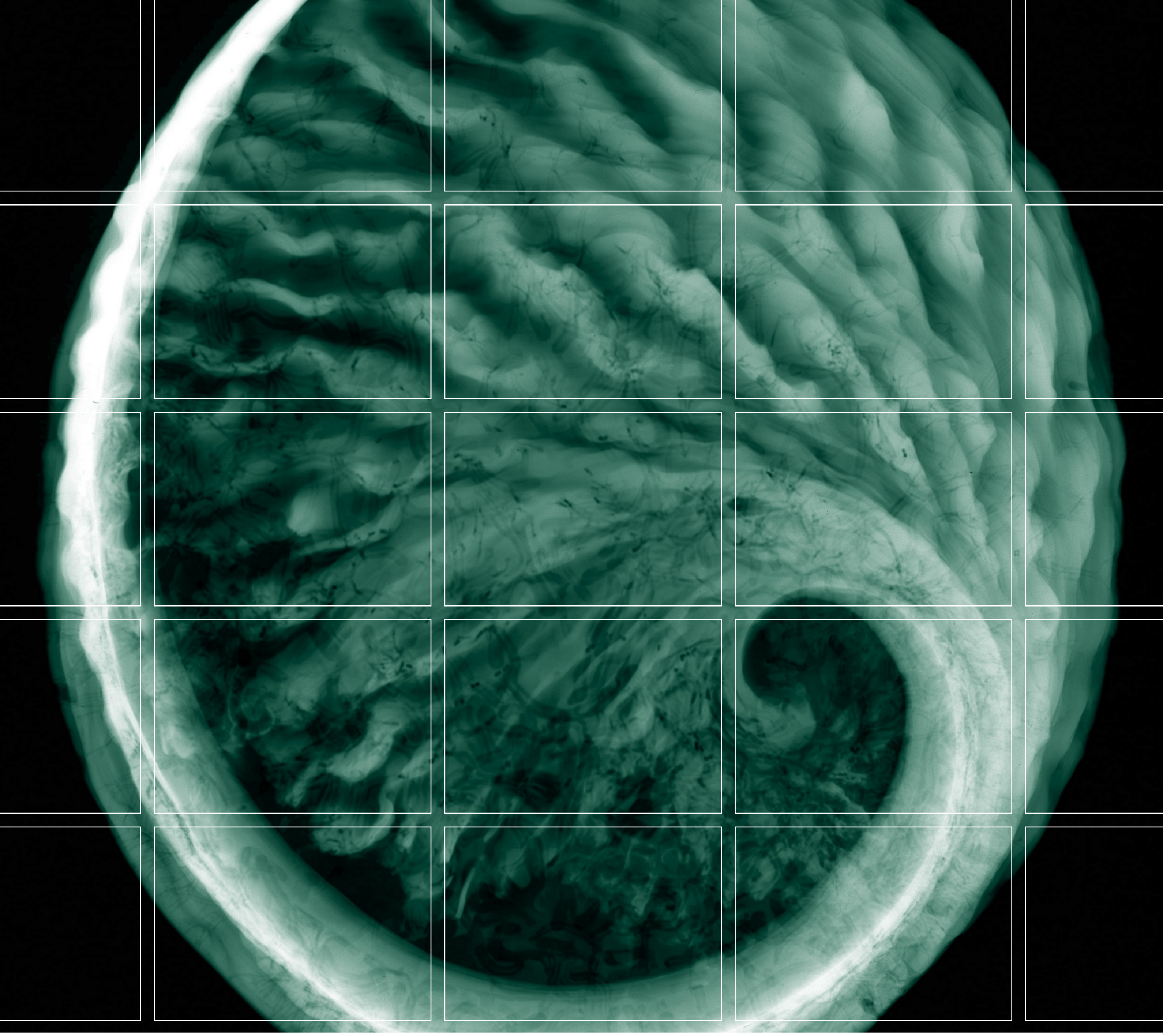
APPENDIX H

Water Quality Assessment



Proposed Additional Crossing of the Clarence River at Grafton NSW

Water Quality Assessment of Locality Options

for

RTA Operations

December 2003

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FINAL REPORT

RTA Operations - Environmental Technology

Proposed Additional Crossing of the Clarence River at Grafton

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December 2003

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RTA Operations - Environmental Technology

Proposed Additional Crossing of the Clarence River at Grafton

Water Quality Assessment of Locality Options

December 2003

Reference: 0010401WQrp3

For and on behalf of:
Environmental Resources Management Australia

Approved by: Murray Curtis

Signed: 

Position: Managing Principal

Date: 8 December 2003

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) has been commissioned by RTA Environmental Technology to investigate proposed locality options for an additional crossing of the Clarence River at Grafton, in terms of potential impacts upon water quality.

The Clarence River catchment is the largest in south eastern Australia in terms of catchment size and river flows. It has significant environmental values and is a valuable socioeconomic resource. The Clarence River estuarine reaches extend upstream to Copmanhurst and include the proposed locality options; hence, this section of the river is not considered a potential potable water source. There is little in the way of aquaculture at Grafton, however, further downstream the Clarence River hosts a variety of aquaculture activities. At Grafton the Clarence River is well used for recreational activities, including annual events such as the Bridge to Bridge Ski Race, Sailing Classic and numerous rowing regattas.

For the purposes of this study the criteria specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000) is used to determine the water quality objectives for the Clarence River at Grafton.

The principal water quality considerations in regard to the construction and operation of an additional river crossing at Grafton relate to possible contamination and degradation of water quality of the Clarence River by:

- erosion and sedimentation during the construction phase;
- generation of pollutants during the construction and operational phase;
- potential for spillage during the construction and operational phases; and
- the disturbance of acid sulphate soils and resultant acidic runoff.

The primary risks to water quality from any additional crossing would most likely occur during the construction phase due to the exposure of disturbed soils and potential pollution incidents. In the long-term the additional crossing would result in additional road pavements where accumulated pollutants and spillages maybe washed into the Clarence River during rainfall events.

The assessment is qualitative considering each of the seven locality options in terms of greatest potential impact to sensitive and surrounding environments.

Soil Erosion and Sedimentation

All locality options are located on the same alluvial soil landscape, which are classed as having low erosion hazard. The relative potential for erosion and sedimentation impacts is therefore related to the area of soil disturbed during construction, slope of disturbed area and number of pylons required for the crossing.

Acid Sulphate Soils

The Clarence River Floodplain at Grafton contains soils with high and low probability of occurrence of acid sulphate soils. The majority of the floodplain contains low probability areas, occurring largely within the urban areas of Grafton and South Grafton. However, the sediments along the bed of the Clarence River and also in the immediate vicinity of Carrs Creek and Alumy Creek have a high probability of occurrence. Increased occurrences of potential acid forming soils are also associated with Susan Island. The relative potential risk to water quality of the Clarence River from oxidation of acid sulphate soils is directly related to the extent of potential disturbance to these soils during construction activities.

Pollutants

There is the potential for accidental spillage of materials associated with road construction and also during the operational phase of the crossing. During construction, fuels, lubricants and other liquids may cause water quality degradation in downstream surface and sub-surface waterways. Once the proposed crossing is opened to traffic, the accumulation of pollutants on the road surface during dry periods would be washed into downstream waterways during subsequent runoff events. The relative potential risk to water quality of the Clarence River from to pollutants generated by the proposal is directly related to catchment area (length of crossing) and number of vehicle movements.

Groundwater

As the proposed locality options for the additional crossing are located on the Clarence River floodplain there is potential for interaction with the local shallow groundwater regime. The three sources of risk to water quality by the proposal, sedimentation, pollutants and acid sulphate soils also have the potential to impact on the quality of groundwater. Further localised changes to groundwater levels may occur due to impacts on hydraulic conductivities from embankments. The relative potential risk of groundwater impacts in addition to the above three risks is directly related to the length of new crossing approaches.

Through a qualitative analysis procedure, each of the proposed crossing localities were ranked low, medium or high according to potential risk to water quality and is summarised below.

Qualitative Assessment of Risk to Water Quality by Locality Option

Risk Item	Locality 1	Locality 2	Locality 3	Locality 4	Locality 5	Locality 6	Locality 7
Erosion and Sedimentation	Low	Low	Low	Medium	Medium	High	High
Pollutants	Medium	Medium	High	Medium	Medium	Medium	Medium
Acid Sulphate Soils	Medium	Low	Low	Medium	Medium	High	High
Groundwater	Low	Low	Low	Medium	Medium	High	High
Overall Ranking	**2**	**1**	**3**	**4**	**4**	**5**	**5**

Results of the assessment indicate that differences between each locality in terms of water quality are primarily related to the location and length of crossing (including approaches) resulting in the upstream and existing localities posing relatively lower risk compared to the downstream localities.

1 INTRODUCTION

1.1 INTRODUCTION

Environmental Resources Management Australia Pty Ltd (ERM) has been commissioned by RTA Environmental Technology to investigate proposed locality options for an additional crossing of the Clarence River at Grafton, in terms of potential impacts upon water quality.

This report details the water quality assessment of the seven proposed locality options for an additional crossing of the Clarence River at Grafton (see *Figure 1.1*). The objectives of the assessment are to:

Determine the potential water quality impacts associated with the construction and operation of an additional crossing of the Clarence River within each of the proposed localities at Grafton:

- determinate the relevant water quality criteria / objectives / targets;
- assessment of potential pollutants;
- assessment of the potential hazards / impacts for each locality option; and
- form a comparison of different locality options for a preferred route selection.

1.2 LOCALITY OPTION DESCRIPTIONS

The following section describes the seven proposed locality options.

Figure 1.1 Aerial Photograph Showing Locality Options

Proposed Additional Crossing of Clarence River at Grafton NSW
RTA Operations

Table 1.1 Description of Locality Options

Locality Option	Origin	Destination
1	From Gwydir Highway to River via rural land crossing river via Susan Island	Direct onto Prince Street, Crossing Victoria, meeting Fitzroy
2	From Gwydir Highway along Abbot Street Abbot and Kennedy Street Abbot and Bank Street	Direct onto Villiers Street (School and Convent on either side of road) Crossing Victoria meeting Fitzroy
3a	Merge with existing route on Bent Street access	Merge with existing Fitzroy Street access
3b	Merge with existing route on Bent Street access	Merge with existing Craig Street access
4	From Pacific Highway to River via rural land	Crossing McHugh Street crossing Breimba Street crossing Bromley / Sutton Street crossing Kent Street crossing Clarence Street meeting Villiers Street
5	From Pacific Highway to River via rural land	Crossing McHugh Street crossing Breimba Street crossing Kent Street Dobie and Waratah Place crossing Clarence Street Dobie and Weiley Ave meeting Villiers Street
6	From Pacific Highway to River via rural land	Crossing Villiers Street crossing Chapman Street crossing Prince Street crossing Queen Street crossing Mary Street (route passes hospital and Gaol) Arthur and Richards Lane crossing Alice Street meeting Turf Street
7	From Pacific Highway at Centenary Drive to River via rural land Crossing River via Elizabeth Island	Crossing Duke Street, crossing Morrison Street, crossing Challinor Street crossing Queen Street, crossing Mary Street, crossing Alice Street, crossing Davey Ave x 2 meeting Richmond Road

1.3 SCOPE OF THIS STUDY

This report describes the water quality of the waterways within the study area for determining the feasibility of each locality. The report assesses the likely impacts associated with the construction and operation of an additional crossing relating to water quality of the Clarence River and associated waterways.

- Chapter 2 Existing Environment
- Chapter 3 Summary of Potential Impacts
- Chapter 4 Assessment of Locality Options

2 *EXISTING ENVIRONMENT*

2.1 *CATCHMENT AND WATERCOURSES*

The Clarence River system is located on the far North Coast of New South Wales and has a catchment area of approximately 22,700 square kilometres. The mouth of the river is located between the towns of Yamba and Iluka, with its estuarine reaches extending upstream past Grafton to Copmanhurst.

There are two creeks flowing through Grafton that have the potential to be affected by one or more of the locality options. Alumy Creek flows into the river from the north, upstream of the current bridge location while Musk Valley Creek enters from the south, downstream of the current bridge.

Flooding in the Clarence River is a common event given the size of the catchment and frequent storms and rainfall that occur in the region. Levee banks have been constructed along both banks of the river for flood protection of the town, using various combinations of concrete, soil and rock walls. North Grafton is protected from floods reaching no higher than 8.25m, in South Grafton only the embankment from the Arden Street drain to the existing bridge is protected for levels up to 7.62m. West of the Arden Street drain the levee bank protects against levels to 6.09m and downstream of the bridge at Clarenza, the levee provides protection to 5.49m.

The levee bank on the northern side of the river would rarely breach as it is designed to withstand a 1 in 50-year flood. Most of South Grafton is more frequently inundated by flooding, except for the area approaching Locality 3 which is one of the few places in South Grafton high enough to be out of range of most of the common flood levels.

2.2 *AGRICULTURE AND AQUACULTURE*

A major percentage of the Clarence River catchment is utilised for a wide range of agricultural activities, including large areas of beef grazing in the upper catchment, potato and other crop growing in the middle section of the catchment, and sugar cane and tea tree growing on the coastal floodplain. Runoff from agricultural lands contributes high loads of nutrients and suspended sediment to freshwater and estuarine sections of the Clarence River, particularly during high flow (HRC 1999).

The vast majority of the suspended solids that occur in the Clarence River can be directly related to agriculture, stream / riverbank erosion, erosion from roads, past mining activities, gravel extraction and forestry activities.

Improved agricultural practices have meant an improvement to the quantity of sediment reaching the river, however there are still tributaries within the catchment that experience exceeding levels of suspended solids during high flow periods.

Whilst there is little in the way of aquaculture at Grafton, downstream of Grafton the Clarence River hosts a variety of aquaculture activities, particularly between Maclean and Yamba. Here there are approximately three operational prawn farms and a fish farm at Palmers Island. Despite problems posed to oyster farmers in northern NSW and Queensland, compared to more suitable rivers in the south, there are still approximately 12 oyster leases around Yamba. Recreational fishing is moderately popular in the area, again particularly downstream of Maclean, with line fishing all year round, some hoop netting, crab trapping and hand hauled prawn nets. Crabbing and prawning are common during the warmer months between October and April.

Commercial fishing along the Clarence River is dependent on seasonal conditions and fish movements. In dry years when conditions are not favourable to sustain an abundance of aquatic life, there is obviously a decrease in commercial fishing. However when the season promotes an increase in the abundance of fish, prawns, crabs, etc, there is also a relative increase in commercial fishing activity. This is also partially controlled by variations in the value of the fish catch.

The Clarence River is the highest producing commercially fished estuary in NSW and has the highest number of commercial fishers in comparison to any other estuary in the State. Mesh nets are used all year round mainly for mullet, while hauling nets are also used during Autumn when the mullet are spawning. Wire mesh crab nets are used extensively downstream from Maclean, and at the entrance during the winter months, large wire fishnets are used to capture Bream.

Trawling for prawns commences in December and extends through until the end of May each year; this tends to closely follow rainfall patterns. For the Clarence River, this is only permitted downstream of Ulmarra, and only during daylight hours of Monday to Friday. Furthermore the use of a 20m long stationary net with an artificial current provided by an anchored motor boat (also known as set pocket prawning) is permitted between August and May from Ulmarra downstream to Palmers Island.

2.3 *RECREATIONAL ACTIVITIES*

The Clarence River at Grafton is host to a number of recreational activities, many of which are held on an annual basis. The Waterways Authority of NSW has provided licenses in 2003 for such events including:

- swimming events;
- barefoot skiing;
- rowing regatta;
- dragon boat racing;
- water skiing;
- rowing regatta; and
- canoe racing.

Each of these events are held or utilise the portion of the river between Susan Island and Elizabeth Island. In addition to these activities Grafton has a rowing club, sailing club and fishing club and is also popular with various general recreation activities including:

- sailing;
- fishing;
- jet skiing;
- occasional demonstrations (eg, water skiing, wake boarding etc);
- rowing; and
- canoeing and general boating.

2003 has also seen this section of the river utilised for the purpose of naval cadet training. Whilst this isn't a regular activity, it has previously occurred in this area.

2.4 SOILS

2.4.1 *Soil Landscape*

Grafton soils consist of deep layered alluvium occurring right across the Clarence River Floodplain. These silty soils vary in texture with well drained, brownish black sandy loams overlaying acidic dark brown sands at the riverbank, which extend out to more low plasticity, poorly drained clays with some fine sand overlaying heavy plastic clays.

The Grafton Area Urban Capability Study (1976) indicates that the floodplain of the Clarence River is the least eroded landform unit in the area, with no appreciable erosion identified at the locality options. Only minor sheeting has been recorded in areas of alluvial terraces where slopes of up to 5 per cent occur.

The concern of erosion susceptibility within the study area is considered to be relatively low due to the alluvial soil landscape. As this alluvial landscape occurs across each locality option the relative potential for erosion and sedimentation impacts would be directly related to the area of soil disturbed during construction, the slope of disturbed area and number pylons required.

2.4.2 *Acid Sulphate Soils*

The Clarence River Floodplain at Grafton contains soils with high and low probability of occurrence acid sulphate soils (see *Figure 2.1*). The majority of the region, including the city and south Grafton, contains low probability areas. Areas of high probability occur predominantly to the north east of Grafton with additional occurrences flanking Cowans Creek, Alumy Creek, Swan Creek and parts of Musk Valley and Carrs Creek. Of these creeks, two may be affected by three of the locality options, these include Cowans Creek affected by locality options 1 and 2 and Alumy Creek affected by locality option 7.

Increased occurrences of potential acid forming soils are also associated with Susan Island and along the bed of the Clarence River within the Grafton area. The relative potential risk to water quality of the Clarence River from oxidation of acid sulphate soils is directly related to the extent of potential disturbance to these soils during construction activities.

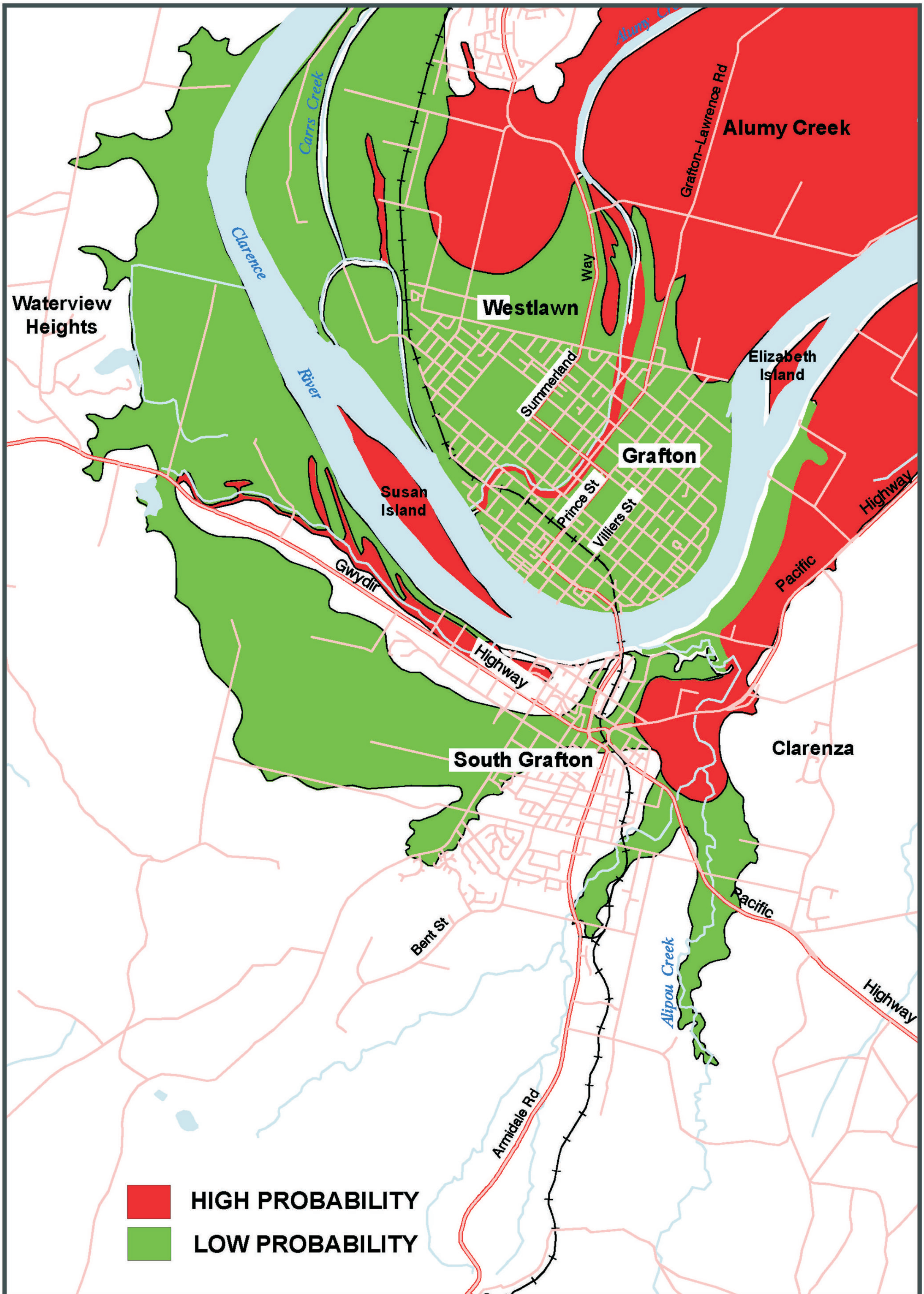
2.5 *WATER QUALITY*

2.5.1 *Water Quality Criteria*

Water quality criteria for the Clarence River at Grafton has been sourced from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000). This document provides a summary of water quality guidelines proposed to protect and mange the environmental values supported by the water resources. The guidelines provide aid in identifying the beneficial use of a water resource such as aquatic ecosystems, human consumption or recreational use and primary industries.

Guidelines are provided for marine and freshwater aquatic ecosystems. Grafton lies along the estuarine portion of the Clarence River and therefore application of the physical and chemical indicators relevant to impacts from road construction, the ecosystem type (as defined in the Guidelines) is a lowland, estuarine river positioned within south east Australia.

Water quality guidelines provide the value of waters for recreational activities such as swimming and boating, and to preserve the aesthetic appeal of water bodies. Given the use of the Clarence River at Grafton for swimming and other direct water-contact sports the recreational primary contact water quality guidelines apply.



0 1km
Approximate only

Figure 2.1 Acid Sulphate Soil Risk Map

Proposed Additional Crossing of Clarence River at Grafton NSW
RTA Operations
Source: Grafton Bridge Feasibility Study (RTA)

Due to the estuarine nature of the Clarence River at Grafton and that aquaculture industry is primarily located downstream of Maclean the water quality guidelines for drinking water and primary industries have not been considered.

The relevant ANZECC & ARMCANZ (2000) water quality guidelines for aquatic ecosystems and recreational primary contact have been provided in *Table 2.1* for comparison with water quality monitoring data of the Clarence River at Grafton provided by Grafton City Council (see Section *2.5.2* below).

2.5.2 Surface Water Quality Data

Water quality data for the Clarence River at Grafton has been provided by Grafton City Council (GCC). Data collected by the Council includes monthly test results from late 1995 to mid 2003 from five primary locations along the Clarence River (see *Figure 1.1*). These locations are:

North Grafton

- Prince Street;
- Sailing Club;
- Fry Street; and
- Corcoran Park.

South Grafton

- South Marina.

A summary of selected water quality parameters over the 18-month period from January 2002 to June 2003 is given in *Table 2.1*, which also provides a comparison with the relevant ANZECC & ARMCANZ (2000) water quality guidelines.

Table 2.1 Summary of Water Quality Data Clarence River Grafton NSW

Location		G/Mean Faecal Coliform per 100mL	G/Mean E Coli per 100mL	pH	Conductivity mS/cm	Turbidity NTU	D.O. mg/L	Te
Corcoran Park	Max	1423.00	1307.00	7.94	23.40	21.00	7.80	
	Min	1.00	1.00	6.14	0.07	7.00	5.56	
	Mean	134.10	126.30	7.26	8.77	11.57	6.73	
Fry Street	Max	2896.00	2896.00	7.96	21.10	38.00	8.45	
	Min	3.00	2.00	6.03	0.15	6.00	6.05	
	Mean	351.61	348.39	7.22	6.21	14.08	7.05	
Sailing Club	Max	1333.00	1292.00	8.95	22.20	100.00	9.09	
	Min	18.00	18.00	6.16	0.15	1.00	5.76	
	Mean	290.55	252.65	7.38	7.48	20.93	7.06	
Prince Street	Max	201.00	145.00	7.99	23.10	45.00	8.61	
	Min	4.00	4.00	6.50	0.12	5.00	4.90	
	Mean	44.75	32.20	7.32	7.31	13.86	6.88	
South Marina	Max	304.00	268.00	8.10	20.70	47.00	8.76	
	Min	1.00	1.00	6.17	0.14	4.00	5.52	
	Mean	44.70	39.90	7.30	6.66	10.86	6.88	
Assessment Criteria - ANZECC & ARMCANZ (2000)								
Aquatic Ecosystems - Estuarine		ns	ns	7.0 to 8.5	ns	0.5 to 10	80 to 110 [1]	
Recreational Primary Contact		100	35	5 to 9	ns	ns	ns	

Notes: ANZECC & ARMCANZ (2000) - Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
ns - no guideline specified.
1. % saturation (80% saturation approximately equivalent to 6mg/L).

Source: Grafton City Council - samples taken from 14/01/2002 to 03/06/2003.

The water quality data in indicates that the Clarence River at Grafton is slightly to moderately saline with mean pH approximately neutral. Water temperature generally falls within the guideline range whilst minimum pH levels are slightly acidic and fall below the aquatic ecosystem guideline range. Mean dissolved oxygen levels are above the desirable minimum of 6 mg/L (ANZECC 1992) and turbidity levels typically exceed the aquatic ecosystem guideline range. However, ANZECC & ARMCANZ (2000) states that "turbidity is not a very useful indicator in estuarine and marine waters" due to the input of turbid water from the catchment.

The water quality data represented in *Table 2.1* also indicates that concentrations of faecal coliforms and enterococci coliforms generally exceed the ANZECC & ARMCANZ (2000) recreational primary contact guideline levels.

2.5.3 *Groundwater Quality Data*

A groundwater bore search conducted by the Department of Infrastructure, Planning and Natural Resources (DIPNR) identified 39 licensed groundwater bores/irrigation ponds located within a 5km radius of Grafton. Of these, two groundwater bores and two irrigation ponds are located in the vicinity of the locality options. The summary data sheets for these locations (provided in *Annex A*) indicate that the water bearing zones are in sands overlain by silty clay soils. Standing water levels are 3m to 5m metres below ground level. Water quality data provided for the irrigation ponds indicate generally that pH ranges between 7.0 to 7.5 and electrical conductivity ranges between 800µS/cm to 1,200µS/cm or relatively non-saline.

3 SUMMARY OF POTENTIAL IMPACTS

3.1 W IMPACTS

RTA's Water Policy for construction is to implement effective water management practices and procedures as an integral part of on-site construction management to ensure that water quality and quantity impacts on the environment are minimised.

Further, RTA's Water Policy for operation is to develop and maintain both structural and non-structural measures to minimise water pollution during operation of roads.

The principal water quality considerations relate to possible contamination and degradation of water quality of the Clarence River by:

- erosion and sedimentation during the construction and operational phases;
- generation of pollutants during the construction and operational phase;
- the disturbance of acid sulphate soils and resultant acidic runoff; and
- changes in shallow groundwater levels due to road embankments.

Four primary water quality issues have been considered as potential hazards during construction and operation of an additional crossing of the Clarence River at Grafton. These issues are discussed below and compared to each of the localities indicating the potential impact level for each hazard.

3.2 SOIL EROSION AND SEDIMENTATION

Soil erosion occurs wherever the soil surface is exposed to the agents of erosion such as water, wind or gravity. The degree of erosion depends largely on the soil type and amount of vegetation covering the site. A poorly consolidated soil with little vegetation would have a higher susceptibility for erosion than the same soil type with well established deep rooted vegetation. Similarly a well consolidated soil will more effectively resist the processes of erosion.

Road construction activities that involve vegetation clearing and soil disturbance result in a decrease in soil strength of surface soils enabling the agents of erosion to have a greater effect, resulting in the potential for soil particles to be distributed downslope of the works. Eroded soil particles entering a water course results in sedimentation of that waterway. Sedimentation also has the potential to occur through the tracking of mud and soil particles from vehicles, which may enter local waterways via surface runoff during rainfall events.

Sedimentation degrades water quality, deposits soil and nutrients downstream and may carry absorbed polluting chemicals. Sedimentation also causes a decrease in the amount of penetrating light, which is required for the maintenance of dissolved oxygen levels and water temperature as well as for the survival of many aquatic flora and fauna species.

3.3 POLLUTANTS

There is the potential for accidental spillage of materials associated with road construction and also during the operational phase of the crossing. During construction, fuels, lubricants and other liquids may cause water quality degradation in downstream surface and sub-surface waterways.

Once the proposed crossing is opened to traffic, the accumulation of pollutants on the road surface during dry periods has the potential to enter downstream waterways during subsequent runoff events. Typical pollutants associated with roads include oils and grease that have leaked from vehicles and other machinery, heavy metals from wear and tear of mechanical vehicle components and sediment and gross pollutants (eg litter) originating from vehicles and pedestrians. *Table 3.1* below summarises the principle heavy metals and their sources for typical road surface runoff (CSIRO 1992).

Table 3.1 Road Runoff Characteristics **(CSIRO 1992)**

Pollutant	Principle Sources
Particulate material	Pavement wear, vehicles, atmosphere, maintenance
Nitrogen, phosphorus	Atmosphere, roadside fertiliser application
Lead	Leaded petrol, tyre wear, oils and greases, bearing wear
Copper	Metal plating, bearing wear, moving engine parts, brake linings
Cadmium	Tyre wear
Chromium[2]	Metal plating, moving parts brake linings
Petroleum hydrocarbons	Spills and leaks, antifreeze and hydraulic fluids, asphalt pavement leachate

Notes: 1. Source Kinhill (1997), adopted from CSIRO (1992)
2. Chromium(III) and Chromium(VI)

A review of road runoff and its impact on receiving waters conducted by CSIRO in 1992 for the NSW RTA, showed that the pollutants which are of most significance in terms of their likely impact on receiving waters are lead, copper and zinc. The study found that these three heavy metals are likely to be the most significant in runoff associated with heavily trafficked roads because of their potential toxicity to aquatic organisms and their expected concentrations in road runoff. The other pollutants commonly present in road runoff, including petroleum hydrocarbons, occur either at much lower concentrations or have relatively low toxicities.

The significance of lead as a pollutant in road runoff may well be significantly reduced due to the introduction of lead-free petrol since the publishing of the CSIRO report (Kinhill 1997).

These metals would most likely be attached to sediment and organic matter and accumulate in bottom sediments due to the relatively stable pH of the Clarence River at Grafton. However, metal ions dissolve in water when the pH becomes sufficiently acidic, increasing dissolved metal concentrations potentially to levels toxic to aquatic organisms. When water pH returns to a more neutral level, the heavy metals precipitate out, reattaching to the sediment and organic matter on the bottom of the river.

3.4 ACID SULPHATE SOILS

Acid Sulphate Soils (ASS) are soils that contain iron sulphides. When these naturally occurring sulphides are disturbed and exposed to air, oxidation occurs and sulfuric acid is produced (Stone, Ahern and Blunden 1998). The sulfuric acid has the potential to enter waterways and cause severe environmental impact. In terms of road construction, the types of activities that may disturb acid sulphate soils include:

- disturbance of bottom sediments of streams and rivers from piling activities;
- excavating material; and
- cutting of streambanks for vertical abutments.

3.5 GROUNDWATER

As the proposed locality options for the additional crossing are located on the Clarence River floodplain there is potential for interaction with the local shallow groundwater regime. Minor ponding of groundwater may occur at the base of cuttings due to seepage or rising groundwater tables following high rainfall events. In addition, minor excavations to replace unsuitable foundation material may be required.

The three sources of risk to water quality by the proposal, sedimentation, pollutants and acid sulphate soils also have the potential to impact on the quality of groundwater. Further localised changes to groundwater levels may occur due to impacts on hydraulic conductivities from embankments. The relative potential risk of groundwater impacts in addition to the above three risks is directly related to the location and length of the new crossing approaches.

4 ASSESSMENT OF LOCALITY OPTIONS

4.1 INTRODUCTION

The primary risks to water quality from any additional crossing would most likely occur during the construction phase due to the exposure of disturbed soils and potential pollution incidents. In the long-term the additional crossing would result in additional road pavements where accumulated pollutants and spillages maybe washed into the Clarence River during rainfall events.

4.1.1 Soil Erosion and Sedimentation

All locality options are located on the same alluvial soil landscape, which are classed as having low erosion hazard. The relative potential for erosion and sedimentation impacts is therefore related to the area of soil disturbed during construction, slope of disturbed area and number of pylons required for the crossing.

4.1.2 Pollutants

There is the potential for accidental spillage of materials associated with road construction. Once the proposed crossing is opened to traffic, the accumulation of pollutants on the road surface during dry periods would be washed into downstream waterways during subsequent runoff events. The relative potential risk to water quality of the Clarence River from to pollutants generated by the proposal is directly related to catchment area (length of crossing) and the number of vehicle movements.

4.1.3 Acid Sulphate Soils

The relative potential risk to water quality of the Clarence River from oxidation of acid sulphate soils is directly related to the location of potentially occurring acid sulphate soils and the extent of potential disturbance to these soils during construction activities.

4.1.4 Groundwater

The relative potential risk of groundwater impacts in addition to water quality due sedimentation, pollutants and acid sulphate soils discussed above is directly related to the location of shallow water tables and the length of new crossing approaches that may potentially result in localised changes to groundwater levels.

4.2 ASSESSMENT OF LOCALITY OPTIONS

The assessment is qualitative considering each of the seven locality options in terms of greatest potential impact to sensitive and surrounding environments.

Locality 1

Locality 1 would have a relatively small area of disturbance avoiding considerable impacts affecting the groundwater and erosion. However, the locality includes areas mapped as containing a high probability of acid sulphate soils including Susan Island. The crossing is moderate in length and predicted to receive moderate traffic volumes relative to the other locality options.

Locality 2

Locality 2 has very similar environmental hazards due to the bridge location, extent of disturbance, length of crossing and volume of traffic to that of Locality 1. However, Locality 2 has a lower probability of disturbing acid sulphate soils compared to Locality 1.

Locality 3

Locality 3 has the shortest crossing distance and the least extent of disturbance and hence a low relative potential for impacts on groundwater, erosion and acid sulphate soils. However due to the relatively high predicted volume of traffic to use the crossing at this locality, there is a high potential for impacts from pollutants.

Locality 4

Locality 4 has a relatively moderate extent of disturbance, length of crossing and predicted volume of traffic. The locality includes a relatively moderate area mapped as having a high probability of acid sulphate soils adjacent to the Pacific Highway and an area mapped as having a low probability of acid sulphate soils adjacent to the Clarence River. The southern approach to the crossing location crosses a relatively moderate length of land with potential shallow groundwater levels.

Locality 5

Locality 5 has a relatively moderate extent of disturbance, length of crossing and predicted volume of traffic. The locality includes a relatively moderate area mapped as having a high probability of acid sulphate soils adjacent to the Pacific Highway and an area mapped as having a low probability of acid sulphate soils adjacent to the Clarence River. The southern approach to the crossing location crosses a relatively moderate length of land with potential shallow groundwater levels.

Locality 6

Locality 6 would have a relatively high extent of disturbance due to the length of the eastern and western crossing approaches and the significantly longer river crossing length needing an increased number of piles. However, the relatively low predicted volume of traffic would reduce level of potential pollutants. The locality includes a relatively large area between the Pacific Highway and the Clarence River mapped as having a high probability of acid sulphate soils and an adjacent area mapped as having a low probability of acid sulphate soils. This relatively high length of land for the eastern approach has potentially shallow groundwater levels.

Locality 7

Locality 7 would have the highest extent of disturbance of all locality options due to the length of the eastern and western crossing approaches and the longest river crossing length (hence requiring the most piles of all locality options). However, the relatively low predicted volume of traffic would reduce level of potential pollutants. The locality includes the largest area of all locality options between the Pacific Highway and the Clarence River mapped as having the probability of acid sulphate soils. This locality option has the longest approach length of all locality options across land with potentially shallow groundwater.

4.3 SUMMARY

Through a qualitative analysis procedure, each of the proposed crossing localities were ranked low, medium or high according to potential risk to water quality at each locality and is summarised below in *Table 4.1*.

Table 4.1 Potential Risks at Each Locality Options

Loc-ality	*Erosion*	*Sulphate Soil*	*Pollut-ants*	*Ground water*	*Explanation*
1 **R 2**[1]	Low	Med	Med	Low	**Erosion**: low extent of disturbance, flat slopes, moderate bridge length. **Acid Sulphate Soils:** moderate disturbance of potential acid sulphate soils. **Pollutants**: moderate bridge length, moderate traffic volumes. **Groundwater**: relatively small area of compaction.
2 **R 1**[1]	Low	Low	Med	Low	**Erosion**: low extent of disturbance, flat slope, moderate bridge length. **Acid Sulphate Soils:** low disturbance of potential acid sulphate soils. **Pollutants**: moderate bridge length, moderate traffic volumes. **Groundwater**: relatively small area of compaction.
3 **R 3**[1]	Low	Low	High	Low	**Erosion**: low extent of disturbance, flat and some steep slopes, low bridge length. **Acid Sulphate Soils**: low disturbance of potential acid sulphate soils. **Pollutants**: low bridge length, high traffic volumes. **Groundwater**: relatively small area of compaction.
4 **R 4**[1]	Med	Med	Med	Med	**Erosion**: moderate extent of disturbance, flat slopes, moderate bridge length. **Acid Sulphate Soils:** moderate disturbance of potential acid sulphate soils. **Pollutants**: moderate bridge length, moderate traffic volumes. **Groundwater**: moderate area of compaction.
5 **R 4**[1]	Med	Med	Med	Med	**Erosion**: moderate extent of disturbance, flat slopes, moderate bridge length. **Acid Sulphate Soils:** moderate disturbance of potential acid sulphate soils. **Pollutants**: moderate bridge length, moderate traffic volumes. **Groundwater**: moderate area of compaction.
6 **R 5**[1]	High	High	Med	High	**Erosion**: high extent of disturbance, flat slopes, long bridge length. **Acid Sulphate Soils**: high disturbance of potential acid sulphate soils. **Pollutants**: long bridge length, low traffic

Loc-ality	*Erosion*	*Sulphate Soil*	*Pollut-ants*	*Ground water*	*Explanation*
					volumes. **Groundwater**: high area of compaction.
7 **R 5[1]**	High	High	Med	High	**Erosion**: high extent of disturbance, flat slopes, long bridge length. **Acid Sulphate Soils**: high disturbance of potential acid sulphate soils. **Pollutants**: long bridge length, low traffic volumes. **Groundwater**: high area of compaction.

1. 'R' indicates an overall ranking for each locality.

Results of the assessment indicate that differences between each locality in terms of water quality are primarily related to the location and length of crossing (including approaches) resulting in the upstream and existing localities posing relatively lower risk compared to the downstream localities.

REFERENCES

ANZECC (1992) **Australian Water Quality Guidelines for Fresh and Marine Waters** National Water Quality Management Strategy Paper No. 4 Australian & New Zealand Environment & Conservation Council Canberra Australia.

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CSIRO (1992) **Investigation Report CET/LH/IR076 – Road Runoff and its Impact on Aquatic Environment: A Review** CSIRO Canberra Australia.

Healthy Rivers Commission (1999) **Independent Inquiry into the Clarence River System Final Report November 1999** Healthy Rivers Commission of NSW Sydney Australia.

Kinhill (1997) **Halfway Creek Pacific Highway Realignment - New South Wales Roads and Traffic Authority Review of Environmental Factors** Prepared by Kinhill Cameron McNamara QLD.

Soil Conservation Service of NSW (1976) **Grafton Area Urban Capability Study** Compiled by B Greaves and KA Emery.

Stone Y, Ahern CR, and Blunden B (1998) **Acid Sulfate Soils Manual 1998** Acid Sulfate Soil Management Advisory Committee Wollongbar NSW Australia.

Annex A

Registered Bore Summary Sheets

GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW037298		14-Dec-73	0:00:00	1973003244/01	Electrical Conductivity @25 C	1052	uS/cm	U	
HISC0001	GW037298		14-Dec-73	0:00:00	1973003244/01	pH	7.3	pH	U	
HISC0001	GW037298		14-Dec-73	0:00:00	1973003244/01	Alkalinity as Bicarbonate (HCO3)	244.068	mg/L	U	
HISC0001	GW037298		14-Dec-73	0:00:00	1973003244/01	Calcium as Ca - total	100.0998	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Alkalinity as Bicarbonate (HCO3)	213.5595	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Sulphate as SO4	132.0825	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Magnesium as Mg - total	41.197	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	pH	7.2	pH	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Electrical Conductivity @25 C	1260	uS/cm	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Calcium as Ca - total	34.8696	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Potassium as K - soluble	8.2106	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Boron as B - total	0.37	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Chloride as Cl	230.4445	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Sodium as Na - soluble	171.0439	mg/L	U	
HISC0001	GW037298		11-Sep-75	0:00:00	1975003561/01	Nitrate as N	2.101	mg/L	U	
HISC0001	GW047024		26-Sep-77	0:00:00	1977005820/01	Hardness as CaCO3 (measured)	90	mg/L	U	
HISC0001	GW047024		26-Sep-77	0:00:00	1977005820/01	pH	7.2	pH	U	
HISC0001	GW047024		26-Sep-77	0:00:00	1977005820/01	Electrical Conductivity @25 C	290	uS/cm	U	
HISC0001	GW047024		26-Sep-77	0:00:00	1977005820/01	Electrical Conductivity	290	uS/cm	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Magnesium as Mg - total	35.9714	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Chloride as Cl	174.0742	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Iron as Fe - total	1.17	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Sodium as Na - soluble	143.916	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Nitrate as N	2.6613	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	pH	7.01	pH	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Calcium as Ca - total	34.068	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Alkalinity as Bicarbonate (HCO3)	225.7629	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Electrical Conductivity @25 C	1060	uS/cm	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Potassium as K - soluble	7.4287	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Sulphate as SO4	121.9962	mg/L	U	

GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW037298		23-Aug-78	0:00:00	1978006946/01	Silica as SiO2 - reactive	35	mg/L	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006947/01	pH	7.2	pH	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006947/01	Electrical Conductivity @25 C	1080	mS/cm	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006947/01	Temperature - Air maximum	7.2	deg C	U	
HISC0001	GW037298		23-Aug-78	0:00:00	1978006947/01	Electrical Conductivity @25 C	1080	uS/cm	U	
HISC0001	GW037298		7-Nov-78	0:00:00	1978006948/01	Temperature - Air maximum	7.6	deg C	U	
HISC0001	GW037298		7-Nov-78	0:00:00	1978006948/01	Electrical Conductivity @25 C	1150	mS/cm	U	
HISC0001	GW037298		7-Nov-78	0:00:00	1978006948/01	Electrical Conductivity @25 C	1150	uS/cm	U	
HISC0001	GW037298		7-Nov-78	0:00:00	1978006948/01	pH	7.6	pH	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Boron as B - total	0.3	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Sulphate as SO4	76.848	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Magnesium as Mg - total	29.409	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	pH	6.8	pH	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Electrical Conductivity @25 C	850	uS/cm	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Sodium as Na - soluble	106.6725	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Nitrate as N	0.2801	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Chloride as Cl	129.4035	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Alkalinity as Bicarbonate (HCO3)	204.407	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Calcium as Ca - total	26.052	mg/L	U	
HISC0001	GW047024		6-Feb-78	0:00:00	1978006950/01	Potassium as K - soluble	7.4287	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006951/01	pH	7.6	pH	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006951/01	Electrical Conductivity @25 C	1110	mS/cm	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006951/01	Electrical Conductivity @25 C	1110	uS/cm	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006951/01	Temperature - Air maximum	7.6	deg C	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Silica as SiO2 - reactive	36.3	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Sulphate as SO4	109.0281	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Sodium as Na - soluble	163.9171	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Chloride as Cl	199.9549	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Calcium as Ca - total	24.048	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	pH	7.02	pH	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Potassium as K - soluble	7.8197	mg/L	U	

GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Magnesium as Mg - total	33.9055	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Electrical Conductivity @25 C	1120	uS/cm	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Alkalinity as Bicarbonate (HCO3)	224.5426	mg/L	U	
HISC0001	GW047024		23-Aug-78	0:00:00	1978006952/01	Nitrate as N	0.8404	mg/L	U	
HISC0001	GW047024		7-Nov-78	0:00:00	1978006953/01	pH	7.2	pH	U	
HISC0001	GW047024		7-Nov-78	0:00:00	1978006953/01	Electrical Conductivity @25 C	1150	mS/cm	U	
HISC0001	GW047024		7-Nov-78	0:00:00	1978006953/01	Electrical Conductivity @25 C	1150	uS/cm	U	
HISC0001	GW047024		7-Nov-78	0:00:00	1978006953/01	Temperature - Air maximum	7.2	deg C	U	
HISC0001	GW037298		1-Mar-79	0:00:00	1979007486/01	Electrical Conductivity @25 C	835	mS/cm	U	
HISC0001	GW037298		1-Mar-79	0:00:00	1979007486/01	Temperature - Air maximum	6.9	deg C	U	
HISC0001	GW037298		1-Mar-79	0:00:00	1979007486/01	pH	6.9	pH	U	
HISC0001	GW037298		1-Mar-79	0:00:00	1979007486/01	Electrical Conductivity @25 C	835	uS/cm	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Magnesium as Mg - total	49.3391	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Iron as Fe - total	1.52	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	pH	7.3	pH	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Calcium as Ca - total	39.078	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Alkalinity as Bicarbonate (HCO3)	209.8985	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Electrical Conductivity @25 C	965	uS/cm	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Nitrate as N	6.303	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Potassium as K - soluble	4.6918	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Sodium as Na - soluble	84.6024	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Sulphate as SO4	149.8536	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Fluoride as F - soluble	ND	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Silica as SiO2 - reactive	31	mg/L	U	
HISC0001	GW037298		10-Aug-79	0:00:00	1979007487/01	Chloride as Cl	119.8311	mg/L	U	
HISC0001	GW037298		10-Dec-79	0:00:00	1979007488/01	Iron as Fe - total	2.95	mg/L	U	
HISC0001	GW047024		1-Mar-79	0:00:00	1979007490/01	pH	7	pH	U	
HISC0001	GW047024		1-Mar-79	0:00:00	1979007490/01	Electrical Conductivity @25 C	1150	uS/cm	U	
HISC0001	GW047024		1-Mar-79	0:00:00	1979007490/01	Temperature - Air maximum	7	deg C	U	

GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW047024		1-Mar-79	0:00:00	1979007490/01	Electrical Conductivity @25 C	1150	mS/cm	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Chloride as Cl	212.0089	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Calcium as Ca - total	29.2584	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Nitrate as N	0.7003	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Iron as Fe - total	4.68	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Sulphate as SO4	147.9324	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Sodium as Na - soluble	181.3893	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Magnesium as Mg - total	36.2145	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Potassium as K - soluble	6.6467	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Fluoride as F - soluble	ND	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Silica as SiO2 - reactive	48.2	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Alkalinity as Bicarbonate (HCO3)	231.8646	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	pH	7.3	pH	U	
HISC0001	GW047024		10-Aug-79	0:00:00	1979007491/01	Electrical Conductivity @25 C	1320	uS/cm	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Silica as SiO2 - reactive	38.3	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Sulphate as SO4	120.075	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Fluoride as F - soluble	0.7409	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Potassium as K - soluble	8.9926	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Nitrate as N	ND	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Chloride as Cl	309.8592	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Calcium as Ca - total	76.152	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Alkalinity as Bicarbonate (HCO3)	228.2036	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	pH	7.72	pH	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Electrical Conductivity @25 C	1650	uS/cm	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Magnesium as Mg - total	34.9992	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Iron as Fe - total	11.61	mg/L	U	
HISC0001	GW047024		10-Dec-79	0:00:00	1979007492/01	Sodium as Na - soluble	200.011	mg/L	U	
HISC0001	GW037298		19-Jun-80	0:00:00	1980006734/01	Electrical Conductivity @25 C	610	mS/cm	U	
HISC0001	GW037298		19-Jun-80	0:00:00	1980006734/01	Electrical Conductivity @25 C	610	uS/cm	U	

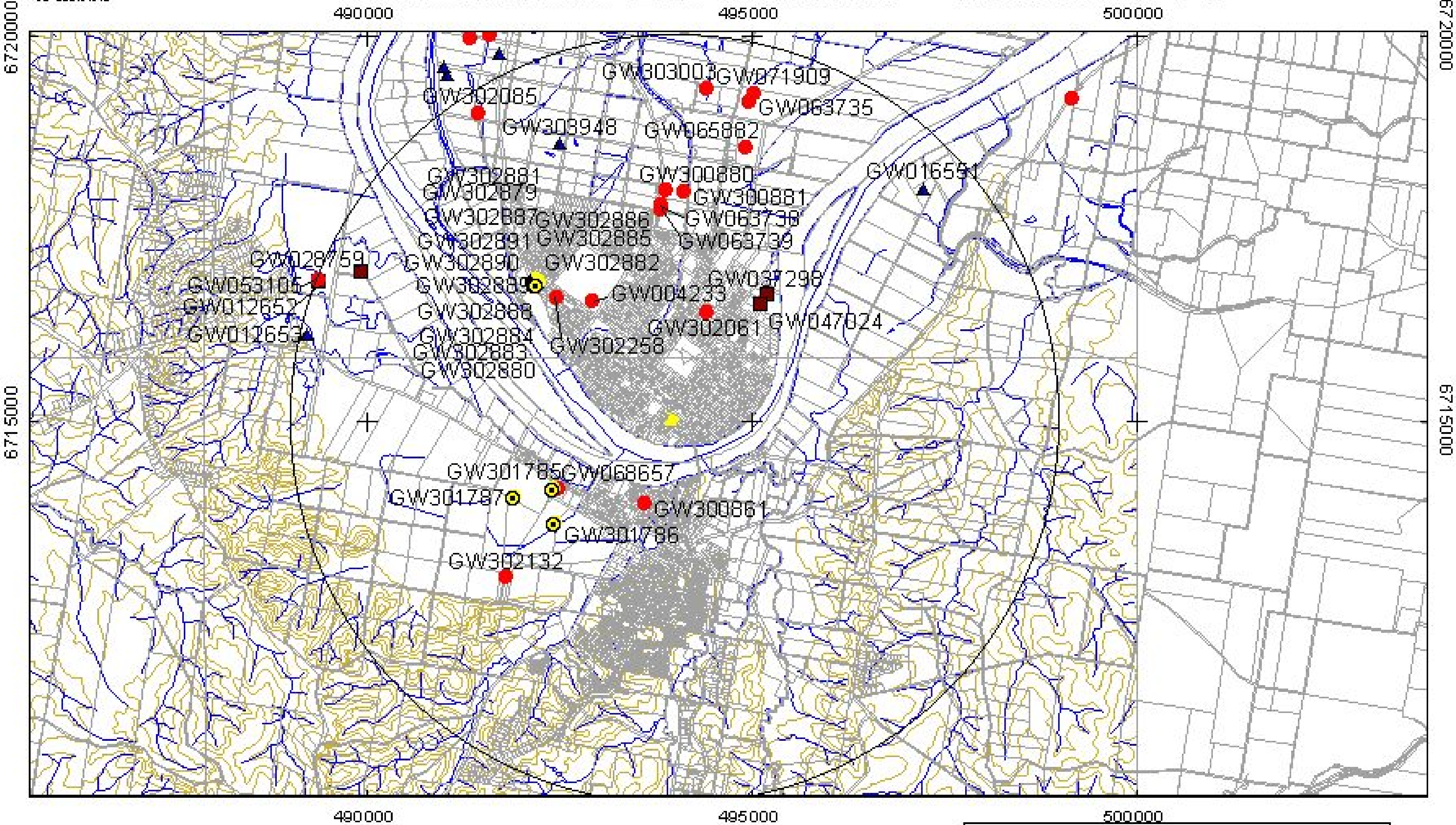
GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW037298		19-Jun-80	0:00:00	1980006734/01	pH	6.6	pH	U	
HISC0001	GW037298		19-Jun-80	0:00:00	1980006734/01	Temperature - Air maximum	6.6	deg C	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Magnesium as Mg - total	39.6172	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Chloride as Cl	216.9724	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Iron as Fe - total	9.3	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Calcium as Ca - total	33.8676	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Alkalinity as Bicarbonate (HCO3)	219.051	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Electrical Conductivity @25 C	1310	uS/cm	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Nitrate as N	3.2215	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Potassium as K - soluble	8.9926	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Sodium as Na - soluble	185.9872	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Sulphate as SO4	144.09	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Fluoride as F - soluble	0.38	mg/L	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	pH	7.66	pH	U	
HISC0001	GW037298		3-Oct-80	0:00:00	1980006735/01	Silica as SiO2 - reactive	38.6	mg/L	U	
HISC0001	GW047024		19-Jun-80	0:00:00	1980006737/01	pH	6.8	pH	U	
HISC0001	GW047024		19-Jun-80	0:00:00	1980006737/01	Electrical Conductivity @25 C	1120	uS/cm	U	
HISC0001	GW047024		19-Jun-80	0:00:00	1980006737/01	Temperature - Air maximum	6.8	deg C	U	
HISC0001	GW047024		19-Jun-80	0:00:00	1980006737/01	Electrical Conductivity @25 C	1120	mS/cm	U	
HISC0001	GW037298		6-Jan-81	0:00:00	1981006796/01	Electrical Conductivity @25 C	1120	uS/cm	U	
HISC0001	GW037298		6-Jan-81	0:00:00	1981006796/01	Electrical Conductivity @25 C	1120	mS/cm	U	
HISC0001	GW037298		6-Jan-81	0:00:00	1981006796/01	pH	6.8	pH	U	
HISC0001	GW037298		6-Jan-81	0:00:00	1981006796/01	Temperature - Air maximum	6.8	deg C	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Silica as SiO2 - reactive	7.4	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Sodium as Na - soluble	8.5062	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Chloride as Cl	9.9268	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Sulphate as SO4	7.2045	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Potassium as K - soluble	1.5639	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Magnesium as Mg - total	2.1875	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Calcium as Ca - total	4.008	mg/L	U	

GRAFTON AREA WATER QUALITY DATA

Project No.	Station No.	Pipe No.	Collect Date	Collect Time	Fraction No.	Determinand	Result	Units	Quality Code	Parent Project No.
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Electrical Conductivity @25 C	87	uS/cm	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	pH	7.07	pH	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Alkalinity as Bicarbonate (HCO3)	21.356	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Nitrate as N	0.1261	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Fluoride as F - soluble	0.7599	mg/L	U	
HISC0001	GW047024		7-Jan-81	0:00:00	1981006798/01	Iron as Fe - total	1.2	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Silica as SiO2 - reactive	6.4	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Calcium as Ca - total	29.2584	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Chloride as Cl	63.4609	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Electrical Conductivity @25 C	703	uS/cm	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	pH	8.26	pH	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Alkalinity as Carbonate (CO3)	0	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Alkalinity as Bicarbonate (HCO3)	180.0002	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Sulphate as SO4	94.1388	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Potassium as K - soluble	8.9926	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Nitrate as N	ND	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Magnesium as Mg - total	27.8292	mg/L	U	
HISC0001	GW053105		4-Nov-81	0:00:00	1981006799/01	Sodium as Na - soluble	73.1075	mg/L	U	

Groundwater Bore Search - Grafton area



Groundwater Bores Legend

- Bore
- Bore Abandoned
- Well
- Excavation
- Monitoring Bore
- Monitoring Bore Abandoned
- High Yield Bore (> 5 l/s)
- High Yield Bore Abandoned
- Drainage
- Contours
- Cadastre

0.8 0 0.8 1.6 2.4 3.2 4 Kilometres

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For further details see the attached letter

North Coast Date: 14/11/2003 h:\hydrog\gds_boresearch\arcview projects\erm\20031114_grafton\proj5.apr

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Construction Management
Corporate Advisory Services
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Environmental & Safety Audits
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Policy & Economics
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Sustainability Solutions
Traffic & Transport Engineering
Waste Management
Water & Wastewater
Visual Assessment

Environmental Resources Management Australia
3/146-148 Gordon Street
Port Macquarie NSW 2444
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