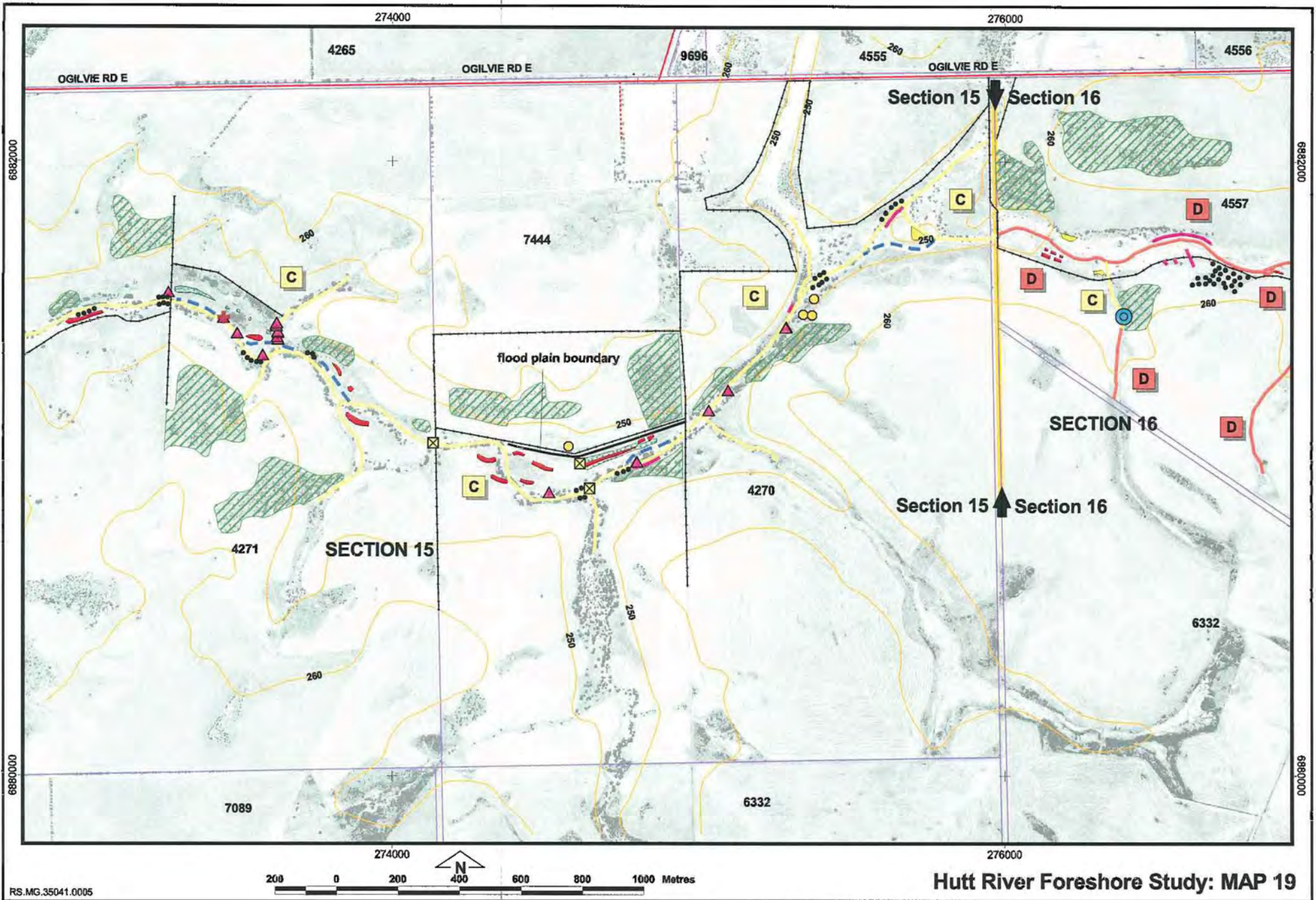


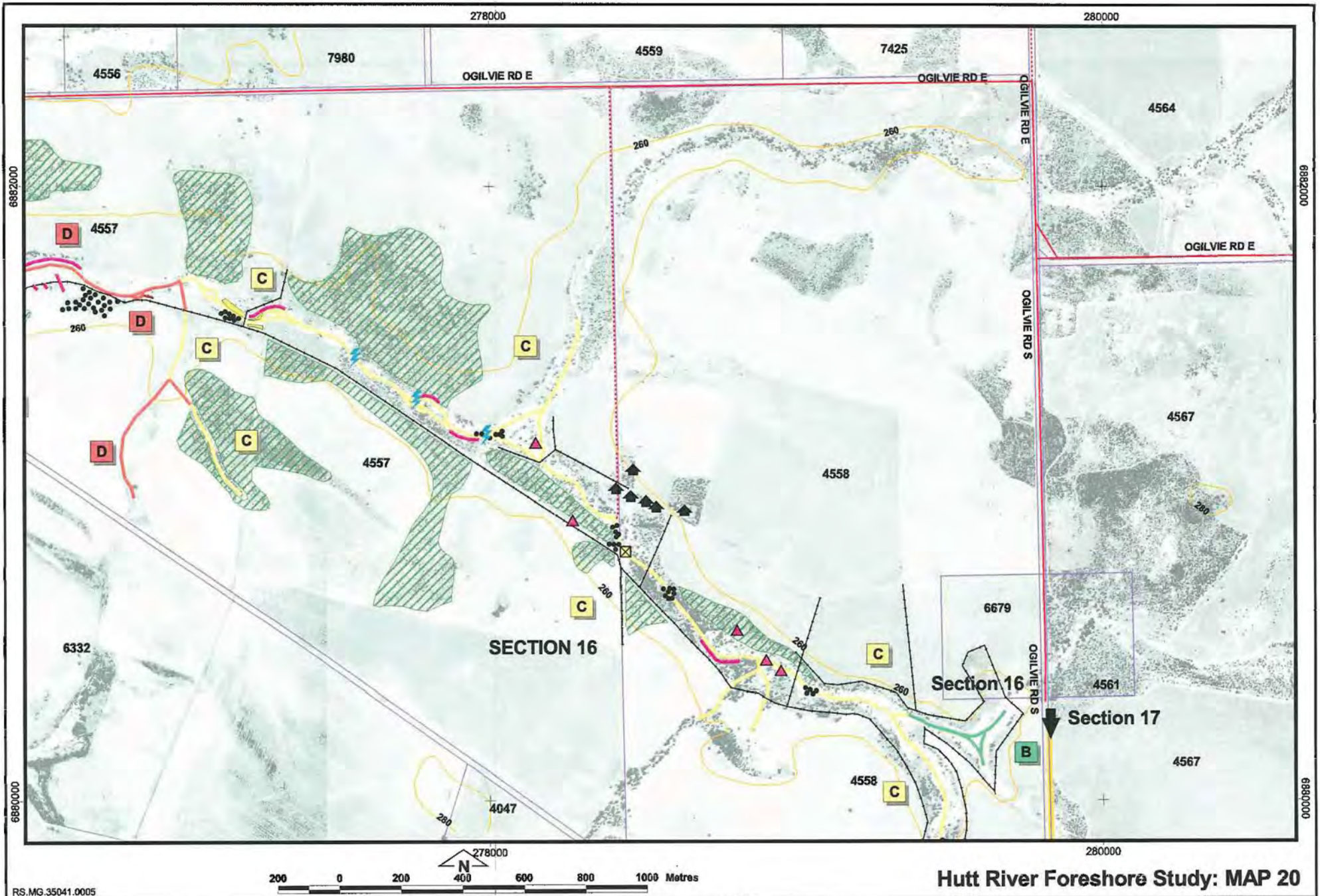


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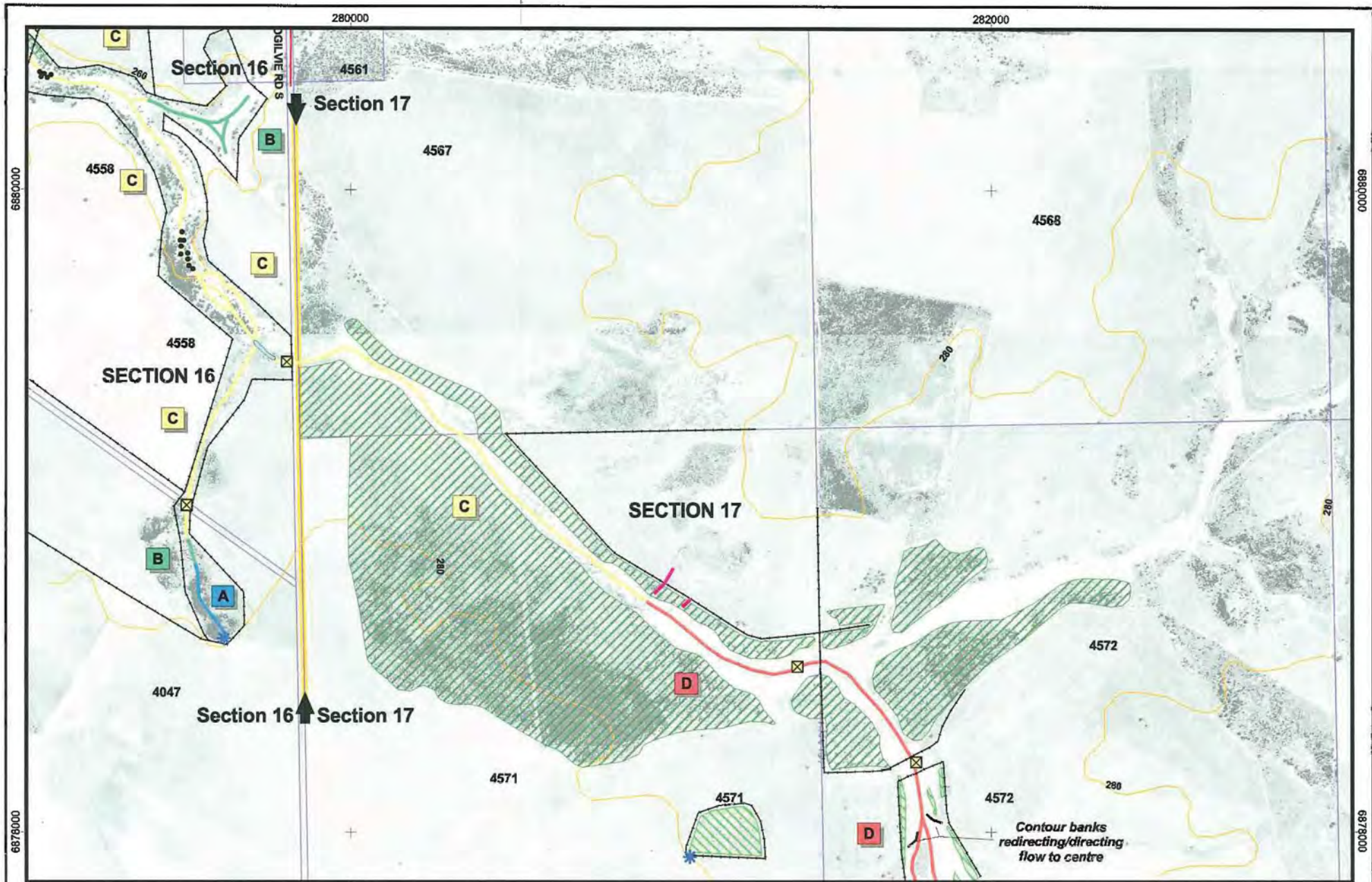


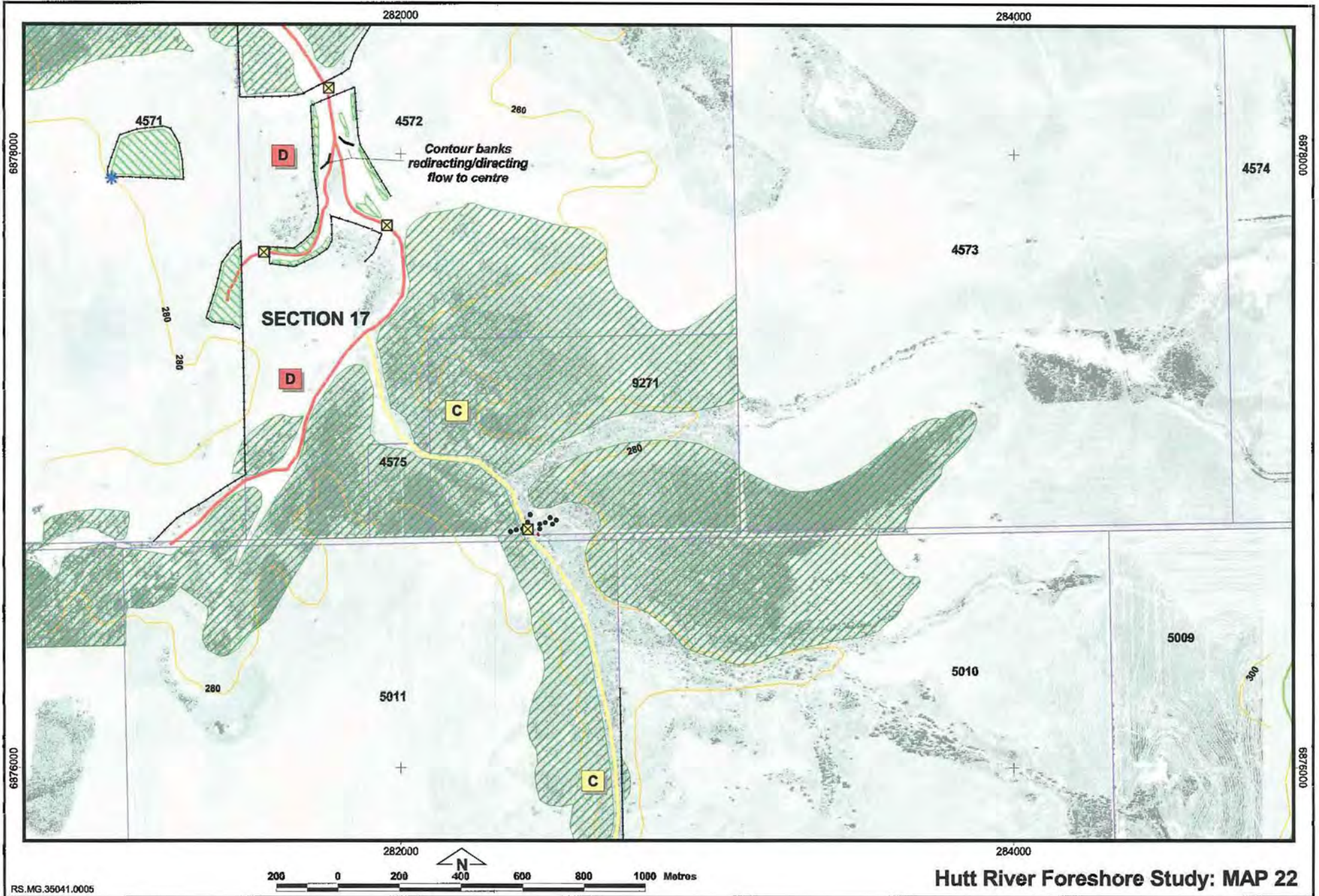


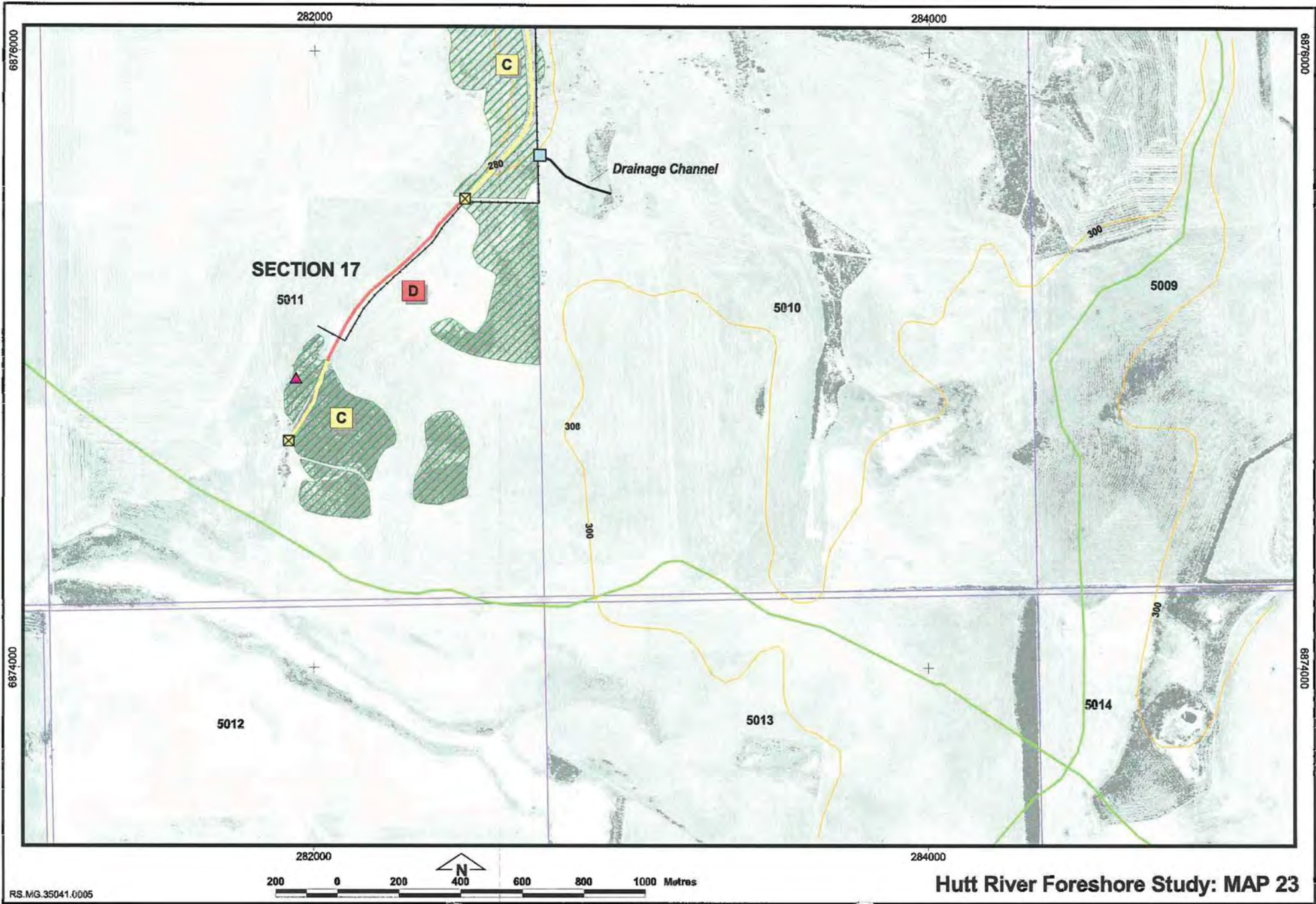




Hutt River Foreshore Study: MAP 20







Hutt River Foreshore Study: MAP 23