Department of Environment and Resource Management

Report on the Effects of the January 2011 Flood on the Mangrove Communities Along the Brisbane River

January 2012

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Executive summary

This report summarises the effect of the January 2011 flood on the mangroves along the Brisbane River.

The length of the Brisbane River from Breakfast Creek to the Bremer River is 56.7 km with a combined bank length of 113.4 km. Prior to the January 2011 flood there was 82.3 km of mangroves present along both banks of the Brisbane River from Breakfast Creek to the Bremer River.

The January 2011 flood had, as at June 2011, resulted in the death, destruction or partial destruction of 76 km of mangroves along the Brisbane River. This represents 92.4 per cent of the mangroves present along the Brisbane River from Breakfast Creek to the Bremer River prior to January 2011.

As a result of siltation caused by the January flooding, an additional 2.4 km of mangroves along the river were dead or dying in June 2011 that were not dead in February 2011. As a result of this siltation along the river it can be expected that losses of grey mangrove in particular will increase and that by December 2012 the January flood will have resulted in a loss of about 95 per cent of the mangroves along the river.

The most severe effects of the January 2011 flood on the mangroves along the Brisbane River were in the area upstream from the Indooroopilly Bridge to the Moggill Ferry where almost complete destruction occurred. Downstream from the Indooroopilly the Bridge the effects were decreased and mainly dependent on the level of siltation that had been experienced.

A similar but somewhat larger flood event occurred in January 1974. However the 1974 flood caused minimal loss to the mangroves along the Brisbane River as at that time mangroves only occurred near the mouth of the river.

It is likely that over time the mangroves along the river will recover. This recovery will however be dependent on seasonal factors. This recovery could take a number of years and it is likely to be about 10 years before full recovery of the mangroves has occurred.

It is recommended that continued monitoring of the mangroves along the river take place until December 2012 so that the full effects of siltation on the mangroves along the river can be ascertained.

Introduction

The Brisbane River catchment in Southeast Queensland covers an area of approximately 15 000 square kilometres. In early January 2011 this catchment was subject to a prolonged and heavy rainfall event (BOM) (Figure 1). This event resulted in moderate to major flooding occurring between 12 and 14 January 2011 along the section of the Brisbane River downstream of its junction with the Bremer River. This flood event resulted in the inundation of a large part of the lower Brisbane River flood plain causing major inundation to properties in Brisbane. At the height of the flooding there was two flood peaks, one late on the evening of Wednesday 12 January and the other in the early hours of Thursday 13 January (Figure 2). The downpour also caused major flooding in other parts of the Brisbane River catchment upstream of the Brisbane and Bremer River junctions.

This flood event resulted in the destruction of and severe damage to, large areas of mangroves along the tidal sections of the Brisbane River downstream of the junction of the Brisbane and Bremer Rivers. This report and associated GIS coverage aims to quantify the nature and extent of loss and damage to the mangroves along the Brisbane River as a result of the January 2011 flood.

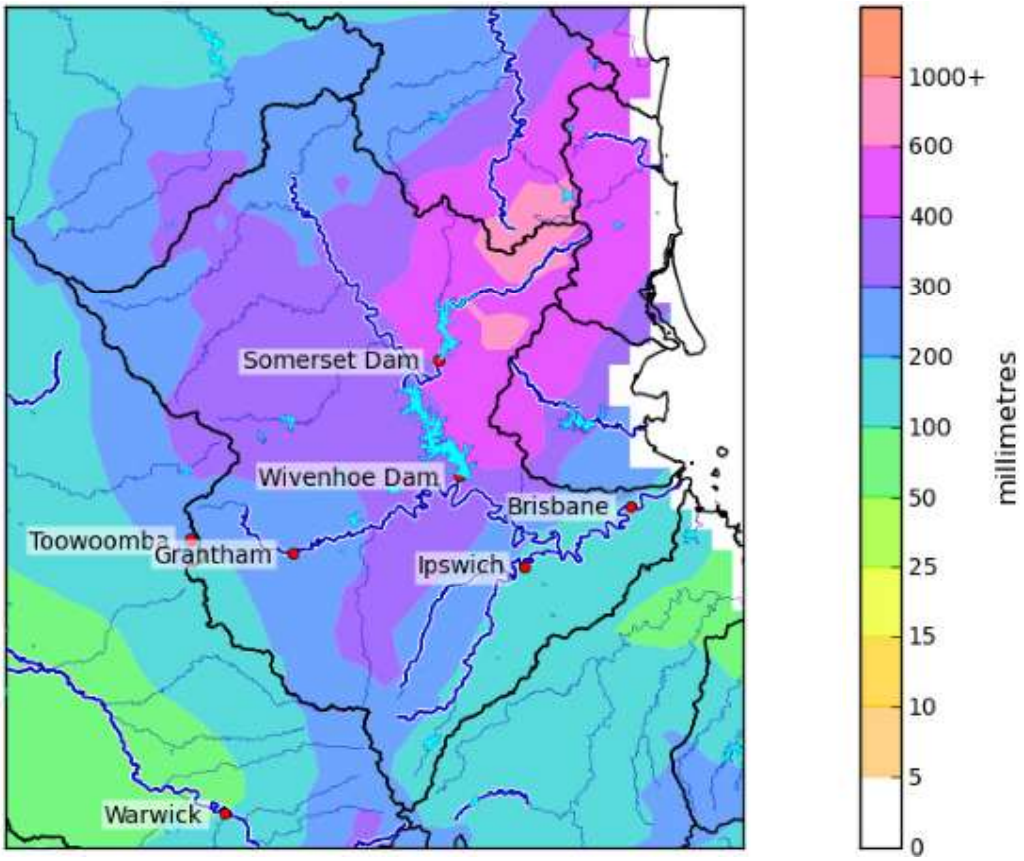

Figure 1: Rainfall map for the Brisbane River catchment for the 96 hours to 9 am on 13/01/2011 (Source BOM).

Brisbane River floods

Flood records for Brisbane extend back as far as the 1840s and indicate that Brisbane has had a long history of flooding (Figure 3). The biggest floods were in 1841 with a flood of 8.43 m and in 1893 with a height of 8.35 m. The largest flood of the 20th century occurred in January 1974, rising to a height of 5.45 metres on the Brisbane City Gauge situated at the river end of Edward Street. The most recent flood of January 2011 had a peak of 4.46 metres at the Brisbane City Gauge (Figure 2). Further upstream flood heights were substantially higher with flood heights of 19.25 m being recorded on the Bremer at Ipswich upstream of the junction of the Bremer and Brisbane Rivers, a flood height of 17.87 m was recorded at Moggill and a flood height of 12.90 m was recorded at Jindalee (BOM).

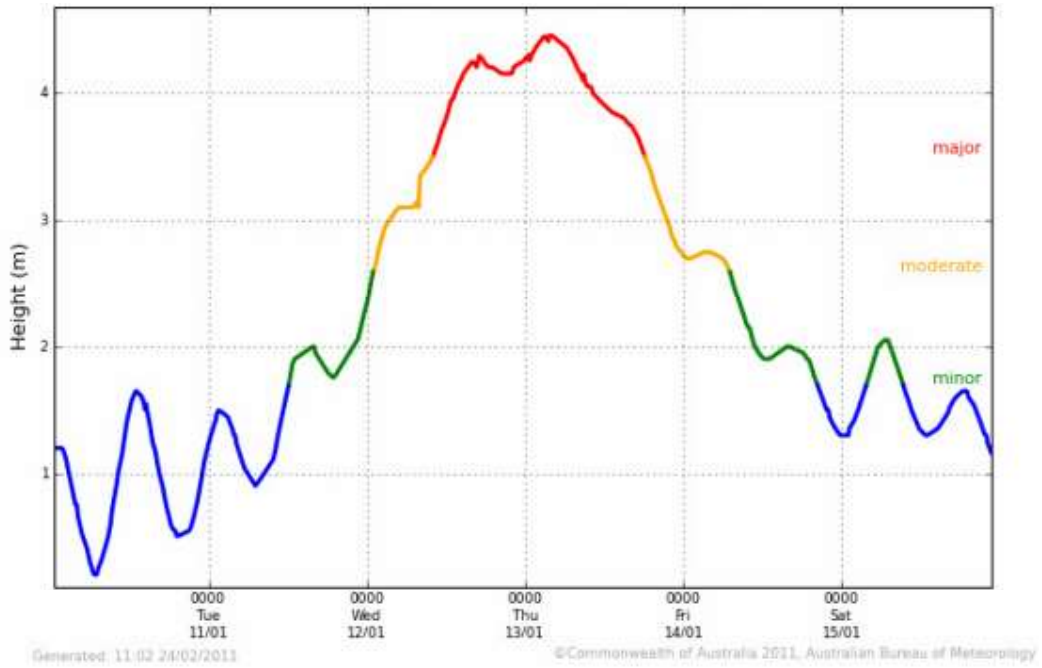

Figure 2: Flood Heights at Brisbane City (Thornton Street Ferry) gauge for 11 to 15 January 2011 (Source BOM).

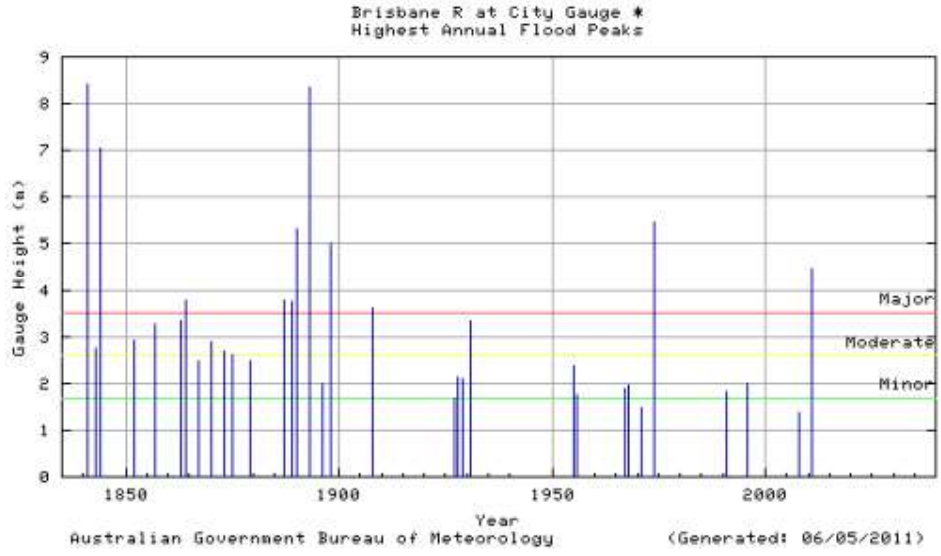

Figure 3: Flood heights for the Brisbane River (Source BOM).

Mangrove distribution along the Brisbane River

The last major flood along the Brisbane River occurred in January 1974. Prior to this flood there were very few mangroves along the Brisbane River. At that time mangroves were mainly located at or adjacent to the mouth of the Brisbane River (Dowling 1986). As a consequence, the flood of 1974 did not have a major impact on mangroves as they were relatively rare along the Brisbane River. Mangroves have only become common along the Brisbane River post 1974. This change in distribution can be attributed to the construction of the Wivenhoe Dam in the early 1980s which has resulted in the restriction of flood events in the downstream reaches of the river. The construction of Wivenhoe Dam for flood mitigation purposes has also resulted in the replacement of what was essentially a freshwater environment with a marine environment in the Brisbane River. Saltwater intrusion now occurs as far upstream as the Bremer River junction. The regular high freshwater flows prior to the construction of Wivenhoe Dam resulted in the flushing of salt water from the river as well as clearing of silt deposits. The removal of rock bars at a number of locations for navigation purposes has also allowed saltwater intrusion further up the river. In addition, dredging of the Brisbane River upstream of the Milton Reach for gravel extraction since that time has resulted in the deposition of silt along the banks of most stretches of the Brisbane River making conditions conducive for mangrove establishment (Hossain et al. 2004). Since dredging of the river ceased in 1997 sand and gravels have once again started to be deposited on areas where mangroves currently exist such as at Captain Burke Park at Kangaroo Point, at New Farm and under the Walter Taylor Bridge at Indooroopilly.

Prior to the January 2011 flood, mangroves occurred along much of the river from its mouth to the Moggill Ferry (downstream of the junction of the Brisbane and Bremer rivers). Mangroves formed a more or less continuous line along both banks of the Brisbane River from Kaye's Rocks at Toowong and the opposite bank at Orleigh Park, West End upstream to the Moggill Ferry. The width of this mangrove fringe varied but in general it became narrower the further upstream they occur. There are some sections of the river bank where mangroves covered a substantial area, mainly in areas where deposits of silt had built up over time. Downstream of Kaye's Rocks the mangroves lining the bank were discontinuous due to the fact that from this point downstream the river banks is continuously lined with rock walls or revetments, which result in an unsuitable habitat for extensive mangrove establishment. However, this downstream section does contain some stands of mangroves especially on the inside corners of bends (e.g. Gardens Point) where there has been a build up of silt and mud over time.

Methodology

To quantify the extent of damage to the mangroves as a result of the January 2011 flood event, two surveys of the mangroves lining the Brisbane River were undertaken from the junction of the Brisbane River and Breakfast Creek upstream to the junction of the Brisbane and Bremer rivers on 15 February and on 27 June 2011. These dates were chosen as the first practical time after the flood and the second later trip was necessary to allow sufficient time for the effects of siltation resulting from the flood on the mangroves, and grey mangrove (*Avicennia marina* subsp. *australasica*) in particular, along the Brisbane River to become apparent.

A survey of the mangroves downstream of Breakfast Creek was not undertaken as mangroves are not common in the lower reaches of the Brisbane River due to revetments and port infrastructure, such as wharfs, being present along the river banks over the whole of this section of the river. Also due to its proximity to the river mouth this section of the river is not subject to the extreme flooding events that occur upstream and in the January flood this area was only subject to minimal rises as compared to areas further upstream.

A series of aerial photographs using NearMaps imagery was used to determine the extent of flooding as NearMap images were available for 14 January 2011 shortly after the peak height of the river, as well as 12 September 2010 which enabled comparisons to be made pre-flood and during the flood. The extent and nature of damage to the mangroves and river bank were documented on these aerial photographs and this information transferred to a GIS coverage using ArcMap 10.

While some areas of mangroves with a width greater than three trees exist along the river (mainly at Gardens Point adjacent to the Brisbane Botanic Gardens, upstream of the Eleanor Schonell Bridge in areas adjacent to the University of Queensland at St Lucia near The Elbow, on Indooroopilly Island at Long Pocket on Indooroopilly Reach, on the north bank of the river opposite Mosquito Island in Mermaid Reach at Jindalee and on the north bank of the Brisbane River at Pinjarra Hills opposite Loffs Road,Westlake), the majority of mangroves along the Brisbane River only tend to form a narrow fringe of one to three trees in width.

Because of this lineal nature of mangroves along the Brisbane River the GIS coverage of the effect of the January 2011 flood on the mangroves along the Brisbane River has been developed using lines rather than polygons and consequently comparisons over time of the effects of the flood have been made on lineal extent only and not on areal extent.

Species of mangroves along the Brisbane River

Of the seven species of mangroves that are known to occur in Moreton Bay only *Avicennia marina* subsp. *marina* (grey mangrove), *Aegiceras corniculatum* (river mangrove) and *Excoecaria agallocha* (milky mangrove) are known to occur in the Brisbane River upstream of Breakfast Creek.

Categories of damage

In assessing the damage to the mangroves along the Brisbane River as a result of the January 2011 flood the categories shown in Table 1 were devised, after field inspection. The areas in which silt had been deposited were also recorded as it is known that covering the roots of grey mangrove with silt causes the plants to die over time. It was considered important to document this information to predict the areas of likely mangrove death or die-back over the coming months. Table 2 lists the categories and photographs of those categories and Table 3 lists the colour legend that they represent on the aerial photographs.

Table 1 Categories of mangrove damage along the Brisbane River.

Category	Comment
Dead and living mangroves	These are areas in which the mangroves present are both living and dead. Generally the mangroves in these areas were in a ratio of approximately one living to one dead plant. Often the dead plants formed the most river ward fringe while the living plants were at the landward edge of the mangrove band.

Category	Comment
Dead mangroves	All the mangroves present in these sections of the river are dead.
Dying	These are areas of mangroves that are dying as at June 2011. They are areas of mangroves that were living in February 2011. In nearly all cases they occur in areas of heavy siltation.
Erosion	These are areas in which mangroves have been totally eroded away, and in which the river bank has obviously been eroded. Also included in this category are the more extensive areas of mangroves in which the outer most edge of the mangroves has eroded away as a result of the flood.
Living mangroves	These are areas in which the mangroves are still alive and appear unaffected by the flood.
Removed and dead mangroves	These are areas from which the mangroves have been removed by the flood but also includes areas in which there are scattered dead mangoves still present along the bank. Usually the base rock along the edge of the river has been exposed in these areas due to erosion.
Siltation	These are areas in which silt has been deposited within the mangroves. Generally this has covered or nearly covered the pneumatophores of grey mangrove and will likely result in their death or decline.
Slumped	These are areas in which the bank of the river has slumped into the river. They are obvious by the presence of mangroves within the river and in some cases by large *Eucalyptus tereticornis* trees present in the river channel.

Table 2 Categories of damage and associated pictures (see Appendix 1).

Category	Photograph
Dead and living mangroves	4, 6
Dead mangroves	5
Dying	7
Erosion	
Living mangroves	
Removed and dead mangroves	8
Siltation	1, 3, 4
Slumped	

Table 3 Colour of categories of mangroves as shown on the aerial photographs (see Appendix 2).

Category	Colour shown on aerial photographs
Dead and living mangroves	
Dead mangroves	
Dying	
Erosion	
Living mangroves	
Removed and dead mangroves	
Silt	
Slumping	

Damage effects along sections of the Brisbane River

It is clear that the mangroves along different sections of the Brisbane River suffered differently as a result of the flood. This is a reflection of the height and period for which the mangroves were inundated as well as flow regimes within the river. The worst damage as a result of inundation occurred in the area upstream of the Walter Taylor Bridge at Indooroopilly to Moggill where there has been an almost total destruction of the mangroves along the river banks. In many areas the lower banks have been eroded back to the base rock that forms the bed or bank of much of the river. In areas of alluvial deposits along the river there was in some cases severe erosion.

Downstream of the Walter Taylor Bridge the damage to the mangroves becomes progressively less until downstream of the Story Bridge where the damage has been negligible to non-existent. However, in the section from the Walter Taylor Bridge to the Story Bridge there has been varying degrees of damage usually reflecting the nature of the substrate and surrounding geological formation on which the mangroves are occurring. Also in this section there are substantial areas in which there have been heavy deposits of silt within the mangroves. In these areas of siltation it can be expected that some remnant mangroves will die over time. The rate and extent at which this will occur is dependent on a number of factors including the nature of the silt and the depth of the silt deposition. Grey mangroves are usually able to survive deposits of sand as these are well drained and aerated. However, if silt causes a lack of aeration of the root system, it can cause mangrove decline and eventually death.

The sections of river

i) Breakfast Creek to the Story Bridge

There are limited occurrences of mangroves along this section of the river and as a result the damage to the mangrove communities is minimal. In the main, sand has been deposited around the root systems of grey mangrove communities over the existing silt deposits in this section. The deposition of sand is not expected to have any impact on the existing mangroves as sands tend to be well aerated (see Photograph 1 Appendix A). Sands were also being deposited in these areas prior to the flood; however the flood has resulted in substantially greater quantities of sand being deposited in these areas.

ii) Story Bridge to Merivale Bridge

Damage to mangroves in this section is mainly the result of erosion to the outside edge of the mangroves and deposition of silt, mainly in the Gardens Point area.

The area of mangroves downstream of the QUT CityCat Terminal to the Goodwill Bridge adjacent to QUT prior to the flood was subject to erosion with the outside fringe of the mangroves falling into the river. The flood resulted in the removal of those trees that had fallen into the river and scouring of the outside edge of the mangroves in this area (Photograph 2). In February 2011 this area had a relatively shallow layer of silt deposited over its surface. In June 2011 this section of river was more or less in the same condition as at February 2011.

At Gardens Point the flood resulted in the deposition of a large amount of silt and mud which in parts formed mounds up to 1.5 m in height. By June 2011 these mounds of silt and mud had smoothed out so that most of the area at Gardens Point was covered by a thick layer of mud (Photograph 3). It can be expected that the grey mangroves within this area will continue to die for some time into the future unless normal hydrological processes continue to remove this thick layer of silt.

iii) Grey Street Bridge to Kaye's Rocks Toowong

All of the mangroves on the northern bank of this section of the river on the Milton and Toowong reaches were growing within the rocks on the revetment walls that line this section of the river. For the most part these mangroves had died or were in poor health. On the southern bank the mangroves were growing in silt deposits that had been deposited riverward of the revetment walls rather than in the rock walls themselves. Some small sections of mangroves were growing in the revetment walls, and all had died post the floods. The mangroves growing riverward of the revetment walls in the silt deposits were healthy but did have a thin layer of silt covering their pneumatophores. It is unlikely that this layer of silt is deep enough to cause long term problems. Normal hydrological action will probably remove this layer of silt over time.

iv) Kaye's Rocks Toowong to the Walter Taylor Bridge, Indooroopilly

This section of the river consisted of areas of dead and living mangroves or areas that had been scoured and eroded. Areas of erosion were predominant on the University of Queensland land downstream of the Eleanor Schonell Bridge (formerly known as the Green Bridge).

Along the northern bank of the river upstream of the Eleanor Schonell Bridge adjacent to the University of Queensland there was an extensive stand of mangroves. The water's edge of much of this stand was eroded and had collapsed into the river in February 2011. The remaining area was a mixture of living and dead trees with the living trees being on the landward edge of the mangroves (Photograph 4). A thick deposit of silt covered much of the area so that the mangroves in this area are likely to decline over time.

The substantial area of mangroves at Indooroopilly Island was intact at the time of the visits however there were some sections that have had their outside edge removed by erosion. In areas upstream of Indooroopilly Island there was extensive death of mangroves on the water's edge. Most of these mangroves had a downstream lean having been forced over by the strength of the flows (Photograph 5). This phenomenon was also evident elsewhere in many areas upstream from Indooroopilly Island such as Mermaid Reach at Jindalee.

Along the southern bank of Indooroopilly Reach from Tennyson to the Walter Taylor Bridge the mangroves were mainly a mixture of dead and living plants with a thick layer of silt on the surface (Photograph 6). The visit in June 2011 revealed that the mangroves over much of this area were dead or dying and the extent of death of the mangroves was much more extensive than in February 2011. The area around the Queensland Tennis Centre at Tennyson which consisted of large old trees of grey mangrove had a much more extensive area of death in June than was present in February 2011 (Photograph 7). This area also had a very deep layer of silt deposition on the surface. It can be expected that the mangroves within this area will continue to die.

v) Walter Taylor Bridge, Indooroopilly to the Moggill Ferry

The most extensive damage of mangroves as a result of the flood occurred in the section of river from the Walter Taylor Bridge, Indooroopilly upstream to the Moggill Ferry. Over most of this area there was a 100 per cent death of mangroves along both banks of the river. For most of this section the mangroves had been either completely killed or they had been scoured from the river banks. Scouring was most severe in areas in which there had been relatively little mud deposition over the years and where mangroves were growing on the base rocks forming the edge of the river (Photograph 8). Along this section of the river is also the area in which the major areas of erosion of the river banks has occurred. This has resulted in areas of relatively minor erosion (Photograph 9, 10) to areas of major erosion such as at Moggill where the erosion is approximately 15 m in height (Photograph 11). Also in this section of the river there were a number of sections of the river that had slumped into the river channel (Photograph 12). From Jindalee to Westlake the mangroves have all been killed but have been left in place along the river bank.

GIS coverage

ArcMap 10 was used to produce a GIS coverage of damage to the mangroves. The results of this GIS coverage are shown at aerial photographs 1 to 15 (see Appendix 2).

Extent of damage to the mangroves along the Brisbane River

The length of the Brisbane River from Breakfast Creek to the Bremer River is 56.7 km with a combined bank length of 113.4 km. Of this length prior to the January 2011 flood there was 98.57 km of mangroves along both banks of the river. Table 4 lists these categories and their changes in type from February to June 2011. In addition silt was deposited along 19.48 km of the river bank and this has been recorded as it is likely to effect the have long term viability of mangroves, and grey mangrove in particular, along the Brisbane River.

Table 4 Lengths of effected areas along the Brisbane River by type.

Category	Length in metres February 2011	Length in metres June 2011
Dead and living mangroves	15343.83	10737.27
Dead mangroves	3808.83	6466.96
Dying	0	2432.95
Erosion	14052.35	14052.35
Living mangroves	6760.05	6275.52
Removed and dead mangroves	40969.9	40969.9
Slumped	1367.98	1367.98
Total	82302.94	82302.94

Siltation	19475.72	19475.72

Conclusions

It can be expected that the mangroves along the river will re-establish in suitable habitats over time. It was noted that many standing milky mangroves appeared to be dead in February. However, by June 2011 most of the milky mangroves were recovering and reshooting, even in areas in which grey mangroves and river mangroves were completely dead. Milky mangrove is most common along the edges of the river in which bedrock normally occurred along the river bank such as at Fig Tree Pocket and occurs at the upper tidal limits on the most landward edge of the mangroves. Because it persists in areas where the other species of mangroves have been eroded away it suggests that it is able to anchor itself to the underlying bedrock and will be the first species to recover along the Brisbane River.

There are a number of larger trees along the Brisbane River that are dead or dying (such as at Tennyson and Gardens Point). As these larger trees die it can be expected that their branches and trunks will fall into the river. These larger branches and trunks have the potential to cause a navigation hazard to marine craft within the river as they are likely to be semi-submerged and difficult to see, especially in the sections of the river that are murky due to silt loads. In addition, this timber is likely to wash ashore at the upper tidal limits and wash around. As a result they are likely to cause physical damage to young seedlings that start establishing post the flood.

While it can be expected that mangroves will re-establish along the river the time frame over which this is likely to occur cannot be predicted with any accuracy. A number of factors will determine this including levels of seed set within the surviving mangroves and the distance to suitable seed sources from un-vegetated areas. Grey mangrove normally drops it seeds (technically propagules) in June and July. The level of seed set varies considerably from year to year dependent on a number of factors. In the normal course of events in some years there are very heavy seed sets while in others seed set can be quite low. It can also be expected that due to siltation covering the pneumatophores of grey mangrove that trees of this species will continue to die. To substantiate this potential loss it will be necessary to continue monitoring of the mangroves along the Brisbane River until December 2012.

Acknowledgements

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Bibliography

BOM:

<www.bom.gov.au/hydro/flood/qld/brochures/brisbane_lower/brisbane_lower.pdf>

<www.bom.gov.au/hydro/flood/qld/brochures/brisbane_lower/brisbane_lower.shtml#PreviousFlooding>

Dowling, R.M. (1986), The Mangrove Vegetation of Moreton Bay. Technical Bulletin No. 6, Botany Branch, Queensland Department of Primary Industries

Hossain, S., Eyre, B.D. and McKee, L.J. (2004), Impacts of dredging on dry season suspended sediment concentrations in the Brisbane River estuary, Queensland Australia. Estuarine, Coastal and Shelf Science, Vol. 61, no. 3, pp. 539–545.

Appendix A Photographs

Photograph 1 Sandy deposits around mangroves, New Farm.

Photograph 2 Eroded mangroves adjacent to QUT and Riverside Expressway, South Brisbane Reach.

Photograph 3 Silt deposition Gardens Point June 2011.

Photograph 4 Dead and living mangroves northern bank of the river upstream of the Eleanor Schonell Bridge adjacent to the University of Queensland with the roots of grey mangrove covered by a thick layer of silt.

Photograph 5 Dead mangroves adjacent to Indooroopilly Island.

Photograph 6 Dead and living mangroves Indooroopilly Reach, Chelmer.

Photograph 7 Dying grey mangroves June 2011 adjacent to Queensland Tennis Centre at Tennyson.

Photograph 8 Scouring was most severe in areas in which there had been relatively little mud deposit over the years and where mangroves were growing on the base rocks forming the edge of the river.

Photograph 9 Eroded River Bank, Fig Tree Pocket.

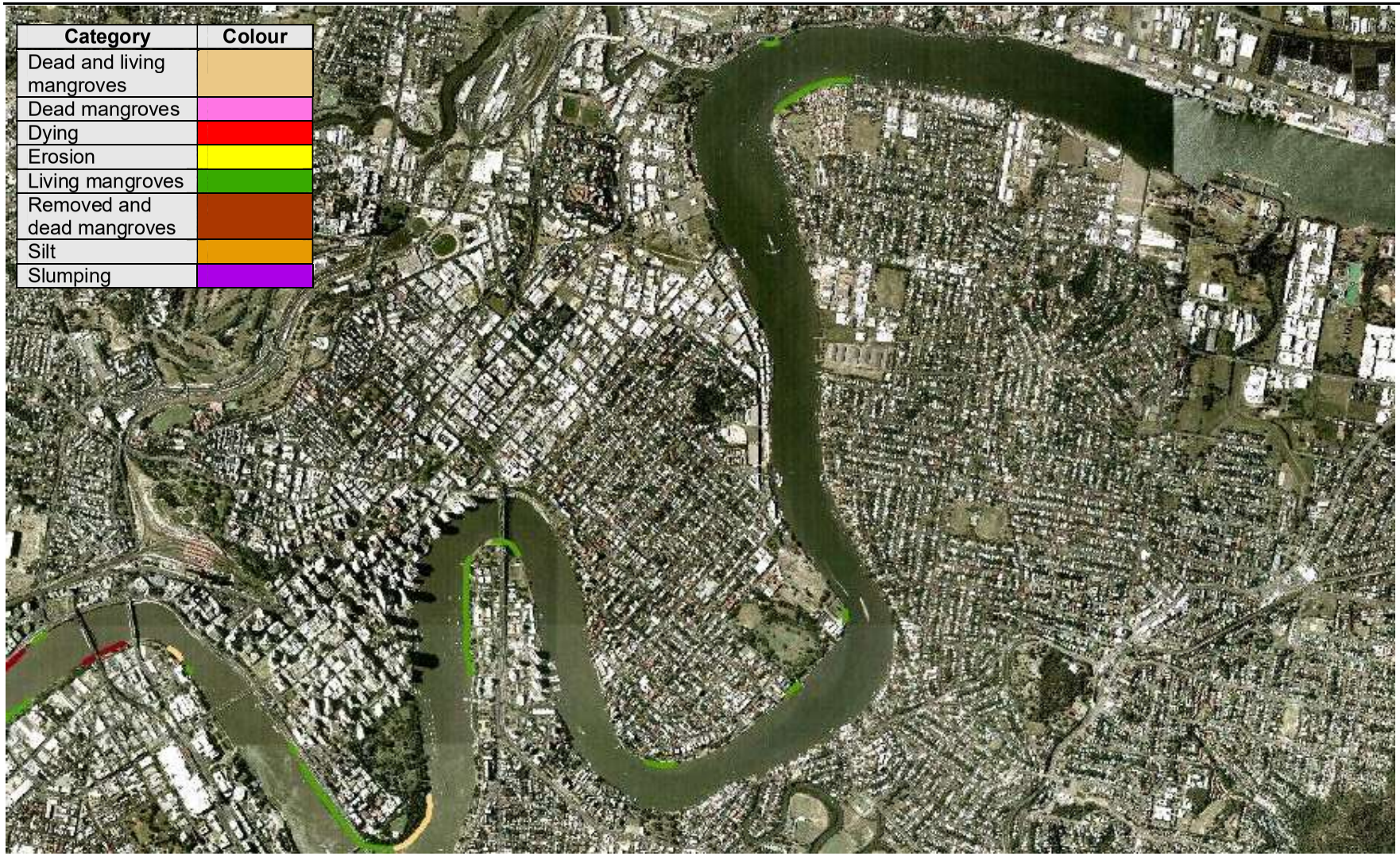
Photograph 10 River bank erosion at Moggill opposite Six Mile Creek.

Photograph 11 Severe erosion of river bank Moggill, adjacent to Avonmore St.

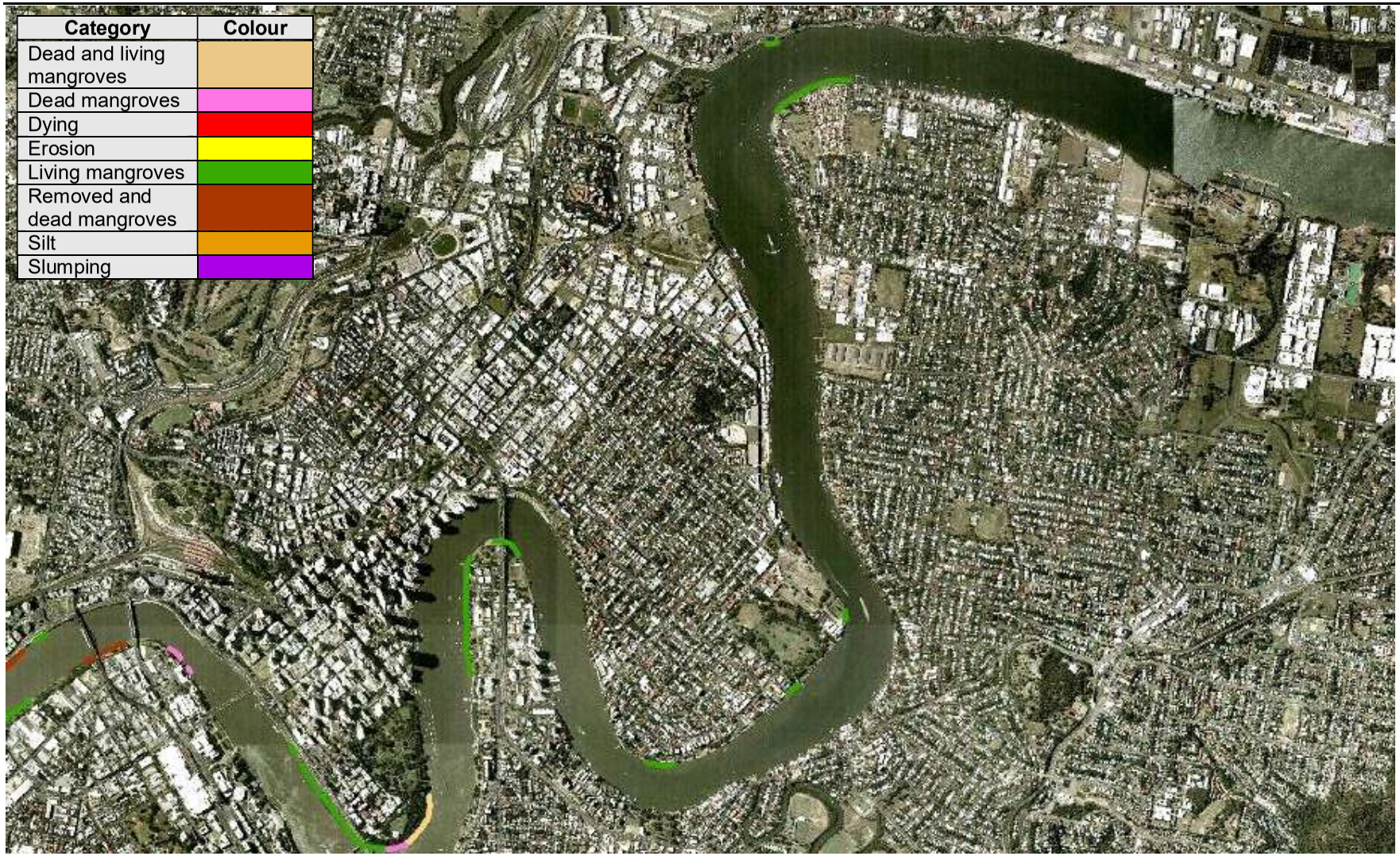
Photograph 12 Slumping of river bank at Wacol.

Photograph 13 Dead grey mangrove at Riverhills near rowing club.

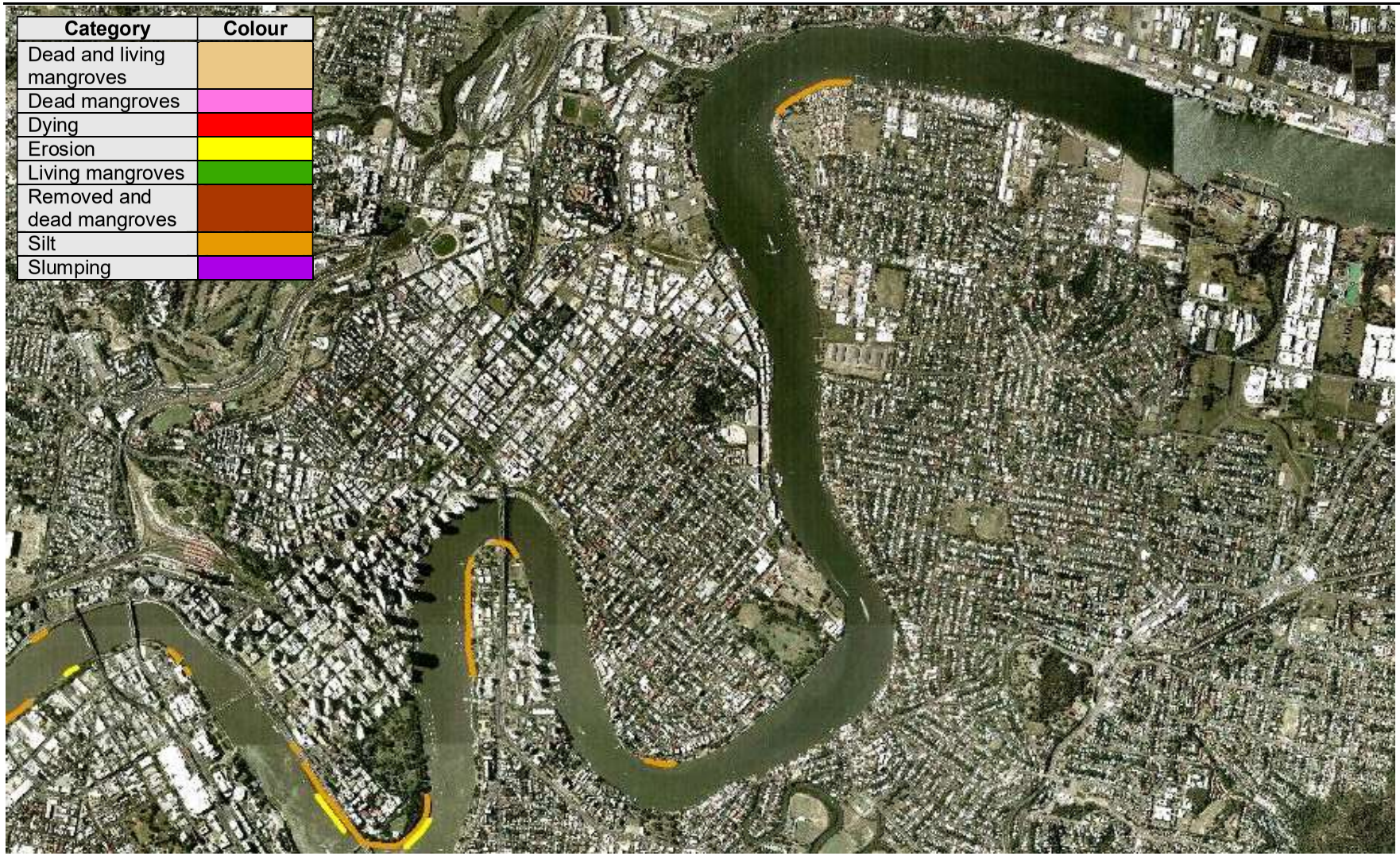
Appendix B Aerial photographs



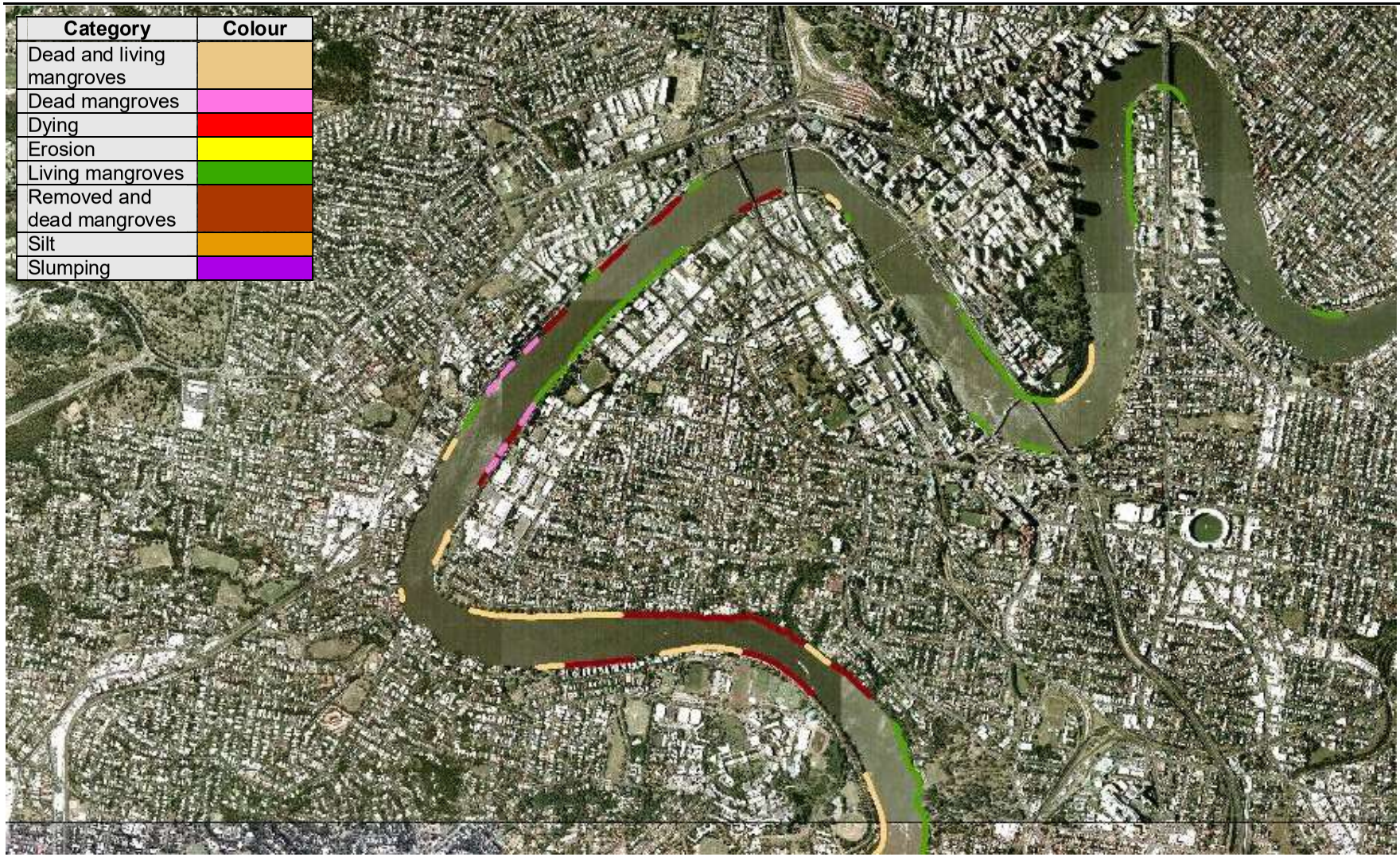
Aerial photograph 1 Breakfast Creek to Story Bridge February 2011.



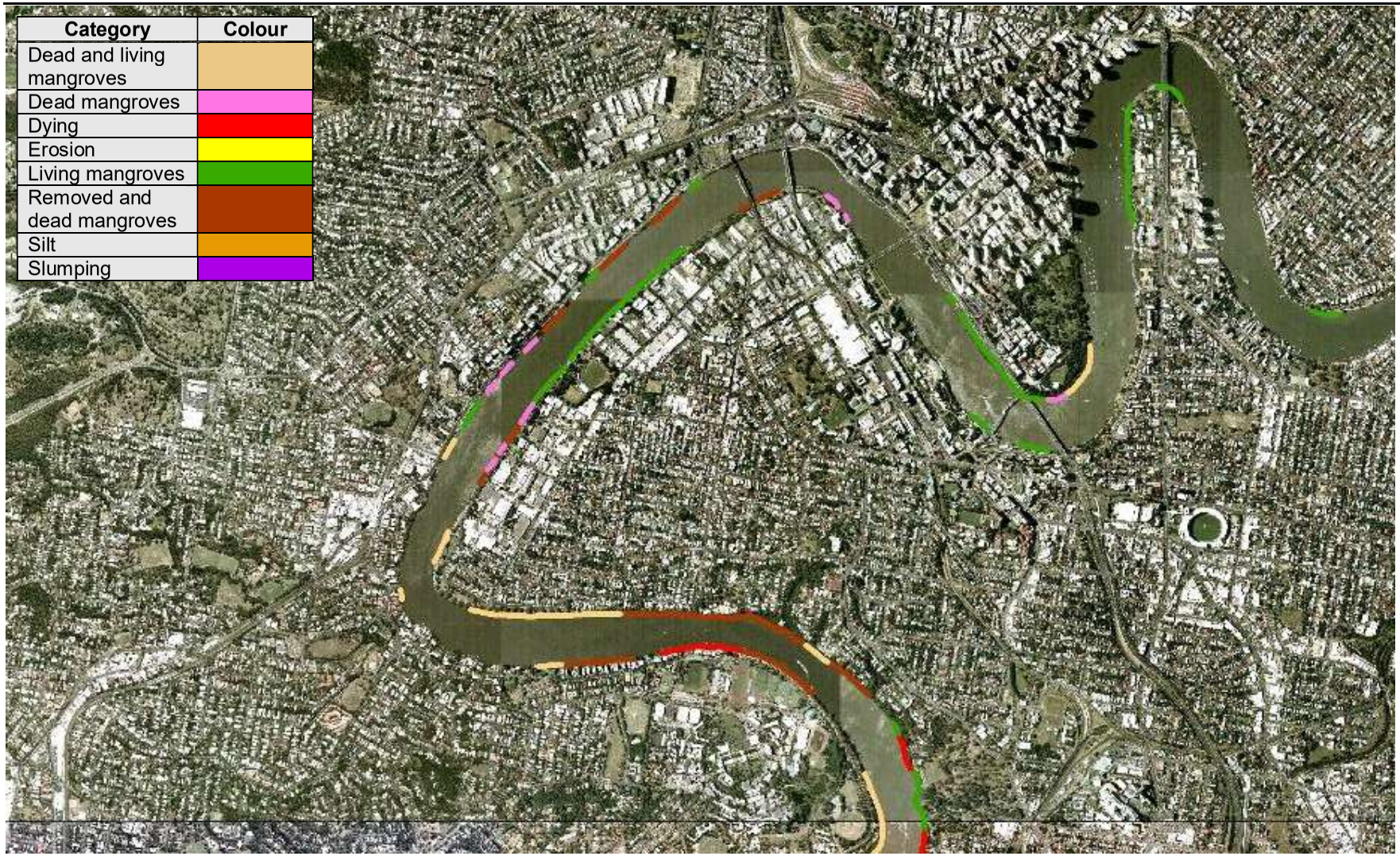
Aerial photograph 2 Breakfast Creek to Story Bridge June 2011.



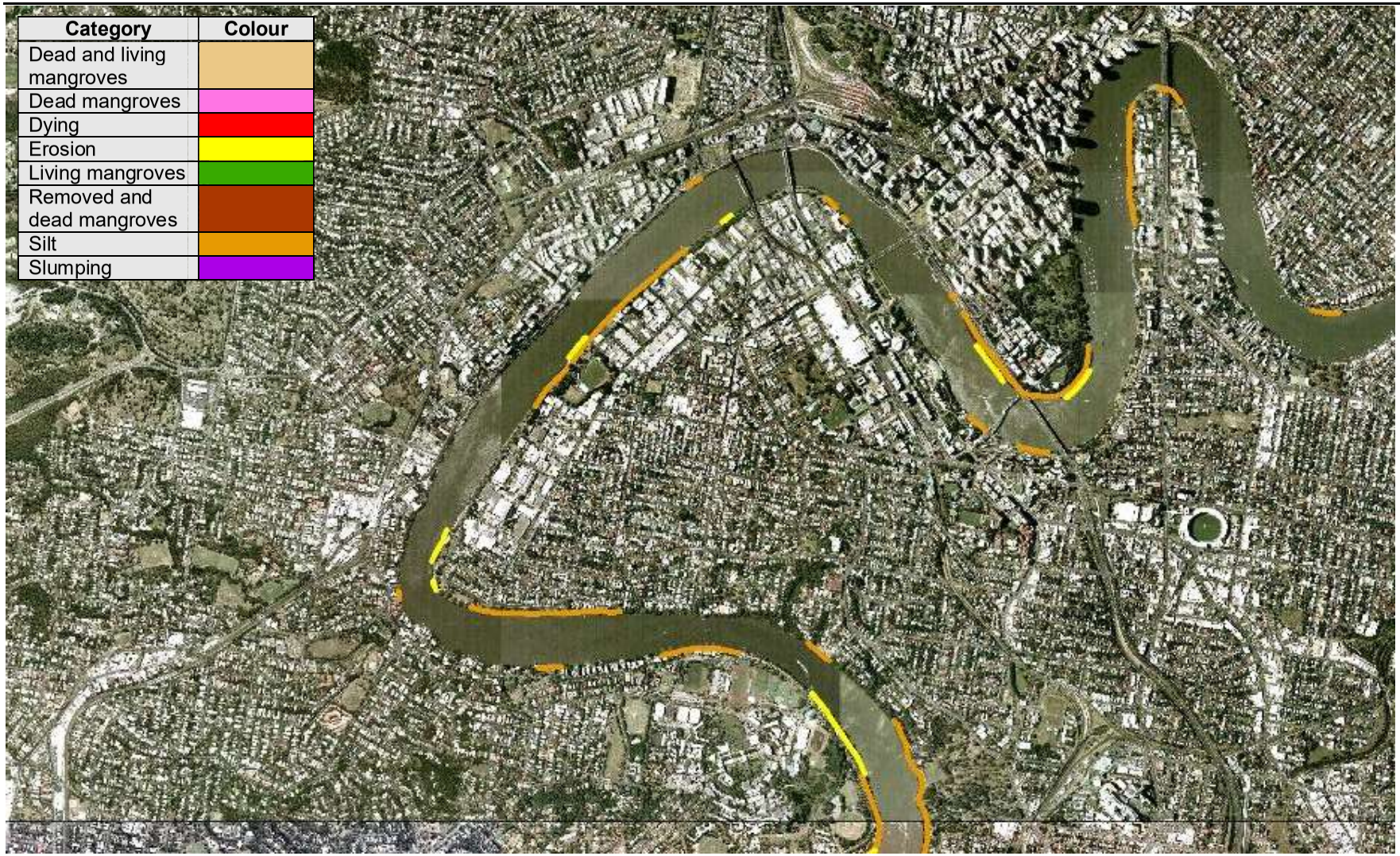
Aerial photograph 3 Breakfast Creek to Story Bridge showing silting, erosion and slumping February 2011.



Aerial photograph 4 Story Bridge to St Lucia February 2011.



Aerial photograph 5 Story Bridge to St Lucia June 2011.

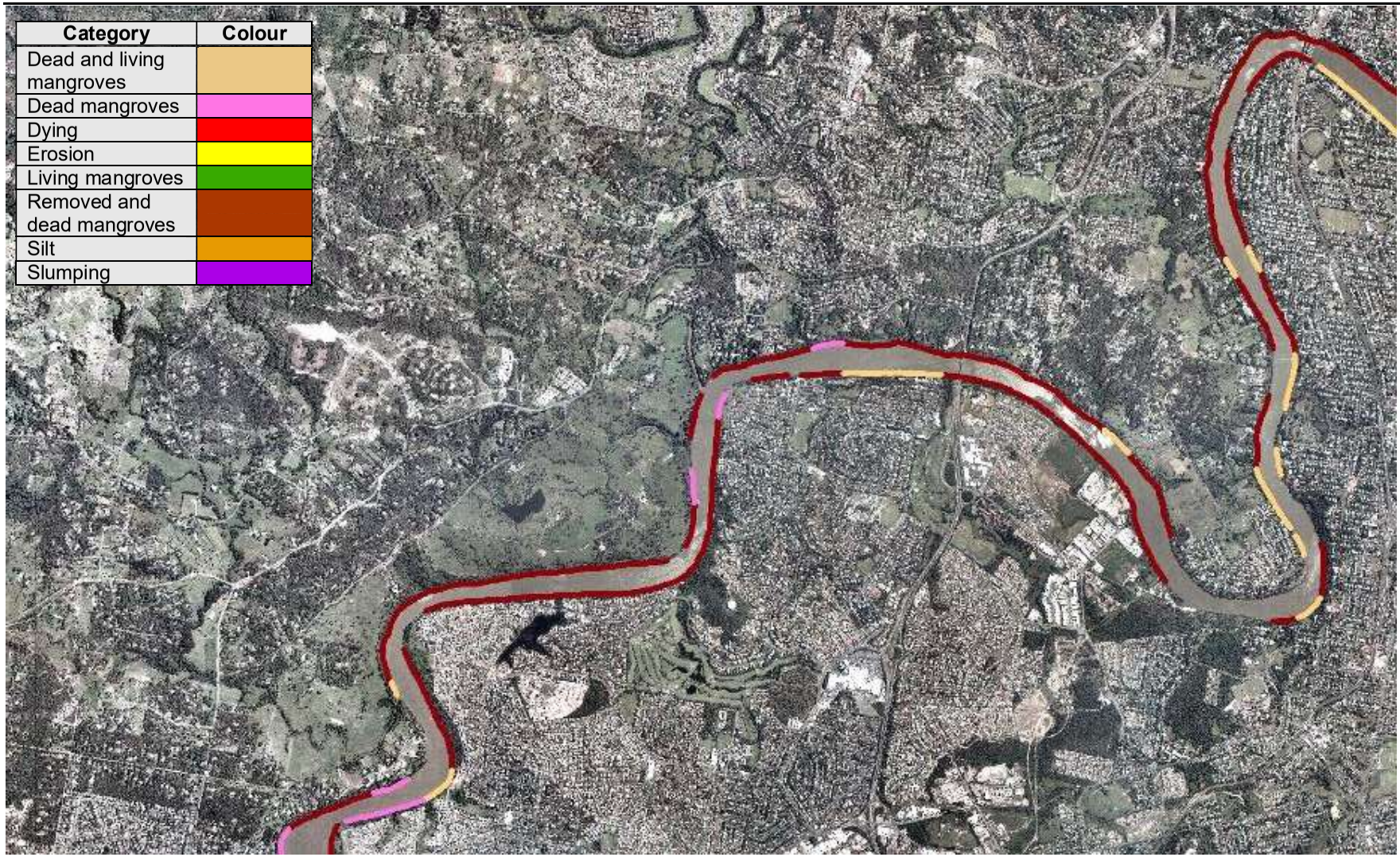


Aerial photograph 6 Story Bridge to St Lucia February 2011 showing silting, erosion and slumping February 2011.

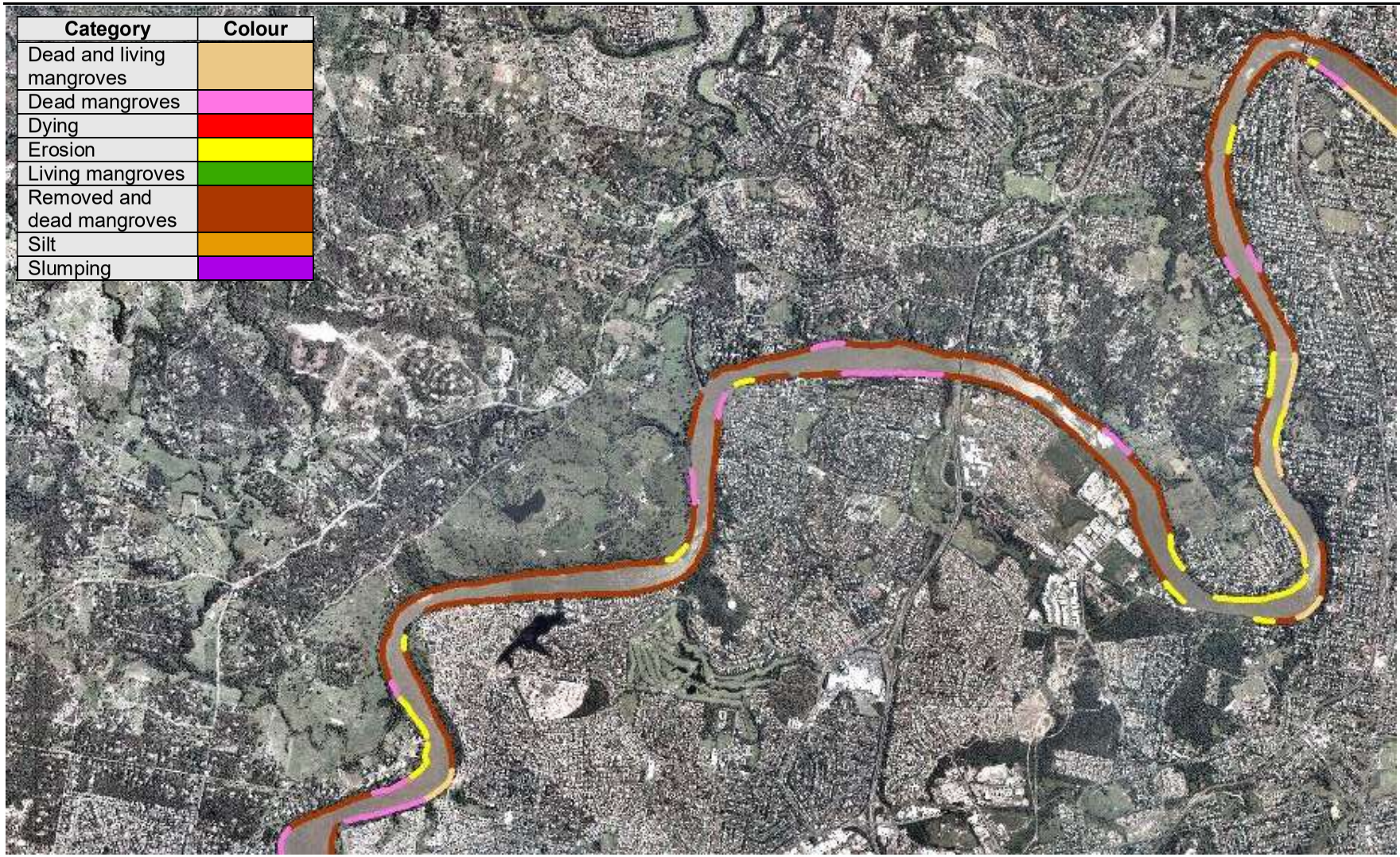
Aerial photograph 7 St Lucia to Walter Taylor Bridge, Indooroopilly February 2011.

Aerial photograph 8 St Lucia to Walter Taylor Bridge, Indooroopilly June 2011.

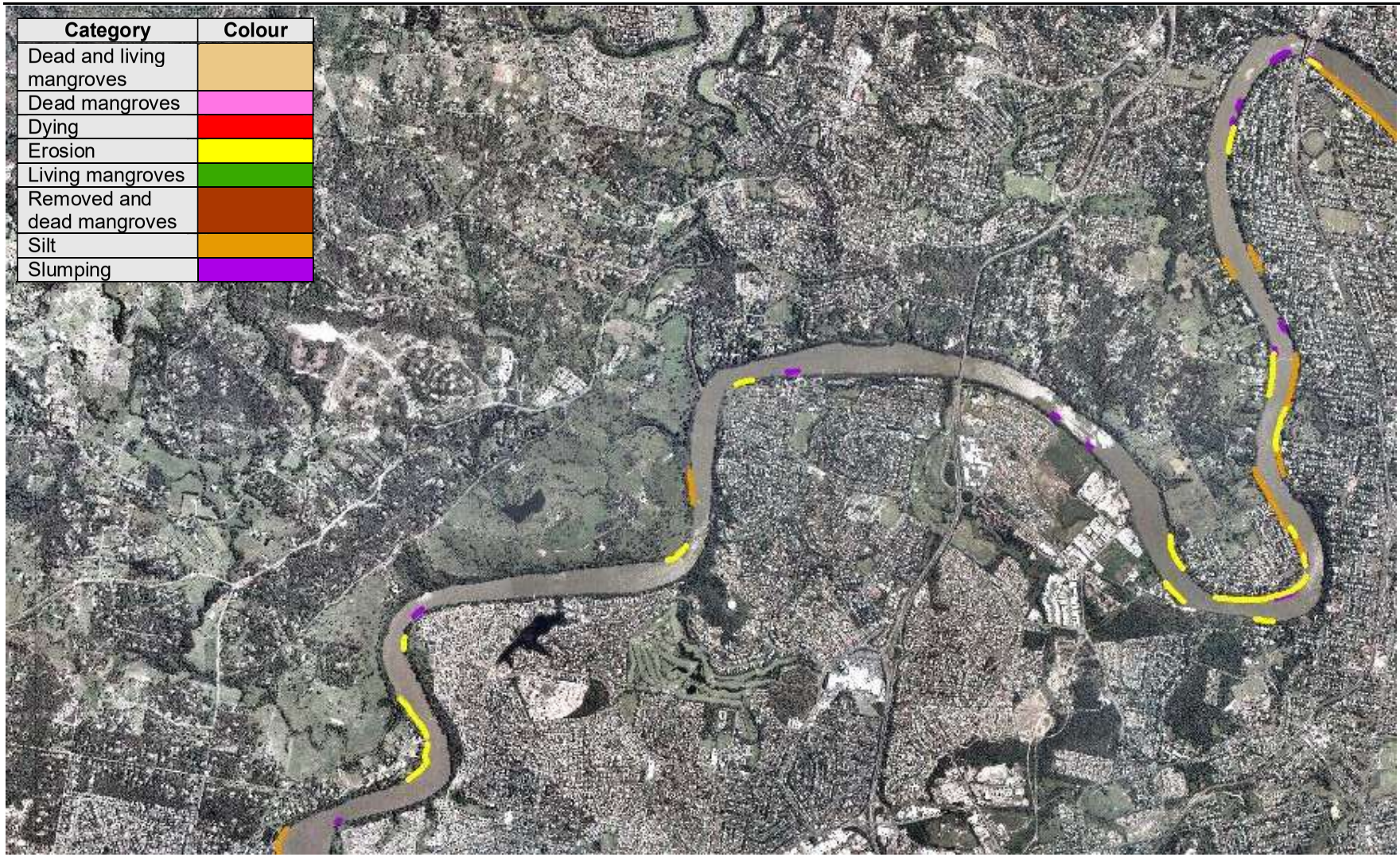
Aerial photograph 9 St Lucia to Walter Taylor Bridge, Indooroopilly showing silting, erosion and slumping February 2011.



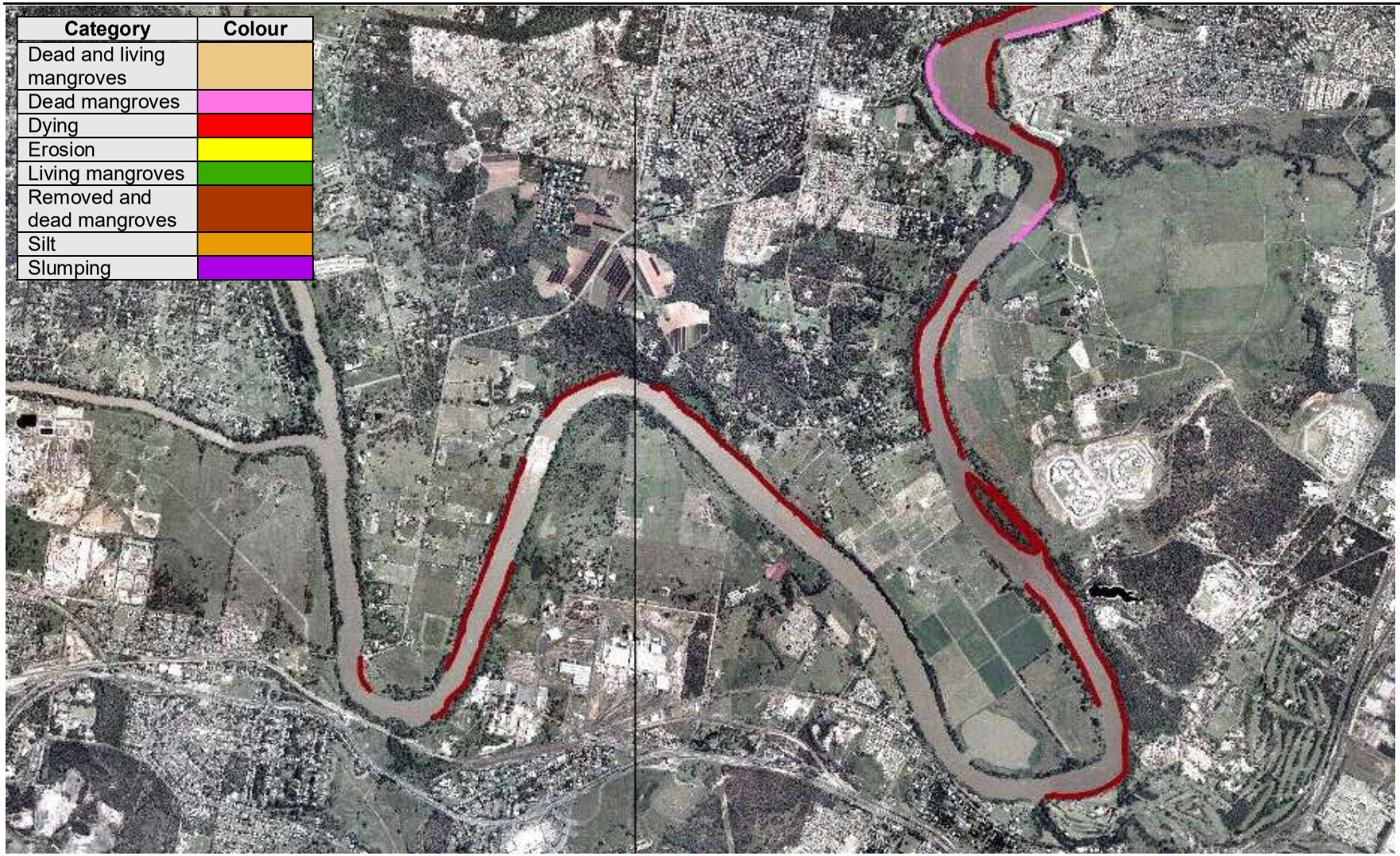
Aerial photograph 10 Walter Taylor Bridge, Indooroopilly to Westlake February 2011.



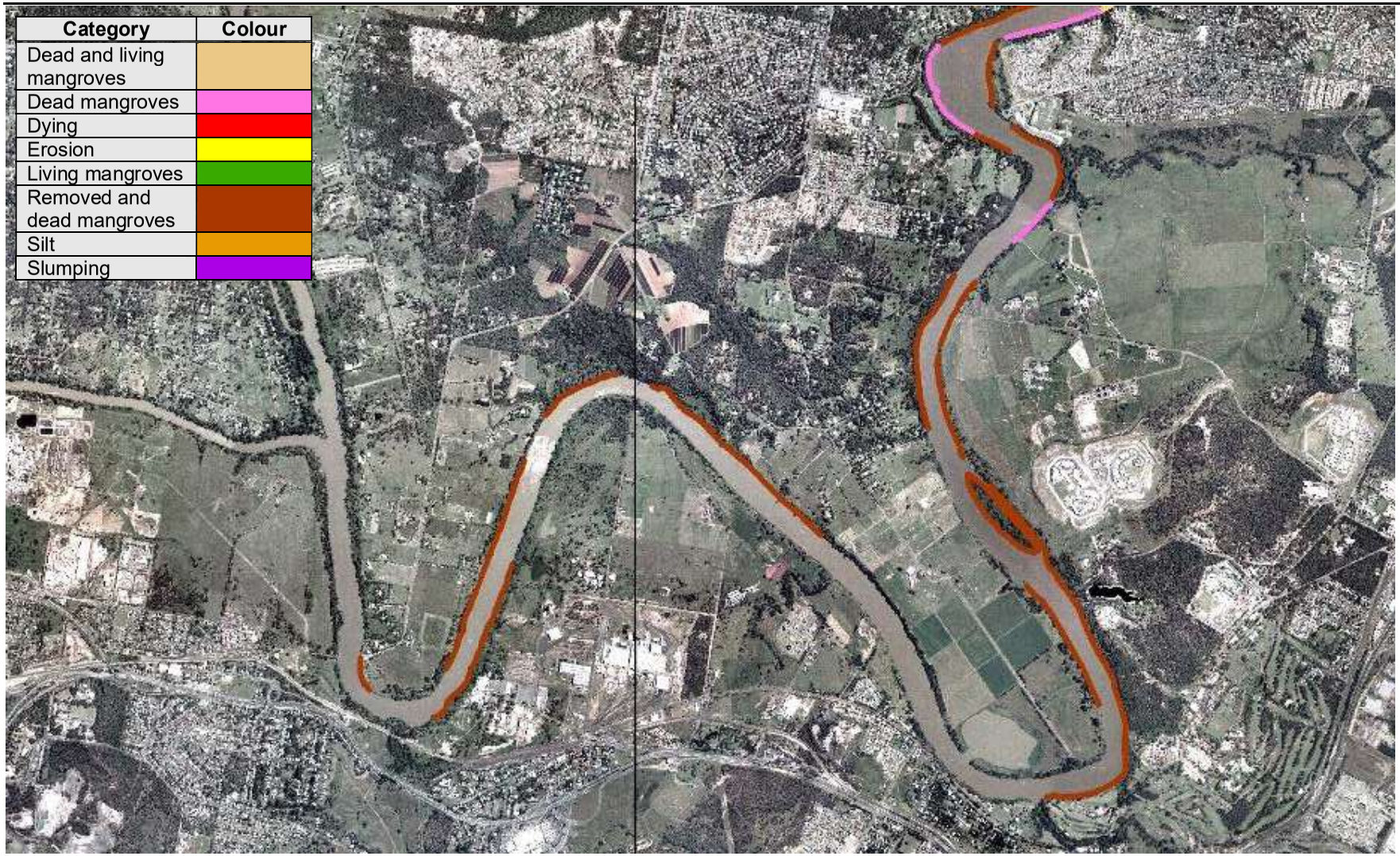
Aerial photograph 11 Walter Taylor Bridge, Indooroopilly to Westlake June 2011.



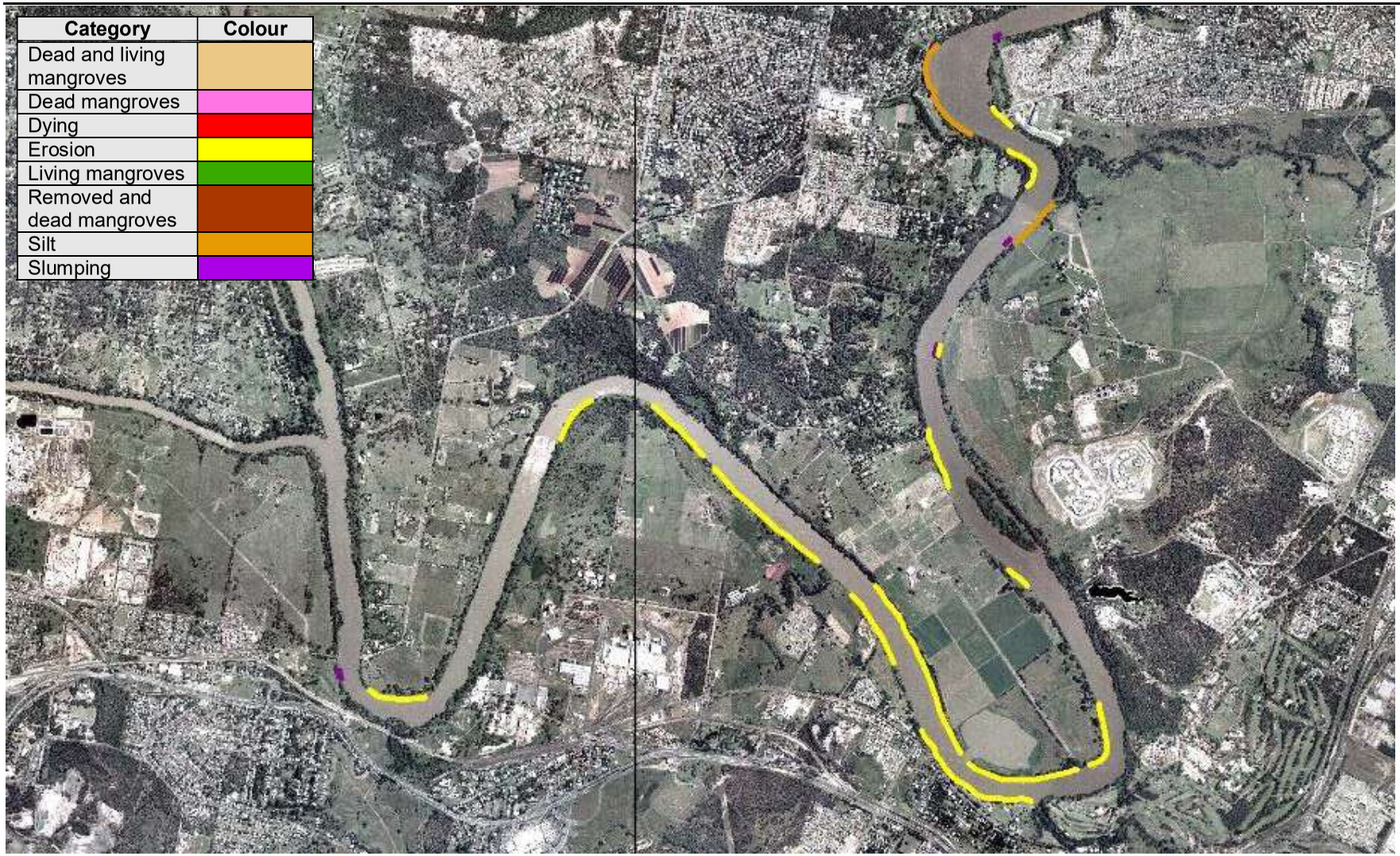
Aerial photograph 12 Walter Taylor Bridge, Indooroopilly to Westlake showing silting, erosion and slumping February 2011.



Aerial photograph 13 Westlake to Moggill February 2011.



Aerial photograph 14 Westlake to Moggill June 2011.



Aerial photograph 15 Westlake to Moggill showing silting, erosion and slumping February 2011.