TWEED SHIRE COUNCIL

Tweed Riverbank Erosion Management Plan 2014

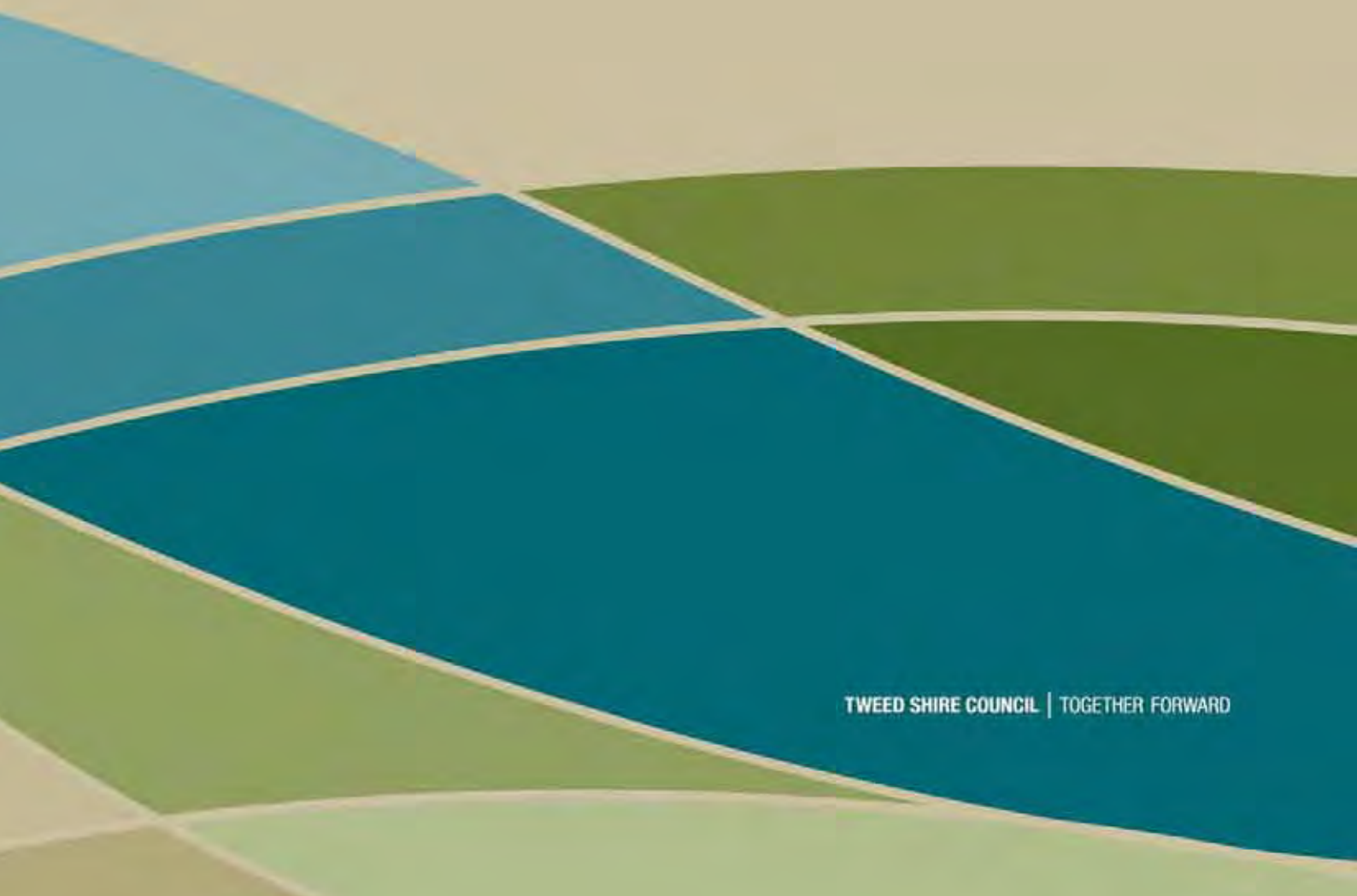

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Table of Contents

Executive Summary

The purpose of the Tweed River Estuary Bank Management Plan 2014 is to provide a schedule of works to stabilise riverbank erosion on public land (to be undertaken by Council), as well as updated design advice for works required on private land.

The plan has been developed based on the following principals:

- Environmental values of the riparian environment will be protected and enhanced.
- High value public infrastructure and public open space will be protected.
- The visual and recreational amenity of the river environment will be protected and enhanced.
- Where practical, vulnerable riverbanks will be managed to increase their resilience to erosion through pre-emptive erosion management.

The severity of riverbank erosion in the Tweed estuary varies considerably, however overall, the scale of the problem is large.

River reaches with the most severe and continuous bank erosion are located between Murwillumbah and Stott's Island, primarily adjacent to the Tweed Valley Way and Tumbulgum Road. Within this river reach, erosion is predominantly impacting on road reserve, as opposed to private land or public open space.

The range of bank stability conditions have been mapped to inform the preparation of this management plan.

Erosion risk	**Severe/high risk**	**Vulnerable**	**Generally Stable**
Length of bank: (Bray Park Weir to Stott's Island both banks combined = 35,855m)	9,207m	10,381m	16,267m

It is estimated that there is 5754 metres of roadway within the priority reach that is at risk of being affected by bank slips within the next five to ten years. At an estimated cost of $1500 per lineal metre to stabilise riverbank erosion (based on the average cost per metre rate of erosion stabilisation work recently undertaken by Council), the total cost to stabilise severe erosion adjacent to roads could be as much as $9,000,000 over ten years. Maintenance costs would add to this figure.

Bank lengths over which various approaches to riverbank stabilisation could occur are as follows:

- Revegetation 15,863m
- Pre-emptive bioengineered stabilisation works 4,668m
- Structural protection - up to 5,754m.

Individual sites where revegetation and pre-emptive erosion stabilisation works could/should occur have been prioritised. These sites are all on public land, however site access and project design would in many cases require consultation with adjacent landowners.

Council is faced with a major challenge in funding the stabilisation of riverbank erosion, and in dealing with erosion without seriously compromising the environmental and amenity values of the Tweed River. Funding models which allow Council to address problem areas **before** they present a critical risk to road stability and community safety must be found.

Any further work to stabilise riverbank erosion in the Tweed River must be designed to minimise environmental impacts and maximise potential for incorporation of, or colonisation by, riparian vegetation. Increasing the resilience of riverbanks through revegetation, and maximising existing habitat values will be an important part of offsetting the ongoing negative impacts of large structural erosion stabilisation projects.

1.0 Introduction

The purpose of the Tweed River Estuary Bank Management Plan 2013 is to provide an update of the recommendations of the Tweed River Estuary Bank Management Plan prepared for Council in 1998 by Patterson Britton and Partners, (Patterson Britton and Partners, 1998). This report does not seek to comprehensively replace or supersede the Patterson Britton report.

This report is informed by the findings of (Patterson Britton and Partners, 1998), as well as an investigation into riverbank erosion prepared in 2012 by SMEC, the Impact of Wake on Tweed Riverbank Erosion Study, (SMEC, 2012). The report is constrained to the estuarine part of the main Tweed River, from Bray Park Weir to Fingal Head. The upper catchment, Rous River and Terranora Creek have not been included, as erosion in these systems is significantly different in character and scale to the main estuary.

This report does not include a comprehensive analysis of the **causes** of erosion. This report makes recommendations on stabilising bank erosion, and includes a proposed schedule of works for public land (to be undertaken by Council), as well as updated design advice for works proposed on private land.

Information contained in (Patterson Britton and Partners, 1998) is still current and relevant with respect to the major hydraulic and geomorphological forces acting on the Tweed River, which either cause or exacerbate riverbank erosion. This document should be referred to for detailed advice on the primary forces causing erosion within specific reaches of the Tweed River Estuary. It can be stated with certainty that erosion is variable in both space and time, and that there is no single force or problem solely to blame for bank erosion in the Tweed River.

The Impact of wake on Tweed Riverbank Erosion Study (SMEC, 2012) aimed to determine the potential impacts of vessel wake on riverbank erosion within the Tweed River Estuary. The SMEC study provides information that can be considered by Council and the NSW Department of Roads and Maritime Services for possible implementation to reduce the impact of vessel operation on riverbank erosion.

This plan does not address vessel wake or provide management recommendations for vessels. The issue of vessel wake induced erosion and potential options for management of this issue are contained in a separate report to Tweed Shire Council entitled 'Wake Impact on Riverbank Erosion - Council Options for Management'. This report was considered on 17 October 2013 and resulted in the adoption of a series of recommendations. This report and its recommendations are included as Appendix 1 to this Management Plan.

1.1 Management Aims

Tweed Riverbank erosion will be managed in accordance with the following aims:

- Environmental values of the aquatic and riparian environment will be protected and enhanced.
- High value public infrastructure and public open space will be protected.
- The visual and recreational amenity of the river environment will be protected and enhanced.
- Where practical, vulnerable riverbanks will be managed to increase their resilience to erosion through implementation of bio-engineered approaches that incorporate erosion resistant materials and enhance vegetation growth.

1.2 Objectives

The objectives of this Plan are to:

1. Provide an updated classification of bank erosion severity within the Tweed Estuary, from the Bray Park Weir to Fingal Head.
2. Provide a prioritised schedule of riverbank erosion stabilisation works to be implemented by Tweed Shire Council on public land.
3. Provide preferred design options for riverbank stabilisation works in the Tweed River, with a focus on revegetation and bio-engineered design that maximise ecological and amenity values.
4. Provide updated advice to private landowners who wish to undertake riverbank erosion stabilisation works on aspects of design and the statutory and environmental approvals process.

2.0 Tweed Riverbank Erosion

2.1 Causes of Riverbank Erosion

The scale and severity of riverbank erosion in the Tweed estuary varies from site to site, depending on a range of natural and anthropogenic factors including:

- Height of the riverbank
- Bank position within the meander and shoal pattern of the river
- Frequency and intensity of vessel wake wave creation
- Presence and condition of natural vegetation, at bank toe and top of bank
- Erosion resistance of riverbank material
- Presence and condition of bank armouring
- Adjacent land use

A series of photos of riverbank condition, ranging from stable to highly eroded, are included below to provide an overview of the range of typical Tweed River estuary bank characteristics.

Figure 1. The range of typical bank stability conditions.

		
Stable bank with bedrock toe, upper estuary.	Eroding bank adjacent to farmland, up-stream of Murwillumbah.	Stable bank, with poor riparian vegetation, adjacent to grazing land upstream of Murwillumbah.
		
Failing private revetment structure, Murwillumbah.	Erosion adjacent to parkland, Commercial Road boat ramp	Large bank slump adjacent to cane land (on public land), upstream of Murwillumbah.
		
Good quality riparian vegetation at Tygalgah.	Large block failure adjacent to Tumbulgum Road, Condong.	Under cut banks adjacent to Tweed Valley Way near Tumbulgum.

		
Full height bank revetment Tweed Valley Way.	Cotton woods and stable 'historic' small diameter bank toe revetment on Tweed Valley Way near Stott's Island.	Well constructed revetment on low bank adjacent to private property.
		
Under cut bank and failed small diameter 'historic' bank revetment Tweed Valley Way.	Severe bank erosion immediately adjacent to the Tweed Valley Way.	Stott's Island.

2.2 Riverbank Erosion Stabilisation

Riverbank erosion stabilisation in the Tweed Estuary is undertaken almost exclusively by armouring the eroding banks, top to toe, with rock. This method of erosion stabilisation is expensive and does not achieve the optimum ecological or amenity outcomes for the river environment. However, rock armour provides reliable and immediate protection to the assets immediately landward of the riverbank, which in the case of significant reaches of the Tweed estuary, are comprised of roads and residential land.

While not providing the optimum environmental outcome, armouring riverbanks with low angle (approx 1:1.5) rock walls (revetment) provides the most structurally appropriate form of bank protection in the river environment. Rock diameter should range from approximately 250mm to 1500mm, with design dependant on bank height, river depth and anticipated flow velocity. Rock armouring is flexible, and may settle and maintain its protective function if sediment is scoured from beneath or behind it's mass. Rock armouring is able to withstand and adsorb/dissipate wave energy and is less prone to undermining by reflected waves than rigid concrete structures.

Construction of rock revetment increases the risk that riverbanks immediately downstream will become more severely eroded.

A site by site risk based assessment of erosion consequence is required to select the most appropriate type of riverbank stabilisation and erosion protection works.

Numerous works have been undertaken on Tweed Riverbanks from Murwillumbah to Tumbulgum in response to significant erosion or slips that have placed infrastructure at risk. These works have occurred in a reactive manner, based on funding availability and assessment of risk.

Funding under Natural Disaster Relief and Recovery Arrangements (NDRRA) has been made available for many bank stabilisation projects following flood events in 2008, 2009 and 2010, with applications for further works pending for 2012 and 2013 floods.

NDRRA guidelines state that "reinstatement of natural riverbanks and foreshores is not eligible as this damage is considered an ongoing natural realignment process".

As a result, bank stabilisation works have only been undertaken on sections of riverbank where roads are at immediate risk of being damaged. This approach to riverbank erosion management has resulted in the construction of bank top to toe rock armoured structures. While effective in managing erosion, these structures have a significant impact on aquatic ecology and river amenity.

Figure 2. Reactive riverbank erosion stabilisation works being constructed adjacent to Tumbulgum Road, Tygalgah.

Recent works are outlined in the following table:

Table 1. Location, length and cost of recent rock protection works.

Location	Description	Approximate length	Cost
623 Tumbulgum Road, Tygalgah	Restore levee foundation, provide rock protection	90m	$98,000
River Street, South Murwillumbah	Restore levee foundation, provide rock protection	2 sites, 25m and 20m	$80,000
River Street, South Murwillumbah	Restore levee foundation, provide rock protection	Additional site 20m	$70,000
Tygalgah Levee	Restore levee foundation, provide rock protection	50m	$29,480

Location	Description	Approximate length	Cost
125 River Street, South Murwillumbah	Restore levee foundation, provide rock protection and restore floodgate	30m	$116,500
Tweed Valley Way, South Murwillumbah opposite Boral Timber	Restore eroded bank and provide rock protection	100m	$174,046
Budd Park, South Murwillumbah	Restore eroded bank at floodgate and provide rock protection	Component of larger project	$45,000
Budd Park, South Murwillumbah	Restore eroded bank and provide rock protection	200m	$150,000
Tweed Valley Way, 1km north of Riverside Drive, Tumbulgum	Restore eroded bank, and provide rock protection	50m	$160,000
Near 623 Tumbulgum Road, Tygalgah	Extend previous rock revetment to restore levee foundation and provide rock protection	50m	$110,000
156 Tumbulgum Road, Tygalgah	Restore levee foundation, provide rock protection	70m	$80,080
97-99 River Street, South Murwillumbah	Restore eroded floodgate and levee foundation, provide rock protection	30m	$39,000
Tweed Valley Way, South Murwillumbah, opposite Buchanan Street	Rectify safety issue. Restore eroded bank and provide rock protection	20m	$15,000
Commercial Road Levee, Murwillumbah	Stabilise levee slip and provide rock protection	50m	$97,496
Commercial Road Levee, Murwillumbah	Restore levee foundation and reinstate	100m	$99,500

River reaches with the most severe and continuous bank erosion are located between Murwillumbah and Stott's Island, primarily adjacent to the Tweed Valley Way and Tumbulgum Road. In public infrastructure and asset management terms, this is the most important section of the river for bank erosion management. For the purpose of further discussion, this part of the river is described as the 'priority reach'. Within the priority reach, erosion is predominantly impacting on road reserve, as opposed to private land or public open space. It is estimated that there is approximately 6000 metres of roadway within the priority reach that is at risk of being affected by bank slips within the next five to ten years. At an estimated cost of $1500 per lineal metre to stabilise riverbank erosion (based on the average cost per metre rate of erosion stabilisation work recently undertaken by Council), the total cost to stabilise severe erosion adjacent to roads could be up to $9,000,000 over ten years. Maintenance costs would add to this figure.

This sum noted above is comparable to the cost of $7,700,000 estimated in the SMEC Impact of Wake Study (SMEC, 2012) to undertake rock armour bank stabilisation projects from Condong to Stott's Island. The SMEC estimate involved addressing all visible erosion, as opposed to focusing on erosion affecting roads. SMEC identified a total cost of $10,000,000 to stabilise all visibly eroding areas within the estuary, without differentiating between public or private land, or the land use that is threatened by erosion.

Between 2010 and 2013, Council expended approximately $1,200,000 on riverbank stabilisation in the estuary, between Murwillumbah and Stott's Island.

2.3 Bio-engineered Riverbank Erosion Management

In certain reaches of the river where erosion is occurring but does not immediately threaten important public infrastructure, erosion stabilisation using natural (revegetation) or bio-engineered (combined use of rock, logs and vegetation) approaches should be considered.

The advantages of bio-engineering can include reduced cost and improved environmental outcomes, however the risk of erosion continuing is higher. Bank stabilisation works using bio-engineered techniques must be undertaken before assets are under immediate threat.

The approach must be pre-emptive, as opposed to reactive, and should aim to increase the ability for banks to withstand erosion, generally by encouraging growth of riparian vegetation. Successful bio-engineered bank erosion stabilisation projects will have less visual impact on the river environment than top to toe bank revetment structures.

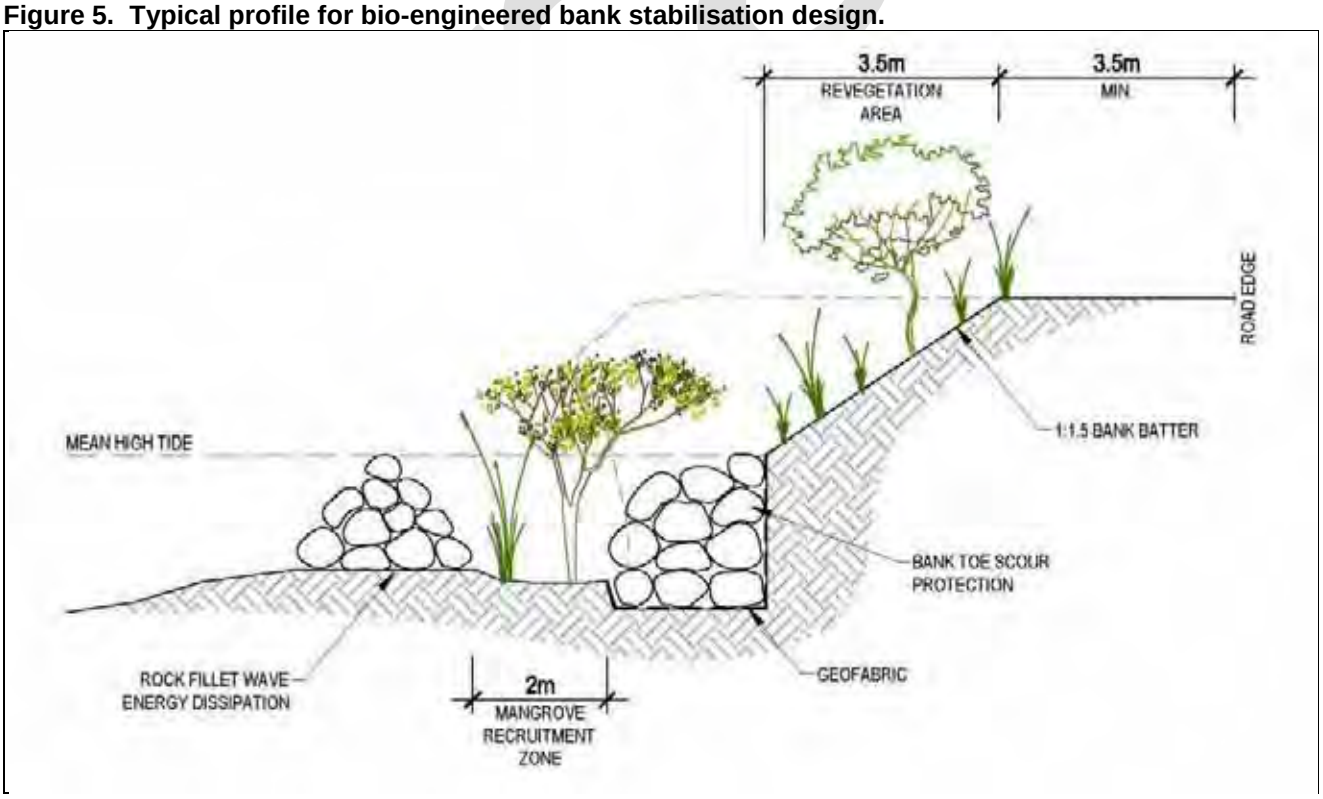
A common bio-engineered approach to riverbank stabilisation is the construction of rock fillets. These structures dissipate wave energy (wind or wake) and create sheltered environments that are colonised by mangroves. Mangrove growth increases the stability of banks and provides habitat for fauna including crustaceans, fish and birds. Encouraging vegetation growth on the riverbank will generally assist in screening the visual impact of rock wall construction.

Figure 3. Rock fillets are a common bio-engineered approach to bank stabilisation. The photo below shows rock fillets immediately after construction in the Manning River, prior to colonisation by mangroves.

Figure 4. Rock fillets constructed at Chinderah, with regenerating mangroves.

Areas in which pre-emptive riverbank stabilisation can be undertaken will be limited by the proximity of the road to the eroding bank. Generally it is considered that a minimum of 7.0 m between road edge and the bank will be required to undertake a bioengineered approach that includes top of bank revegetation. This allows for a planting set-back of 3.5 metres from the road edge. Further detail of this approach is included in section 4.4.

Figure 5. Typical profile for bio-engineered bank stabilisation design.



In some areas a full bank height rock stabilisation structure will be required, but may be able to include a rock fillet at its toe, allowing partial offset of the ecological and amenity impacts.

2.4 Impact of Sea Level Rise on Riverbank Erosion

Council has adopted sea level rise bench marks authorised by the CSIRO. These include a rise on 1990 sea levels of 40cm in 50 years, and 90cm in 100 years.

While there has not been a detailed analysis of the potential impacts of sea level rise on riverbank erosion in the Tweed Estuary, a number of general conclusions can be drawn.

As ocean levels rise, river levels will increase correspondingly. Waves (wind and wake) and tidal flows will more frequently affect parts of the upper riverbank that are not currently adapted to regular inundation. In low flat areas this will result in a gradual landward progression of marine vegetation, for example mangroves, which may replace terrestrial species. In areas of steep banks existing vegetation may die off, increasing erosion vulnerability.

In many parts of the Tweed floodplain vegetation migration (under the influence of climate change) will be constrained because the riverbank is cut off from the floodplain by roads and sugar cane fields.

Increased climate variability, including increased storm intensity and prolonged drought may also have an impact on riverbank stability. More frequent and severe flooding has the potential to increase erosion through scour and over saturation of bank soils, whereas drought can have an impact on river salinity and the health of native vegetation.

In general, it is likely that riverbank erosion will increase, rather than decrease, as a result of increased climate variability and sea level rise.

3.0 Riverbank Erosion Classification

Council's Waterways Program has recently mapped and classified the severity riverbank erosion in the Tweed estuary. Table 3 provides a summary of bank erosion severity, and highlights the river reaches between the Bray Park Weir and the river mouth where erosion is most serious.

This classification is based on riverbank inspections undertaken in July 2013, using a GPS to record areas of bank erosion. The river was broken into reaches, and then each reach into sections, as a means of assessing stability status. . Reaches have been given a colour coded erosion classification, as follows:

Table 2. Erosion classification code.

Generally stable:	Low risk of problem erosion.
Vulnerable:	Significant risk of erosion initiating, or erosion becoming worse.
Active and severe:	Bank is eroding, high risk of erosion increasing.

It is noted that there are exceptions to the overall summarised condition with in a reach. For example, within reaches classified overall as being, 'generally stable' there may be some severe, localised erosion, and vice versa. The table also provides a brief assessment of the implications of erosion, primarily as it relates to *management of Council infrastructure or land*. As such, erosion affecting private agricultural or residential land is not identified as a serious problem, *for Council*. The table does not present the environmental implications of riverbank erosion.

Note: Left and right bank are indicated, this refers to left and right bank when looking down stream.

Table 3. Summary of erosion status.

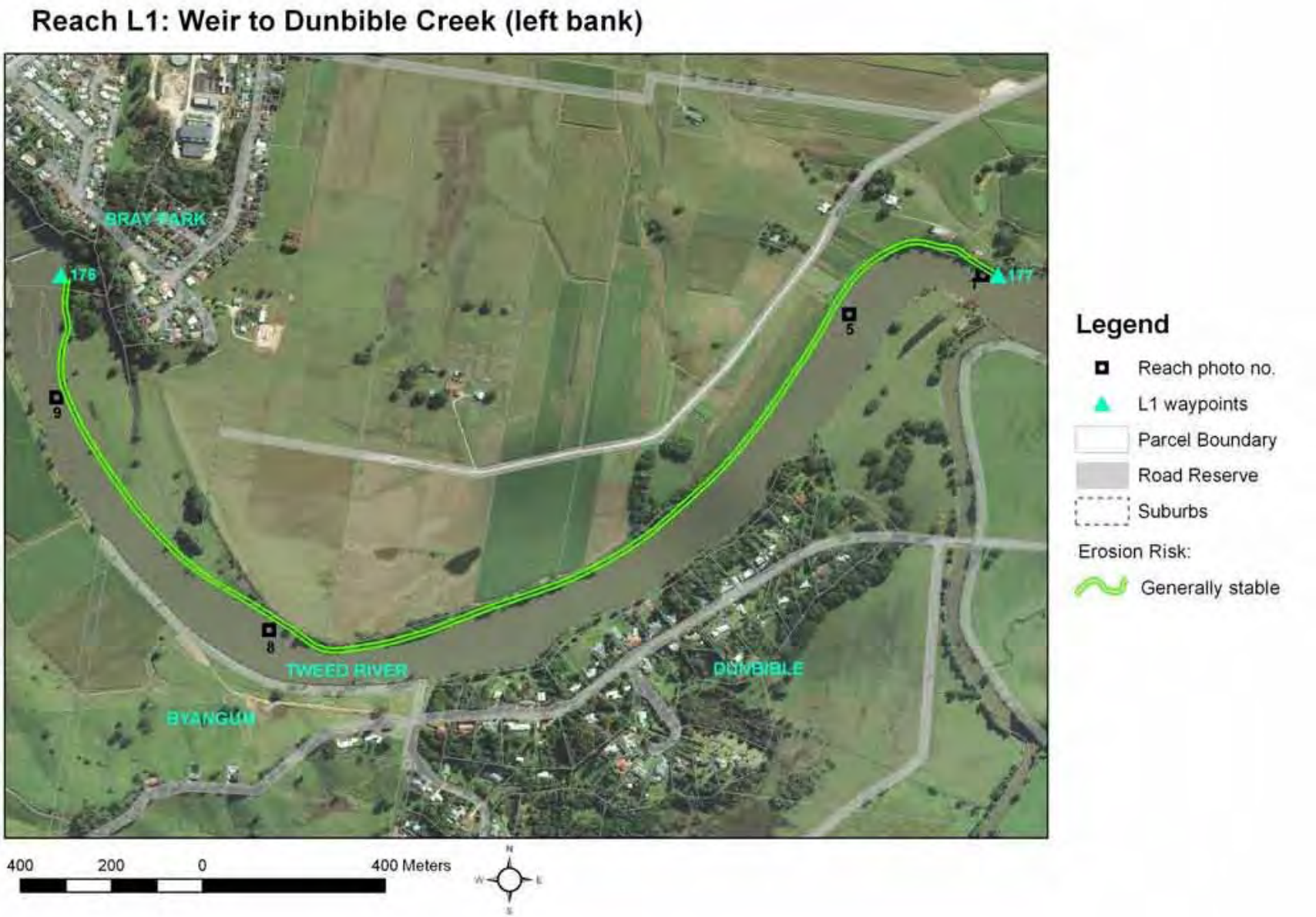
Reach	Overall classification	Management Implication
Bray Park Weir to Dunbible Creek - Left	Generally stable	Some opportunities for bank revegetation should be pursued with land owners.
Bray Park Weir to Dunbible Creek - Right	Generally stable, but includes a 200 m section highly vulnerable, and a section of 100 which is severely eroded.	No public assets at risk. Erosion in this location will impact on the operation of a cane farm and grazing land. Erosion on outside river bend. Environmental and landowner benefits would be gained through stabilisation.
Dunbible Creek to Murwillumbah Bridge - Left	Vulnerable, with some severe erosion.	No public assets at immediate risk, however Commercial Road flood levee wall and park land at the boat ramp are adjacent to a vulnerable and eroding bank. Cane farm affected by severe erosion over a significant length.
Dunbible Creek to	Generally stable, with a	Several private homes need

Reach	Overall classification	Management Implication
Murwillumbah Bridge - Right	significant vulnerable bank upstream of Murwillumbah bridge on Council land, and some sections of severe erosion on private land.	protection. Ongoing loss of grazing land will also occur if not stabilised. Council land should be managed to increase bank resilience.
Murwillumbah Bridge to Condong Bridge - Left	Variable. Some severe erosion, some stable areas. Significant potential to improve riverbank management and reduce erosion in upper part of reach.	No public assets at risk. Proposed area for investment by Council Waterways Program.
Murwillumbah Bridge to Condong Bridge - Right	**High vulnerability with severe erosion present. Recent major slips requiring bank stabilisation by Council. High risk of multiple additional bank slips in the area. Residential land is almost all protected by rock walls - if not, it is severely eroding.**	**Approx. 700m of Tweed Valley Way potentially affected by erosion and requiring ongoing stabilisation work as slips occur.**
Condong Bridge to Tumbulgum - Left	**Significant erosion over most of the reach, some severe. Multiple slips affecting Tumbulgum Road. Most of the reach is vulnerable to erosion. One stable section supports good native vegetation and will be enhanced through revegetation.**	**Approx 2.5 km length of Tumbulgum Road threatened by erosion and requiring ongoing stabilisation work as slips occur.**
Condong Bridge to Tumbulgum - Right	**Vulnerable, with sections of severe erosion over majority of reach.**	**Approx. 1.5 km length of Tweed Valley Way threatened by erosion and requiring ongoing stabilisation work as slips occur. Parkland at Condong and Condong School grounds also require protection.**
Tumbulgum to McCauley's Road boat ramp - Left	**Severe erosion upstream of Tumbulgum Bridge, however generally stable downstream of bridge to McCauley's Road boat ramp.**	**Approx. 600 metre section of Dulguigan Road threatened by erosion and will require ongoing stabilisation work.**
Tumbulgum to Stotts Island - Right	**Severe erosion. Over much of the reach, stability is only provided by recent heavy duty rock armour, or old rock armour, which is at high risk of failure.**	**Approx. 1000 metre section of Tweed Valley Way threatened, and will require ongoing stabilisation work at multiple locations.**

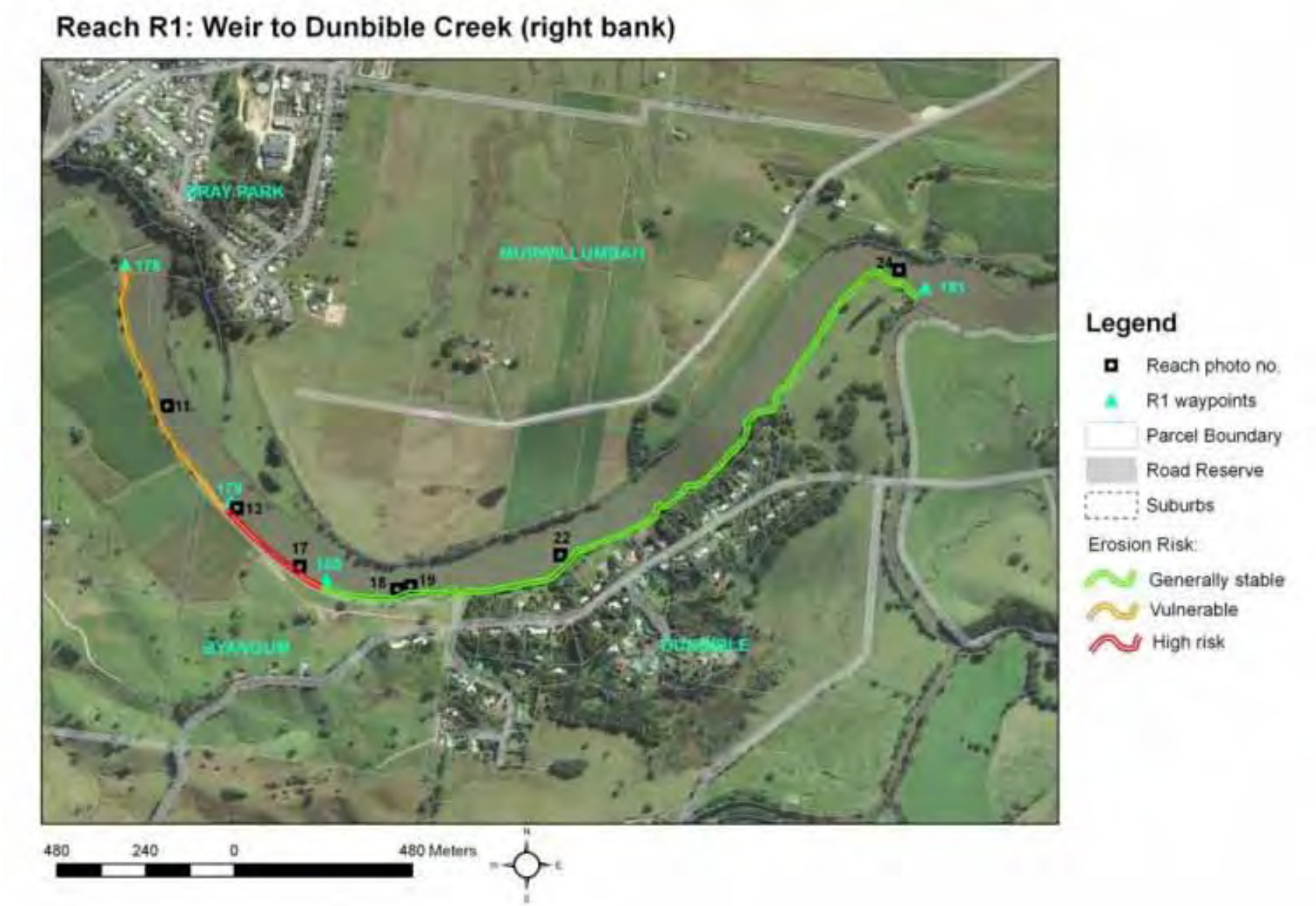
Reach	Overall classification	Management Implication
Stotts Island	Some areas vulnerable, and showing signs of active erosion. The majority of the bank is stable.	Highly significant nature reserve that should be protected from erosion. No potential for armouring of bank.
McCauley's Road boat ramp to River Road, Banora Point - Left	Generally stable. One bad slip.	Slip on grazing land.
Stotts Island east to Dodd's Island west - Right	Generally stable, signs of loss of mangroves due to scouring/undermining.	Bank adjacent to road reserve/cane land.
Dodd's Island to Chinderah boat ramp - Right	Severe erosion present on Dodd's Island. Dodd's channel to Chinderah stable.	Dodd's Island is private land.
Chinderah boat ramp to Barneys Point Bridge - Right	Generally stable, however riverbank behind caravan park has been poorly armoured with concrete debris. Area is unstable and has very low amenity value.	Land behind caravan park is public open space and requires significant work to achieve a good amenity outcome.
Barneys Point Bridge to Tweed Bar - Right	Stable. Entire river foreshore is armoured. Maintenance required at some locations.	Ad hoc maintenance required.
River Road Banora Point to Barney's Point Bridge - Left	Severe erosion present on River Road and adjacent to Oxley Cove Canal Estate entrance. Natural bank downstream of canal estate vulnerable.	Stabilisation work required - urgent at canal estate entrance.
Barneys Point Bridge to Tweed Bar - Left	Generally stable. Some natural erosion on Ukerebagh Island. Some vulnerable areas adjacent to golf course.	No major maintenance or management required.
Terranora	Multiple minor erosion problems that can be addressed as resources permit. Most significant erosion area is downstream of Ray Pascoe Park on Kennedy drive.	Risk of exposure of old landfill material adjacent to Ray Pascoe Park.
Rous River	Not formally mapped. Significant areas of erosion vulnerability adjacent to private cane land.	Some areas of Dulguigan Road threatened.

Erosion has been presented graphically in the following series of maps, 1 - 18. Within the maps, more detail of erosion variability is shown than for the summarised condition assessments in the table above. Maps 1-18 include numbered camera icons, which correspond to photographs of bank condition, included as **Appendix 2.**

Map 1

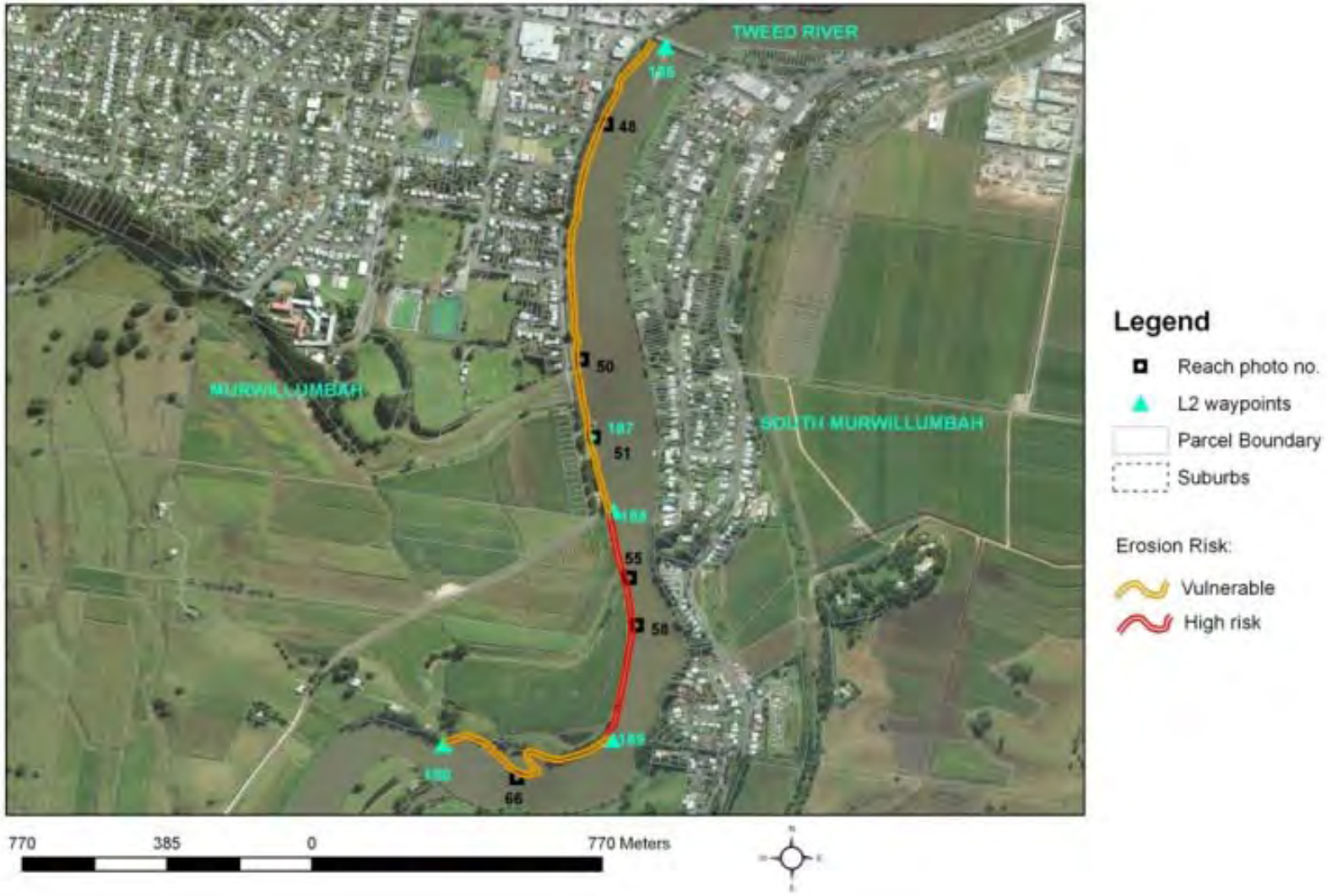

Reach L1: Weir to Dunbible Creek (left bank)
BRAY PARK
176
177
9
8
5
TWEED RIVER
DUNBIBLE
BYANGUM
Legend
Reach photo no.
L1 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
400
200
0
400 Meters

Map 2

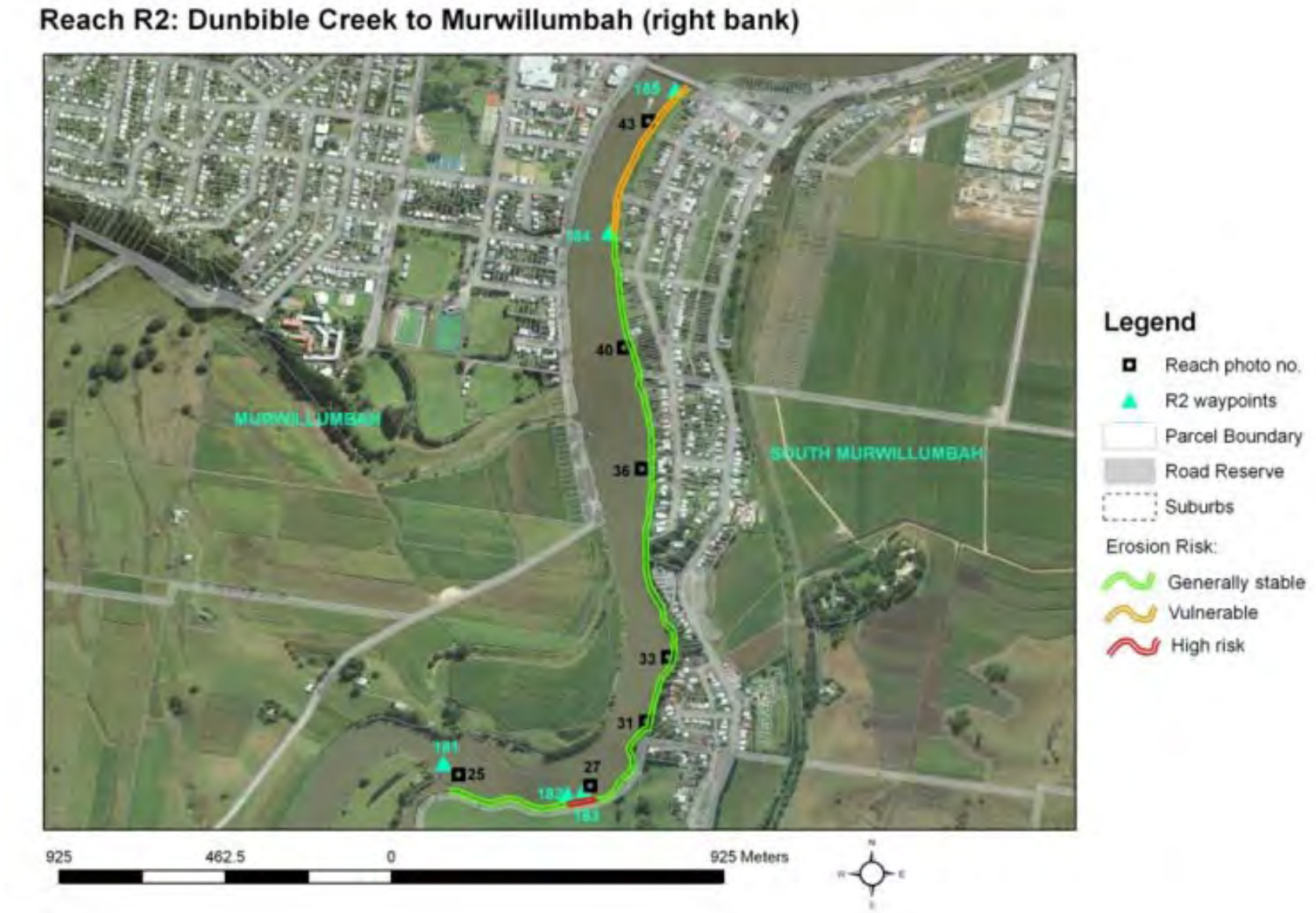

Reach R1: Weir to Dunbible Creek (right bank)
480
240
0
480 Meters
Legend
Reach photo no.
R1 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk

Map 3

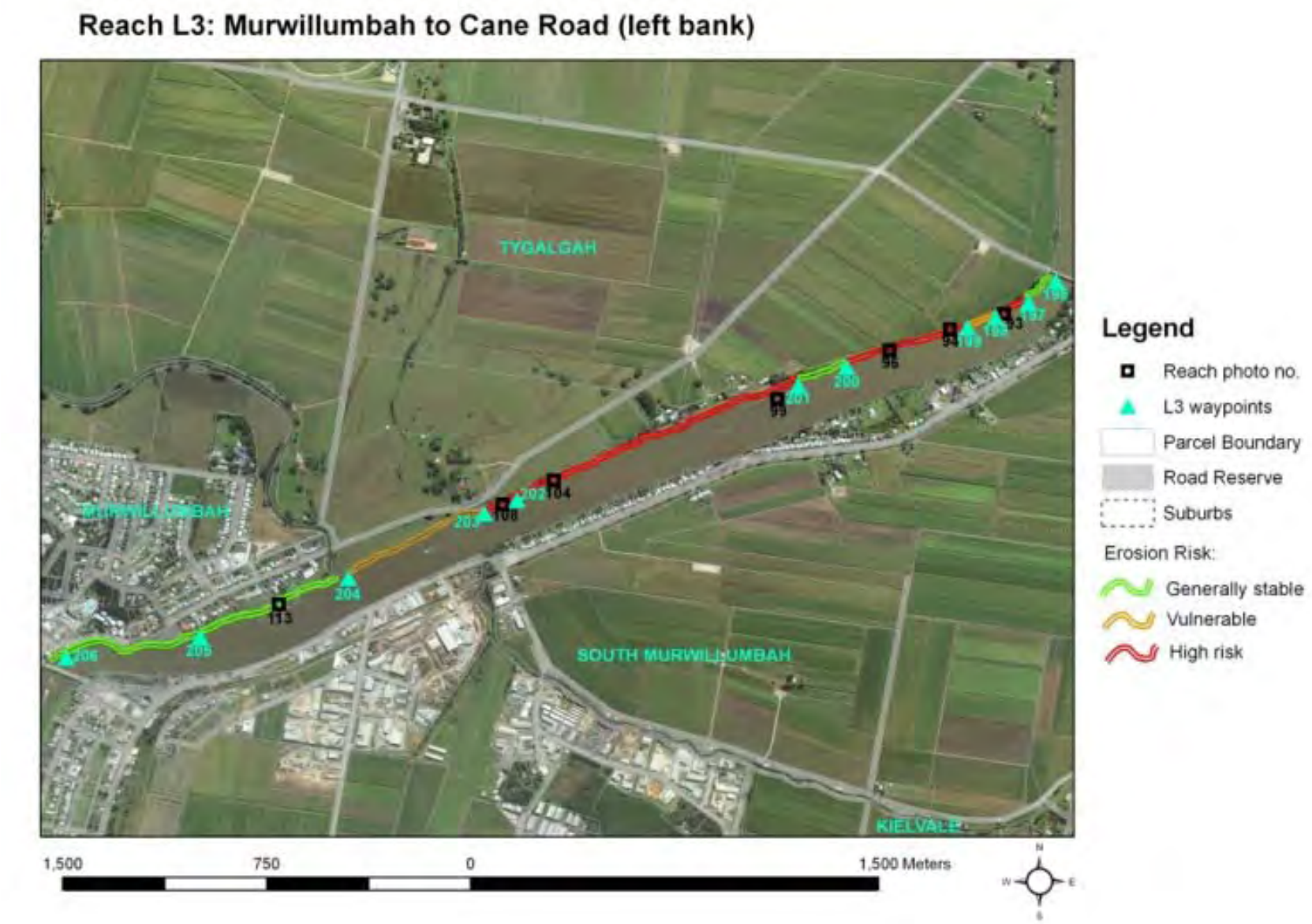
Reach L2: Dunbible Creek to Murwillumbah (left bank)



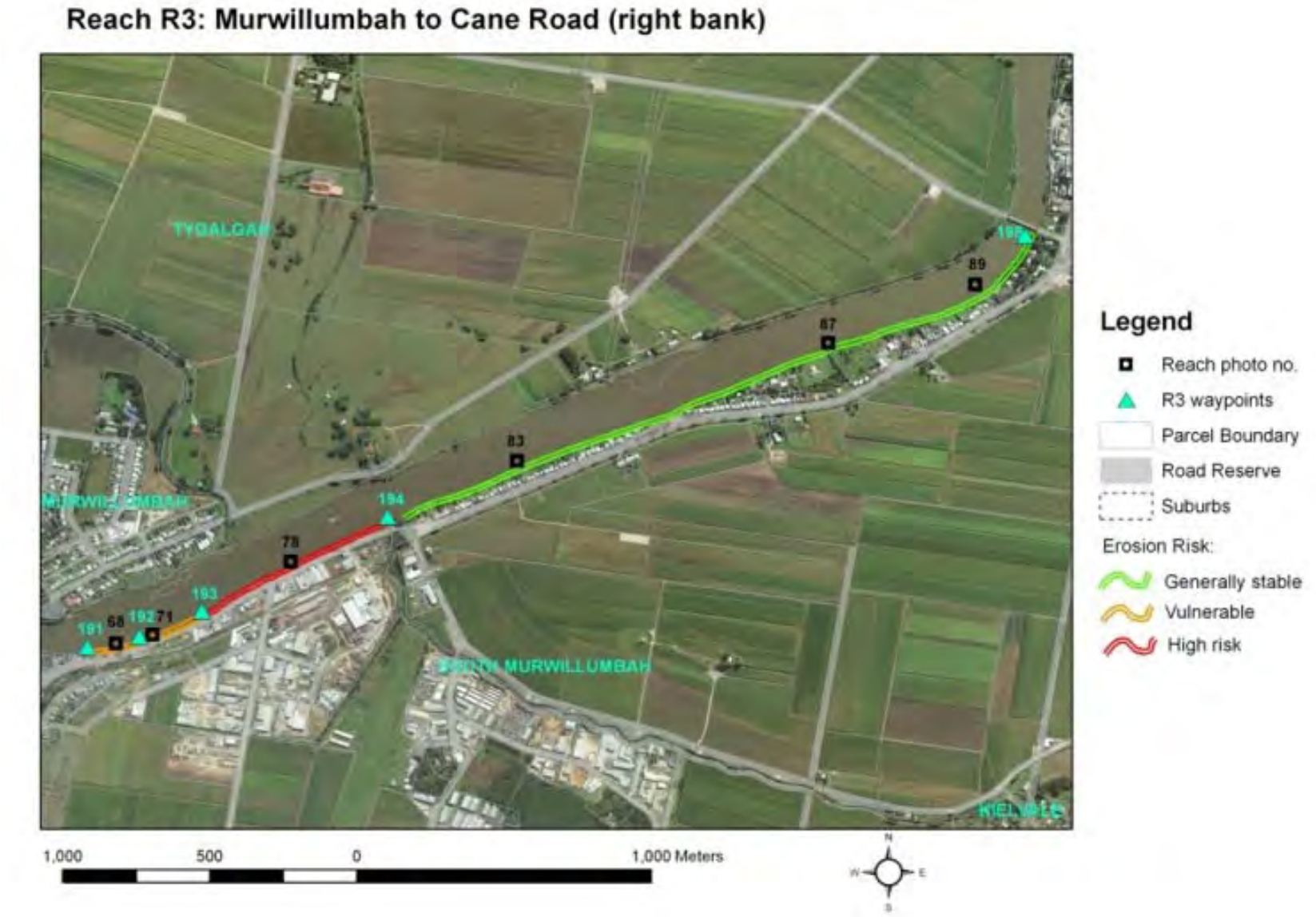
Map 4


Reach R2: Dunbible Creek to Murwillumbah (right bank)
MURWILLUMBAH
SOUTH MURWILLUMBAH
185
43
184
40
36
33
31
27
25
181
183
Legend
Reach photo no.
R2 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
925
462.5
0
925 Meters

Map 5

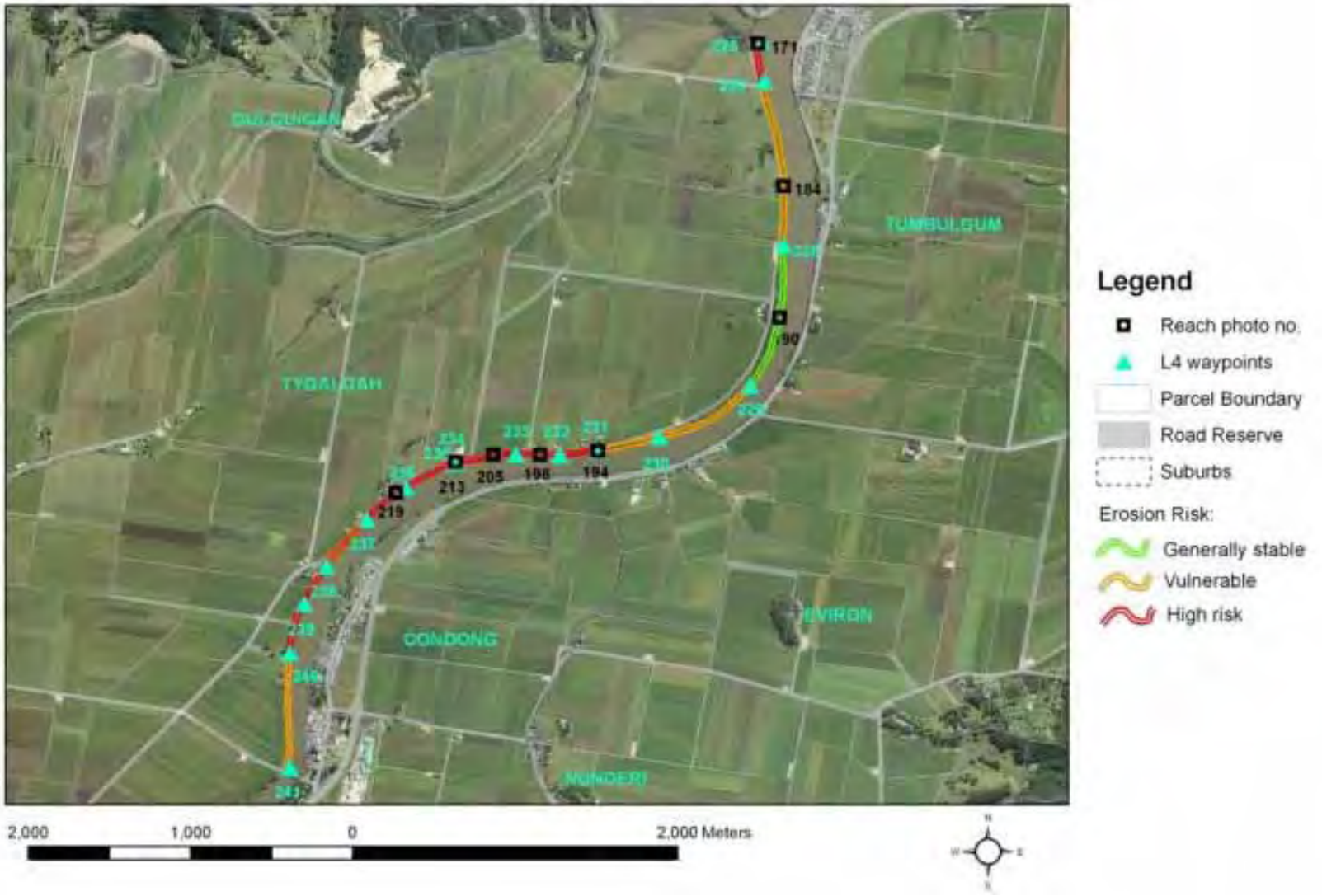

Reach L3: Murwillumbah to Cane Road (left bank)
TYGALGAH
MURWILLUMBAH
SOUTH MURWILLUMBAH
KIELVALE
Legend
Reach photo no.
L3 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
1,500
750
0
1,500 Meters

Map 6

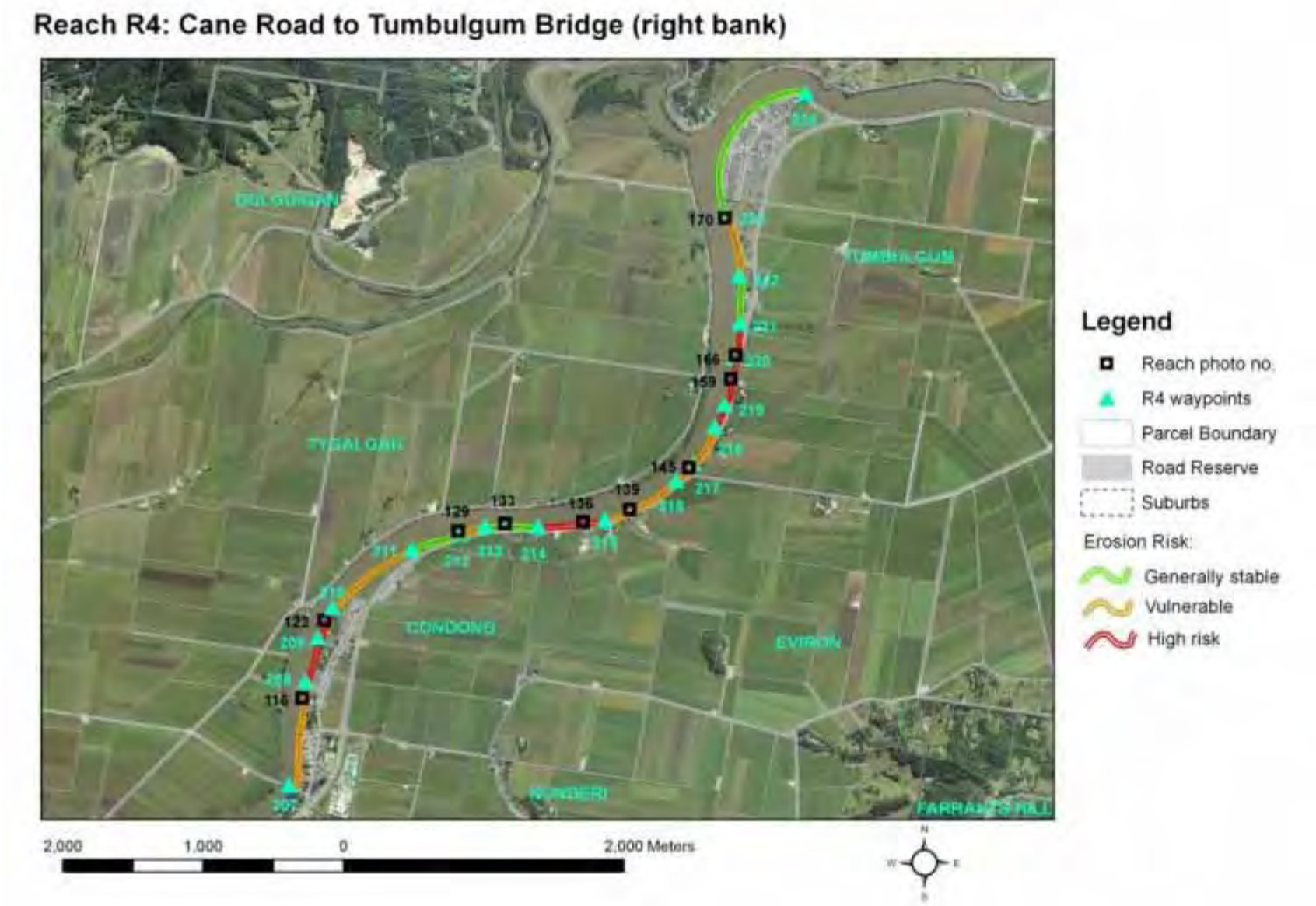

Reach R3: Murwillumbah to Cane Road (right bank)
TYDALGAH
MURWILLUMBAH
SOUTH MURWILLUMBAH
KIELVALE
191
68
192
71
193
78
194
83
67
89
195
1,000
500
0
1,000 Meters
N
W
E
S
Legend
Reach photo no.
R3 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk

Map 7

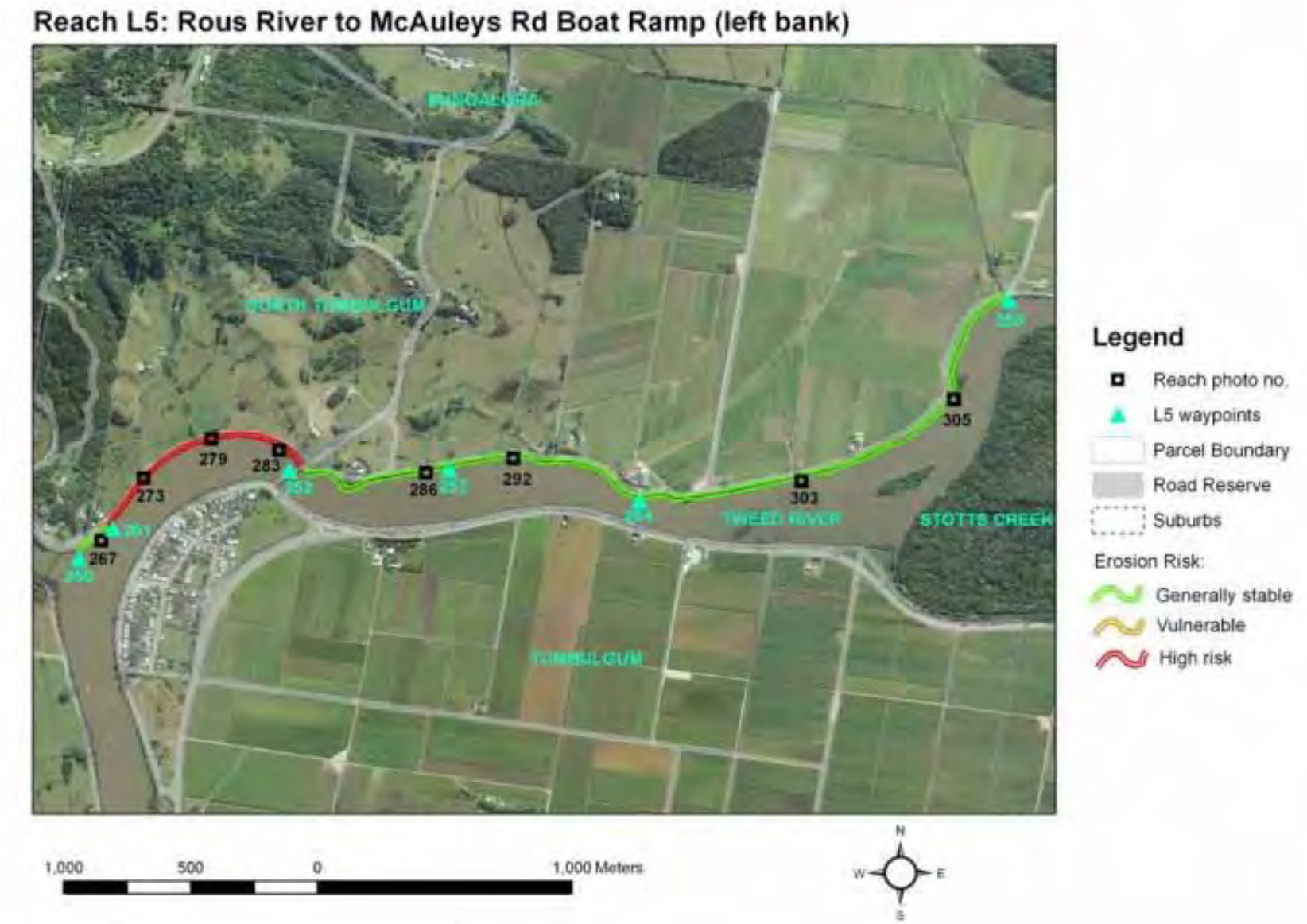
Reach L4: Cane Road to Rous River (left bank)



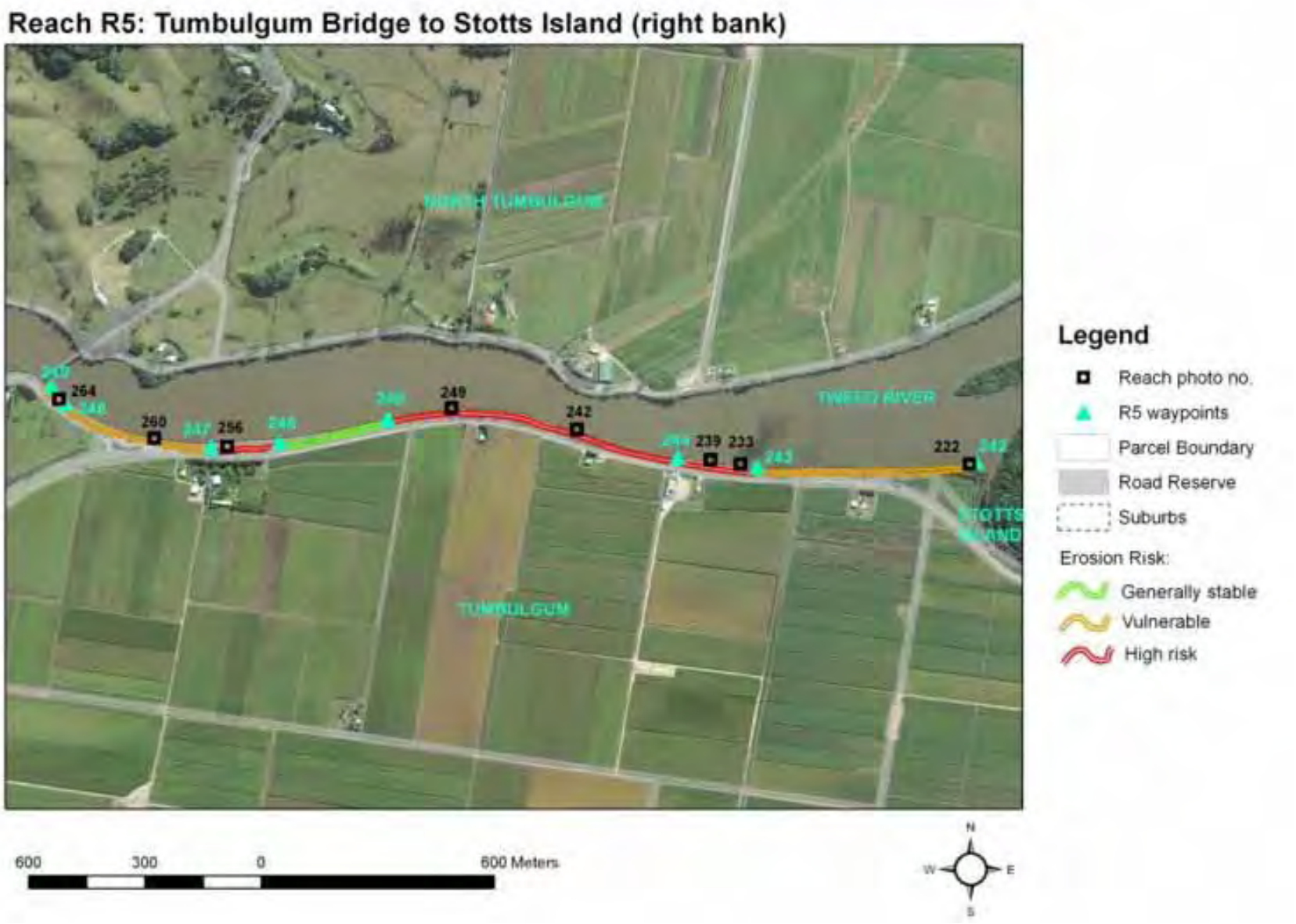
Map 8


Reach R4: Cane Road to Tumbulgum Bridge (right bank)
DULGUNGAN
TUMBULGUM
TYDALGAH
CONDONG
EVRON
FARRANTS HILL
170
166
159
145
139
136
133
129
123
116
Legend
Reach photo no.
R4 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
2,000
1,000
0
2,000 Meters

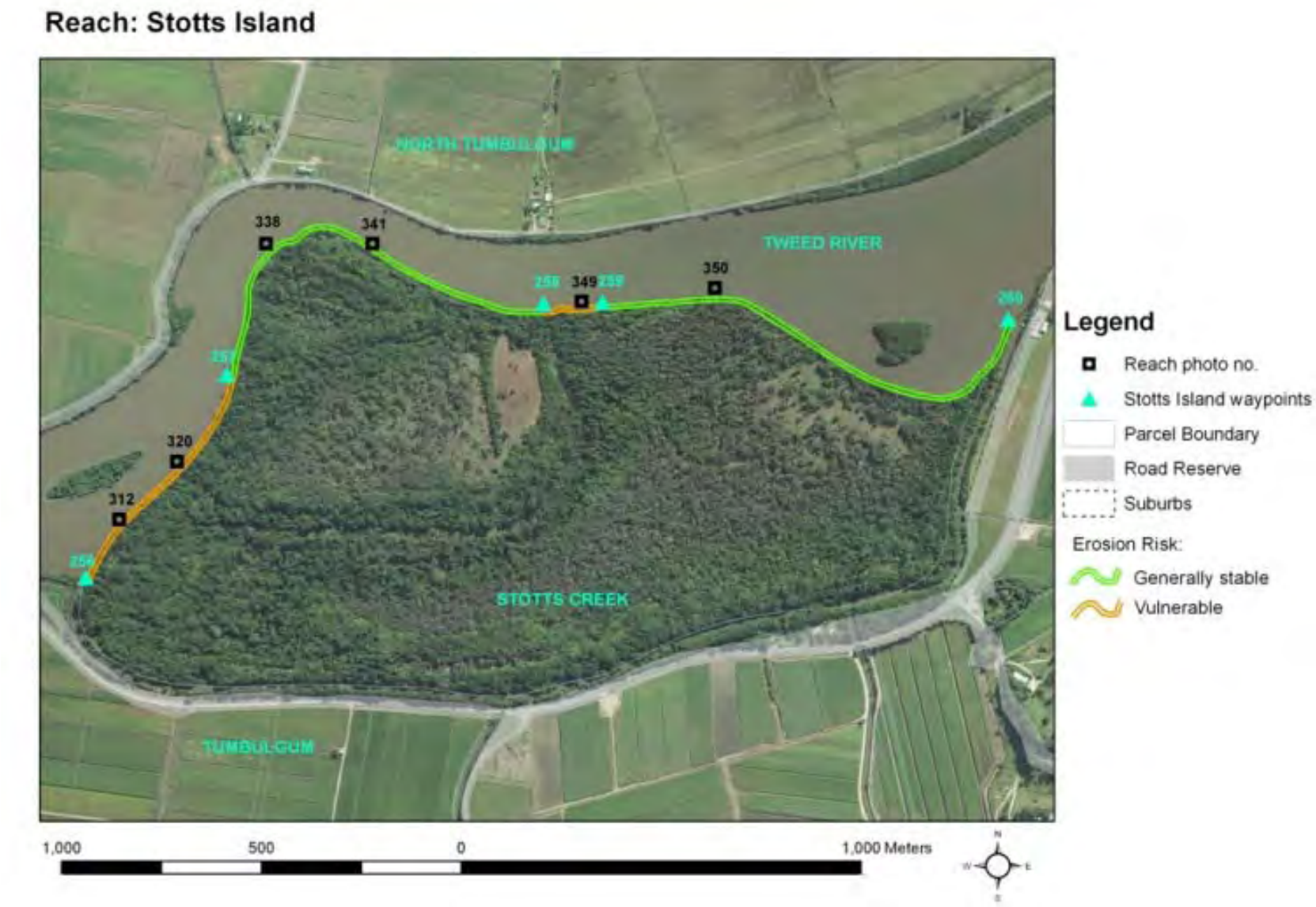
Map 9


Reach L5: Rous River to McAuleys Rd Boat Ramp (left bank)
273
279
283
286
292
303
305
267
TWEED RIVER
STOTTS CREEK
Legend
Reach photo no.
L5 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
1,000
500
0
1,000 Meters
N
W
E
S

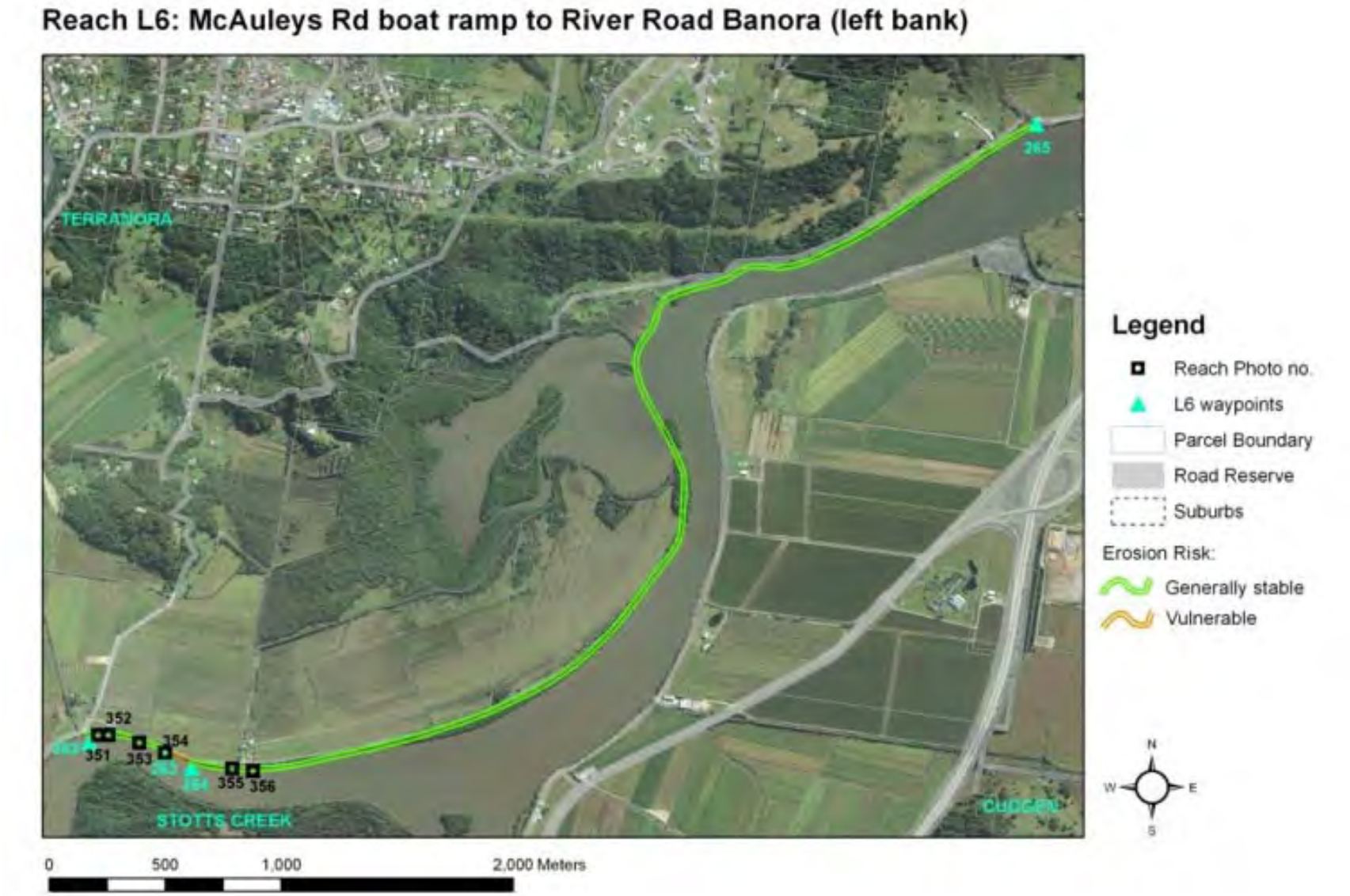
Map 10


Reach R5: Tumbulgum Bridge to Stotts Island (right bank)
NORTH TUMBULGUM
TWEED RIVER
TUMBULGUM
STOTTS ISLAND
264
260
256
249
242
239
233
222
Legend
Reach photo no.
R5 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
600
300
0
600 Meters
N
W
E
S

Map 11

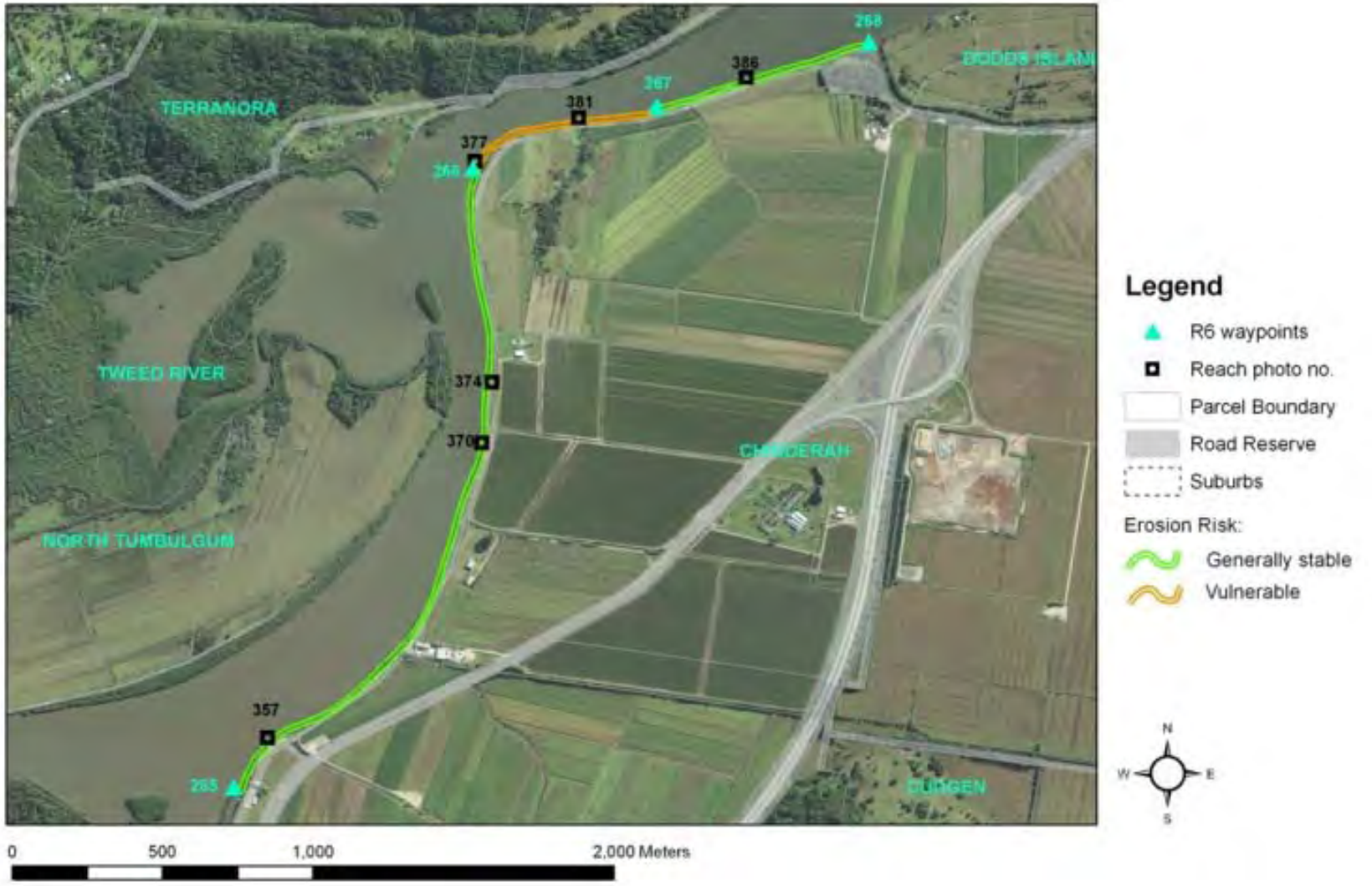

Reach: Stotts Island
NORTH TUMBULGUM
TWEED RIVER
STOTTS CREEK
TUMBULGUM
338
341
350
320
312
1,000
500
0
1,000 Meters
Legend
Reach photo no.
Stotts Island waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable

Map 12

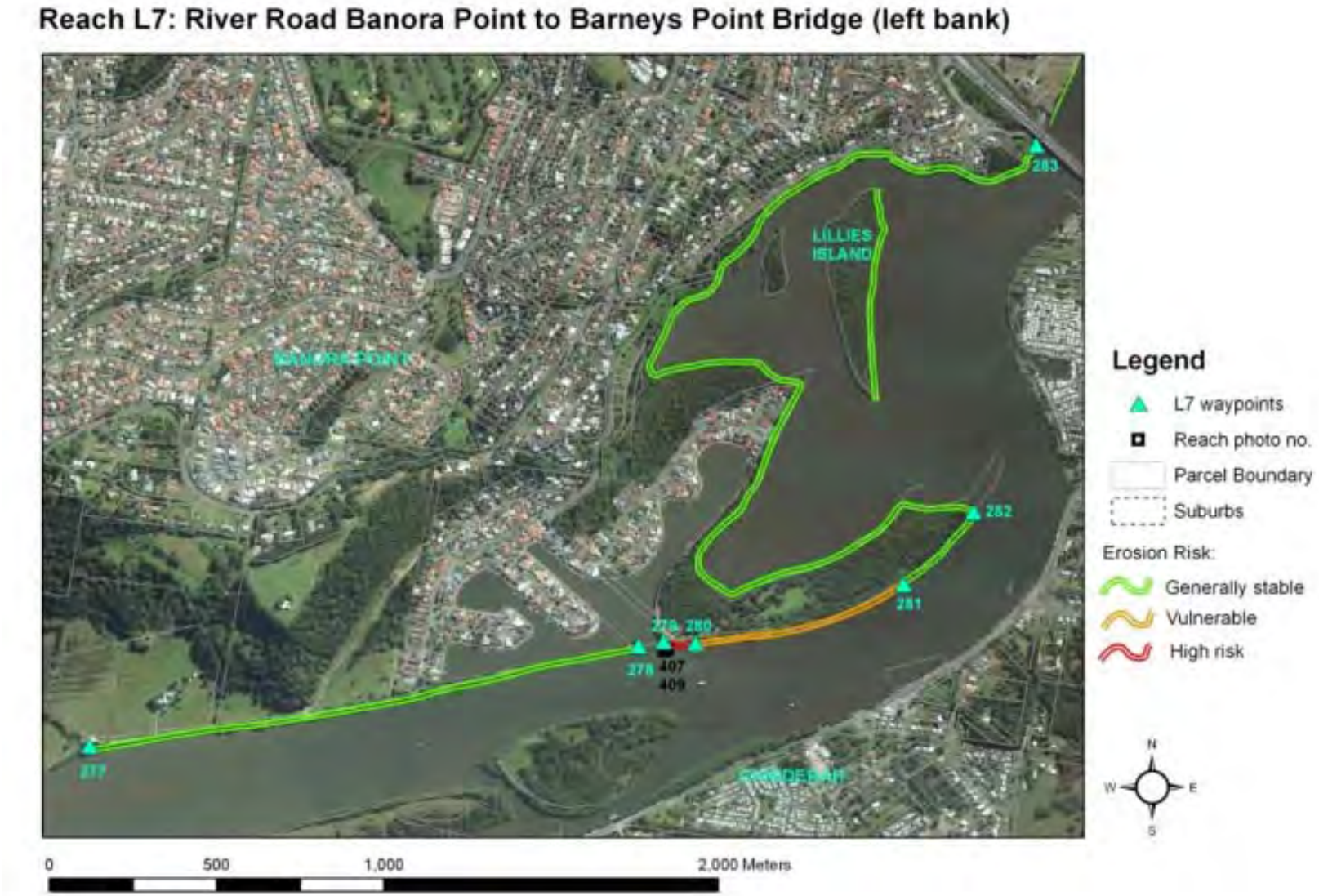

Reach L6: McAuleys Rd boat ramp to River Road Banora (left bank)
TERRANORA
STOTTS CREEK
265
352
351
353
354
355
356
Legend
Reach Photo no.
L6 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
N
W
E
S
0
500
1,000
2,000 Meters

Map 13

Reach R6: Stotts Island to Dodds Island channel (right bank)

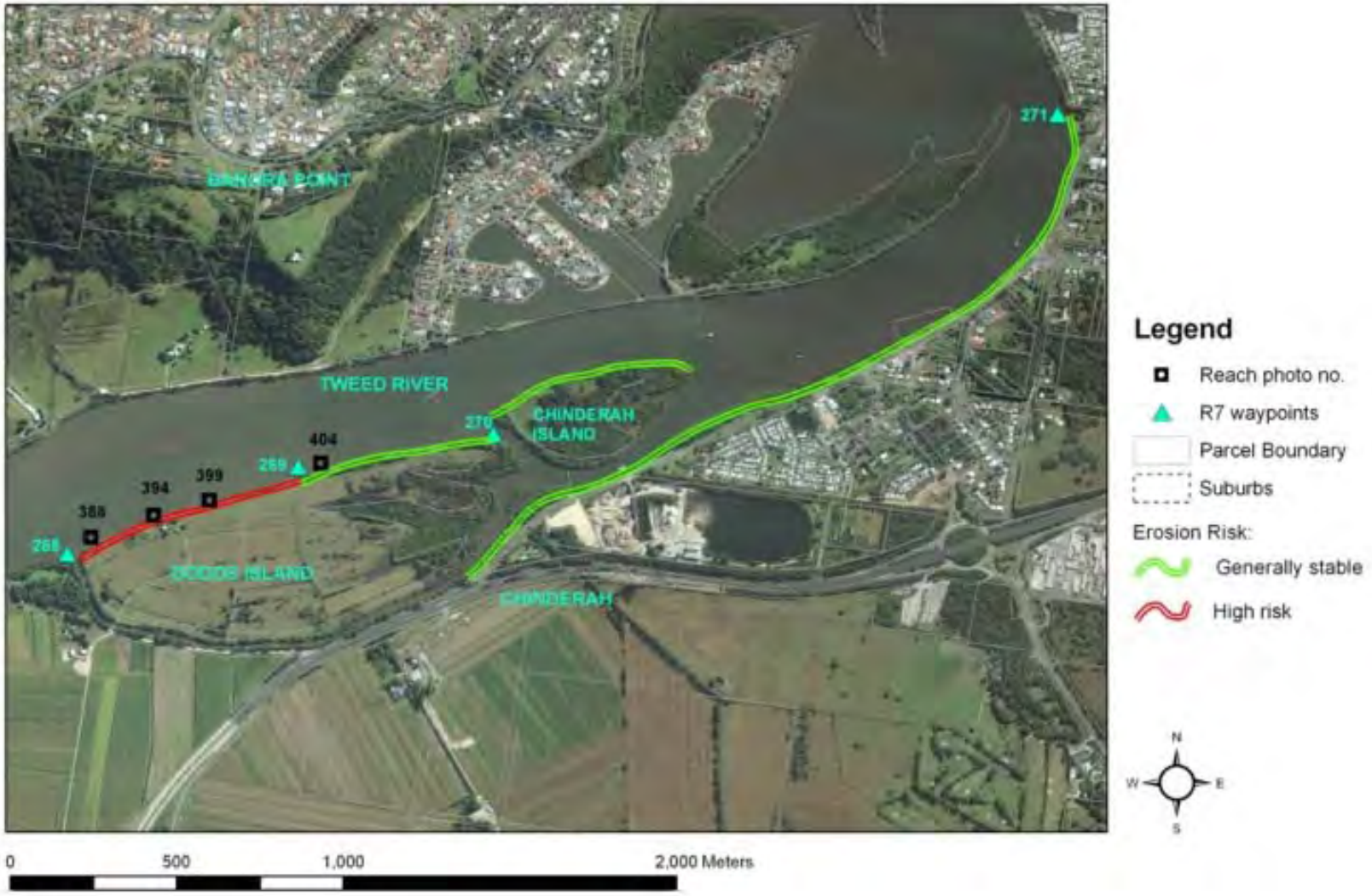


Map 14

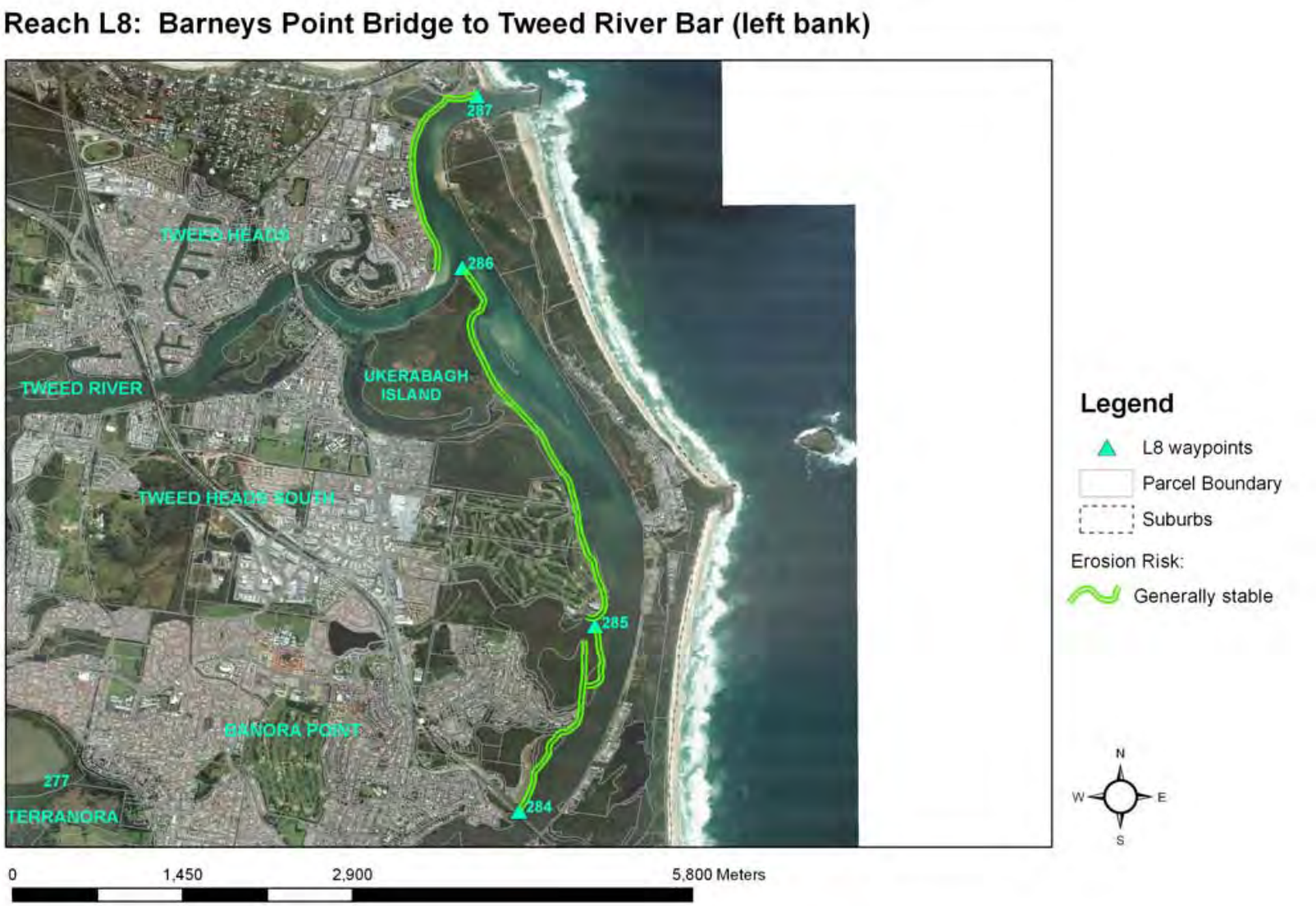

Reach L7: River Road Banora Point to Barneys Point Bridge (left bank)
LILLIES ISLAND
283
282
281
280
279
278
407
409
277
Legend
L7 waypoints
Reach photo no.
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
N
W
E
S
0
500
1,000
2,000 Meters

Map 15

Reach R7: Dodds Island to Chindera Boat Ramp



Map 16


Reach L8: Barneys Point Bridge to Tweed River Bar (left bank)
287
286
285
284
277
TWEED HEADS
TWEED RIVER
UKERABAGH ISLAND
TWEED HEADS SOUTH
GANORA POINT
TERRANORA
Legend
L8 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
N
W
E
S
0
1,450
2,900
5,800 Meters

Map 17


Reach R8: Chindera Boat Ramp to Barneys Point Bridge
274
273
272
TWEED RIVER
CHINDERAH
Legend
R8 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
N
W
E
S
0
175
350
700 Meters

Map 18


Reach R9: Barneys Point Bridge to Tweed River bar
276
TWEED HEADS
TWEED RIVER
TWEED HEADS SOUTH
BOGANGAR POINT
TERRANGORA
275
Legend
R9 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
N
W
E
S
0
1,250
2,500
5,000 Meters

4.0 Erosion Stabilisation

Council's approach to bank stabilisation works can be broadly grouped into areas where:

- no work is required,
- areas suitable for revegetation,
- areas suitable for pre-emptive bio-engineered stabilisation, and
- areas that are likely to require full structural protection.

Table 4 shows the total length of riverbank between the Bray Park Weir and Stott's Island, where revegetation, pre-emptive/bio-engineered stabilisation works and structural protective works are likely to be appropriate and/or required. This assessment has been undertaken based on field assessment and an assessment of width between road edge and riverbank using 2012 aerial photography.

Table 4. Total length appropriate to stabilisation approach.

Stabilisation approach	Bank length (metres)
Revegetation	15,863
Pre-emptive bioengineered works	4668
Structural protection	Up to 5754*

There are 10,667m of riverbank within 7.5 metres of the road, with 5,754 m classified as severely eroded.

Section 5.0 includes a prioritised schedule of works to be undertaken by Council.

Given the highly variable nature of erosion within the immediate proximity of the Tweed Valley Way and Tumbulgum Road, a prioritised list of sites to undertake reactive, structural protection works has not been prepared. Councils Works Unit have determined that stabilisation of severe slips is best undertaken on an as needs basis.

4.1 No work required by Council

The focus of works proposed in this plan is on eroding riverbanks on Council or State controlled land. There are significant lengths of the river where erosion threatens private property, including both residential and agricultural land. This report does not make recommendations for erosion stabilisation on private property (though it does provide technical guidelines for this work), and as such, private property has not been classified in terms of the appropriate stabilisation approach. The management aims stated in section 1.1 of this document are relevant however, and will be applied when Council considers any riverbank stabilisation project proposed on private land.

Council will work with landowners to assist in managing erosion. Council's River Health Grants program is specifically intended to assist rural landowners undertake works that will improve riparian vegetation and bank stability.

4.2 Revegetation

Where bank erosion does not present a threat to public assets and the distance between the riverbank and roads exceeds 8 metres, revegetation of the riverbank with native riparian vegetation should be undertaken. Riparian revegetation has many benefits, including increasing riverbank stability and resistance to erosion during and after floods. It must be recognised however that revegetation of riverbanks does not begin to address mechanisms

of erosion until vegetation attains a significant level of maturity, estimated to be at least five years in the case of trees, and that revegetation alone will not be effective in protecting banks from erosion by wake waves.

Appendix 3 includes an assessment of areas where revegetation could/should be undertaken. A total bank length of 15,863m comprising an area of 181,099sqm has been identified as potentially suitable for revegetation. Prioritisation of revegetation sites should be toward those areas where additional positive benefits can be accrued, in particular the buffering of existing native vegetation, or increasing connectivity with core habitat or existing riparian corridors.

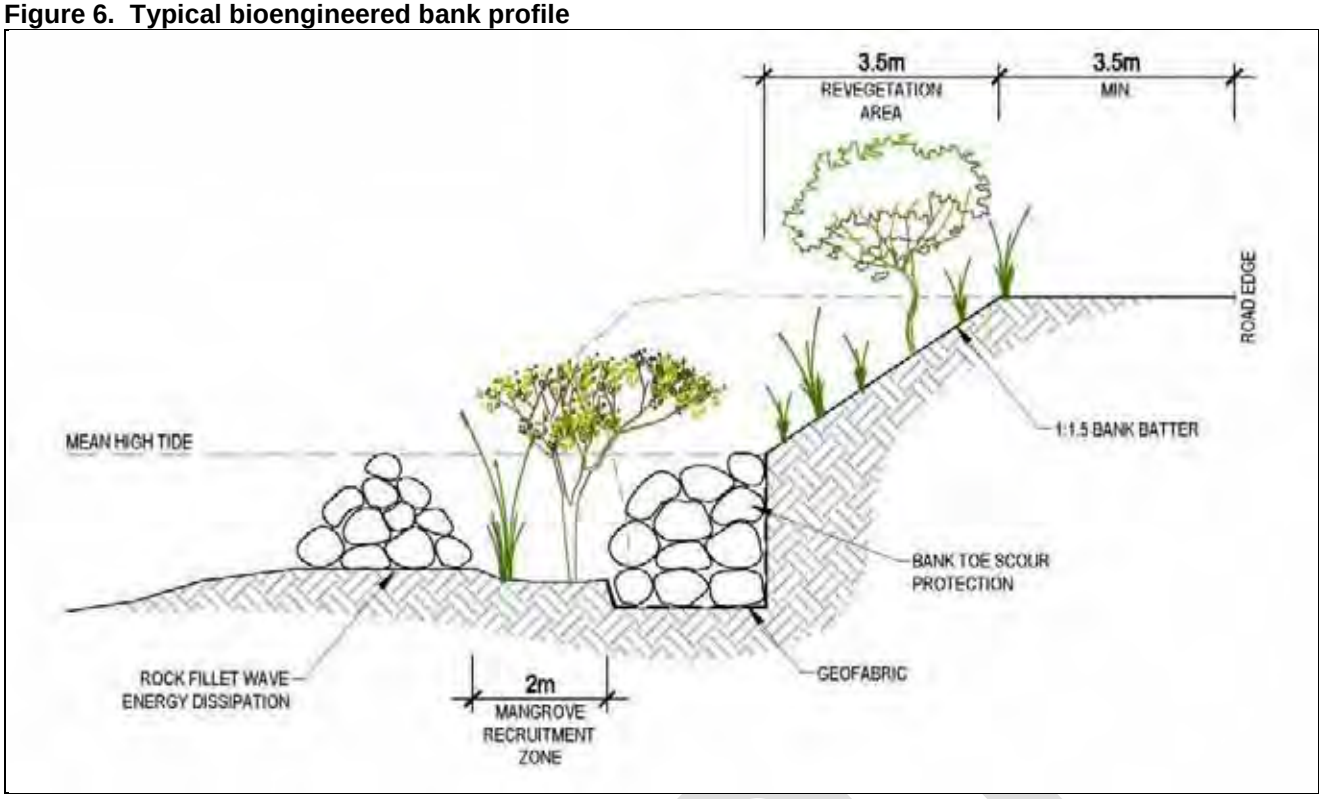
4.3 Restoration of existing toe revetment

A common feature in the estuary is the presence of old rock revetment that has been hand placed at the toe of the riverbank. In many locations this revetment is still providing effective protection from bank toe scour, however it can also be seen to have outflanked in many locations, with severe bank erosion occurring as a result. An advantage of the low level bank toe revetment is that it has frequently been colonised by vegetation on the top of bank. It would be advantageous to maintain and restore these areas. This will not be possible by the usual means of working with machinery from the top of bank, due to the need to remove top of bank vegetation. The possibility of restoring and extending the benefit provided by areas of old bank toe protection should be investigated as it may provide an important additional approach to pre-emptive erosion management.

4.4 Pre-emptive erosion stabilisation using bio-engineered designs

A minimum distance of approximately 7.5 metres is required between the road edge and riverbank edge to undertake riverbank stabilisation using a bio-engineered approach. This allows for a 3.5 metre setback from the road edge to any planting incorporated into the top of bank stabilisation works, and also allows for a minimum 3.5 metre work zone where bank battering and revegetation could occur.

Figure 6. Typical bioengineered bank profile



Site specific designs for individual banks will be required, but will usually include the following elements:

- wave energy dissipation
- bank toe stabilisation
- bank battering
- revegetation
- maintenance

In some locations a low level toe protection structure, battering and revegetation will be sufficient to achieve bank stability. Rock fillets for wave energy dissipation and encouraging colonisation by mangroves will only be effective where a wide shallow intertidal bench is present.

A total length of 4668 m is potentially suitable for this type of erosion stabilisation.

4.5 Designs for Structural protection

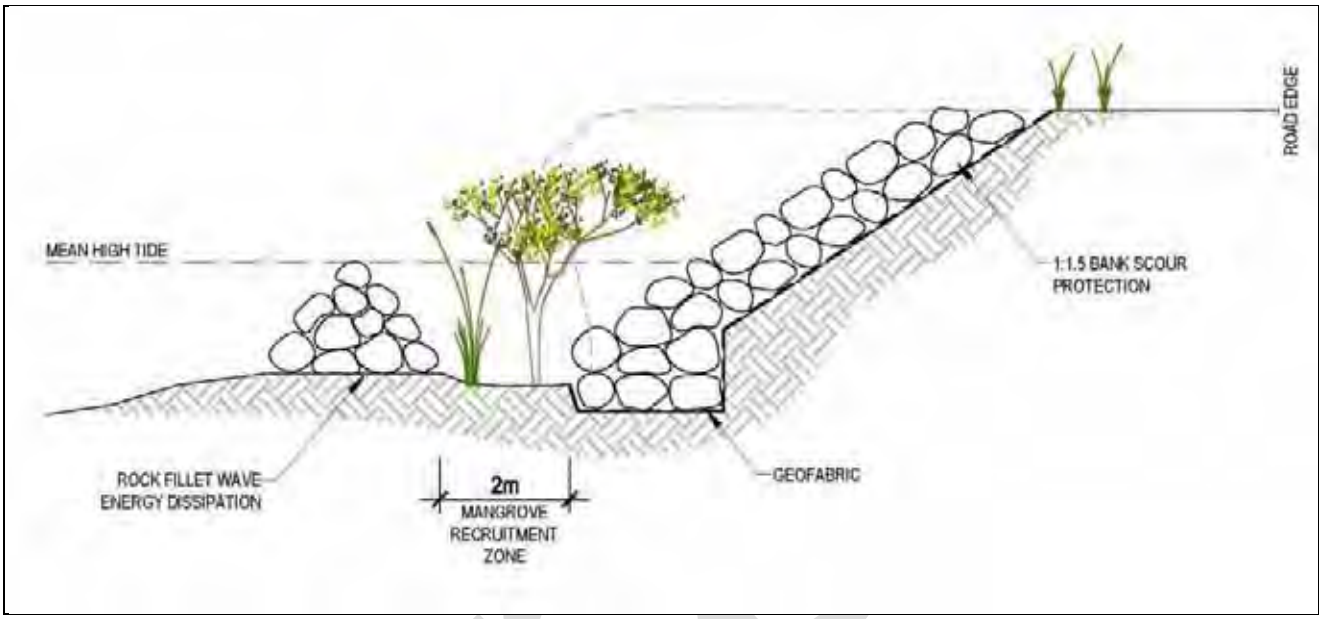
The choice of a detailed design for each bank stabilisation project will be dependent on site specific factors, predominantly influenced by bank height, water depth and proximity of infrastructure. It is possible for designs to combine elements of both the structural and bio-engineered approaches shown above, and vary along the length of bank being treated in accordance with variable bank condition.

The design of all bank stabilisation works should include consideration of elements that can mitigate post-construction environmental impacts. This will primarily involve creating opportunities for vegetation to either naturally recolonise intertidal areas, or plantings to be incorporated into the upper bank profile

Where revegetation or a bio-engineered bank stabilisation approach is not considered sufficient to manage erosion threats to infrastructure, structural stabilisation options must be considered. The total bank length within 7.5 m proximity of the road edge is 10,667 m. The portion of this overall total where erosion is severe, is 5,754 metres.

Wherever possible the principal of incorporating rock fillets to encourage mangrove colonisation of the bank toe should be employed in addition to full structural protection of riverbanks. This is depicted in figure 7.

Figure 7. Full bank height structural protection including a rock fillet to encourage mangrove recruitment.



5.0 Prioritised Schedule of Council Works

5.1 Revegetation

Table 5. Prioritised sites for riparian revegetation. Site locations are shown in Figure 8 following the table.

Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
Tumbulgum Road, Tygalgah 1 (Site K)	High	1385	29,000	Bank is vulnerable to erosion along upstream site and stable, protected by mangrove and phragmites on downstream site. Revegetation. High Priority. Good width available, the most significant reach of mangroves upstream of Stott's Island. Existing vegetation (except mangroves) is very weedy.	$87,000
Tumbulgum Road, Tygalgah 2 (Site L)	High	455	5,900	Active and recent erosion of the low bank, which is vulnerable, due to ongoing damage of mangrove root systems by waves and cattle. Revegetation and stock exclusion fencing required. Good width available, especially on the downstream reach. Good connectivity to mangroves at Rous River mouth. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse.	$17,700
Condong Boat Ramp - downstream of park (Site I)	High	600	10,000	Area downstream of boat ramp has high restoration potential. Planting will increase the riparian buffer width adjacent to mangroves. Potential conflict with adjacent agricultural land use.	$30,000
Downstream Bray Park Weir (Site A)	High	750	50,000	High priority over the longer term given it is the largest floodplain in study area under Crown ownership. Very large area (5+ ha). Currently grazed by adjacent landowner. Potential for vegetation to increase flows to opposite vulnerable bank (Site B). Detailed restoration plan required.	$150,000
Byangum Below Weir (Site B)	High	765	15,000	Vulnerable to severe erosion. Road Reserve (plus small area of Crown waterway). High priority over the longer term as this section will continue to erode without management intervention. Requires consultation with cane farmer. Vertical sections of bank require battering. Possible rock armouring along toe if bank continues to be undercut. Work should ideally begin before revegetation of Site A	$45,000

Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
				opposite bank which may increase scour potential due to deflected flows. Detailed restoration plan required.	
Upstream Murwillumbah (Site C)	High	1000	34,500	Erosion severe along most of site with some areas of mass failure (slumping). Crown Land (waterway) and small area of TSC Crown Land. High priority over the long term due to large area of Crown Land available. Narrow riparian zone (existing), mostly less than 7m to cane headland. Bank may require battering to stabilise. This is a large area of Crown waterway with extensive area of cane under cultivation by two adjacent landowners. Requires consultation prior to restoration planning.	$103,500
Dunbible (Site E)	High	600	14,000	Generally stable, 70m section of severe erosion. (photo 27). Road Reserve. Negotiate with adjacent landowner for stock exclusion fencing. Investigate impact on views from Art Gallery. Battering could help stabilise eroding section of bank. Approximately 20m wide, revegetation could be undertaken in stages.	$42,000
Tweed Valley Way, Windmill Corner road reserve (Site N)	Medium-High	480	4800	Downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion. Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. Slip and severe erosion near floodgate upstream of site N1. Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.	$14,400
Tweed Valley Way Condong (Site J)	Med-Low	415	3700	Bank is vulnerable to erosion along most of Site J, stable where mangroves and cottonwoods are along bank toe, area of severe erosion between flood gates. TSC Road Reserve. Moderate priority due to narrow extent between River and Tweed	$11,000

Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
				Valley Way and weedy condition of vegetation. Potential to increase cottonwoods along the lower bank. Good linkage to Condong Site I. Powerlines along Road side needs to be accounted for in site plans.	
North Tumbulgum (Site M)	Med-Low	100	1000	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge. Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. Requires consultation with adjacent house owners. Battering may help stabilise area in photo 267. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.	$3,000
Total					**$503,600**

*Cost estimate calculation on basis of 25 trees per $100m^2$ at $12 per tree, (planted and maintained for 1 year).

Figure 8. Location of sites referred to in table 5 and 6

5.2 Pre-emptive erosion management

Table 6: Prioritised sites for pre-emptive (bio-engineered) erosion management. Site locations are shown in Figure 8.

Location	Priority	Length	Area	Description	Estimate cost
Murwillumbah, Myall Creek (Site H)	High	1525	14,282	Generally stable upstream and areas of severe erosion downstream. Waterway & State Crown Land. Grazing occurs along this section of river with no riparian exclusion fencing. Rock toe revetment + fencing and revegetation. Investigate potential for rock fillets in conjunction with toe armouring to encourage Phragmites growth. Two landowners only between Myall Creek and Condong Bridge. High revegetation potential downstream to Condong Bridge on Freehold land.	Fence $20, 000 Reveg $42,000 Earthworks and rock $100,000 Total:$162,000
Condong Boat Ramp (Site I)	High	230	2,300	High risk / severe erosion adjacent to boat ramp. TSC Public Recreation Reserve and Waterway (Crown Land) Toe revetment and rock fillets required. Detailed design required which maximises opportunities to incorporate vegetation. Needs community consultation and to acknowledge existing uses of the site..	$100,000
Commercial Road Boat Ramp (Site D)	High	285	1335	Vulnerable, recent slumping as bank continues to become undercut. Road Reserve. High priority for stabilisation as bank continues to erode. Rock toe revetment, battering and revegetation will be required. Investigate potential for fillets to encourage Phragmites.. Limited width for revegetation due to car parking/public recreation space Requires detailed design which maximises opportunities to incorporate vegetation. Investigate appropriateness of revegetation on the river side of levy wall downstream to Murwillumbah Bridge (not mapped as part of this study).	$40,000
Stott's (Site N)	Medium - High	480	4825	Downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion. Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. Slip and severe erosion near floodgate upstream of site N1. Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.	$80,000

Location	Priority	Length	Area	Description	Estimate cost
North Tumbulgum (Site M)	High	100	1013	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge. Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. Requires consultation with adjacent house owners. Battering may help stabilise area in photo 267. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.	$50,000
Total					**$432,000**

5.3 Prioritised sites for structural protection works

Table 7: Prioritised sites for structural works, excluding erosion affecting roads in priority reach.

Location	Priority	Length	Description	Estimate cost
Philp Parade, South Tweed	Medium-high	200m	Erosion of Terranora Creek bank adjacent to Philp Parade. Bank approx 1.5 m high. Existing revetment has failed. Bank approx 4m from road edge.	$150,000
Oxley Cove Canal Estate, Banora Point	Medium	60m	Existing rock revetment has failed on the downstream side of entrance to Oxley Cove canal estate. This area has high tidal current and flood flow velocity as well as deep water. Work last undertaken in 2007. Erosion is severe but does not present a safety risk or threaten high value infrastructure or land. Rebuilding the wall will require placement of significant quantities of large rock.	$50,000
Chinderah Public Foreshore at Hacienda Caravan Park	Medium	200-300m	Public foreshore in this location is protected by ad-hoc revetment comprised of concrete building waste and rock. Erosion looks bad, but is not severe in terms of the risk posed to public land. Existing revetment provides very poor visual and user amenity, including safety risks from exposed reinforcing steel.	$200,000
Ray Pascoe Park, Kennedy Drive Tweed Heads.	Low-medium	40m	Erosion affecting public open space on Banks of Terranora Creek. No risk to infrastructure and erosion of relatively minor consequence to use of park.	$30,000

Location	Priority	Length	Description	Estimate cost
Condong School, Condong	Low-medium	70m	Erosion of riverbank on crown land adjacent to school.	$50,000
Crown land opposite Condong Boat Ramp	Low-medium	200m	Erosion on riverbank on crown land, adjacent to houses on Tumbulgum Road.	$150,000
Total				**$630,000**

6.0 Planning and Environmental Approvals

When riverbank erosion stabilisation projects involve earth works or the placement of rock or any other material into a waterway, approval and permits are required to be sought from Council and a number of state government agencies.

The types of approvals required are different for Council and private land owners. For private landowners, the approval pathway is different when works are in tidal and non-tidal waters.

6.1 Council Work

Council is required to seek a Part V activity approval under the Environmental Planning and Assessment Act 1979 for riverbank stabilisation projects. Preparation of an application for Part V approval requires the undertaking of a review of environmental factors (REF). The REF process is aimed at identifying and assessing the significance of any potential impact of the proposed project on matters such as flora, fauna, water quality, cultural heritage etc.

If works are to be undertaken on Crown Land (or within a Crown waterway reserve), land owners consent to lodge an application to undertake the activity must be sought from the Department of Lands. Upon receipt of an approval to undertake works, a temporary license to occupy the Crown land and undertake the works must also be sought.

If works are to be undertaken within a waterway, a permit from the NSW Department of Primary Industries Fisheries must also be sought.

This process is applicable for works in both tidal and non-tidal waterways.

6.2 Work on Private Land

The Tweed LEP 2014 is the planning instrument that defines the permissibility and approval process required for work and activities in the Tweed Shire.

Under section 5.7 of the LEP 2014, Development Consent is required to carry out development on any land below the mean high water mark of any body of water subject to tidal influence (including the bed of any such water).

Under section 7.2 of the LEP 2014, development consent is required for earth works. Before granting consent for earthworks, Council must consider matters such as the proximity to, and the potential for adverse impacts on any waterway, drinking water catchment or environmentally sensitive area.

By virtue of the two sections of the Tweed LEP 2014 named above, all riverbank stabilisation projects that involve earth works or the use of rock, fill or other material, will required a development approval from Council. This covers both tidal and non-tidal waterways.

If works are to be undertaken on Crown Land (or within a Crown waterway reserve), land owners consent to lodge an application to undertake the activity must be sought from the Department of Lands.

If works are to be undertaken within a waterway, a permit from the NSW Department of Primary Industries Fisheries must also be sought.

Any bank stabilisation project involving earthworks, rock revetment or removal of vegetation will also require a Controlled Activity Permit from the NSW Office of Water.

Council has prepared a fact sheet, available on the internet at: xxxxxxx which provides further details and advice on the approval processes described above. This is included as **appendix 4** in this management plan.

7.0 Recommendations

1. As the institution with primary responsibility for management of the Tweed River, Council must continue to take a proactive, ongoing role in addressing riverbank erosion. Council should work with the community, State Government agencies and river users to stabilise riverbanks, addressing the impact of erosion on roads, river amenity and the environment.

2. Council must stabilise areas of riverbank erosion that threaten infrastructure, but also as a matter of urgency, implement trials of pre-emptive riverbank stabilisation techniques that can mitigate the ecological and amenity impacts of full bank height rock armour work.

3. All work to stabilise riverbank erosion in the Tweed River must be designed to minimise environmental impacts and maximise potential for incorporation of, or colonisation by riparian vegetation.

4. Increasing the ecological value and erosion resistance of riverbanks through revegetation, and maximising existing habitat values will be an important part of offsetting the ongoing negative impacts of large structural erosion stabilisation projects.

5. Riverbank stabilisation and revegetation at sites identified in table 5.1, 5.2 and 5.3 should be delivered over a ten year program of works.

6. Council must work to identify a source of funding that can be used to address severe bank erosion adjacent to roads, prior to erosion becoming an immediate threat to road stability and public safety.

Appendix 1: Council Report on Wake Management Options

TITLE:
SUBMITTED BY: Natural Resource Management

Valid

Caring for the Environment

LINKAGE TO INTEGRATED PLANNING AND REPORTING FRAMEWORK:

4	Caring for the Environment
4.3	Maintain and enhance Tweed's waterways and its catchments

SUMMARY OF REPORT:
This report provides Council with information relating to erosion of the Tweed River (estuary only) banks, and deals specifically with the impact that power boat wake has on riverbank erosion and consequent impact on road infrastructure.

The report provides Council with an opportunity to adopt a position on power boat wake, as it relates to riverbank erosion, that could inform:

- development of a policy relating to commercial use of the river for activities that may create significant wake.
- a submission to NSW Department of Roads and Maritime Services on the issue of wake management in their review of the Tweed River Estuary Boating Plan of management.

The report contains a detailed description of the current state of riverbank erosion, and highlights potential costs to manage the problems in the next five to ten years.

The report includes a summary of community submissions to the Impact of Wake on Tweed Riverbank Erosion Study (2012).

RECOMMENDATION:
That Council:

1. **Continues to take a proactive, ongoing role in addressing riverbank erosion. Council should work with the community, State Government agencies and river users to address the issue of riverbank erosion, and its impact on roads and the environment. Council's activities in managing riverbank erosion should acknowledge that wake waves are one of several important factors that cause erosion.**

2. **Continues to stabilise areas of riverbank erosion as required, but also as a matter of urgency, implement trials of pre-emptive riverbank stabilisation techniques that can mitigate the ecological and amenity impacts of full bank height rock armour work.**

3. **Investigates funding options for pre-emptive stabilisation of riverbank erosion adjacent to Tumbulgum Road and the Tweed Valley Way. Council should also liaise with the Department of Roads and Maritime Services to identify sources of funding that can be used to build the resilience of riverbanks adjacent to the**

Tweed Valley Way, rather than rely on disaster relief funding and emergency repairs as a primary means of managing riverbank erosion.

4. **Writes to both the NSW Office of Environment and Heritage and NSW Roads and Maritime Services highlighting the level of erosion vulnerability of certain sections of the Stotts Island riverbank, and recommend to Roads and Maritime Services and Office of Environment and Heritage that the river reach adjacent to Stotts Island be designated as a no towing zone.**

5. **Writes to NSW Roads and Maritime Services (RMS) advising the department that Council considers use of wake enhancement devices and wake surfing on the Tweed River to be incompatible with Council's objective of reducing riverbank erosion and the related impacts on roads and the environment. RMS be requested to ban use of such devices and wake surfing on the Tweed River.**

6. **Proactively partners with and supports the Tweed Water Ski Club led boat driver education program, as a means of maximising the effectiveness of this program and encouraging best practice vessel use to achieve environmental outcomes and reduction of wake impact on riverbank erosion.**

7. **Adopts a policy position that precludes operation of commercial towing activities on the Tweed River, and that this position be embodied in the report requested from officers as per item 13 of the Council meeting Thursday 20 June 2013, that being:**

   That Council brings forward a report no later than the April 2014 Council meeting outlining a comprehensive planning proposal capable of adoption by Council to regulate commercial wakeboarding operations and events throughout the Tweed Shire.

REPORT:

1.0 Introduction

This report provides Council with information relating to erosion of the Tweed River (estuary only) banks, and deals specifically with the impact that power boat wake has on riverbank erosion.

The report provides Council with an opportunity to adopt a position on power boat wake, as it relates to riverbank erosion, that could inform:

- development of a policy relating to commercial use of the river for activities that may create significant wake,
- a submission to NSW Department of Roads and Maritime Services (RMS) on the issue of wake management in their review of the Tweed River Estuary Boating Plan of management.

It is noted that Council has a limited ability to take action on the issue of vessel use and wake creation in the Tweed River. RMS controls this activity, with regulations set out in the Tweed Estuary Boating Plan of Management. Council has been advised that RMS intends to undertake a review of the Tweed Estuary Boating Plan of Management, and it is expected that Council will make a submission on a draft document as part of the plan review process.

Council has an important role in assessing applications for commercial use of vessels on the river, managing the environmental condition of the Tweed River, and protecting public assets that may be damaged by riverbank erosion. Council spends significant sums on stabilising riverbank erosion adjacent to public land, particularly roads.

This report summarises the current level of riverbank erosion in the Tweed estuary and provides information on the works required to address existing and probable future erosion problems. This has been informed by recent riverbank erosion inspections (July 2013) and the costs associated with recent erosion stabilisation work.

In a discussion of the impact of wake, this report takes information from the Impact of Wake on Tweed Riverbank Erosion Study (SMEC, 2012), and addresses the key points of submissions made by the public and State Government Agencies to it.

Recommendations in this report have been developed in conjunction with the Tweed River Committee.

2.0 Riverbank Condition in the Tweed Estuary

Council's Natural Resource Management Unit has recently mapped and classified riverbank erosion in the Tweed estuary. Table 2 provides a summary of bank erosion severity, and highlights the river reaches between the Bray Park Weir and the river mouth where erosion is most serious.

This classification is based on manned vessel inspections undertaken in July 2013, using a GPS to locate areas of bank erosion. The river was broken into reaches, and then each reach into sections, as a means of assessing stability status. Overall stability/erosion condition is summarised reach by reach in table 2. Reaches have been given a colour coded erosion classification, as follows:

Table 1. Erosion classification code.

Generally stable:	Low risk of problem erosion.
Vulnerable:	Significant risk of erosion initiating, or erosion becoming worse.
Active and severe:	Bank is eroding, high risk of erosion increasing.

It is noted that there are exceptions to the overall summarised condition with in a reach. For example, within reaches classified overall as being, 'generally stable' there may be some severe, localised erosion, and vice versa. The table also provides a brief assessment of the implications of erosion, primarily as it relates to *management of Council infrastructure or land*. As such, erosion affecting private agricultural or residential land is not identified as a serious problem, *for Council*. The table does not present the environmental implications of riverbank erosion.

A more detailed assessment and presentation of riverbank condition will be presented in the Tweed Riverbank Erosion Management Plan 2013. This document will also provide a series of detailed recommendations on how Council should prioritise allocation of resources to address riverbank erosion. Upon completion, this document will be presented to Council for adoption. More detailed maps of riverbank erosion are provided as an appendix to this report.

Note: Left and right bank are indicated, this refers to left and right bank when looking down stream.

Table 2. Summary of erosion status.

Reach	Overall classification	Management Implication
Bray Park Weir to Dunbible Creek - Left	Generally stable	Some opportunities for bank revegetation should be pursued with land owners.
Bray Park Weir to Dunbible Creek - Right	Generally stable, but includes a 200 m section highly vulnerable, and a section of 100 which is severely eroded.	No public assets at risk. Erosion in this location will impact on the operation of a cane farm and grazing land. Erosion on outside river bend. Environmental and landowner benefits would be gained through stabilisation.
Dunbible Creek to Murwillumbah Bridge - Left	Vulnerable, with some severe erosion.	No public assets at immediate risk, however Commercial Road flood levee wall and park land at the boat ramp are adjacent to a vulnerable and eroding bank. Cane farm affected by severe erosion over a significant length.
Dunbible Creek to Murwillumbah Bridge - Right	Generally stable, with a significant vulnerable bank upstream of Murwillumbah bridge on Council land, and some sections of severe	Several private homes need protection. Ongoing loss of grazing land will also occur if not stabilised. Council land should be managed to

Reach	Overall classification	Management Implication
	erosion on private land.	increase bank resilience.
Murwillumbah Bridge to Condong Bridge - Left	Variable. Some severe erosion, some stable areas. Significant potential to improve riverbank management and reduce erosion in upper part of reach.	No public assets at risk. Proposed area for investment by Council Waterways Program.
Murwillumbah Bridge to Condong Bridge - Right	High vulnerability with severe erosion present. Recent major slips requiring bank stabilisation by Council. High risk of multiple additional bank slips in the area. Residential land is almost all protected by rock walls - if not, it is severely eroding.	Approx. 700m of Tweed Valley Way potentially affected by erosion and requiring ongoing stabilisation work as slips occur.
Condong Bridge to Tumbulgum - Left	Significant erosion over most of the reach, some severe. Multiple slips affecting Tumbulgum Road. Most of the reach is vulnerable to erosion. One stable section supports good native vegetation and will be enhanced through revegetation.	Approx 2.5 km length of Tumbulgum Road threatened by erosion and requiring ongoing stabilisation work as slips occur.
Condong Bridge to Tumbulgum - Right	Vulnerable, with sections of severe erosion over majority of reach.	Approx. 1.5 km length of Tweed Valley Way threatened by erosion and requiring ongoing stabilisation work as slips occur. Parkland at Condong and Condong School grounds also require protection.
Tumbulgum to McCauley's Road boat ramp - Left	Severe erosion upstream of Tumbulgum Bridge, however generally stable downstream of bridge to McCauley's Road boat ramp.	Approx. 600 metre section of Dulguigan Road threatened by erosion and will require ongoing stabilisation work.
Tumbulgum to Stotts Island - Right	Severe erosion. Over much of the reach, stability is only provided by recent heavy duty rock armour, or old rock armour, which is at high risk of failure.	Approx. 1000 metre section of Tweed Valley Way threatened, and will require ongoing stabilisation work at multiple locations.
Stotts Island	Some areas vulnerable, and showing signs of active erosion. The majority of the bank is stable.	Highly significant nature reserve that should be protected from erosion. No potential for armouring of bank.
McCauley's Road boat	Generally stable. One bad	Slip on grazing land.

Reach	Overall classification	Management Implication
ramp to River Road, Banora Point - Left	slip.	
Stotts Island east to Dodd's Island west - Right	Generally stable, signs of loss of mangroves due to scouring/undermining.	Bank adjacent to road reserve/cane land.
Dodd's Island to Chinderah boat ramp - Right	Severe erosion present on Dodd's Island. Dodd's channel to Chinderah stable.	Dodd's Island is private land.
Chinderah boat ramp to Barneys Point Bridge - Right	Generally stable, however riverbank behind caravan park has been poorly armoured with concrete debris. Area is unstable and has very low amenity value.	Land behind caravan park is public open space and requires significant work to achieve a good amenity outcome.
Barneys Point Bridge to Tweed Bar - Right	Stable. Entire river foreshore is armoured. Maintenance required at some locations.	Ad hoc maintenance required.
River Road Banora Point to Barney's Point Bridge - Left	Severe erosion present on River Road and adjacent to Oxley Cove Canal Estate entrance. Natural bank downstream of canal estate vulnerable.	Stabilisation work required - urgent at canal estate entrance.
Barneys Point Bridge to Tweed Bar - Left	Generally stable. Some natural erosion on Ukerebagh Island. Some vulnerable areas adjacent to golf course.	No major maintenance or management required.
Terranora	Multiple minor erosion problems that can be addressed as resources permit. Most significant erosion area is downstream of Ray Pascoe Park on Kennedy drive.	Risk of exposure of old landfill material adjacent to Ray Pascoe Park.
Rous River	Not formally mapped. Significant areas of erosion vulnerability adjacent to private cane land.	Some areas of Dulguigan Road threatened.

River reaches with the most severe and continuous bank erosion are located between Murwillumbah and Stotts Island, primarily adjacent to the Tweed Valley Way and Tumbulgum Road. In public infrastructure and asset management terms, this is the most important section of the river for bank erosion management. For the purpose of further discussion, this part of the river will be described as the 'priority reach'. Within the priority reach, erosion is predominantly impacting on road reserve, as opposed to private land or public open space. It is estimated that there is approximately 6000 metres of roadway within the priority reach that is at risk of being affected by bank slips within the next five to ten years. At an estimated cost of $1500 per lineal metre to stabilise riverbank erosion (based on the average cost per metre rate of erosion stabilisation work recently undertaken by Council), the total cost to stabilise severe erosion adjacent to roads could be up to $9,000,000 over ten years. Maintenance costs would add to this figure. A more fine scale

classification of the distance between the river and the road will be presented in the Tweed Riverbank Erosion Management Plan 2013. This will provide Council with greater confidence in the length of road that will potentially require stabilisation within the five to ten year planning horizon.

This sum noted above is comparable to the cost of $7,700,000 estimated in the SMEC report to undertake rock armour bank stabilisation projects from Condong to Stotts Island. The SMEC estimate involved addressing all visible erosion, as opposed to focusing on erosion affecting roads. The SMEC report identifies a total cost of $10,000,000 to stabilise all visibly eroding areas within the estuary, without differentiating between public or private land, or the land use that is threatened by erosion. Over the last four financial years, Council has expended approximately $1,200,000 on riverbank stabilisation in the estuary, between Murwillumbah and Stotts Island.

A major implication of the concentration of severe riverbank erosion within very close proximity to roads is that it will predominantly need to be stabilised by constructing rock armour from the toe to the top of the bank. The need to protect assets with a high level of certainty and immediacy precludes the use of more natural, 'bio-engineered' options. As a result, there may be significant areas within the Tweed River estuary in which full height rock armour will have a serious impact on visual amenity and environmental quality. It is hoped that trials of vegetation establishment within and on the top of rock walls will lead to the development of techniques that can effectively camouflage these structures.

It should be an urgent priority for Council to develop a pre-emptive approach to bank stabilisation within the priority reach. This would involve installing rock protection to the toe of banks that are vulnerable, but not already in a severely eroded condition, and then encouraging vegetation at both the toe and top of bank. This type of erosion control structure is called a rock fillet. In this reach of the Tweed, they would be constructed two to three metres out from the toe, with the aim of creating a low energy zone where mangroves or reeds could flourish, landward of the rock fillet. Rock protection would also be provided at the immediate bank toe to protect against undermining, and where necessary, bank tops battered to create a stable angle for revegetation. While this approach has several advantages, sites suitable for such treatment may be limited, and the costs no less than a full height armour approach. The advantages of this approach include significantly improved aesthetic and environmental outcomes. Figure 1 below shows a schematic view of rock fillets, and the photograph in figure 2 shows part of the Chinderah foreshore where this approach has been implemented adjacent to Chinderah Bay Drive. In this area, mangrove recruitment has been prolific and bank erosion fully contained.

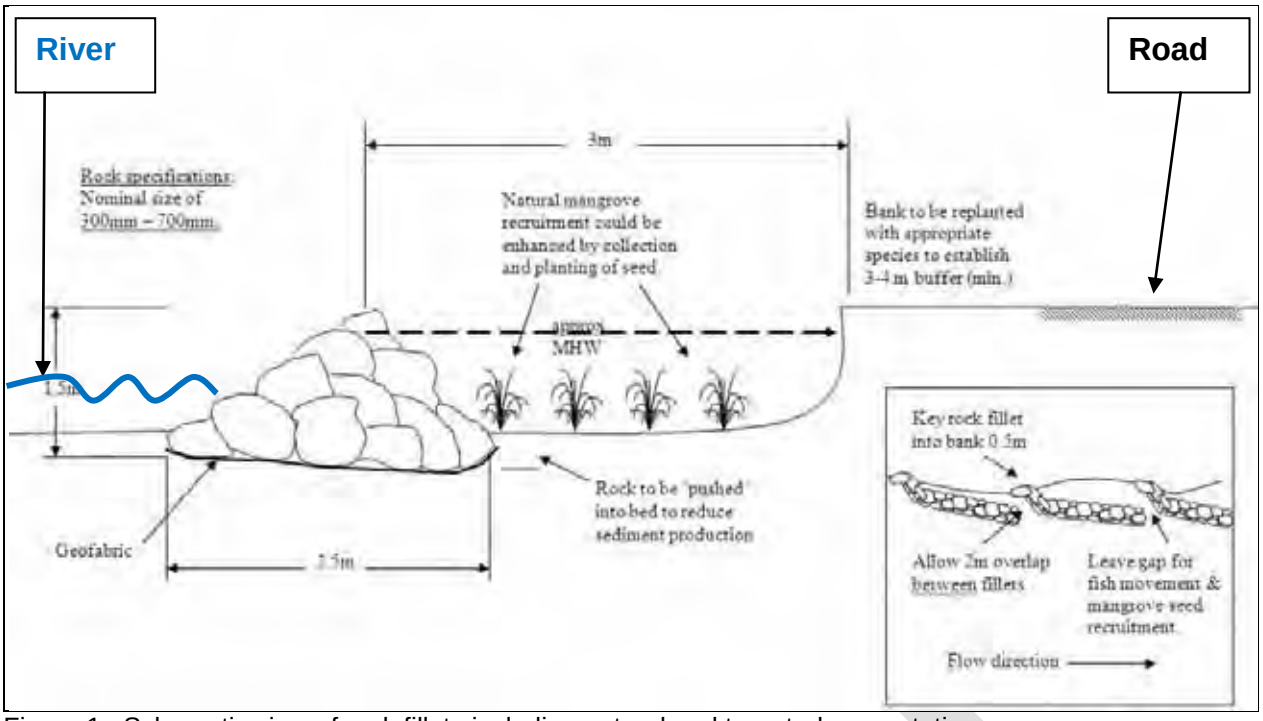


Figure 1. Schematic view of rock fillets including natural and targeted revegetation.

Figure 2. Rock fillets constructed on Chinderah bay drive showing natural mangrove recruitment. This area provides excellent fish habitat, a high level of erosion protection and will eventually have a very low visual impact.

2.1 Prioritising Council Work

Riverbank erosion stabilisation is undertaken by three Council work units:

- Works - where erosion affects roads.
- Infrastructure - where erosion affects levee banks and flood gates.
- Waterways Program - where erosion affects public open space or waterways infrastructure (canals, jetties, boat ramps).

Each work unit will prioritise stabilisation of erosion sites based on the risk posed by erosion to the asset being managed, and availability of funding to undertake the works.

Erosion is not gradual or consistent in severity along large stretches of bank, particularly the areas adjacent to the Tweed Valley Way and Tumbulgum Road. Erosion occurs as 'slips', which result in sections of bank falling into the river, and creating a high risk of damage to the adjacent roadway. Figure 3 below shows a typical slip and proximity to the Tweed Valley Way.

Figure 3. Bank slip adjacent to the Tweed Valley Way near Stotts Island. Road safety barrier anchor posts can be seen exposed in the top of the bank.

In the priority reach, it is unlikely, given the degraded nature of the riverbanks and the potential for banks to slip following floods, that bank erosion can be prevented exclusively through enhanced vessel or vegetation management. Bank erosion will need to be remediated through a structural approach as described above.

Council's Waterways Program has identified three areas in the estuary where bank stabilisation will be prioritised within its work program. This includes the Oxley Cove Canal Estate entrance, in park land adjacent to Condong boat ramp, and riverbank grazing land near Murwillumbah. The Waterways Program also works continually to stabilise small scale areas of erosion adjacent to waterways infrastructure and parks in Terranora Creek and adjacent to Cudgen, Cudgera and Mooball Creeks.

Council's Works Unit and Infrastructure Unit will continue to address priority bank erosion as it occurs, with risk assessments being regularly undertaken to determine where and when bank erosion threatens infrastructure. Council's Engineering and Operations Division does not currently allocate funding to pre-emptive management of erosion adjacent to the roads affected. Funding for bank stabilisation works is accessed through State Government emergency restoration funding following flood events.

3.0 Causes of Riverbank Erosion

In 1998 Council engaged Patterson Britton and Partners to produce the Tweed River Estuary Bank Management Plan. This plan included a comprehensive survey of erosion and identification of factors causing erosion in the Tweed estuary.

Factors identified as contributing to bank erosion included:

- Altered flow patterns due to catchment changes and river bed disturbance (catchment clearing and gravel extraction)
- Tidal currents
- Floods, in particular slumping of saturated riverbanks following floods
- Wind and boat waves

In January 2011 Council appointed SMEC to prepare an investigation into the impact of boat wake on riverbank erosion.

This report included:

- A review of current literature and knowledge in relation to the impact of boat wake on riverbank erosion.
- Mapping and classification of erosion.
- An estimate of the potential costs of stabilising riverbank erosion.
- A comparison of wind and wake wave energy in the Tweed River, and discussion of the relative importance of power boat wake as a causal factor in riverbank erosion.
- A discussion of theoretical options for vessel and wake management.
- Recommended priorities for Council works to stabilise severe areas of bank erosion.

It was concluded in the SMEC report that:

- Vessel wake has the potential to cause and increase erosion of riverbanks in the study area, particularly the sheltered upper estuary.
- Towing activities are the vessel activities most likely to cause wake waves capable of causing significant bank erosion. This is due to the repetitive nature of the activity within a river reach, the practice vessels coming onto and off the plane numerous times and undertaking turns under power to retrieve fallen riders. It was identified that wake boarding has the potential to cause higher energy waves than water skiing due to the typically slower speeds at which wake boarding is practiced. The maximum wave energy that is created by all small powered vessels is similar, and occurs as vessels are moving at approximately nine knots and coming onto, or off a planeing trim.
- Wake from towing activities has become a dominant riverbank erosion mechanism in the Tweed estuary.

SMEC confirmed findings of the Patterson Britton report (1998) that other dominant factors affecting erosion in the Tweed River are flooding, river bed and bank morphology (position

in bend, depth, bank material, bank height) and riverbank condition (existing vegetation cover and type, existing bank protection).

Riverbank erosion seen in the Tweed estuary, and in particular the priority reach between Murwillumbah and Stotts Island, is a result of the combination and interaction of the four factors of (1) wake waves, (2) flooding, (3) river bed and bank morphology and (4) riverbank condition.

It would be very difficult to apportion relative blame to these factors, and transpose this across the entire estuary, or the priority reach. It is not possible to isolate a single, most significant factor, causing erosion in the priority reach.

For erosion at a particular site, detailed investigation and measurement would allow a specific assessment of the relative importance of each of the aforementioned factors in causing erosion.

Of particular importance in the existing condition of riverbanks in the priority reach is the presence of significant lengths of old riverbank toe protection. Figure 4 below shows a typical example of this feature. This rock armour is thought to have been constructed during the 1960's and 1970's. The rock armour is situated predominantly at the toe of the riverbank, forming a band approximate 1m high, and was constructed by hand using small (100-300 mm) quarried stone. Where it remains in good condition, this bank protection is significantly increasing bank stability, particularly where it occurs in conjunction with mangroves and top of bank vegetation. Conversely, where it can be seen that the old rock protection has failed or been outflanked, serious bank erosion is occurring.

3.1 Environmental Impacts of Riverbank Erosion

The three major impacts of riverbank erosion are discussed briefly below.

Water quality

Riverbank erosion increases river turbidity and nutrient levels due to the large amount of sediment that is contributed to the river following bank loss. High turbidity and nutrient levels are a key water quality problem affecting the Tweed River estuary.

Loss of habitat

Riverbank erosion often results in the undermining of trees. In many parts of the Tweed, riparian vegetation is found in narrow and fragmented corridors. Loss of canopy trees and width in riparian corridors further reduces bank stability, degrades aquatic habitat and impacts on the ability of fauna to utilise or move through riverbank areas.

Impacts of undertaking bank stabilisation works

Stabilising riverbank erosion with rock is a very resource intensive process. Importing large volumes of quarried rock to site is extremely expensive and has an array of impacts ranging from fuel use to traffic disruption. The site specific impacts of riverbank stabilisation works include a loss of habitat at both the top and toe of riverbanks, and a severe visual impact for river users. Given the extent of severe riverbank erosion in the priority reach, and its proximity to important roads, it is likely that the ongoing efforts to address bank stability in the Tweed River will have a significant, detrimental impact on riverbank environmental and amenity values.

3.2 The Impact of Wake Waves on Riverbank Erosion

Waves are an expression of energy. When waves break in shallow water, kinetic energy is transformed into force which can displace riverbank sediments. Depending on riverbank morphology and tidal state, waves, either wind or wake generated, may either break in shallow water on a gently sloping tidal beach, or impact directly on steep unconsolidated riverbanks. Waves breaking on beaches or directly onto riverbanks can displace sediments and lead to undermining of banks, increasing the risk of bank failure, or slips.

Boat traffic in the river has increased wake wave energy, over and above that experienced under natural conditions. This has decreased the frequency and duration of low wave energy periods. In certain areas, wake wave energy has the ability to continually re-mobilise fine sediments deposited at bank toes, restrict the colonisation of bank toes by aquatic vegetation, and erode fine sediment from around mangrove and reed root zones. As such, a high level of wake creation has reduced the ability for riverbank toes to recover and restabilise in inter-flood periods. This occurs within the context of a river that is highly modified by riverbank and catchment clearing, dredging and artificial armouring of banks in many locations.

It is considered that an increase in the frequency of large wake wave generation in the river over the past decade, following the rise in popularity of wake boarding, and the more frequent use of vessels producing an atypically large wake wave, may have accelerated out flanking and deterioration of the historic bank armouring. Increased vessel traffic in the Tweed River, and the use of vessels designed to create larger than average wake waves, adds cumulatively to the erosion forces acting on riverbanks, and increases the risk of slips occurring at vulnerable locations within the priority reach.

While it is not possible to single out wake waves as the most important cause of bank erosion, it is clear that large waves occur more frequently as a result of boating activity of all types. In the case of the priority reach, where towing activities are most popular and natural wind wave energy is generally low, it is reasonable to conclude that wake wave energy has the potential to make riverbank erosion, which is already a problem, worse.

3.3 Community and State Government Response to the Wake Study

Council put the Impact of Wake on Tweed Riverbank Erosion Study on public exhibition in March 2012. Theoretical management options used to generate a cost benefit analysis of erosion management included the concept of restricting towing activities on the river. The study created significant attention and generated a large number of submissions. By far the majority of submissions were template emails generated by a website created to encourage objections to the concept of restricting towing activities on the Tweed. The website was created by an organisation called the Tweed River Awareness Committee (TRAC) and encouraged submissions to the study based on a misleading statement concerning the content of the study, and Council's intent and powers with respect to management of vessels. The website and a copy of the wording of the template email are included as figure 5 below.

Figure 5. TRAC Website landing page.

The intent of the SMEC Wake Impact Study, as specifically described in the executive summary on page one of the document is as follows:

"A number of mitigation options have been suggested for consideration in managing the accelerated rate of bank erosion within the Tweed River based on the river characteristics and the physical mechanisms of erosion. The possible erosion management options range from non-engineered preventative measures to engineered hard protection.

Based on the findings of the assessment a series of hypothetical management options have been subject to a cost benefit analysis as a means of broadly demonstrating the economic, social and environmental impacts of recreational towing activities that generate wake in the Tweed estuary. The analysis is presented for discussion purposes only, to inform debate on the relative merits of the types of management options considered."

The TRAC web page significantly undermined the potential for well informed debate on the true content of the report and the possibilities for improved management of the river. Regardless, the number of submissions generated by the website clearly show that the Tweed is a popular and highly used waterway for water skiing and wake boarding.

The wording of the generic email generated by the TRAC website is as follows:

"My name is xxxx from xxxx and I am a user of the Tweed River and support local business. This is my submission of opposition to the Impact of Wake Study and to the banning of power boats on the Tweed River. I am opposed to any changes to the current status of the Tweed River in relation to boating activities. If you attempt to implement any restrictions or

ban power boats, jet skis or towing in any way I will make a statement in September (2012) at the Council election."

Many of the submissions also included brief comments relating to the individuals opinion of the validity of the findings of the study, or highlighted the recreational benefits of skiing and wake boarding, particularly their value as sports that families enjoy together. Submissions emphasised the benefit of skiing and wake boarding on local businesses and submissions from non-Tweed residents emphasised water sports as the reason that they come to the Tweed.

An analysis of the submissions by the location nominated as the persons address shows that 29.7% of the 511 submissions received were generated by people from within the Tweed, 30.9% from people in neighbouring LGA's (predominantly the Gold Coast), and 39.3% from further afield.

A significant number non-generic submissions to the study were also received. Despite the broad range of issues covered in the wake study, almost all submissions were singularly concentrated on the issue of the possibility of restrictions being imposed on towing activities. The following summary of submissions covers the key points made, both for and against towing activities. A number of the submissions expressing opposition to any change in the existing level of regulation of towing activity make well informed and valid criticisms regarding the methodology of the study. Separate tables have been used to summarise submissions for and against restrictions on towing activities, and to summarise the response of State Government agencies to the study.

Table 3. Submissions in support of increased controls on towing activity

Source of submission	Summary of key points
North Tumbulgum resident	• Pleased that TSC is considering erosion of the river as erosion is cause for alarm. • Bank erosion has become dangerous and threatens Dulguigan Road. • Recent acceleration of erosion noted. • Cruise vessel a significant contributing factor. • Increasing number of wake boarders can be seen to be attacking banks. • Wakeboarding needs to be restricted to areas of river not prone to high levels of erosion. • Cruise boat skippers need to keep well away from riverbanks.
Charter boat operator	• Clients use Rous River to escape wake impact of wake board vessels. Wake board impact has impact on business. • Considers that wakeboarding is main cause of riverbank erosion. • Wake boarding has an impact on fishers, with wake 'almost tipping them out of their boats'. • Water skies have a much less pronounced wake, only creating a large wake when they turn to pick up skiers. • Wake boarding should use more suitable areas in lower estuary where there are revetment walls or beaches. • Not practical for Council to build revetment walls the entire length of the river, and it would destroy habitat if this did occur. • Wakeboarding destroys habitat.
Dunbible resident	• Far upper reach of estuary not badly affected by towing activities,

Source of submission	Summary of key points
	but still affected by wake erosion from power boats and jet skis. • On unstable sections of bank impacted by wake, work on reshaping and revegetation without rock is probably futile. • Compliance of rules of operation of power boats is ineffective. The most effective solution is to exclude power boats from certain sections of the river ineffective. The most effective solution is to exclude power boats from certain sections of the river. • Requests that power boats and jet ski's be excluded from tweed River upstream of Condong bridge
Oxley Cove Community Group	• Study provides a basis to introduce bylaws to restrict wakeboarding and slow tow activities in environmentally sensitive areas to protect the river ecosystem. • Slow tow activities are causing mangroves to be undermined, riverbanks to be eroded, destruction of seagrass, erosion of sand island bird habitats. • Wake board boast using ballast tanks create the most damage. • Concerned regarding the effect of wake on other passive users including kayaks, house boats, fishers in boats and on banks • Majority of people using the Tweed for towing are visitors, seem to create little commercial benefit to local business operators. • Tweed rate payers are paying costs of damage caused by others. • Due to cost to Tweed ratepayers, request that Council impose limits on use of tow vessels to area that are not environmentally sensitive, and to areas where cost of protective work is not prohibitive. • If suitable area cannot be found the activities should be banned.
Murwillumbah Resident	• I own two river front properties in Murwillumbah • They are both eroding • I am vehemently opposed to skiing and in particular wake boarding in front of residential properties in Murwillumbah due to the riverbank erosion that these activities cause • Riverbank erosion should be controlled with rock
Helidon Resident	• Author has constructed a private water ski lake which has been used for official competitions • Has found that American designed tow boats are much heavier than Australian designed ski boats and cause much more damage to riverbanks • Erosion and large wake has escalated over the past ten years • Controlling the weight of tow boats could assist with reduction in wake energy and erosion
Fingal Community Association	• Favour implementation of a no towing policy on the Tweed River • Recommend Tweed Shire council act to prevent ongoing damage to riverbanks and other environmental resources • SMEC study clearly outlines riverbank vulnerability to towing activity in present, and the potential for cumulative impact in future.

Source of submission	Summary of key points
	• Ratepayers are covering the costs of riverbank damage so that a privileged few can enjoy themselves • Wake boarding is increasing, with a corresponding increase in wake and its cumulative impact • No one is monitoring the increase to quantify impacts • There is insufficient compliance by NSW Maritime • Towing activities negatively impact on more peaceful river activities • Potential of wake to impact on sites of Aboriginal cultural significance • Lower estuary has internationally recognised value as habitat for migratory birds - loud wake producing activity conflicts with these values, and there is no compliance action to control impacts • Fair and equitable access to boating facilities and calm water for passive users is being affected by increasing dominance of large wake producing vessels • As ratepayers we refuse to bear the cost of the impact of a minority of recreational and commercial towing activities on our vulnerable river
Town planning consultant - acting for a potential commercial water sports operator	• The theoretical option of protecting all riverbanks between Condong and Stotts Island and restricting towing activities to this river reach should be pursued
Tweed Resident	• Based on the wake study and its findings, commercial and recreational wake boarding, water skiing and jet skiing should be banned from the Tweed River • Towing activities have been banned in QLD which is why they are increasing here • Towing vessels are destroying the unique natural ambience and beauty of the Tweed River • Passive river uses such as fishing, kayaking and picnicking are being negatively affected by continuous intrusive noise • If motorised activities continue to grow it will have an irreversible long term impact on biodiversity and ecological balance of the river. • It is Council's obligation to protect and enhance the river • Long term sustainability should be given priority over short term economic gain
Tweed Resident	• Recommend that all towing activities be banned • Council should support existing passive recreational use and low impact commercial activities in efforts to seek economic gain from the river • The river is nationally recognised for unique and diverse ecosystem and Aboriginal cultural heritage and quiet natural ambience • I have seen a substantial increase in motor boat activity, this is due to intensive motor activities being banned from rivers on the gold coast. The majority of wake, ski and jet ski boats operating on the Tweed are Queensland registered

Source of submission	Summary of key points
	• Protect and enhance the environment for residents and visitors for years to come
Tweed Resident	• Have lived on river for ten years and spent $50,000 on repair to erosion and retaining walls • Use of towing vessels is degrading the river at an alarming arte • Often boats impede rowers, fishermen and leisure craft and do not observe safety regulations • Have attempted to revegetate riverbank and this is near impossible due to wake • River should be used by recreational craft but should be limited to appropriate areas where erosion damage is minimised

Table 4. Submissions against increased controls on towing activity

Source of submission	Summary of key points
Murwillumbah Resident	• Strongly encourage council to maintain the status quo and allow continued use of all current areas for towing activities. • Purchased water front property in order to be able to ski from the property. • River reach from Murwillumbah to Condong is an excellent place to ski due to calm conditions and less busy than closer to Tumbulgum. • Restricting towing activities in one reach of the river will concentrate impacts in another reach and increase danger. • Most houses from Murwillumbah to Condong have walls protecting their property and many have boats and jetties so they can utilise the area. • Considers that erosion in Murwillumbah to Condong reach is not significant or extensive. Proactive steps should be undertaken to stabilise erosion rather than restrictions on towing. • Towing brings visitors and money to the local economy.
Gold Coast Resident	• Strong opposition to banning of power boats • There should be no restrictions whatsoever, any existing restrictions should be lifted • People who don't like boats are in the minority • I will never accept any restrictions to power boating • Boating has been part of life on the Tweed for generations • Skiing and fishing are healthy activities for kids • Restrictions concentrate uses into smaller areas causing congestion and increasing safety concerns • Riverbank erosion is natural and not bad for a river • Council should stop wasting time and money on this issue • Council should ignore minority and interest groups
Murwillumbah Resident	• The Impact of wake study is bias and incorrect • Study over estimates ski boat traffic on the river • Erosion exists in many areas where there is no skiing or wake boarding • Erosion is also caused by natural factors-skiing can't be blamed

Source of submission	Summary of key points
Banora Point Resident	• 30 years experience in skiing and wake boarding, and very environmentally conscious • Considers experienced participants all respect the environment • Some inexperienced participants can tarnish image of sport • Only very advanced riders use large wakes (wake enhancing devices). The predominant user group in the Tweed are intermediate and do not ride a large wake. • Cruise boats produce a larger wake than most wake board boats • Disputes findings of SMEC study, claims bias against towing, and in particular an over estimate of the numbers of boats and riders using the river, as well as a lack of focus on non-towing vessels as a cause of wake. This results in an over estimation of the amount of wake being produced in the river, and unfair apportioning of blame for erosion on towing. • Requests that real data on all vessel movements be used to identify impacts • Notes that erosion is often adjacent to cleared agricultural areas, and that these areas are subject to erosion regardless of wake • Supports the concept of user pays licence for towing, similar to a fishing license • Supports no change to existing towing restrictions, advocates ongoing education of users and fixing eroding areas
Murwillumbah Resident	• Very concerned about any proposed changes to uses of the Tweed River arising from the Wake Impact Study • Assumed numbers of vessels using the river in calculations in wake impact assessment have been over estimated • Notes lack of adherence to existing regulations by some vessels, and identifies lack of signage and lack of compliance enforcement by NSW maritime as a major existing issue • Suggests adoption of a towing permit system which allows education and collection of a nominal fee • Economic benefit of towing sports extends to people who move to Murwillumbah and live here because of their ability to ski • First step should be to better educate people on impacts and ensure compliance with existing regulations
Kingscliff Resident	• Does not believe the wake study provides a rational basis for changed vessel management • Erosion has not become worse on the river in the period 1998 - 2012, based on results of inspections undertaken during Patterson Britton Study and SMEC study. • Based on findings above, disputes projections that erosion will become worse due to wake creation • Notes that several high priority sites for erosion stabilisation described in 1998 study are still recommend for treatment in 2012 study, that is, no work untaken over period - evidence that erosion is not continuing/worsening. Provides additional examples of areas that have not become more eroded in intervening study period. Implication is that boat use over past 13 years has had very little detrimental effect on riverbank

Source of submission	Summary of key points
	erosion. • Disputes assumption that tow boats will travel 22 m from bank, and provides calculations to suggest waves would be more attenuated than assumed in SMEC calculations. Implication is that wake waves energy is overstated in SMEC report. • Suggests that implied costs to manage riverbank erosion in cost benefit analysis will not actually be spent by TSC • Expresses concern with option to restrict towing to a certain river reach - due to problems with safety. Notes that there is a cost implication of trying to mange a user pays system, and that inequities arise in comparison to other free Council services like libraries, beaches and parks. • Recommends maintaining existing towing activities with installation of additional riverbank stabilisation works as required • Maintain river assets in an acceptable condition • Monitor erosion
Murwillumbah Resident	• Resident of Tumbulgum Road for 20 years • Have seen erosion of the bank but disagree that towing activities are the main cause of erosion • Water skiing and wake boarding are great family sports, particularly undertaken together from the back yard • Purchased property for specific purpose of skiing and wakeboarding • Our family investment in the sport has a very significant impact on local businesses, and this is multiplied many times due to the large number of locals participating • A restriction on towing in the Murwillumbah to Condong reach would detrimentally affect property prices. • 25 years ago there were only two families with ski boats in the river reach, now nearly every property in the reach has a water ski or wake board boat and pontoon • Bank erosion is caused by floods, saturated riverbank soils, and the only way to stabilise banks is by building a rock wall. • Some erosion in the Murwillumbah reach adjacent to farm land is caused by spraying of reeds with herbicide, rabbit burrows and uncontrolled cattle access • Wind can do more damage in certain areas than boat wake • Cruise boast crate a larger wake than towing activities • The number of vessels using the river for towing are significantly over estimated - leading to an over estimate of wake creation in the SMEC report • Restricting use in certain areas will increase traffic in other areas and lead to accidents. This management option is totally unacceptable • Areas where towing does not occur show significant erosion. This shows that other factors such as ground saturation, flood events, debris damage, live stock and rabbit burrows are the cause • Sections of Tweed Valley Way and Tumbulgum Road are built

Source of submission	Summary of key points
	too close to the river • Best method to stabilise banks is to dredge the river and use spoil to armour banks • Council should be promoting the river as a fabulous destination, not scaring off tourism dollars or investors • Please do not change regulations on towing activities
Ports and Coastal Environmental Pty Ltd - commissioned review	• Identifies that specific baseline data on wave characteristics was not collected in the area • Identifies that actual statistics of boating use were not collected for the study area - estimates based on prior survey used • Removing towing activities in the expectation that it would address the root causes of erosion is misguided. Significant investment would still need to be undertaken to protect infrastructure • Highlights concerns with using SMEC study as a definitive management tool due to issues with data, particularly an over estimation of vessels, and wake created • Highlights the impact of flooding on bank erosion in a heavily modified catchment • Monitoring of infield conditions should be undertaken prior to adoption of a management response involving vessel restriction • A range of technical recommendations on improved local data collection and assessment techniques are provided.

Submissions on the study were also received from the following NSW Government Departments.

Table 5. Summary of NSW Government submissions

Source of submission	Summary of key points
NSW Department of Primary Industries - Fisheries	• Excessive un-natural erosion, armouring riverbanks to stop erosion, loss of riparian vegetation impacts negatively on fish habitat. • Survival of fish can be linked to the quality of riparian vegetation in a river system • DPI Fisheries have typically found that recreational fishers prefer to fish areas away from frequent wake boarding and other towing due to annoyance by wake and noise. • Riparian vegetation need to be protected from both land based and wake impacts. • A restriction on towing activities in certain reaches of the river could lead to an increase in recreational fishing in the same areas. • DPI Fisheries support Council's efforts via preparation of the Wake Study to develop a well informed bank management plan.
NSW Office of Environment and Heritage	• The Impact of Wake on Tweed Riverbank Erosion Study ('the Study') is generally well written and appropriately structured. The Study is based on what is considered a reasonably comprehensive assessment of the physical processes operating

Source of submission	Summary of key points
	in the Tweed River derived from relevant existing studies. This has enabled the assessment of the mechanisms of riverbank erosion within the Tweed River as exacerbated by boat wake. The findings of the report are generally supported. • It is noted that a comprehensive literature review was completed as part of the project. This review provides a broad overview of the key findings of relevant studies and highlights the issues associated with vessel wake, in particular tow vessel wake, in many NSW water bodies.
NSW Transport, Roads and Maritime Services	• It is considered that the study provides only circumstantial evidence to support the assertion that wake waves have become a dominant erosion mechanism in the Tweed river Estuary. The report does not provide the scientific evidence necessary for ascertaining the relative importance of any single mechanism • Notes the costs associated with theoretical management options, and highlights the issue that the study does not take into account the real risk that bank erosion (and associated costs) may continue even if towing activities were restricted • RMS does not favour option of banning towing activities. Restricting towing will not necessarily prevent further bank erosion and will displace activities to other areas • The Tweed boating plan contains management measures aimed at enhancing safety and protecting the environment. • When considering restrictions on vessel use as a management option, it is critical to reflect on the practicality of the options. Attempts to restrict vessel size, hull types or imposing variable speed limits (eg. slow-towing) are difficult to enforce.

4.0 Wake Management Options and Recommendations

Option: Do nothing

Doing nothing about riverbank erosion is not an option that Council can realistically consider. Having spent approximately $1,200,000 on riverbank erosion management in recent years, Council is clearly a major stakeholder in riverbank erosion management. It is in fact necessary for Council to do more to address the risk of erosion significantly damaging roads, and the impact that ongoing rock armour stabilisation works are having on river amenity and ecology. Reactive erosion management adjacent to major roads is potentially more expensive, and certainly more environmentally and socially damaging than pre-emptive bank stabilisation work.

Council could chose to do nothing about the issue of wake on the river, but this would be neglectful of the wishes of a broad range of people who value the river and who feel that Council has a role to play in showing leadership on this important issue. While not the single most important cause of riverbank erosion, wake is one of the most important factors contributing to and exacerbating the problem in the area of most concern.

While Council does not have the power to impose restrictions on the use of vessels in the river, it has the potential to approve or refuse operation of commercial use of the river, and to make its view on the protection of the river environment known to ratepayers and state government agencies.

Recommendation 1
That Council continues to take a proactive, ongoing role in addressing riverbank erosion. Council should work with the community, State Government agencies and river users to address the issue of riverbank erosion, and its impact on roads and the environment. Council's activities in managing riverbank erosion should acknowledge that wake waves are one of several important factors that cause erosion.

Option: Ongoing riverbank stabilisation works - including mitigation of impacts and improved funding models

Council will of necessity continue to undertake riverbank stabilisation works in order to protect valuable public infrastructure. Given the potential extent of rock armour riverbank stabilisation work that may have to be undertaken to protect Tumbulgum Road and the Tweed Valley Way, it will be critical for Council to develop methods of riverbank stabilisation that can mitigate the significant ecological and amenity impacts that recent works have highlighted.

Council must work on development of a funding model that permits pre-emptive riverbank stabilisation works. Pre-emptive riverbank stabilisation works will be able to be designed to reduce ecological and visual impact. If funding is allocated to riverbank stabilisation adjacent to major roads only when there is imminent danger of the road falling into the river, the impact of stabilisation works will continue to be severe, and will cumulatively increase.

A program of targeted riverbank revegetation should also be undertaken adjacent to areas of the Tweed Valley Way and Tumbulgum Road. In certain areas, this will increase the resistance of riverbanks to erosion.

Recommendation 2
That Council continues to stabilise areas of riverbank erosion as required, but also as a matter of urgency, implement trials of pre-emptive riverbank stabilisation techniques that can mitigate the ecological and amenity impacts of full bank height rock armour work.

Recommendation 3
That Council investigates funding options for pre-emptive stabilisation of riverbank erosion adjacent to Tumbulgum Road and the Tweed Valley Way. Council should also liaise with the Department of Roads and Maritime Services to identify sources of funding that can be used to build the resilience of riverbanks adjacent to the Tweed Valley Way, rather than rely on disaster relief funding and emergency repairs as a primary means of managing riverbank erosion.

Option: Vessel use restrictions
Riverbank erosion is caused by several interrelated factors. While wake waves are certainly a factor cumulatively contributing to riverbank erosion, it is considered that imposition of a general ban on towing activities in the river reach where erosion is worst will not preclude the need to undertake ongoing bank stabilisation works. The impact of floods and the generally degraded nature of riverbanks will mean that slips will almost certainly continue to occur.

Council could request RMS to implement a general ban on towing activities, however it is not considered likely that this would be supported. RMS have highlighted scope and methodological constraints of the SMEC Wake Impact on Tweed Riverbank Erosion Study that result in it not providing, in their assessment, 'evidence' that wake is a factor singularly responsible for riverbank erosion. RMS have indicated that they are concerned that a ban

on towing in one area would result in the displacement of towing traffic to other river reaches, and the attendant safety implications of this.

If Council requested a ban on towing activities in the priority reach (Murwillumbah to Stotts Island) on the basis that it would prevent erosion, and this was supported by RMS, it would probably have the effect of displacing towing activities to upstream of Murwillumbah and downstream of Stotts Island. If erosion consequently increased in these areas (as a result of intensification of use), it would be more difficult to undertake management works. This is because the majority of riverbank upstream of Murwillumbah is private land, and downstream is comprised of more high conservation value estuarine habitats. In essence, if the Tweed River is going to continue to be used for towing activities, the best place for this to occur is within the priority reach where habitat values are lowest, land is predominantly in public ownership, and the ability to undertake protective works is highest.

It is noted that there is a large range of other issues related to the practice of wakeboarding that have been raised through community consultation on this topic. These impacts relate to the level of disturbance that wake boarding can create for other river users, for example disturbing houseboats or a tranquil fishing experience. Council has a clear role in managing riverbank erosion, despite not having a role in managing vessel use. To examine the potential for restrictions on towing activities as the practice relates to amenity degradation for other river users is beyond the scope of this report.

While it is not considered practical for Council to call for a ban of towing activities in the area where river erosion is at its most severe, that is, between Murwillumbah and Stotts Island, it is recommended that Council act on two issues with respect to vessel use and wake creation.

(i) Enhanced protection for Stotts Island Nature Reserve

Stotts Island is the last fragment of the once extensive Sub-tropical Rainforest on Floodplain that dominated the lower portion of the Tweed valley. It is a Nature Reserve, an Endangered Ecological Community and provides critical habitat for the endangered Mitchell's Rainforest Snail, a nationally listed threatened species.

Parts of the northern bank of Stotts Island shows clear signs of bank undercutting and loss of soil from around tree roots systems. Numerous large trees have fallen, and more are at risk of being undermined. This erosion is influenced by floods, however wake waves are also a factor. There is a clear case for enhanced efforts to conserve all aspects of the ecology of Stotts Island, in particular tall trees on the northern bank which contribute to shading and buffering of the forest environment.

As it would not be appropriate or feasible to undertake riverbank stabilisation work on Stotts Island, all measures possible should be used to reduce the frequency and intensity of factors leading to erosion of the northern foreshore.

It is recommended that Council write to both the NSW Office of Environment and Heritage and NSW Roads and Maritime Services highlighting the values of Stotts Island and the level of erosion vulnerability of certain sections of the riverbank. Council should recommend to RMS and OEH that the river reach adjacent to Stotts Island be designated as a no towing zone. This step would reduce the cumulative wake wave impact on the banks of Stotts Island as well as promote the more tranquil fishing, nature observation and passive recreational opportunities and values of this area. This recommendation is made primarily in recognition of the extremely high nature conservation values of Stotts Island.

(ii) Banning Wake Enhancement Devices

Wake enhancement devices such as water holding ballast tanks are used in some wake boarding vessels to maximise the size of the wake wave that they can produce. It is considered that use of such modifications in vessels using the Tweed River is in direct conflict with Council's role in managing riverbank erosion. It is recommended that Council write to RMS advising the department that Council considers use of these devices on the Tweed River to be incompatible with Council's objective of reducing riverbank erosion and the related impacts on roads and the environment. RMS should be requested to ban use of such devices on the Tweed River. The use of enhancement devices can be associated with wake surfing. RMS should also be requested to ban this practice.

Recommendation 4

That Council writes to both the NSW Office of Environment and Heritage and NSW Roads and Maritime Services highlighting the level of erosion vulnerability of certain sections of the Stotts Island riverbank, and recommend to Roads and Maritime Services and Office of Environment and Heritage that the river reach adjacent to Stotts Island be designated as a no towing zone.

Recommendation 5

That Council writes to NSW Roads and Maritime Services advising the department that Council considers use of wake enhancement devices and wake surfing on the Tweed River to be incompatible with Council's objective of reducing riverbank erosion and the related impacts on roads and the environment. RMS should be requested to ban use of such devices and wake surfing on the Tweed River.

Option: Partner with and support the Tweed Water Ski Club to deliver a boat driver education and training program

The Tweed Water Ski Club has advised the Tweed River Committee of an educational campaign that it intends to implement. This education program deals specifically with the issue of boat wake and its impact on riverbank erosion, as well as impacts on other river users. Council should seek to partner with the Tweed Water Ski Club and other relevant industry and sporting associations to maximise the effectiveness of this program. This involvement would include in-kind contributions such as promotion, as well as monetary support in the form of sponsorship.

Recommendation 6

That Council proactively partners with and supports the Tweed Water Ski Club led boat driver education program, as a means maximising the effectiveness of this program and encouraging best practice vessel use to achieve environmental outcomes and reduction of wake impact on riverbank erosion.

Option: Policy on Commercial Operators

It is not considered appropriate for Council to approve commercial operations in the Tweed River that undertake or promote towing activities. There is a risk that approval of a commercial ski or wake boat operator will create a precedent leading to the establishment of a significant number of such businesses on the Tweed. The highly vulnerable nature of riverbanks and the cumulative impact of vessel wake on riverbank erosion make this type of commercial operation incompatible with objectives for reducing erosion and stabilising riverbanks.

This recommendation is made with regard to the following policies:

Upper Tweed Estuary Management Plan
Council prepared a management plan for the Upper Tweed Estuary in 1996. The plan does not specifically address the issue of commercial operation of tow based water sports in the river.

Relevant objectives of the management plan are to provide an integrated program of works that will:

- Identify, enhance and protect significant habitat, particularly tidal wetlands and riparian corridors
- Protect heritage
- Provide recreation facilities
- Encourage boating activities
- Increase awareness
- Address riverbank erosion
- Improve water quality, particularly in Rous
- Minimise ASS impacts
- Conserve scenic qualities of the river

The plan contains a comprehensive list of management constraints and opportunities. Most relevant to consideration in the assessment of this development proposal is the following:

- There is widespread bank erosion along the upper Tweed Estuary. Appropriate measures are required in areas where significant assets may be threatened and where waves from increased boating would exacerbate erosion.

While the plan does acknowledge and recognise the need to accommodate recreational boating in the Upper Tweed Estuary, it highlights that protection of wetland vegetation and riparian corridors and addressing riverbank erosion is a high priority.

It is considered that operation of commercial water sport vessels engaging in towing activities is not consistent with the Upper Estuary Management Plan objectives of, "Identify, enhance and protect significant habitat, particularly tidal wetlands and riparian corridors."

NSW State Rivers and Estuary Policy 1993
The objective of the NSW Rivers and Estuary Policy is to manage the rivers and estuaries of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation in their systems,
- Ensure the long-term sustainability of their essential biophysical functions, and
- Maintain the beneficial use of these resources.

These objectives are to be achieved through application of the following management principles:

- Those uses of the rivers and estuaries that are non-degrading should be encouraged.
- Non-sustainable resource uses which are not essential should be progressively phased out.
- Environmentally degrading processes and practices should be replaced with more efficient and less degrading alternatives.
- Environmentally degraded areas should be rehabilitated and their biophysical functions restored.

- Remnant areas of significant environmental values should be accorded special protection.
- An ethos for the sustainable management of river and estuarine resources should be encouraged in all agencies and individuals who own, manage or use these resources, and its practical application enabled.

Operation of commercial water sports vessels that include towing activities is not in accordance with the first objective of the NSW Rivers and Estuaries Policy. The activity would add to the cumulative impact of wake on riverbank erosion, and as such, would not slow, halt or reverse the overall rate of degradation (in this case, riverbank erosion) in the Tweed River. Approval of such developments would be inconsistent with the first management principal, that being to encourage uses of the estuary that are non-degrading.
It is also noted that Stotts Island would qualify for special protection from any potential impact by wake creating activities under the fifth management principle, as it is an area of significant environmental value.

Recommendation 7
That Council adopts a policy position that precludes operation of commercial towing activities on the Tweed River, and that this position be embodied in the report requested from officers as per item 13 of the Council meeting Thursday 20 June 2013, that being:

That Council brings forward a report no later than the April 2014 Council meeting outlining a comprehensive planning proposal capable of adoption by Council to regulate commercial wakeboarding operations and events throughout the Tweed Shire.

5.0 Detailed Maps of Riverbank Erosion
(removed from this appendix - refer to maps in section 3.0 of the Bank Erosion Management Plan 2014).

OPTIONS:
Council can adopt or reject any or all of the recommendations made in this report, or propose amendments to them, or make additional recommendations.

COUNCIL IMPLICATIONS:
a. Policy:
Corporate Policy Not Applicable.

b. Budget/Long Term Financial Plan:
Council's Waterways Management Program will endeavour to identify and secure funds to undertake erosion stabilisation works at a number of sites that fall within its remit, these being, adjacent to park land at Condong, the Oxley Cove Canal Estate entrance and on agricultural foreshore in Murwillumbah.

c. Legal:
Not applicable.

d. Communication/Engagement:
Consult-We will listen to you, consider your ideas and concerns and keep you informed.

Appendix 2: Photographs of riverbank condition corresponding to maps 1-18

Reach: L1

001

005

008

009

Reach: R1

011

013

017

018

Reach: R1

019

022

024

Reach: L2

048

050

051

055

Reach: L2

058

066

Reach: R2

025

027

031

033

Reach: R2

036

040

043

Reach: L3

093

094

096

099

Reach: L3

104

108

113

Reach: R3

068

071

078

083

Reach: R3

087

089

Reach: L4

171

184

190

194

Reach: L4

198

205

213

219

Reach: R4

116

122

129

133

Reach: R4

136

139

145

159

Reach: R4

166

170

Reach: L5

267

273

279

283

Reach: L5

286

292

303

305

Reach: R5

233

234

239

242

Reach: R5

249

256

260

264

Reach: L6

351

352

353

354

Reach: L6

355

356

Reach: R6

357

370

374

377

Reach: R6

357

370

374

377

Reach: R6

381

386

Reach: L7

407

409

Reach: R7

388

394

399

404

Reach: R8

476

480

490

495

Reach: R9

497

500

Reach: Stott's Island

312

320

338

341

Reach: Stott's

349

350

Appendix 3: Potential Restoration Sites Murwillumbah Weir to Stott's Island

This document details bank restoration activities which maximise opportunities to incorporate vegetation on public land along the Tweed River between Murwillumbah (Bray Park) Weir and Stott's Island. This study was undertaken as a desk top analysis of public land suitable for undertaking bank stabilisation works incorporating vegetation, and is limited to land that is generally greater than 7m from the shoulder of public roads to the top of the riverbank. The rationale for a 7m minimum distance for restoration activities is to ensure the required 3.5m clear buffer from the shoulder of public roads is maintained, and therefore allows a 3.5m minimum strip for revegetation, considered to the minimum viable width to assist in bank stabilisation.

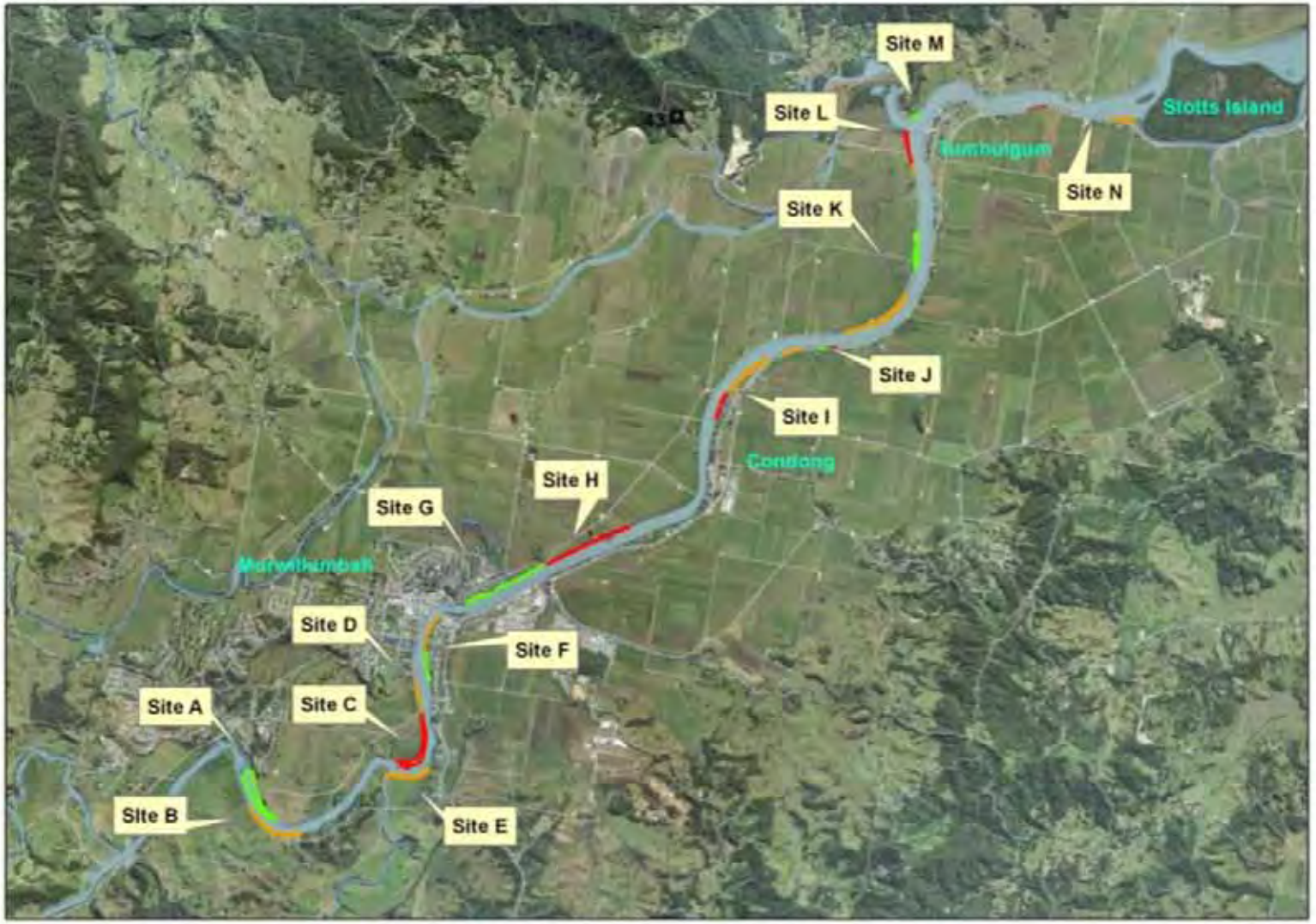
Restoration activities detailed in this study include: revegetation and/or bush regeneration; bank battering combined with revegetation; bank toe armouring using rock incorporating vegetation on the riverbank; bioengineering approaches including rock fillets to encourage natural vegetation establishment along the lower bank. Figure 2 details the area and/or length of riverbank identified as suitable to incorporate these techniques within the study area.

The Tweed River between the weir at Bray Park and Stott's Island was assessed from the water for erosion risk in August 2013 to inform the Tweed Riverbank Management Plan. Figure 1 summarises the erosion risk and bank condition for both left and right banks of the river from field observations and associated data collection.

Table 1. Erosion Risk - Tweed River, Murwillumbah Weir to Stott's Island.

Erosion risk	**Severe/high risk**	**Vulnerable**	**Generally Stable**
Length of bank (both banks combined = 35,855m)	9,207m	10,381m	16,267m

Map 1. Restoration Sites Murwillumbah Weir to Stotts island



Restoration Sites

Bank restoration and erosion stabilisation activities have been categorised as either: revegetation; pre-emptive erosion management (incorporating bioengineering approaches); and re-active erosion management (including structural bank stabilisation works).

Table 2 below summarises the total bank length over which these typical bank restoration and erosion stabilisation activities can be undertaken.

Fourteen sites on public land were identified in the study as being suitable for vegetation restoration activities (Map 1). These sites were selected based on their being an acceptable minimum width of bank available for revegetation. In some cases adjacent sites may be linked over time to provide contiguous habitat.

The length of public riverbank vulnerable to or at high risk of erosion and not suitable for revegetation or a pre-emptive bio-engineered approach to stabilisation is also shown in table 2. The primary basis of exclusion from the revegetation or pre-emptive stabilisation category is narrow linear width.

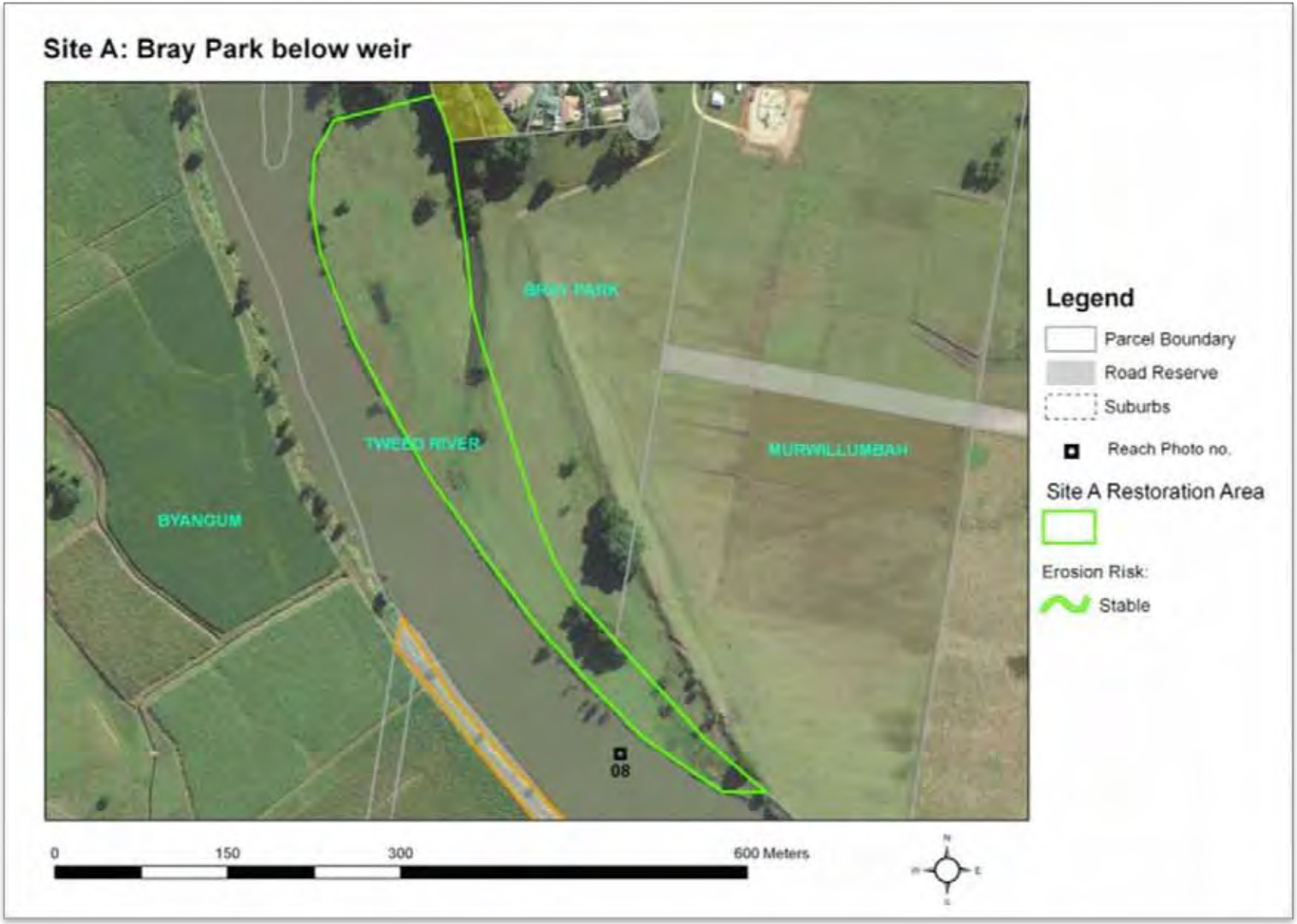
All individual sites where full structural works are required to address bank erosion have not been mapped as part of this project. These reactive management sites will be prioritised for works as erosion threatens assets such as roads and powerlines, and as funds become available.

Eroding riverbanks on private land have not been included in this assessment, however restoration works on these sites may be eligible for funding through Councils River Health Grant program or other external grants.

Table 2. Length of Bank by Restoration Activities, Murwillumbah Weir to Stotts Island.

Restoration Activity	**Length of bank (m)**	**Area (m^2)**
Revegetation	15,863.5	18,1099
Pre-emptive erosion management	4,668	n/a
Re-active erosion management	10,667 (includes 5,754m of severe erosion)	n/a

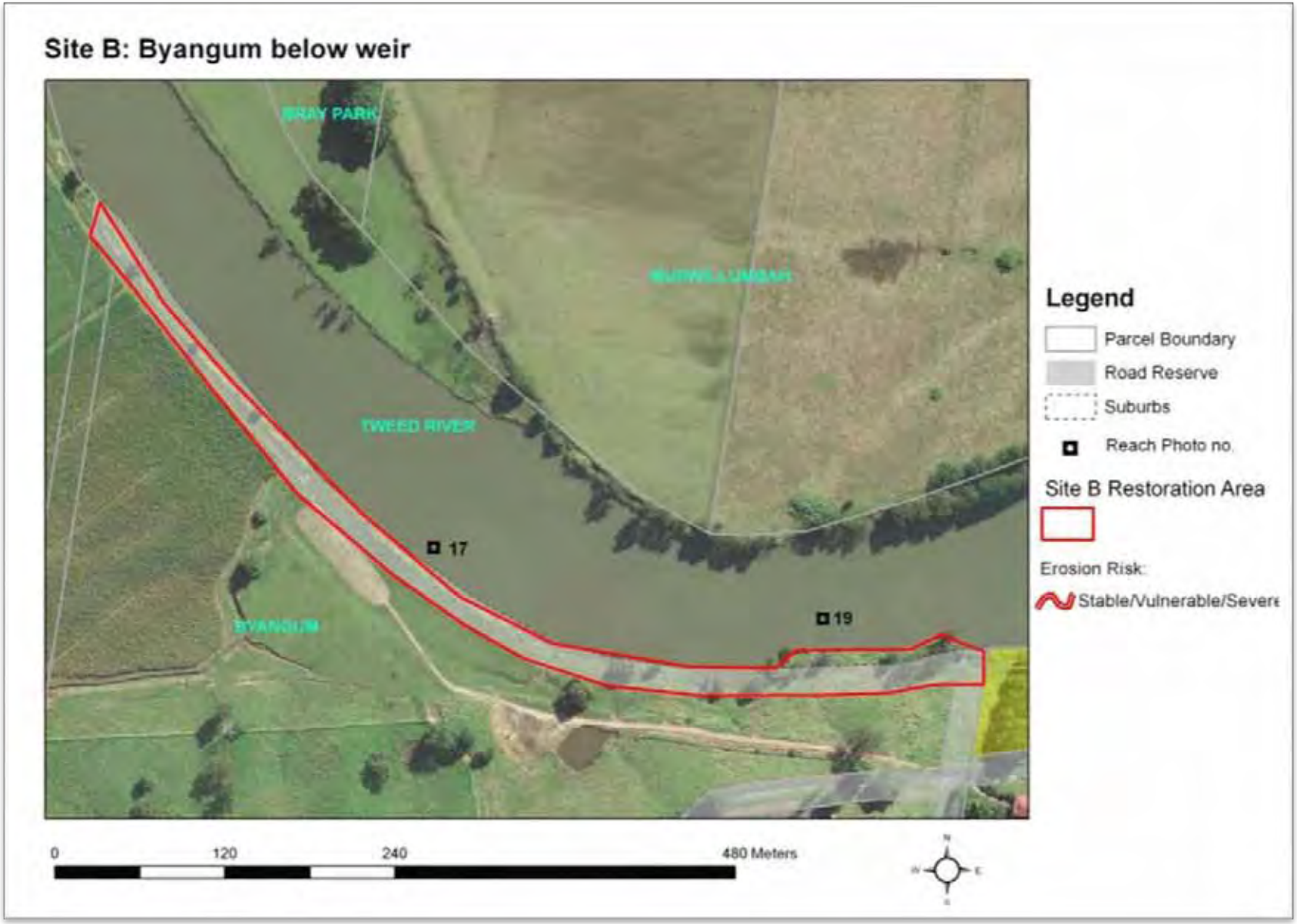
Proposed bank restoration activities and priorities are detailed for each site in the document below, as well as a brief discussion on constraints and/or opportunities for implementation. It should be noted that each site will require detailed designs which maximises opportunities to incorporate vegetation.


Site A: Bray Park below weir
BRAY PARK
TWEED RIVER
MURWILLUMBAH
BYANGUM
08
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site A Restoration Area
Erosion Risk:
Stable
0
150
300
600 Meters

Site A - Bank Restoration Activities

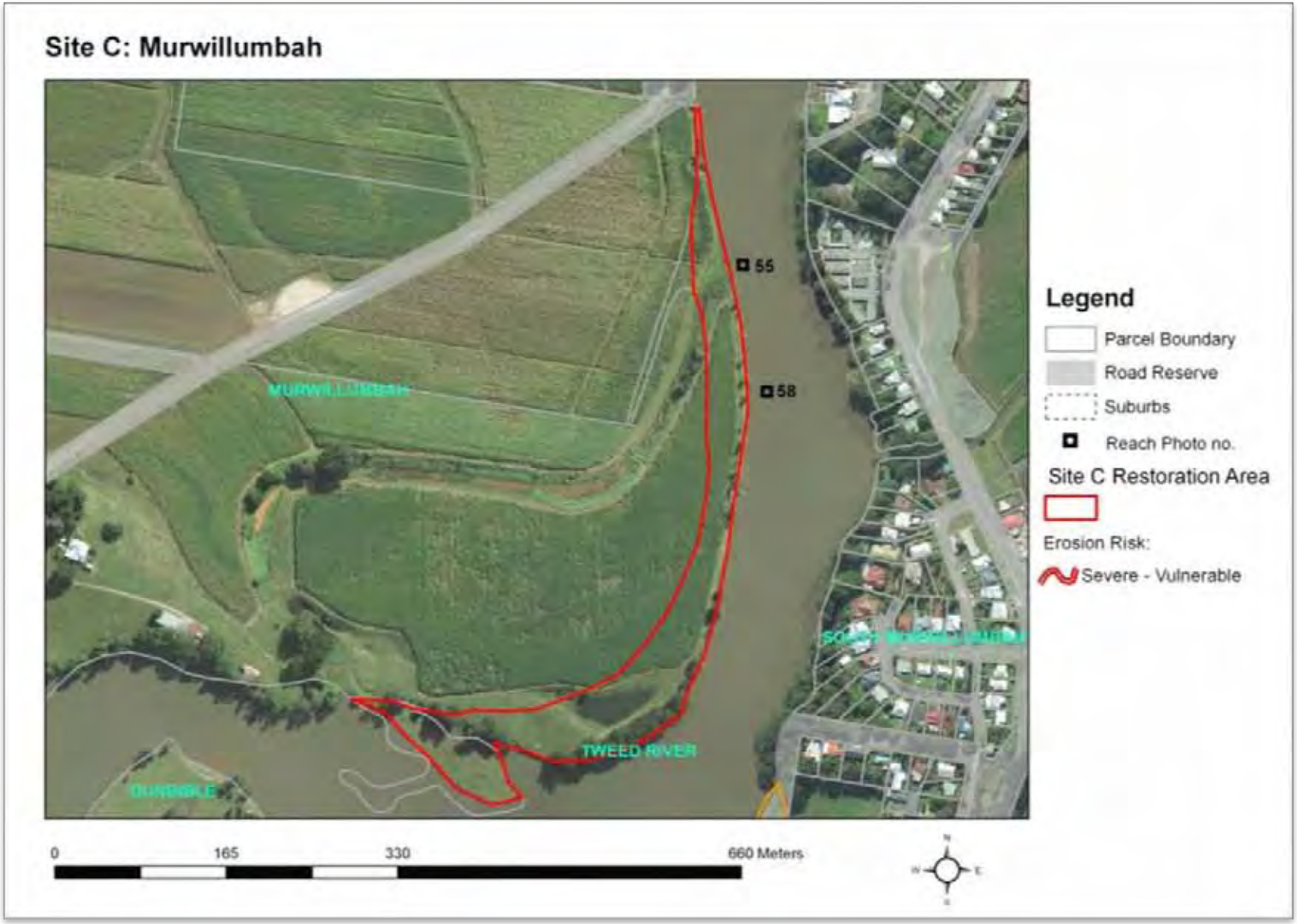
Length (m)	750m
Width (m)	Up to 100m
Area m^2	50,837
Bank height (m)	1-2
Erosion Risk	Stable with some minor undercutting becoming worse towards downstream end of site.
Tenure	Crown Land (waterway)
Restoration activity and priority	Revegetation. High priority over the longer term given it is the largest floodplain in study area under Crown ownership.
Constraints/opportunities	• Very large area to revegetate (5+ ha). • Currently grazed by adjacent landowner. • Potential for vegetation to increase flows to opposite vulnerable bank (Site B). • Detailed restoration plan required.

Photo 08– looking upstream, site A located on the floodplain at right of photo.


Site B: Byangum below weir
BRAY PARK
TWEED RIVER
BYANGUM
17
19
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site B Restoration Area
Erosion Risk:
Stable/Vulnerable/Severe
0
120
240
480 Meters

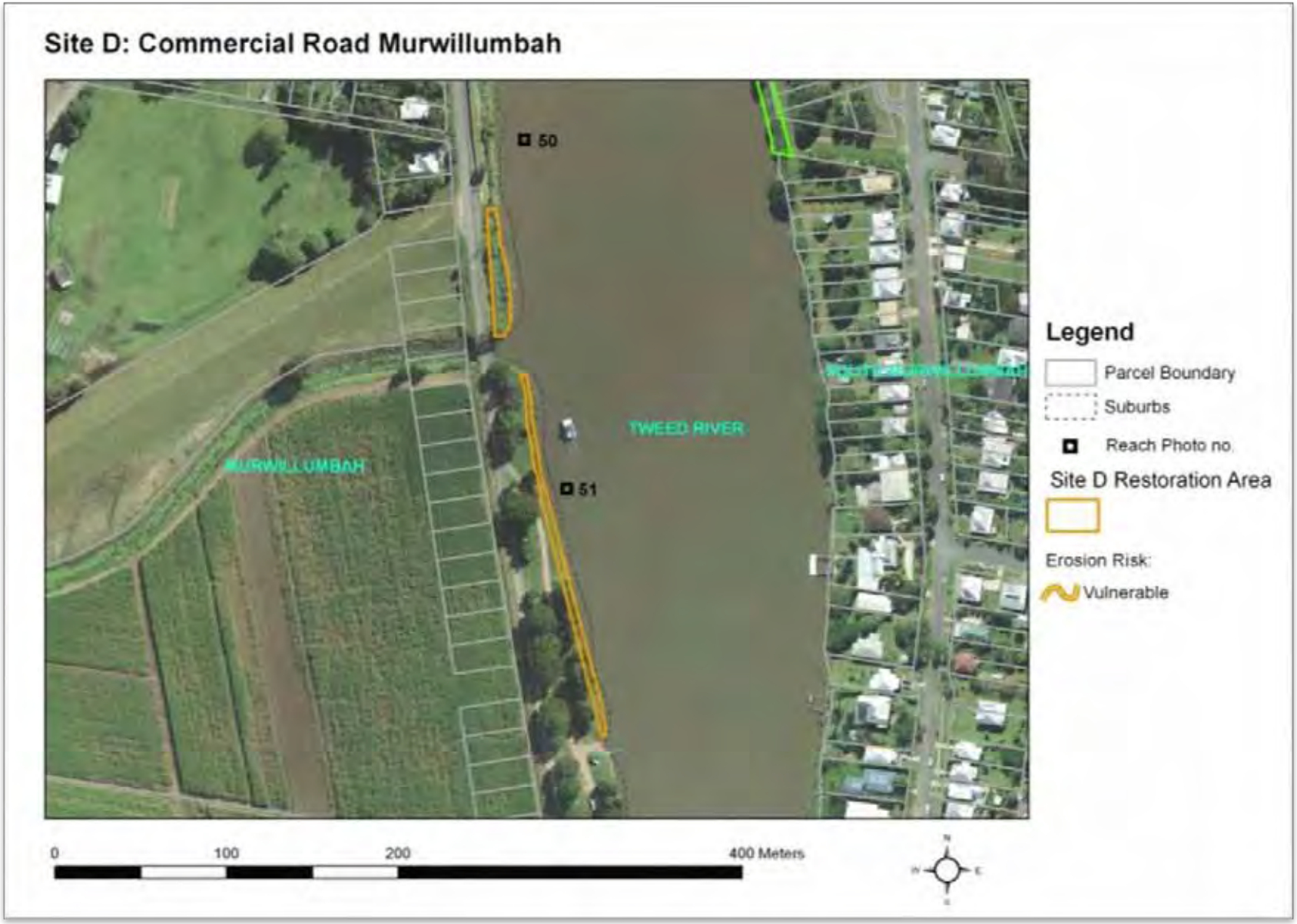
Site B - Bank Restoration Activities

Length (m)	765m
Width (m)	10 - 30
Area m^2	15,092
Bank height (m)	1-4
Erosion Risk	Upstream section: Vulnerable. Mid-section: Severe. Downstream section: Stable (bedrock control).
Tenure	Road Reserve (plus small area of Crown waterway)
Restoration activity and priority	Revegetation. High priority over the longer term as this section will continue to erode without management intervention.
Constraints/opportunities	• Requires consultation with cane farmer. • Vertical sections of bank require battering. • Possible rock armouring along toe if bank continues to be undercut. • Work should ideally begin before revegetation of Site A opposite bank which may increase scour potential due to deflected flows. • Detailed restoration plan required.
 Photo 17 – severe erosion on mid-section of site, grassed bank upstream considered vulnerable to erosion.	 Photo 19 – Downstream section of site. Bank is stable due to bed rock control on right bank.


Site C: Murwillumbah
55
58
TWEED RIVER
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site C Restoration Area
Erosion Risk:
Severe - Vulnerable
0
165
330
660 Meters

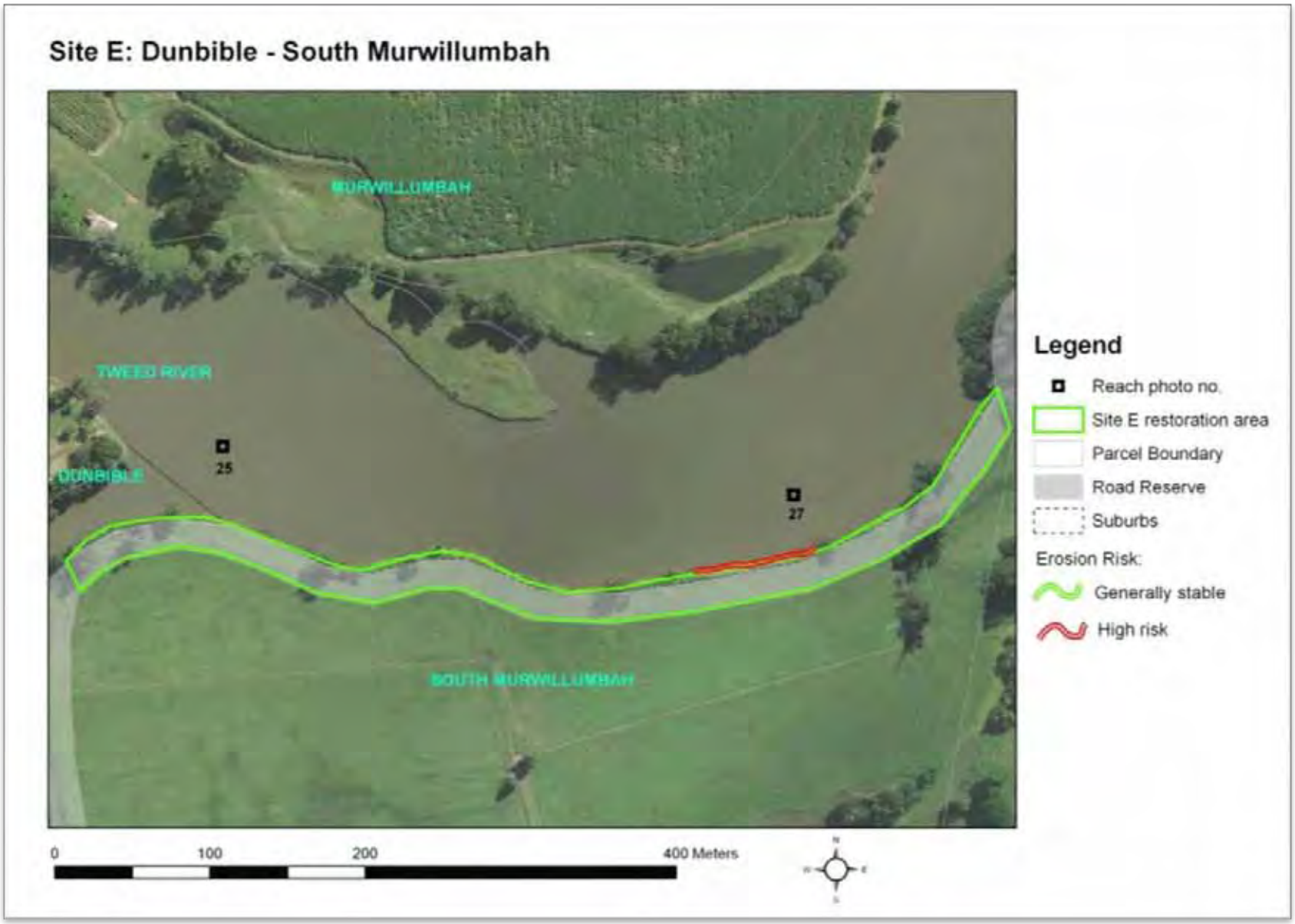
Site C - Bank Restoration Activities

Length (m)	1000m
Width (m)	Up to 65m
Area m^2	34,500
Bank height (m)	1-4
Erosion Risk	Severe along most of site with some areas of mass failure (slumping). Vulnerable along low-lying upstream section of site.
Tenure	Crown Land (waterway) and small area of TSC Crown Land
Restoration activity and priority	Revegetation. High priority over the long term due to large area of Crown Land available.
Constraints/opportunities	• Narrow riparian zone, mostly less than 7m to existing cane headland. • Bank is slumping in sections, and may require battering to stabilise. • Camphor laurel on bank at bend in river in process of being undercut, these could be progressively removed to allow native regrowth. • This is a large area of Crown waterway with extensive area of cane under cultivation by two adjacent landowners. Requires consultation prior to restoration planning.
 Photo 55 – looking upstream	 Photo 58 – showing bank slump with cane land on top of bank.


Site D: Commercial Road Murwillumbah
50
51
TWEED RIVER
MURWILLUMBAH
Legend
Parcel Boundary
Suburbs
Reach Photo no.
Site D Restoration Area
Erosion Risk:
Vulnerable
0
100
200
400 Meters

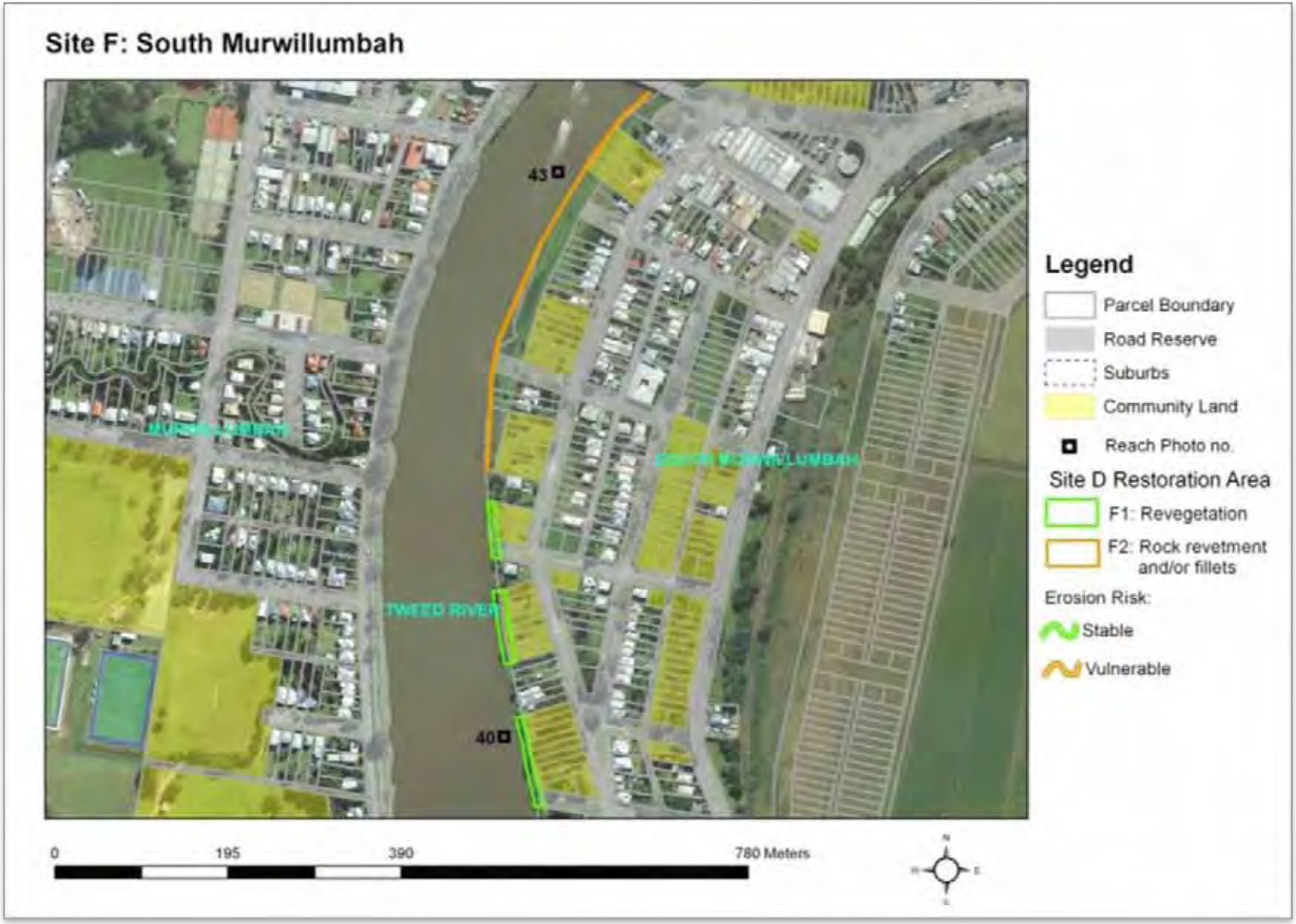
Site D - Bank Restoration Activities

Length (m)	285m
Width (m)	7-10m
Area m^2	1335
Bank height (m)	~1.0
Erosion Risk	Vulnerable, recent slumping as bank continues to become undercut.
Tenure	Road Reserve
Restoration activity and priority	Rock toe revetment and investigate potential for fillets. High priority as bank continues to erode.
Constraints/opportunities	• Existing rock revetment along toe at upstream end of site (towards boat ramp) may be adequate to protect bank. • Limited width for revegetation due to car parking/public recreation space • Requires detailed design which maximises opportunities to incorporate vegetation. • Investigate appropriateness of revegetation inside of levy wall to Murwillumbah Bridge (not mapped as part of this study).
 Photo 50 – rock revetment of slump downstream of site D	 Photo 51 – active bank erosion adjacent to boat ramp.


Site E: Dunbible - South Murwillumbah
MURWILLUMBAH
TWEED RIVER
DUNBIBLE
SOUTH MURWILLUMBAH
25
27
Legend
Reach photo no.
Site E restoration area
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
High risk
0
100
200
400 Meters

Site E - Bank Restoration Activities

Length (m)	600m
Width (m)	20m
Area m^2	14,194
Bank height (m)	1 – 4
Erosion Risk	Generally stable, 70m section of severe erosion (photo 27 below)
Tenure	Road Reserve
Restoration activity and priority	Revegetation. High priority.
Constraints/opportunities	• Negotiate with adjacent landowner for stock exclusion fencing. • Investigate impact on views from Art Gallery. • Battering could help stabilise eroding section of bank. • Road reserve ~20m wide, revegetation could be undertaken in stages.
 Photo 25 – Site E right bank	 Photo 27 – active bank erosion


Site F: South Murwillumbah
43
40
TWEED RIVER
Legend
Parcel Boundary
Road Reserve
Suburbs
Community Land
Reach Photo no.
Site D Restoration Area
F1: Revegetation
F2: Rock revetment and/or fillets
Erosion Risk:
Stable
Vulnerable
0
195
390
780 Meters

Site F - Bank Restoration Activities

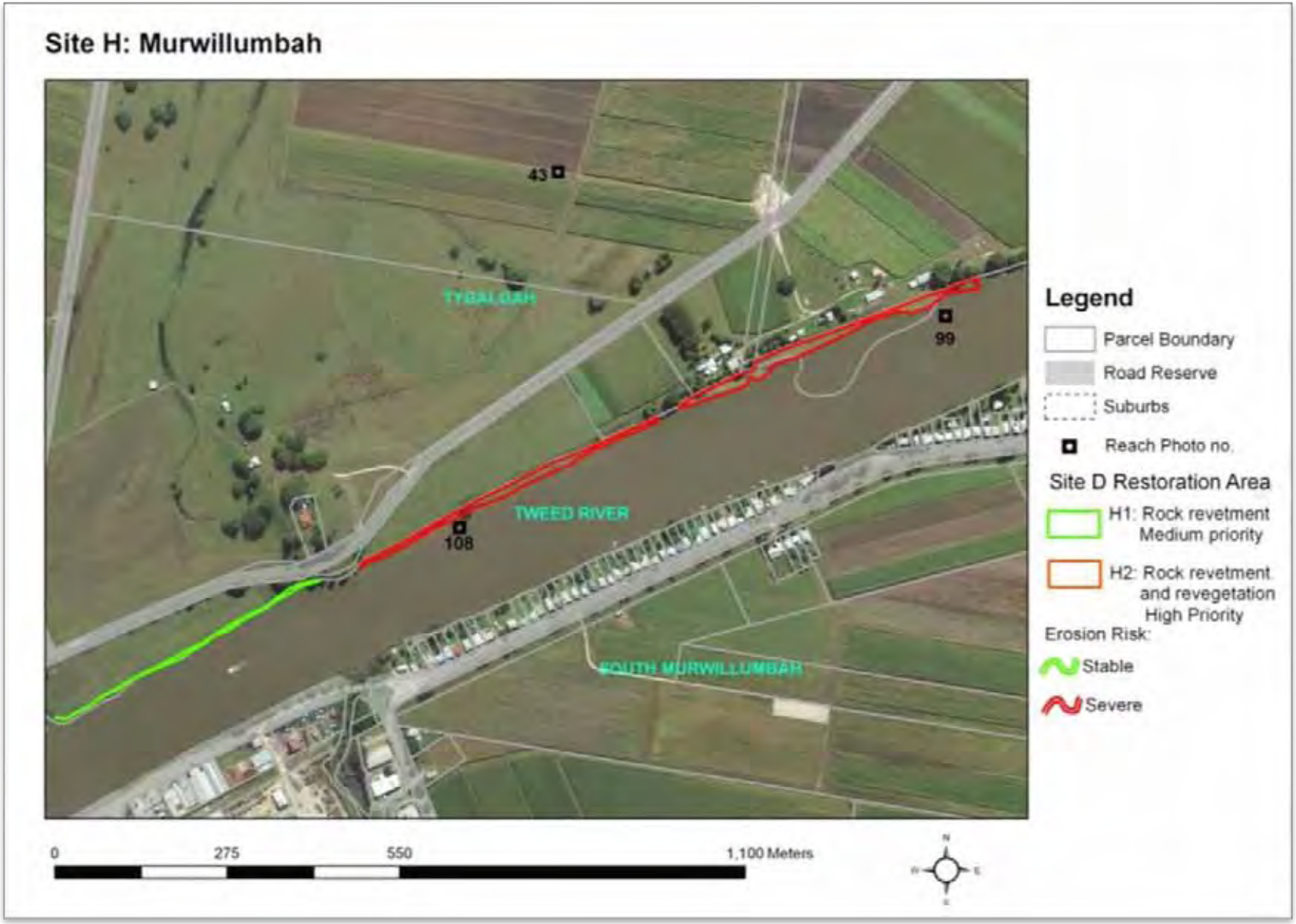
Length (m)	473m (combined)
Width (m)	~10m
Area m^2	5735
Bank height (m)	~1.0
Erosion Risk	Generally stable - vulnerable
Tenure	Community Land (Tweed Shire Council), Crown Waterway
Restoration activities and priority	Revegetation in upstream areas: Medium Priority. Rock revetment/fillets along bank adjacent to levy bank: Medium priority.
Constraints/opportunities	• Sections of bank are slumping along this reach - requires investigation of need/potential for battering or rock revetment. • Tidal bench present along lower section of this site, investigate rock fillet potential. • Potential to revegetate riverside of levy bank, consult with Council engineers. • Requires consultation with South Murwillumbah community (revegetation may impact on access/views).
 Photo 40 – Site F1 showing slump at drain outlet	 Photo 43 – Site F2 minor bank erosion with levy bank in background


Site G: Murwillumbah
43
113
TWEED RIVER
Legend
Site E restoration area
Reach photo no.
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
0
115
230
460 Meters

Site G - Bank Restoration Activities

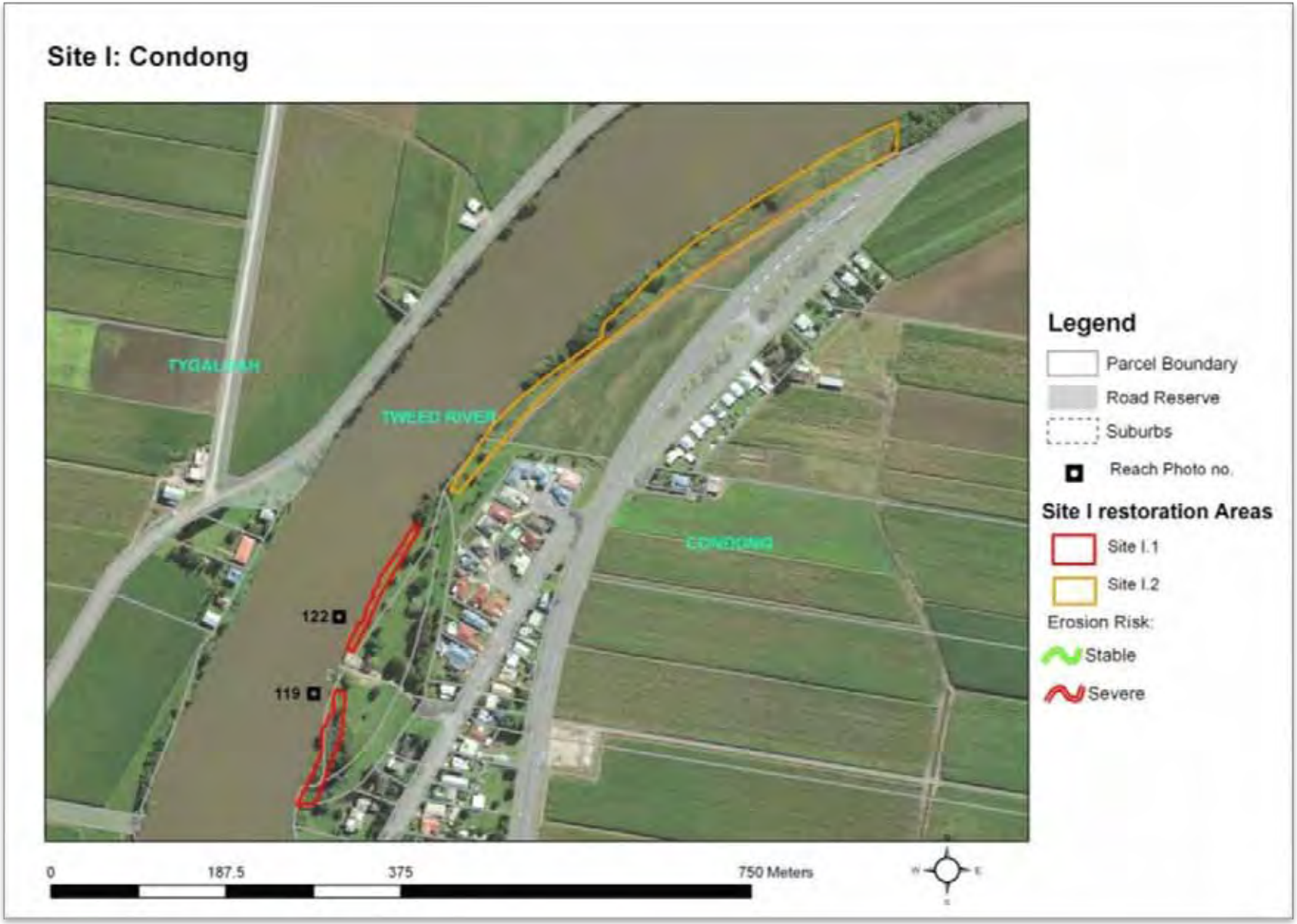
Length (m)	445 (combined)
Width (m)	7-15
Area m^2	5200
Bank height (m)	~1.0
Erosion Risk	Generally stable with minor erosion along the bank toe
Tenure	State Crown
Restoration activity and priority	Rock revetment +/- fillets +/- revegetation. Low priority unless erosion becomes worse.
Constraints/opportunities	• Revegetation could block views and river access of adjacent houses, therefore low potential for planting trees. • Possible to batter and stabilise with lomandra/phragmites in higher risk areas. • Tidal bench along much of this reach, potential to stabilise bank toe with rock revetment and/or install rock fillets. • Crown Lands licence required for environmental enhancement structures (e.g. rock fillets).

Photo 113 – showing minor erosion along bank toe


Site H: Murwillumbah
43
99
108
TWEED RIVER
SOUTH MURWILLUMBAH
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site D Restoration Area
H1: Rock revetment Medium priority
H2: Rock revetment and revegetation High Priority
Erosion Risk:
Stable
Severe
0
275
550
1,100 Meters

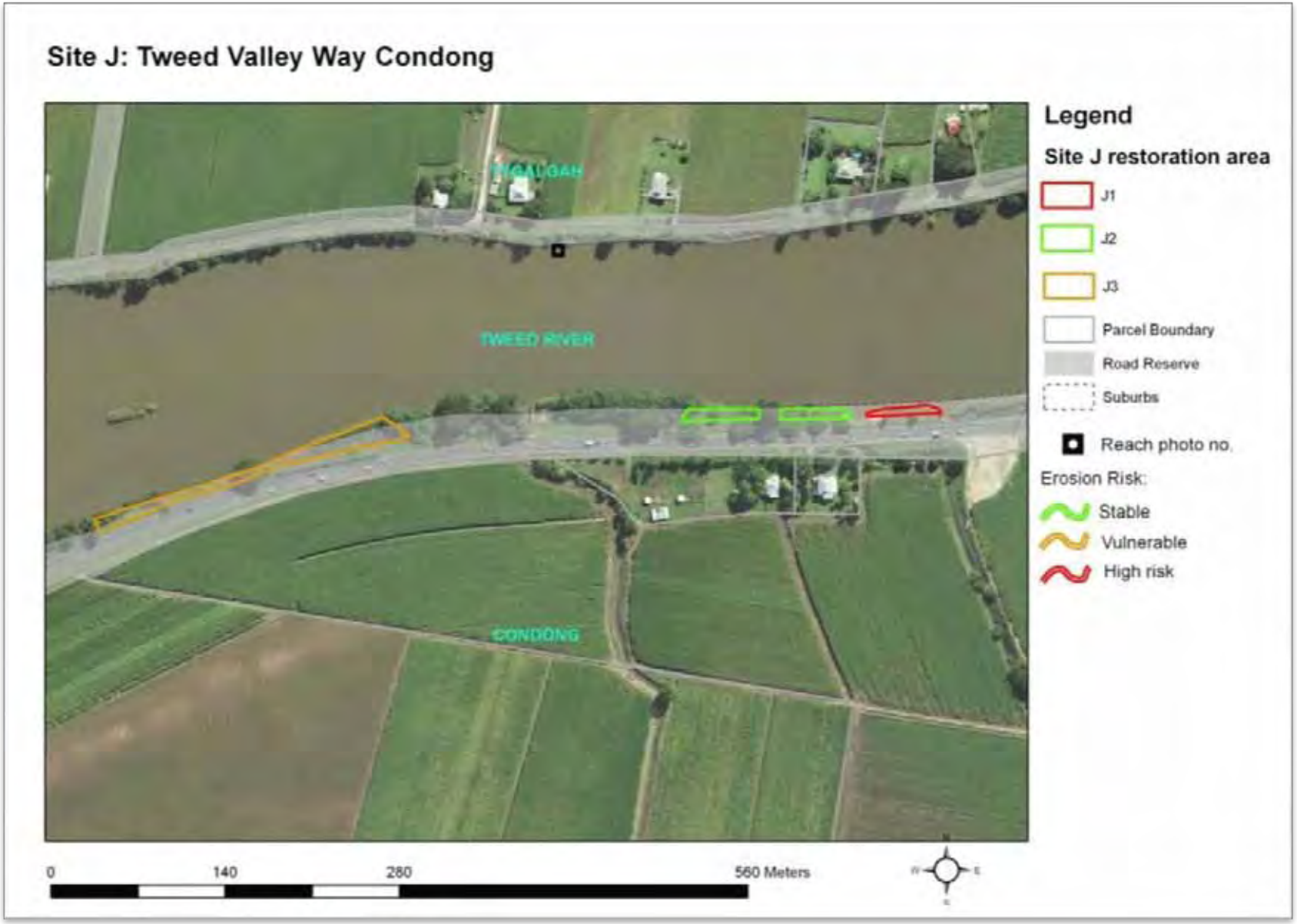
Site H - Bank Restoration Activities

Length (m)	1525 (combined)
Width (m)	<5-15
Area m^2	14282
Bank height (m)	<1-4
Erosion Risk	Generally stable upstream and areas of severe erosion downstream.
Tenure	Waterway & State Crown
Restoration activities and priority	Rock toe revetment along upper section of site: Medium priority. Rock toe revetment + revegetation along mid section of site: High Rock toe revetment + revegetation along lower section of site: High
Constraints/opportunities	• Grazing occurs along this section of river with no riparian exclusion fencing. • Two landowners only between Mayal Creek and Condong Bridge. • High revegetation potential downstream to Condong Bridge on Freehold land. • Investigate potential for rock fillets in conjunction with toe armouring. • Crown Lands licence required for environmental structures (e.g. fillets).
 Photo 99 – severe bank erosion	 Photo 108 – bank collapse is occurring along most of this site


Site I: Condong
TWEED RIVER
CONDONG
122
119
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site I restoration Areas
Site I.1
Site I.2
Erosion Risk:
Stable
Severe
0
187.5
375
750 Meters

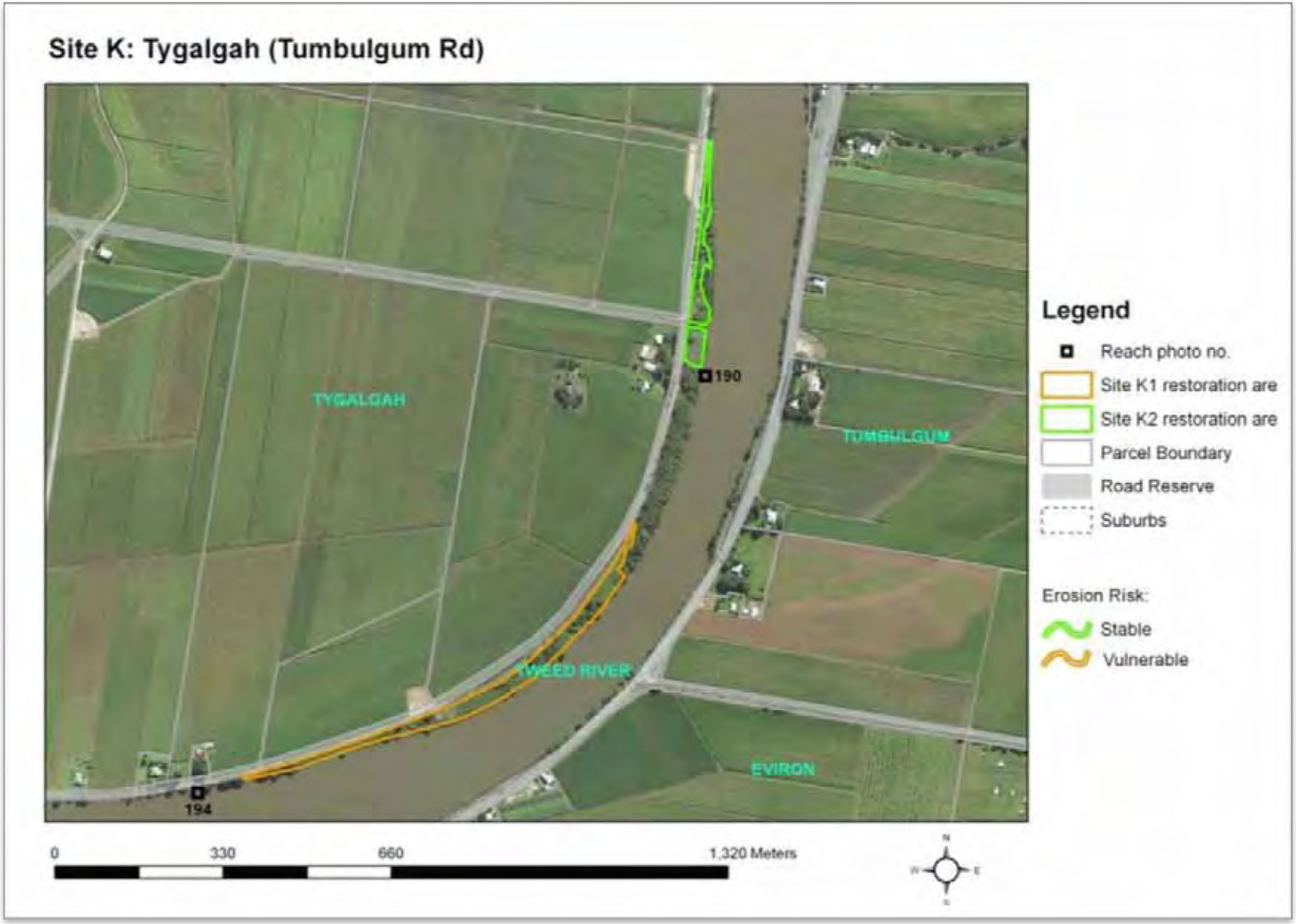
Site I - Bank Restoration Activities

Length (m)	900 (combined)
Width (m)	7-25
Area m^2	19019
Bank height (m)	<1-3
Erosion Risk	High risk / severe particularly downstream of boat ramp. Vulnerable (undercutting) in downstream site I.2.
Tenure	TSC Crown Land (Public Recreation Reserve) and Waterway (Crown Land)
Restoration activities and priority	Toe revetment and rock fillets. High Requires detailed design which maximises opportunities to incorporate vegetation.
Constraints/opportunities	• Erosion severe along recreation reserve bank. Investigate battering/fillets potential. Need approval from Manager Recreation Services + community consultation. • Revetment is required in association with planting and a trial of rock fillets upstream of the pontoon. • Downstream area I.2 adjacent to cane land has high restoration potential. Mangroves line the bank along most of this zone, loss of sediment around roots. Potential revegetation/buffer zone of 1.35ha up to 25m wide.
 Photo 119 – bank toe erosion above boat ramp	 Photo 122 – bank toe erosion downstream of boat ramp


Site J: Tweed Valley Way Condong
TWEED RIVER
CONDONG
Legend
Site J restoration area
J1
J2
J3
Parcel Boundary
Road Reserve
Suburbs
Reach photo no.
Erosion Risk:
Stable
Vulnerable
High risk
0
140
280
560 Meters

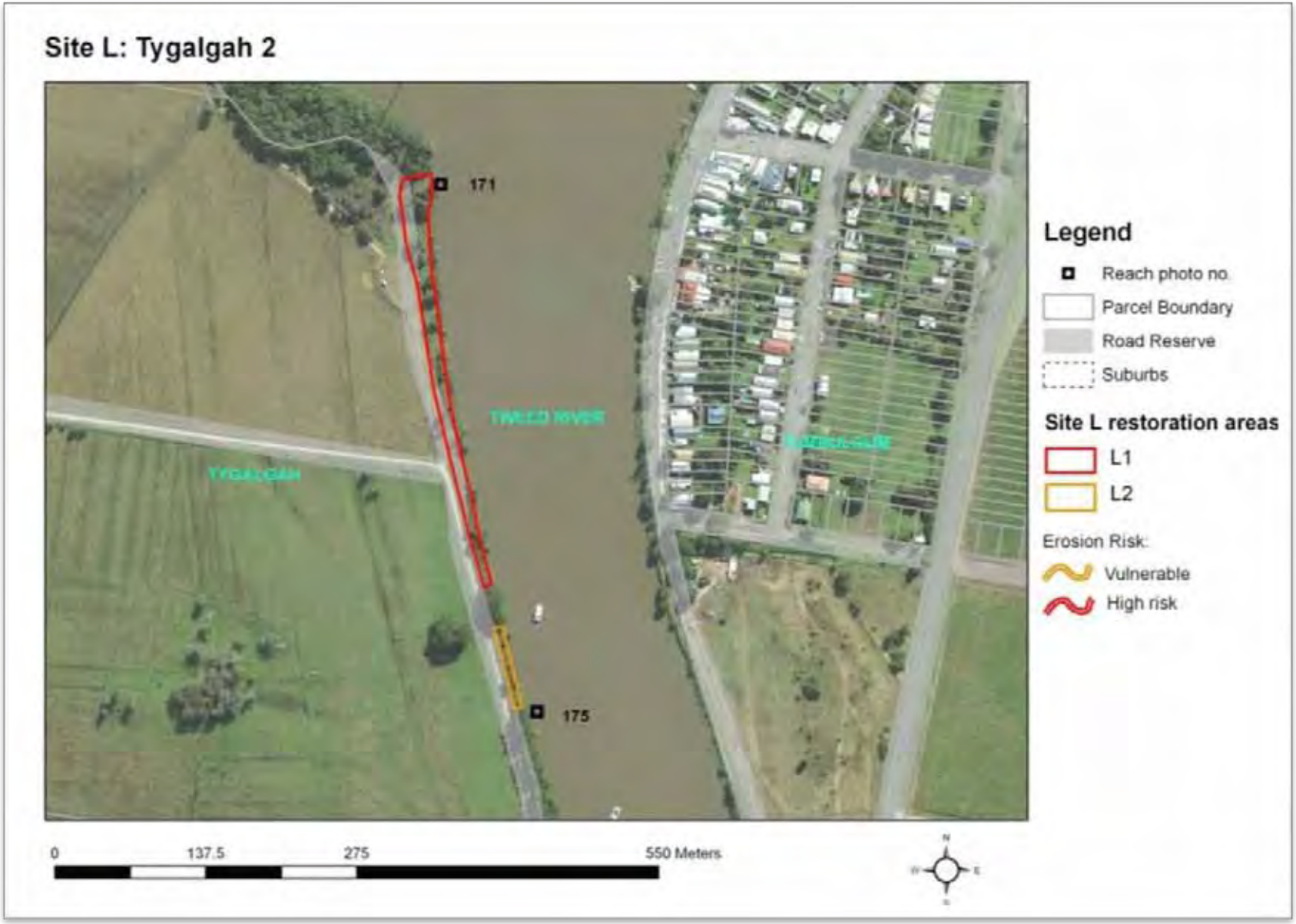
Site J - Bank Restoration Activities

Length (m)	415 (combined)
Width (m)	7-20
Area m^2	3778
Bank height (m)	<1-3
Erosion Risk	Bank is vulnerable to erosion along most of Site J, stable where cottonwoods are along bank toe, area of severe erosion between flood gates.
Tenure	TSC Road Reserve
Restoration activities and priority	Revegetation. Moderate priority due to narrow extent between River and Tweed Valley Way and weedy condition of vegetation.
Constraints/opportunities	• Potential to increase cottonwoods along the lower bank. • Good linkage to Condong Site I. • Generally these areas are very weedy. Mangroves and cotton woods exist throughout site. • Powerlines along Road side needs to be accounted for in site plans.
 Photo 129 – bank undercutting increases risk of failure especially where camphor laurel occur.	 Photo 134 – Bahna grass provides some bank protection but does not protect bank from slumping if toe is eroding.


Site K: Tygalgah (Tumbulgum Rd)
TYGALGAH
TUMBULGUM
TWEED RIVER
EVIRON
190
194
Legend
Reach photo no.
Site K1 restoration are
Site K2 restoration are
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Stable
Vulnerable
0
330
660
1,320 Meters

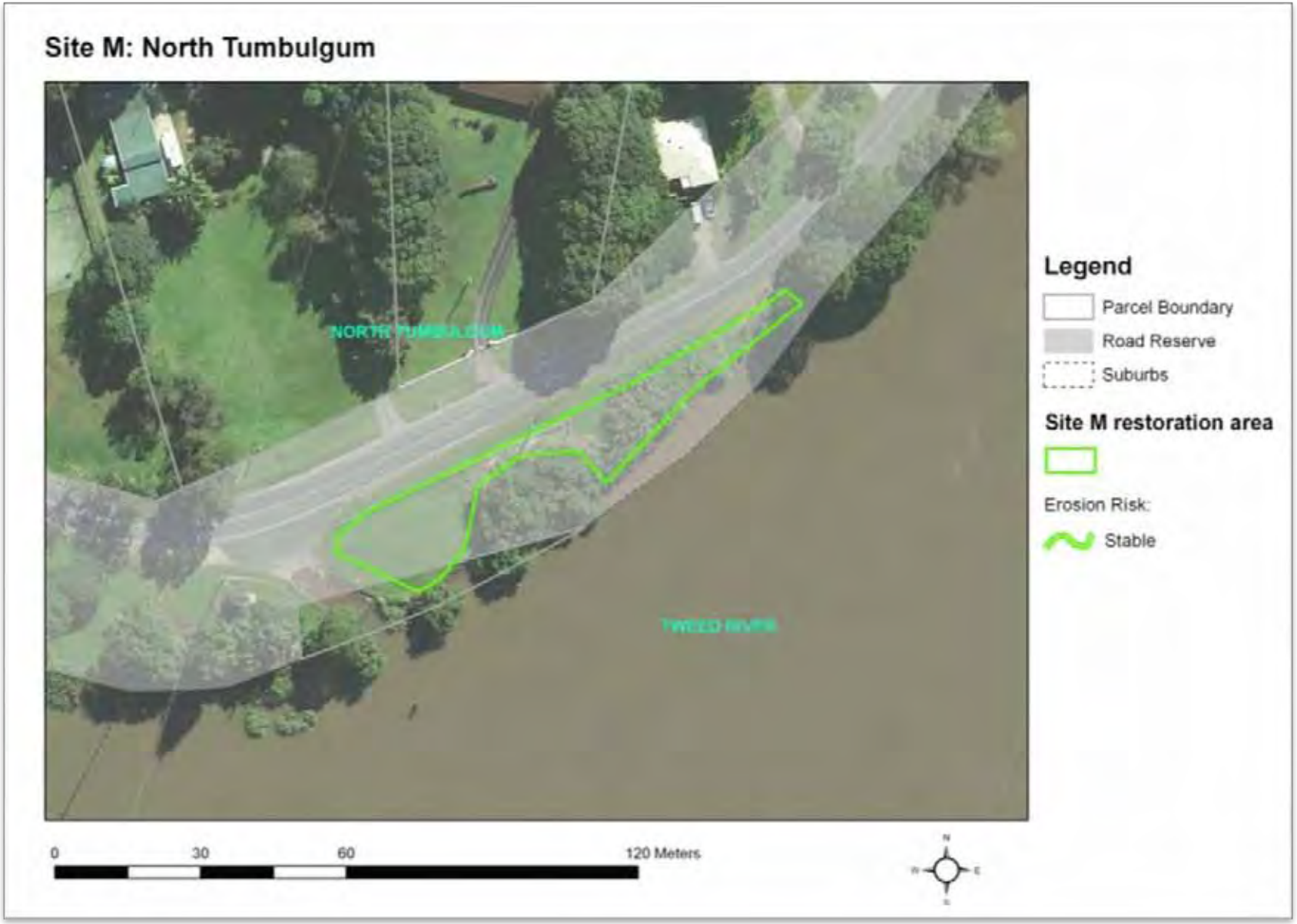
Site K - Bank Restoration Activities

Length (m)	1385 (combined)
Width (m)	7-30
Area m^2	29020
Bank height (m)	<1.0 – 2m
Erosion Risk	Bank is vulnerable to erosion along upstream site and stable, protected by mangrove and phragmites on downstream site.
Tenure	Waterway (Crown Land)
Restoration activities and priority	Revegetation. High Priority. Good width available, the most significant reach of mangroves upstream of Stotts Island. Existing vegetation (except mangroves) is very weedy.
Constraints/opportunities	• Priority revegetation site due to length and width and buffer to mangrove habitat. • Area upstream of site is experiencing bank failure and there is a narrow area between River and Tumbulgum Rd, little opportunity to batter. Investigate fillets and bank revetment. • Potential view blockage issues in Site K1 opposite homestead.
 Photo 190 – Mangroves along reach.	 Photo 194 – bank erosion immediately upstream of site (note this area is too narrow to revegetate and may require alternative approaches (fillets and or toe revetment).


Site L: Tygalgah 2
171
175
TWEED RIVER
TYGALGAH
Legend
Reach photo no
Parcel Boundary
Road Reserve
Suburbs
Site L restoration areas
L1
L2
Erosion Risk:
Vulnerable
High risk
0
137.5
275
550 Meters

Site L - Bank Restoration Activities

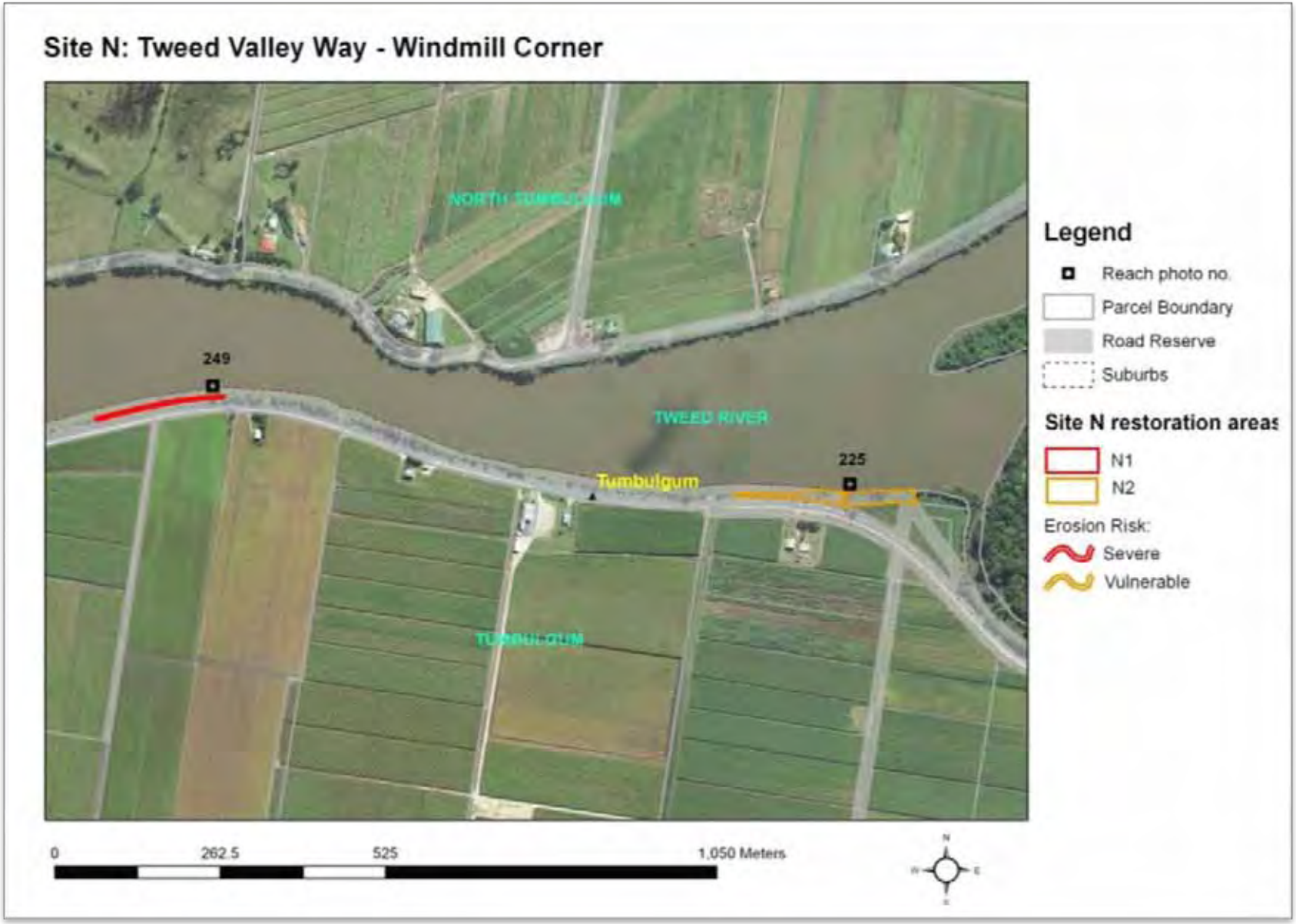
Length (m)	455 (combined)
Width (m)	7-30
Area m^2	5946
Bank height (m)	<1-3
Erosion Risk	Active and recent erosion of the low bank, which is vulnerable to ongoing damage of mangrove root systems by waves and cattle.
Tenure	Road Reserve & Waterway (Crown Land)
Restoration activities and priority	Revegetation and stock exclusion fencing. High priority.
Constraints/opportunities	• Good width available, especially on the downstream reach. Good connectivity to mangroves at Rous River mouth. • Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. • Site requires fencing, consult with land manager.
 Photo 171– Downstream site J, bank erosion possibly exacerbated by grazing.	 Photo 175 – camphor laurel along bank showing undercutting (note photo taken at high tide).


Site M: North Tumbulgum
Legend
Parcel Boundary
Road Reserve
Suburbs
Site M restoration area
Erosion Risk:
Stable
0
30
60
120 Meters

Site M - Bank Restoration Activities

Length (m)	100
Width (m)	7-20
Area m^2	1013
Bank height (m)	<1-3
Erosion Risk	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge.
Tenure	Road Reserve
Restoration activities and priority	Revegetation Medium-Low priority. Small area.
Constraints/opportunities	• Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. • Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. • Requires discussion with Recreation Services as to status of old boat ramp (fenced off). • Requires consultation with adjacent house owners. • Battering may help stabilise area in photo below. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.

Photo 267– Bank erosion on downstream end of this site.


Site N: Tweed Valley Way - Windmill Corner
249
225
TWEED RIVER
Tumbulgum
Legend
Reach photo no.
Parcel Boundary
Road Reserve
Suburbs
Site N restoration areas
N1
N2
Erosion Risk:
Severe
Vulnerable
0
262.5
525
1,050 Meters

Site N - Bank Restoration Activities

Length (m)	480 (combined)
Width (m)	7-20
Area m^2	4825
Bank height (m)	<2-4
Erosion Risk	Bank is very susceptible to erosion; downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion.
Tenure	Road Reserve
Restoration potential	Medium - High. High potential at Windmill Corner, more difficult on upstream section due to narrow width of riverbank between river and Tweed Valley Way.
Constraints/opportunities	• Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). • Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. • Slip and severe erosion near floodgate upstream of site N1. • Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.
 Photo 225 – old rock revetment at Windmill Corner (L2)	 Photo 249 – Undercutting at site L1

TWEED
SHIRE COUNCIL

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