APPENDIX D:

SOLUTION ASSESSMENT METHODOLOGY

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Waterway Riparian Revegetation

The following methodology and equations were utilised by Moreton Bay Regional Council (MBRC) to determine stream bank erosion rates for all waterways within the MBRC area in order to quantify the effectiveness of riparian revegetation. The resultant data was provided to BMT WBM in GIS format, providing erosion rates along with current condition of riparian vegetation for each stream length.

This data quantifies stream bank erosion only, and does not take into account gully erosion or hillslope erosion in the catchments.

Buffer Width (m)

$$B = k + h + (r \times t)$$

Where B is required buffer width for bank stabilisation, k is the minimum recommended buffer width (5m), h is the stream bank height, t is the time that it takes for vegetation to mature and r is the rate of bank erosion. (Abernathy and Rutherford 1999)

Stream Bank Erosion

The equation used for bank erosion was derived through studies in Northern Queensland where Rutherford (2000) found that there was a relationship between stream power and stream bank erosion.

$$\textit{Stream Power} = \rho g Q_{bf} S_X \qquad (1)$$

Where p=density of water, g=gravity, Q_{bf}=Bankfull Discharge rate and S_X = Slope)

A linear relationship has been adopted for this study similar to the works of Bartley and Wilkson (2006) under two main assumptions. Firstly, bank erosion rates decrease with the proportion of riparian vegetation until bank erosion is negligible under completely intact riparian vegetation (100% riparian proportion). The second assumption is that the rate of bank erosion is reduced in narrow valleys where there is limited exposure of rock and other un-erodible materials. To accommodate this factor, a relationship has been found between rock exposure and floodplain width (F_X) which is also included in the bank erosion equation.

$$\textit{Bank Erosion} = 0.00002\, \rho g Q_{bf} S_X (1-PR)(1-e^{-0.008\, F_X}) \qquad (2)$$

Where PR is the proportion of riparian vegetation and F_x is the flood plain width. Applications of this equation have produced the most consistent results within large river networks in Australia (DeRose et al 2005). For this reason it is now one of the underlying equations in the SedNet model used largely in catchments around the country.

The results from equation 2 can then be converted into sediment loss loads in tonnes/year by multiplying it by the mean bank height, the stream reach length and the mean dry bulk density (DBD) of sediments. This study was completed under the suggested assumption for DBD of 1.5 t/m^3. This gives the final equation below:

$$Bank\ Erosion\ Mass = 0.00002\ \rho g Q_{bf} S_X\ (1-PR)(1-e^{-0.008\ FX})L..H.DBD.Pb \qquad (3)$$

Where L is the length (m) of the stream link, h is the mean bank height of the stream and Pb is the proportion of bank material that contributes to bedload.

Bank Height

There is no record of bank heights within the MBRC region. Therefore, there is a need to determine a way of best estimating the bank heights for each minor basin as coastal areas are likely to differ from upper steeper catchments due to varying topology. In previous studies, a uniform bank height of 2 or 3m has been used. To be more precise, there is also the option to vary the bank height with the size of the contributing upstream catchment.

$$H = Coefficient \times (Catchment\ Area)^{Exponent} \qquad (4)$$

A series of bank height samples taken from each minor basin within a region were plotted against cumulative catchment area and were fitted with a power function curve to obtain the coefficients in equation 4.

A desktop assessment involved taking twenty stream cross-section samples for each minor basin using either 1m or 2.5m DEMs. The bank height equations obtained for each Minor basin are as follows:

- Pumicestone $h= 0.9703 \times (\text{Catchment Area})^{0.2547}$
- Upper Pine $h= 0.6955 \times (\text{Catchment Area})^{0.3815}$
- Lower Pine $h= 0.6072 \times (\text{Catchment Area})^{0.4357}$
- Sidling Creek $h= 0.4834 \times (\text{Catchment Area})^{0.6804}$
- Brisbane Coastal $h= 1.3829 \times (\text{Catchment Area})^{0.2318}$
- Burpengary $h= 0.5416 \times (\text{Catchment Area})^{0.5312}$
- Caboolture $h= 0.7585 \times (\text{Catchment Area})^{0.4104}$
- Hays & Redcliffe $h= 0.7148 \times (\text{Catchment Area})^{0.4044}$
- Stanley $h= 0.6022 \times (\text{Catchment Area})^{0.3915}$
- Neurum Creek $h= 0.7222 \times (\text{Catchment Area})^{0.4067}$

The new bank heights that were determined from these equations were applied to the bank erosion rates to determine the quantity of sediment eroded from banks each year. For larger order streams, the bank height was capped as there was some uncertainty surrounding the bank heights in areas such as the Caboolture river approaching the mouth, Pine River and Stanley River.

Rural Best Management Practices

The effectiveness of implementing best management practices (BMPs) on farming land in the MBRC region was undertaken using the following methodology. The rationale which of the various BMPs included in the assessment is also discussed.

Approximately 2.7% of the MBRC area is covered by various forms of horticulture as defined by the Land Use Mapping from NRM.

There are a number of BMPs which could be applied to agricultural areas to reduce the loss of soil from the site and to reduce the export of sediment and nutrients to the waterways. Three key management practices include:

- Minimise soil disturbance through the reduction of tillage operations and providing a cover for bare soil through mulching.
- Manage water flow by minimising disturbance to natural watercourses and diverting external runoff. This can also include planting buffer strips adjacent to watercourses.
- Management of fertilizer application.

Previous studies have aimed to summarise the performance and costs of a number of rural BMPs and these are outlined in Table D-1.

Table D- 1 Summary of Rural BMPs performance and costs

BMP	Reported performance (pollutant removal in kg/ha/yr)	% Reduction	Establishment cost per ha (AU$2008)		Maintenance cost per ha/yr (AU$2008)	
			Lower limit	Upper limit	Lower limit	Upper limit
Buffer Strips	TSS: 377.3- 441 TP: 0.9- 1.26 TN: 9.12	TSS: 77-90 TP: 50-100 TN: 50-90	$5	$1,500	$30	$359
Conservation Tillage	TSS: 347.9- 480.2	TSS: 71-98	$5,000	$15,00		
Minimum Tillage	TSS: 147- 441 TP: 0.63- 1.53 TN: 4.8- 7.68	TSS: 30-90 TP: 35-85 TN: 50-80	$165			$165
Diversion Banks, Grassed drains/ waterways.	TSS: 465.5 TP: 0.9- 1.62 TN: 2.88- 6.72	TSS: 95 TP: 60-100 TN: 50-90	$120	$437	$52	$107
Contour Banks	TP: 0.09- 0.216 TN: 0.48- 1.152	TP: 5-12 TN: 5-12	$1,947		$389	$392
Modified fertiliser use (Market gardens and turf)	TP: 0.18- 0.36 TN: 0.96- 4.8	TP: 10-20 TN: 10-50			$14	$26
Modified fertiliser use (orchards and vineyards)	TP: 0.18 TN: 0.96- 4.8	TP: 10 TN: 10-50			$14	$26

From the previous table, the costs were then attributed to each measure, based on a total life cycle of 30 years and assuming that the treatments would be universally applied (i.e. that the rates of removal would be obtained regardless of location or adoption rate). To derive the cost of each measure, the establishment cost was assumed to be borne in the first year of the device and maintenance applied at the rate identified for each year of the life span (i.e. maintenance was assumed in both the first and last year of the life cycle). The cost was determined by the following equation:

$$\text{Mean Annual Cost (\$AU2008/kg)} = \frac{\text{(Establishment Cost (\$/ha) / 30) + Maintenance Cost (\$/ha/yr)}}{\text{Removal Efficiency (kg/ha)}}$$

The results are presented in Table D-2.

Table D- 2 Cost per kg pollutant removed

BMP	Cost per kg TSS removed (AU$2008/kg)		Cost per kg TP removed (AU$2008/kg)		Cost per kg TN removed (AU$2008/kg)	
	lower limit	upper limit	lower limit	upper limit	lower limit	upper limit
Buffer Strips	$0.07	$1.08	$17	$455		$45
Conservation Tillage	$0.00	$1.44				
Conservation Tillage, Minimum Tillage	$0.39	$1.16	$111	$271	$22	$36
Diversion Banks, Grassed drains/ waterways.	$0.12	$0.26	$32	$113	$8	$42
Contour Banks			$2,115	$5,049	$396	$947
Modified fertiliser use (Market gardens and turf)			$40	$142	$2.97	$27
Modified fertiliser use (orchards and vineyards)			$79	$142	$2.97	$27

To simplify the use in the Source Catchments model only one BMP was selected. The BMP which provided the best cost effectiveness was buffer strips (highlighted in yellow).

This was applied to all horticultural land uses in the Source Catchments model.

Level of Rural BMP Adoption

The current level of adoption of BMPs for horticultural and chicken meat producers has been estimated based on a study in the Pumicestone catchment (Nicholls, 2010) and with discussions with Zane Nicholls (Department of Employment, Economic Development and Innovation).

Horticulture

A study which was undertaken in the Pumicestone catchment between November 2009 and June 2010, benchmarked a total of 59 horticultural farms to determine their current level of adoption of BMPs against an ABCD Framework for Horticulture in South East Queensland (Nicholls, 2010).

The benchmarking utilised a four scale classification system for practices, which range from A to D. The framework classifies practices based on their ability to achieve improvements in resource conditions (i.e. reduce degradation) and their consequent impact on farm profitability.

The benchmarking process classified approximately 30% of horticultural producers surveyed as managing their natural resources at a B class level (best current recommended practice). The remaining 70% were classified as class C (conventional management practices).

Discussions with Zane Nicholls (14/2/2011) indicated that although the benchmarking assessment was undertaken in the Pumicestone catchment, it could generally be applied across the Moreton Bay Regional Council area.

The most effective BMP that could be applied to the horticultural lands to reduce sediment and nutrient runoff from their sites is to include inter row cover (*pers comm* Zane Nicholls, 14/4/2011).

Although there is no specific information about the effectiveness of inter row cover in the literature there is a summary of the pollutant removal performance of buffer strips which perform in a similar manner. The average percentage reduction is outlined in Table D-3.

Table D- 3 Average percentage reduction of pollutants through the use of filter strips / buffer zones (from Table D-1 above)

Pollutant	% reduction
Total suspended solids	84%
Total phosphorus	75%
Total nitrogen	70%

Chicken meat production

Ten chicken meat producers were benchmarked using their Industry Environmental Management System (EMS). As the chicken meat producers have an EMS to adhere to their land use practices are generally a class B within the ABCD framework. That is, they apply the recommended BMPs which have been demonstrated to minimize resource degradation (*pers comm* Zane Nicholls, 14/2/2011).

References

BMT WBM (2010). *Rural Best Management Practices – Unit Costing Rates*, BMT WBM P/L Internal Document (Reference R.B17117.001.00).

Nicholls, Z. (2010). *Agricultural Benchmarking Report: Pumicestone Catchment.* http://www.healthywaterways.org/HealthyCountry/Resources/SustainableLandManagementResources.aspx

WSUD Retrofit in Existing Urban Areas

The following methodology was used by MBRC to determine suitable potential locations for WSUD devices in existing urban areas of MBRC.

Bioretention Site Selection Study

Stage One – Application of Mapping Rules in GIS

The mapping rules methodology adopted during the bioretention site section process were drawn largely from the City Design document; '*Stormwater Treatment Site Selction Mapping Rules Methodologies*' that was provided to council in September 2010. Through the application of these rules, amendments were made following observations and suggestions from management and senior staff within MBRC.

The mapping rules that were amended from the City Design's methodology are shown in the table below:

Mapping Rule	**Reasoning**
Open Space Area- Must be within Council-owned open space areas	Instead of completely excluding these areas, a value of '1' was assigned to council owned lands and '0' assigned for not council owned. This recognises areas where there is a potential for land acquisition where feasible
Ground Gradient- Ground Gradient must be less than 4%	The slope gradients have been extended from 0-6% this provides a more of a buffer to the ground gradient and allows for errors and roughness associated with the DEM used. A grid code value from 1-6 was assigned to coincide with it's associated slope range e.g. Grid Code of '2' = slope 1-2%

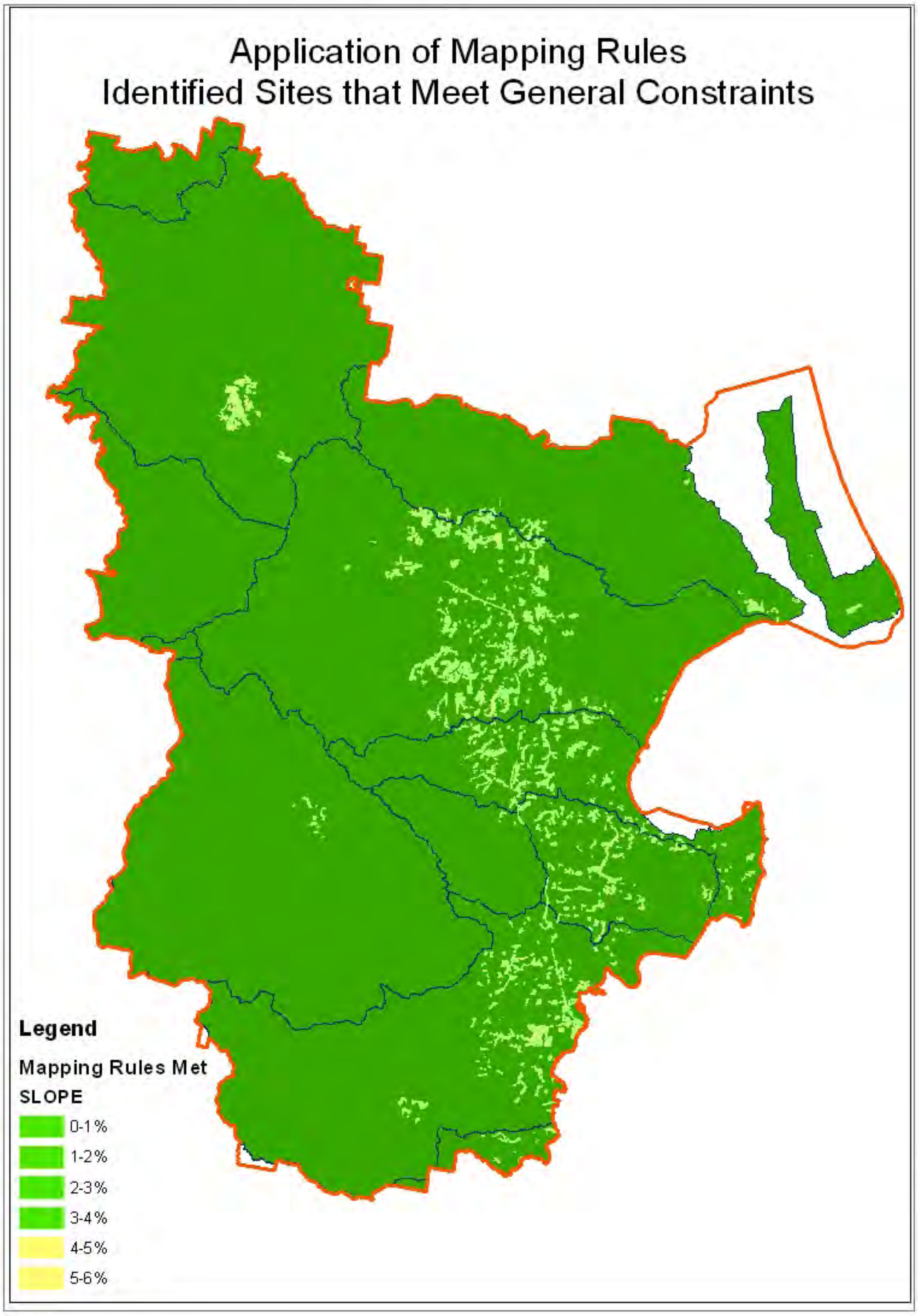
The mapping rules listed below have been applied in GIS to exclude all areas where bioretention sites would not be feasible due to topographic and landuse constraints.

1. Areas outside the urban footprint *excluded*
2. Areas outside the CIGA* *excluded*
3. Areas < 5m AHD *excluded*
4. Areas with slope >6%** *excluded*
5. Areas within a Development Application parcel *excluded*
6. Areas within road reserves (DCDB) *excluded*
7. Areas within waterways (DCDB) *excluded*
8. Areas that are densely vegetated *excluded*
9. Areas on 'contaminated land' *excluded*
10. Areas on high usage parks *excluded*
11. Areas on State Forest (Tenure 'SF') *excluded*
12. Areas on Forest Reserve (Tenure 'FR') *excluded*
13. Areas where Future Land Use = High Density Residential *excluded*
14. Areas where Future Land Use = Centre Showroom *excluded*
15. Areas where Future Land Use = Centre Retail *excluded*
16. Areas where Future Land Use = Centre Office *excluded*
17. Areas where Future Land Use = Public Utilities/Schools *excluded*
18. Areas < 3000m² (freehold) *excluded*
19. Areas >=15m from pipe (450-1600mm) *excluded*
20. Areas outside a 20m buffer of Overland Flow*** *excluded*
21. Areas within Council Owned land TYPE = 1

**CIGA (Caboolture Investigation Growth Area)*

***The 20m Buffer of the Overland Flow path assisted in removing hill tops, ridges and high points in the landscape*

The figure below captures the areas that remain after the mapping rules were applied.



Stage 2 – Initial Site Selection (Site by site basis)

After the completion of stage 1 each minor catchment that contained a potential bioretention site area was assessed individually over 2009 and 2010 aerial imagery and preliminary sites were recorded if the potential area appeared to be suitably sized and placed in the local catchment for bioretention treatment. The next stage involves a collective review by Waterways and Coastal Planning staff where comments and decisions on further progression were made in terms of Yes, No or Maybe for each potential site.

Wetland Site Selection Study

A similar study for potential wetland sites was completed recently and has identified 49 potential wetland sites. These sites are identified by polygons in the GIS data which indicate actual footprints of the wetland site and include inlet ponds, macrophyte zone, high flow by-pass and outlet.