E4 Surface Water

Santos | PETRONAS

Report

GLNG EIS Supplement

Gas Transmission Pipeline, Surface Water Assessment

NOVEMBER 2009

Prepared for

Santos

32 Turbot Street,
Brisbane, QLD 4000.

42626443

URS

Project Manager:

Julian Long
Principal Water Quality Scientist

Project Director:

Chris Pigott
Senior Principal

Author:

Roberta Carter
Environmental Engineer

Reviewer:

Julian Long
Principal Water Quality Scientist

URS Australia Pty Ltd

Level 16, 240 Queen Street
Brisbane, QLD 4000
GPO Box 302, QLD 4001
Australia
T: 61 7 3243 2111
F: 61 7 3243 2199

Date:	**November 2009**
Reference:	42626443/1/C
Status:	FINAL

Document delivery

URS Australia provides this document in either printed format, electronic format or both. URS considers the printed version to be binding. The electronic format is provided for the client's convenience and URS requests that the client ensures the integrity of this electronic information is maintained. Storage of this electronic information should at a minimum comply with the requirements of the Commonwealth Electronic Transactions Act (ETA) 2000.

Where an electronic only version is provided to the client, a signed hard copy of this document is held on file by URS and a copy will be provided if requested.

Table of Contents

1 Introduction 1

1.1 Methodology 2

1.2 Regulatory Framework 2

1.3 Hydrological Overview 2

2 Existing Environmental Values 5

3 Climatic Data 6

4 Existing Flood Characteristics 7

4.1 Study Area Description 7

4.2 Flood Hydrology 7

4.3 Flood Flows 7

4.4 Flood Hydraulics 8

4.5 Flood Limitations 10

5 Existing Water Quality 11

6 Potential Impacts and Mitigation Measures 12

7 References 13

8 Limitations 14

Tables

Table 2-1 Environmental Values of Watercourses and Receiving Environment of the Pipeline 5

Table 4-1 Predicted peak flows at key watercourse crossing locations 8

Table 4-2 Adopted Mannings 'n' values 9

Table 4-3 Predicted flood depths, at key watercourse crossing locations 10

Figures

Figure 1-1 New GTP Alignment – GSDA component of CPIC 3

Figure 1-2 New GTP Alignment - Callide Range Alternative Route and CICSDA Component of the CPIC 4

Appendices

Appendix A Site Visit Assessment

Abbreviations

Abbreviation	Description
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
AusIFD	Australian Rainfall Intensity Frequency Duration
CICSDA	Callide Infrastructure Corridor State Development Area
CPIC	Common Pipeline Infrastructure Corridor
CSG	Coal Seam Gas
EIS	Environmental Impact Statement
GSDA	Gladstone State Development Area
HEC RAS	Hydrologic Engineering Centers River Analysis System
MRD	Main Road Department

1

Introduction

This report has been prepared as part of the EIS Supplement to provide additional information on the surface water impacts associated with the GLNG Gas Transmission Pipeline (GTP) route.

The GTP pipeline route was proposed by Santos in March 2009 (EIS GTP (March 2009)) between the CSG field and the LNG facility on Curtis Island, including the northern pipeline deviation, and was assessed as part of the EIS. EIS Supplement Route Alternatives (GLNG GTP (September 2009)) were identified by Santos since March 2009 as the result of further engineering, geotechnical, environmental and other investigations.

This report builds on information provided in the surface water assessment of the proposed impacts of the EIS GTP (March 2009) in EIS Section 7.5.

Although at the time of completion of the EIS the government had announced its preference for an "Energy Corridor" for common user infrastructure between the Gladstone State Development Area (GSDA) and the Callide Range (now known as the 'Callide Infrastructure Corridor State Development Area' [CICSDA]), the particular route of the corridor had not yet been selected. Consequently detailed assessment of the proposed common corridor in the EIS was not possible. The CICSDA was gazetted on 1 October 2009. Further refinement of the common corridor route as within the Gladstone State Development Area (GSDA) has also occurred since the completion of the EIS. Assessment of the CICSDA (CPIC (CICSDA Section) Route) route as gazetted and the impact of changes to the common corridor route within the GSDA (CPIC (GSDA Section) Route) have been included in this EIS Supplement.

Although it is Santos preference to utilise the common corridor route, this is dependent on the government's resumption of the underlying land interest and negotiation with the various proponents as to the applicable terms and conditions of access.

The final GTP route corridor will be determined once the final engineering design for the pipeline has been developed and is subject to Santos and/or the government obtaining the necessary underlying land interest and negotiation of access terms and conditions with respect to the CPIC Route.

The original EIS GTP (March 2009) route alignment has also been further optimised as a result of geotechnical, environmental and other investigations. The impact of these route changes are assessed in this EIS. Supplement.

In regards to surface water, the most pertinent changes since completion of the EIS are:

- Callide Pipeline Infrastructure Corridor (CPIC) Route– changes have been made to the proposed watercourse crossing locations for Larcom Creek (CPIC (GSDA Section) Route), refer to Figure 1-1 and Calliope River (CPIC (CICSDA Section) Route), refer to Figure 1-2. In addition the modifications to the EIS GTP (March 2009) involve the crossing of watercourses not previously traversed by the GTP including Targinie Creek, Mosquito Creek, Humpy Creek, Scrubby Creek, Sneaker Gully (CPIC (GSDA Section) Route); refer to Figure 1-1); and
- Callide Range Alternative Route – changes have been made to the Bell Creek crossing locations (Figure 1-2).

The potential for the CPIC (GSDA Section) Route changes to the GTP was raised nearing completion of the EIS. A desktop assessment was prepared at the time to identify any environmental constraints associated with the CPIC (GSDA Section) Route. This assessment was included as EIS Appendix AA. The changes to the GTP route in the Callide Range Alternative Route have arisen since completion of the EIS.

URS

The purpose of this report is to:

- Build on the desktop assessment presented in the EIS for the CPIC (GSDA Section) Route; and
- Assess the potential surface water impacts of changes to the EIS GTP (March 2009) in the Callide Range Alternative Route, CPIC (GSDA Section) and CPIC (CICSDA Section) Route.

1.1 Methodology

The methodology adopted for this surface water assessment is as presented in EIS Section 7.5.2.

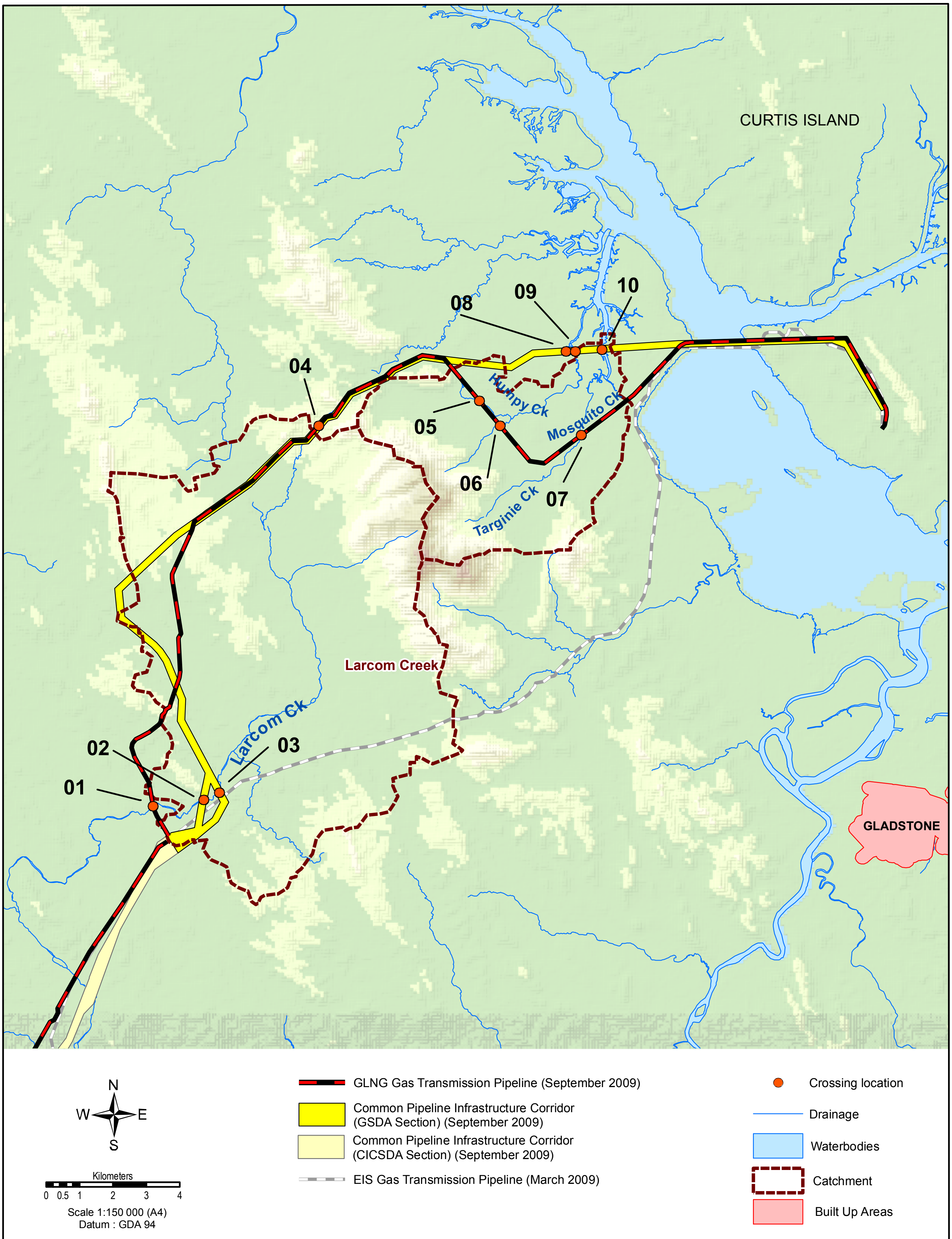
1.2 Regulatory Framework

The key legislation relevant to this assessment is as presented in EIS Section 6.5.3.

In addition, is the recently prepared "Development Scheme for the Callide Infrastructure Corridor State Development Area (CICSDA)". The scheme was approved on 1 October 2009. The development scheme is a land use control instrument, administered by the Coordinator General to guide future development in the state development area (Queensland Government, 2009).

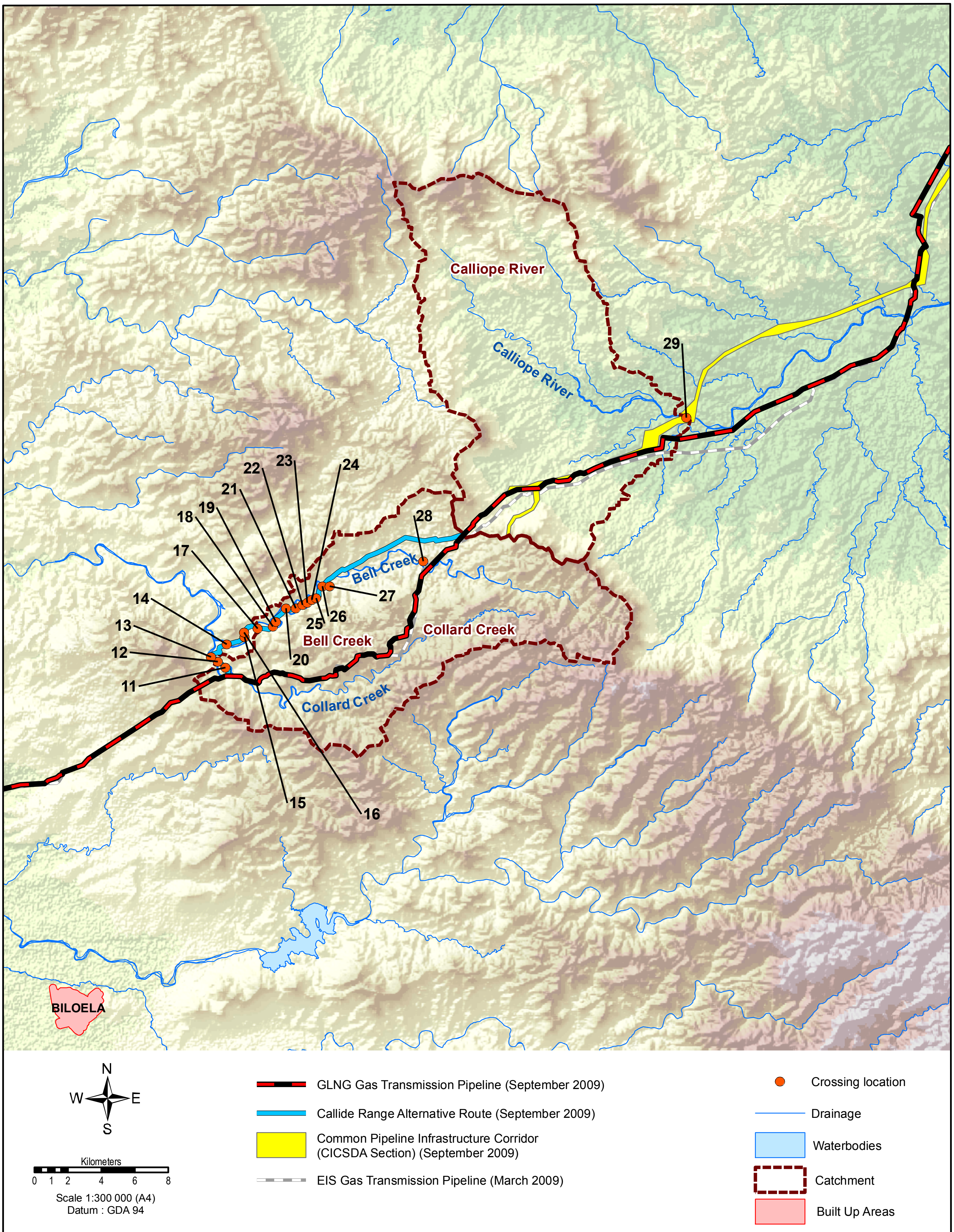
1.3 Hydrological Overview

The changes to the EIS GTP (March 2009) route affect watercourses within the Fitzroy and Calliope River Basins. The main watercourse potentially affected within the Fitzroy River basin is Bell Creek (Figure 1-1). The main watercourses potentially affected within the Calliope River basin are Calliope River (Figure 1-1), and Larcom Creek, Sneaker Gully, Targinie, Mosquito, Humpy and Collard Creeks (Figure 1-2). The potentially affected watercourses are all ephemeral in nature with periods of flow being generally short and limited to periods immediately after rainfall. The downstream receiving water for the Calliope River basin is the Great Barrier Reef, a designated wetland and a World Heritage Area.



Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT SURFACE WATER ASSESSMENT	**NEW GLNG GTP ALIGNMENT GSDA COMPONENT OF THE CPIC**
	Drawn: MG / Approved: RC / Date: 11-11-2009	Figure: **1-1** / Rev.B
	Job No: **4262 6440**/6220 / File: **42626440-g-2113.mxd**	**A4**



Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project			Title	
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT SURFACE WATER ASSESSMENT			**NEW GLNG GTP ALIGNMENT CALLIDE RANGE ALTERNATIVE ROUTE AND CICSDA COMPONENT OF THE CPIC**	
URS	Drawn: MG	Approved: RC	Date: 11-11-2009	Figure: **1-2**	Rev.B
	Job No: **4262 6440**/6220	File: **42626440-g-2112mxd**			**A4**

Existing Environmental Values

Specific environmental values for the watercourses potentially affected by changes to the EIS GTP (March 2009) route are not defined within the *Environmental Protection (Water) Policy 2009* (EPP Water) and there are no detailed local plans relating to environmental values for the catchments. Using data gathered from site visits to the specific watercourse crossings and relevant literature, environmental values have been identified for the watercourses within the study area (Table 2-1).

Table 2-1 Environmental Values of Watercourses and Receiving Environment of the Pipeline

Environmental Values	Calliope Basin	Fitzroy Basin
Protection of high ecological value aquatic habitat	X	X
Protection of moderately disturbed aquatic habitat	✓	✓
Protection of slightly disturbed aquatic habitat	✓	✓
Protection of highly disturbed aquatic habitat	X	X
Suitability for agricultural use	✓	✓
Suitability for aquacultural use	X	X
Suitability for producing aquatic foods for human consumption	✓	✓
Suitability for primary contact recreation (e.g. swimming)	✓	✓
Suitability for secondary recreation (e.g. boating)	✓	✓
Suitability for drinking water supplies	X	X
Suitability for industrial use (including manufacturing plants, power generation)	✓	✓
Protection of cultural and spiritual values	✓	✓

Table Notes:

✓: River basin is suitable for the environmental value.

X: River basin is not suitable for the environmental value.

Climatic Data

Due to the location and in the case of the Fitzroy Basin its broad extent, both the Fitzroy and Calliope basins are subject to a range of climatic regimes. The region as a whole is described as subtropical to semi-arid, with a summer-dominant but variable rainfall pattern.

Rainfall and evaporation data was obtained from the Bureau of Meteorology (BOM) and is discussed in EIS Appendix O2. The meteorological stations in close proximity to the study area include Gladstone Airport (Station Number 039326), Gladstone Radar (Station Number 039123) and Gladstone Post Office (Station Number 039041).

Rainfall averages suggest a distinct wet and dry season, with the wet generally October to March and the dry April to September. Mean daily evaporation is greatest in December and January and lowest in June and July.

The location of each gauging station in relation to the study area can be seen in EIS Section 7.5.

Existing Flood Characteristics

4.1 Study Area Description

The assessment of existing flood characteristics has been focused on major watercourses where significant environmental risk could occur from inappropriate design, or construction. Desktop analysis identified 28 key watercourse crossing locations (Figure 1-1 and Figure 1-2). Of these 28 key watercourse crossing locations, 19 locations were assessed. This was due to access limitations at a number of locations. It was considered, however, given the close proximity of sites that could be accessed to those that could not be assessed, that the 19 sites assessed gave a good representation of the watercourse crossing conditions in the study area.

4.2 Flood Hydrology

A hydrological assessment was undertaken for each of the 19 key watercourse crossing locations to estimate flood flows. A catchment area, upstream of each pipeline crossing, was attributed to each of the 19 key locations. Each watercourse's catchment was delineated based on 1:100,000 topographical maps which illustrate ground elevations in 20 m contours.

Estimates of flood flows were derived using hydrological methods in Australian Rainfall and Runoff (AR&R) (IEAust, 1987). The assessment considered probable design floods, a theoretically derived flood which has a certain likelihood of occurrence, expressed as an average recurrence interval (ARI). Flood flow estimates for each watercourse were estimated for a range of flood events considered as mean, minor and major respectively: 2, 10, 100 year ARI events (Table 4-1).

4.3 Flood Flows

The selection of hydrological estimation method for flood flows at each watercourse crossing location was based on guidance provided in the technical reference AR&R (IEAust, 1987). AR&R Section 5.3 suggests, for small ungauged catchments where considerable data is available for a site, flood frequency, unit hydrograph or runoff routing methods are preferred.

The Rational Method was applied to estimate peak flows for design floods for crossing locations. The Rational Method is given by the equation:

$$Q_Y = 0.278 \cdot C_Y I_{t_c,Y} A \qquad \textit{Equation 1}$$

Where Q_Y = peak flow rate (m^3/s) of average recurrence interval (ARI) of Y years

C_Y = runoff coefficient (dimensionless) for ARI of Y years

A = area of catchment (km^2)

$I_{tc, Y}$ = average rainfall intensity (mm/hr) for design duration of t_c hours and ARI of Y years.

Weeks (1991) suggested that time of concentration estimated by Bransby Williams formula (AR&R, 1987) gives extended durations, and the flow estimation method provides a large number of unrealistically high runoff coefficients. The alternate Pilgrim and McDermott formula (1982) was recommended as a result of Weeks' (1991) analysis, as this provided consistently shorter duration. Accordingly, the hydrological estimations for all 19 creek locations adopted the Pilgrim and McDermott formula, a slightly more conservative approach.

Design rainfall intensity was obtained by using the AusIFD program and AR&R (IEAust, 1987).

Two methods of calculating the runoff coefficient were undertaken for the small watercourse hydrological estimation;

- Queensland Main Roads Department (MRD) Bridge – Branch Method (AR&R, 1987); and
- Weeks (1991).

The Weeks (1991) method was developed for catchments with limited landuse and terrain information. The MRD method considers catchment characteristics and provided a higher flow estimate. In view of this, a conservative approach was adopted and the MRD method was used for determining the rational method runoff coefficients.

The 0.1 AEP runoff coefficient was adjusted for a range of flood probabilities using Equation 2, developed by Weeks (1991):

$$C_Y = (0.54 \cdot Log(Y) + 0.46) \cdot C_{10} \qquad \textit{Equation 2}$$

The peak flow estimates for the 19 key locations are presented in Table 4-1 below.

Table 4-1 Predicted peak flows at key watercourse crossing locations

No	Watercourse	Catchment Area (km2)	2yr ARI Peak Flow (m^3/s)	10yr ARI Peak Flow (m^3/s)	100yr ARI Peak Flow (m^3/s)
1	Larcom Creek	95	75	176	420
2	Larcom Creek	85	74	173	411
3	Larcom Creek	85	74	173	411
4	Sneaker Gully	0.9	0.6	1.3	3.2
5	Humpy Creek	5	11	26	61
7	Targinie Creek	15	21	48	114
8	Mosquito Creek Trib	1	3.3	7.6	17.9
9	Mosquito Creek	14	6.3	15	35
10	Targinie Creek	16	6.3	15	35
11	Collard Creek	71	90	211	503
12	Collard Creek	75	91	213	506
17	Bell Creek	108	94	221	527
18	Bell Creek	105	92	216	514
21	Bell Creek	92	88	206	491
23	Bell Creek	91	87	203	484
25	Bell Creek	90	85	201	477
26	Bell Creek	88	84	197	468
28	Bell Creek	53	56	131	312
29	Calliope River	193	123	289	694

4.4 Flood Hydraulics

To estimate the flood depths at each watercourse crossings, a flood assessment of the 19 key watercourse crossing locations, as identified above, has been undertaken using the Hydrologic

Engineering Centers River Analysis System (HEC RAS). HEC RAS is a one-dimensional hydraulic estimation model. The model inputs include a geometric file, a flow file and simulation parameters.

Geometric File

Using a 12D digital terrain model, developed from available survey (predominately 5 m contours) cross sections were extracted for each of the 19 locations.

Along with the cross-sectional data the geometric file requires a description of the bed, channel wall and floodplain roughness. Hydraulic roughness values (Mannings 'n') were adopted from hydraulic references based on field observations. The values relate to land use, reference values are provided in Table 4-2 below.

Table 4-2 Adopted Mannings 'n' values

Surface Type	Roughness Value
Floodplains	
Cultivated areas	0.04
Light brush and trees, in winter	0.06
Medium to dense brush, in winter	0.07
Heavy stand of timber, a few down trees, little undergrowth	0.08 – 0.1
Main Channel	
Clean, winding, some pools and shoals, some weeds and stones	0.04- 0.045
Clean, winding, some pools and shoals, some weeds and stones, lower stages, ineffective slopes and sections	0.05
Sluggish reaches, weedy, deep pools	0.07

Sources: (Chow, 1959) Open Channel Hydraulics, McGraw-Hill Book Company, Inc.

Flow File

Each model contains two boundary conditions, an upstream flow boundary and a downstream water level boundary. The inflow values were taken from the peak flows determine in the hydrological analysis Table 4-1 at each location. As the downstream environment was relatively flat, a normal depth downstream boundary was adopted; this was based on the watercourse gradient determined from 20 m contour maps.

Simulation File

The HEC RAS model was simulated using steady state conditions, due to the flat topographic nature of all the watercourses identified; subcritical flow conditions were also adopted.

The HEC RAS models were run to generate estimated flood depths for each watercourse location. These are presented in Table 4-3 below.

Table 4-3 Predicted flood depths, at key watercourse crossing locations

No	Name	2yr ARI Depth (m)	10yr ARI Depth (m)	100yr ARI Depth (m)
1	Larcom Creek	0.2	0.4	0.7
2	Larcom Creek	1.0	1.4	1.9
3	Larcom Creek	1.1	1.6	2.2
4	Sneaker Gully	0.01	0.02	0.02
5	Humpy Creek	0.47	0.69	1
7	Targinie Creek	0.2	0.3	0.5
8	Mosquito Creek Trib	0.3	0.4	0.5
9	Mosquito Creek	0.2	0.2	0.3
10	Targinie Creek	0.7	1.0	1.3
11	Collard Creek	1.2	1.6	2.0
12	Collard Creek	1.0	1.5	2.2
17	Bell Creek	0.6	1.1	1.9
18	Bell Creek	0.7	1.2	2.1
21	Bell Creek	1.4	2.1	3.0
23	Bell Creek	2.5	3.1	3.9
25	Bell Creek	1.5	2.3	3.4
26	Bell Creek	0.5	0.8	1.4
28	Bell Creek	0.6	1.0	1.6
29	Calliope River	1.7	2.5	3.7

Further detail of each watercourse crossing is provided in Appendix A.

4.5 Flood Limitations

The peak flows and water depths at each location are estimates only due to a lack of gauged stream flow data. The topographic information which was limited to 5 m to 20 m contours and creek assessment was undertaken slightly upstream of Targinie Creek (location 7) and Bell Creek (location 18 and 28) due to access limitations. Channel definition is assumed to be similar, which has been supported by aerial photography.

Existing Water Quality

Relevant water quality objectives for the watercourses affected by the changes to the proposed EIS GTP (March 2009) route were discussed on a catchment scale in EIS Section 7.5.4.6. A baseline water quality assessment was undertaken and presented in EIS Appendix O2. Water quality data is limited within the study area and no further data was found for Targinie Creek, Mosquito Creek, Humpy Creek, Scrubby Creek, or Sneaker Gully. The available water quality data for the study area was analysed and compared against the DERM's Queensland Water Quality Guidelines 2006 in EIS Appendix O2. As such no further analysis is presented here.

6 Potential Impacts and Mitigation Measures

This assessment has not identified any additional impacts to those previously identified. Consequently the potential impacts and mitigation measures as summarised for the EIS GTP (March 2009) in EIS Section 7.5 and EIS Appendix AA remain applicable for the study area.

References

Chow, V.T. (1959) *Open Channel Hydraulics*, McGraw-Hill Book Company, Inc.

(EPP 1997) Queensland Government, Environmental Protection Act 1994, “Environmental Protection (Water) Policy 1997”, Reprinted as in force on 20 July 2007, Reprint No. 3A, Online: [www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProWatePo97.pdf].

Institution of Engineers Australia, (1987) Australian Rainfall and Runoff: A Guide to Flood Estimation.

Pilgrim, D.H, and McDermott, G.E, (1982) Design floods for small rural catchments in eastern New South Wales. Civ, Eng. Trans., Inst. Engrs. Aust., Vol. CE24, pp. 226-234.

Queensland Government (2009) *Development Scheme for the Callide Infrastructure Corridor State Development Area*, October 2009.

Weeks, WD, (1991) *Design Floods for Small Rural Catchments in Queensland,* Civ Eng Trans, IE Aust, Vol CE 33, No 4, pp 249-260.

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 15th July 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 12 October 2009 and 19 October 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Site Visit Assessment

Photo: Looking Upstream

Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**1**
Location Name	**Larcom Creek**
Easting:	297,715
Northing:	7,358,412
Site Description: *Larcom Creek is located within the Calliope River Catchment. The site is located at the Bruce Highway road crossing. An assessment was undertaken slightly upstream of the road crossing. This ephemeral creek is heavily vegetated with eroded bans and bed.*	
Channel Depth:	*LB 5m, RB 6m*
Channel Width:	*6m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 2:1, RB 2:1*
Channel Banks: Both banks were extremely eroded with undercutting evident. Banks were grassed with small and larger trees.	
Substrate Type: The bed substrate is moderate compaction, which is framework dilated (32 - 60% fine sediment, low availability of interstitial spaces). The predominate particle size is gravel and silt/clay.	
Channel Bed: A considerable amount of debris and overlying trees were found within the channel. The bed was severely eroded and dominated by gravel and silt/clay.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*184km^2*		
Channel Slope:	*3.1 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	10mm	15mm	23mm
Flow	117m^3/s	15m^3/s	661m^3/s
Depth	0.2m	0.4m	0.7m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**2**
Location Name	**Larcom Creek**
Easting:	235,610
Northing:	7,358,610
Site Description: *Larcom Creek is located within the Calliope River Catchment. The site is located east (upstream) of the Bruce Highway. Water was present within this heavily vegetated ephemeral creek.*	
Channel Depth:	*LB 10m, RB 6m*
Channel Width:	*10m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 2:1, RB 3:1*
Channel Banks: Both left and right banks are fair to moderately unstable. The bank slope is convex in shape. Vegetation (ie small and large trees) are present along the banks, before entering a grassy floodplain.	
Substrate Type: Water was present therefore the bed compaction and sediment matrix of the bed was unable to be identified. The predominate particle size is silt/clay.	
Channel Bed: The bed is predominantly silt/clay. The stability of the bed was unable to be determined due to the presents of water.	
Water Quality: Water was absent of sediment oils and odours. Water sheen present. The water was slightly turbid, and of brown colouring. No flow.	
Floodplain: Grazed bushland.	

Catchment Size:	*193km^2*		
Channel Slope:	*2.9 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	10mm	15mm	23mm
Flow	123m^3/s	288m^3/s	693m^3/s
Depth	1.0m	1.4m	1.9m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**3**
Location Name	**Larcom Creek**
Easting:	299,526
Northing:	7,358,747
Site Description: *Larcom Creek is located within the Calliope River Catchment. The site is located east (upstream) of the Bruce Highway and consisted of moderately eroded banks and bed with overlying trees.*	
Channel Depth:	*LB 2.5m, RB 2m (LB 1m, RB 2m low flow channel)*
Channel Width:	*6m (4m low flow channel)*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:1, RB 2:1*
Channel Banks: Many eroded areas were evident on both banks. The banks are convex in shape with overlying trees.	
Substrate Type: The bed substrate is packed, unarmoured which is framework dilated (32 - 60% fine sediment, low availability of interstitial spaces). The predominate particle size is silt/clay and gravel.	
Channel Bed: Moderate erosion is apparent with the channel bed. The bed consists of gravel and silt/clay.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*194km^2*		
Channel Slope:	*2.9 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	10mm	15mm	23mm
Flow	123m^3/s	289m^3/s	695m^3/s
Depth	1.1m	1.6m	2.2m

Photo: Looking Upstream

Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**4**
Location Name	**Sneaker Gully**
Easting:	302,110
Northing:	7,369,845
Site Description: *Sneaker Gully is located upstream of Larcom Creek. The site was found to be heavily grassed with a clay silt bed surface..*	
Channel Depth:	*LB 2m, RB 1m*
Channel Width:	*3m (2m low flow channel*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:1, RB 1:1*
Channel Banks: Both banks are poor to unstable. The left bank is convex in shape whereas the right bank is concave in shape.	
Substrate Type: The bed substrate is tightly packed, armoured, which is framework dilated (32 - 60% fine sediment, low availability of interstitial spaces). The predominate particle size is silt/clay.	
Channel Bed: The channel has a clay silt bed surface which is tightly packed, armoured. The bed is severely eroded.	
Water Quality: Profuse sediment oils and globs of water oils were found. No water or sediment odours were detected. The water was turbid, brown in colour, with the presence of moulds.	
Floodplain: Grazed bushland.	

Catchment Size:	*0.88km^2*		
Channel Slope:	*2.9 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	10mm	15mm	23mm
Flow	0.6m^3/s	15m^3/s	23m^3/s
Depth	0.01m	0.02m	0.02m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**5**
Location Name	**Humpy Creek**
Easting:	306,504
Northing:	7,370,677
Site Description: *Humpy Creek is a tributary of Mosquito Creek located within the Calliope River Catchment. Water was found within this ephemeral stream. Large trees were present on the banks.*	
Channel Depth:	*LB 5m, RB 1m*
Channel Width:	*3m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:1, RB 1:1*
Channel Banks: Both left and right banks appear fairly stable. The banks are concave. The left bank consists of grasses and small and large trees, whereas the right bank it predominantly grassed at the location assessed.	
Substrate Type: Water was present therefore substrate type was not identified.	
Channel Bed: Characteristics of the bed were unable to be determined due to the presents of water. The width of bed was 3m.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*5.04km²*		
Channel Slope:	*12 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	29mm	42mm	65mm
Flow	$11m^3/s$	$26m^3/s$	$61m^3/s$
Depth	0.5m	0.7m	1.0m

Photo: Looking Upstream

Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**7**
Location Name	**Targinie Creek**
Easting:	307,440
Northing:	7,368,074
Site Description: The small stream is l*ocated upstream of the coastal plain north of Gladstone. The location the proposed pipeline will cross on Targinie Creek was inaccessible. Therefore a site upstream of this location was assessed instead. The bed of Targinie Creek at this site was dominated by boulders and cobbles.*	
Channel Depth:	*LB 0.5m, RB 2m*
Channel Width:	*4m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:3, RB 1:3*
Channel Banks: Both left and right banks appear fair to moderately stable, with areas of erosion detected. The left bank slope is concave in shape, whilst the right slope is convex in shape. The banks are grassed with small and large trees.	
Substrate Type: The bed substrate is tightly packed, armoured, which is matrix filled contact framework (5 - 32% fine sediment, moderate availability of interstitial spaces). The predominate particle size is boulder/cobble.	
Channel Bed: Large log jams were found across the entire width of channel bed. The bed was also dominated by boulders/cobbles and was tightly packed. The bed was found to be stable.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*15km^2*		
Channel Slope:	*14 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	22mm	31mm	48mm
Flow	21m^3/s	48m^3/s	114m^3/s
Depth	0.2m	0.3m	0.5m

Photo: Mosquito Creek

Photo: Mosquito Creek

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**8,9,10**
Location Name	**Mosquito Creek and Targinie Creek**
Easting:	306,504
Northing:	7,370,677
Site Description: *Mosquito Creek and downstream Targinie Creek are within the coastal plain and are estuarine. An assessment was undertaken within the floodplain due to difficulties accessing watercourses.*	
Channel Banks: The waterways are fringed by narrow riparian strips of vegetation which are relics of the extensive woodlands that were once present throughout the region.	
Substrate Type: Silty-clay	

Catchment Size:	*8. Mosquito Creek Tributary: 1km²*		
Channel Slope:	*12 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	29mm	42mm	65mm
Flow	$3m^3/s$	$8m^3/s$	$18m^3/s$
Depth	0.3m	0.4m	0.5m

Catchment Size:	*9. Mosquito Creek: 14km²*		
Channel Slope:	*12 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	29mm	42mm	65mm
Flow	$23m^3/s$	$54m^3/s$	$126m^3/s$
Depth	0.2m	0.2m	0.3m

Catchment Size:	*10. Targinie Creek: 16km²*		
Channel Slope:	*12 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	29mm	42mm	65mm
Flow	$6m^3/s$	$15m^3/s$	$35m^3/s$
Depth	0.7m	1.0m	1.3m


Photo: Looking Downstream


Photo: Looking Upstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**11**
Location Name	**Collard Creek**
Easting:	255,734
Northing:	7,320,137
Site Description: *Collard Creek, a tributary of Bell Creek, is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees, dense scrubs on the banks and juvenile trees on the coarse gravel bed.*	
Channel Depth:	*<0.5m*
Channel Width:	*1.5m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:10, RB 1:10*
Channel Banks: Both left and right banks appear fairly stable, with no evidence of erosion or bank failure at the site location. The low grade left bank slope is concave in shape, whilst the right steeper slope is convex in shape. The banks are grassed with a scatter of small trees.	
Substrate Type: The bed substrate is of low compaction which is matrix dominated (>60% fine sediment, interstitial spaces virtually absent). The predominate particle size is a coarse gravel.	
Channel Bed: This small stream is approximately 1.5m wide and has a depth of less than 0.5m. The channel has a flat gravel bed surface.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*71km^2*		
Channel Slope:	*9.7 m/km*		
Catchment Storage: Well defined system of small watercourses.			
Catchment Relief: Hilly, with average slopes of 4 – 8%			
	Q2	Q10	Q100
Intensity	15mm	21mm	33mm
Flow	90m^3/s	211m^3/s	503m^3/s
Depth	1.2m	1.6m	2.0m

Photo: Looking Upstream

Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**17**
Location Name	**Bell Creek**
Easting:	257,438
Northing:	7,322,521
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees, dense scrubs on the banks and juvenile trees on the coarse gravel bed.*	
Channel Depth:	*0.5m*
Channel Width:	*8m*
Floodplain Width:	*20m*
Bank Slope:	*LB 1:40, RB 1:40*
Channel Banks: The left bank is fair to moderately unstable whilst the right bank is unstable with evidence of erosion. Both banks are concave. The banks are grassed with a scatter of small and larger trees.	
Substrate Type: The bed substrate is of low compaction which is matrix dominated (>60% fine sediment, interstitial spaces virtually absent). The predominate particle size is gravel and sand, with pebbles and some boulders.	
Channel Bed: The bed is fairly sandy and has moderate deposition. The bed is approximately 8m wide.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*108km^2*		
Channel Slope:	*6 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes 1.5 - 4%			
	Q2	Q10	Q100
Intensity	13mm	19mm	29mm
Flow	94m^3/s	19m^3/s	526.5m^3/s
Depth	0.6m	1.1m	1.9m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**18**
Location Name	**Bell Creek**
Easting:	260,885
Northing:	7,322,770
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees, dense scrubs on the banks and juvenile trees on the coarse gravel bed. This overgrown reach of the creek was unable to be accessed therefore the assessment was taken from the upper banks.*	
Channel Depth:	
Channel Width:	
Floodplain Width:	*>100m*
Bank Slope:	
Channel Banks: The channel banks were considerably high (approximately 25m). Banks were fairly stable and concave in shape. Banks were overgrown in grasses, small and large trees.	
Substrate Type: Water was present therefore the bed compaction and sediment matrix of the bed was unable to be identified. The predominate particle size is silt/clay.	
Channel Bed: Unable to access creek bed as too overgrown.	
Water Quality: Unable to identify if water was present in creek channel.	
Floodplain: Grazed bushland.	

Catchment Size:	*105km^2*		
Channel Slope:	*6 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	13mm	19mm	29mm
Flow	84m^3/s	m^3/s	514m^3/s
Depth	0.7m	1.2m	2.1m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**21**
Location Name	**Bell Creek**
Easting:	259,502
Northing:	7,323,830
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees, dense scrubs on the banks and juvenile trees on the coarse gravel bed.*	
Channel Depth:	*LB 1m, RB 2m*
Channel Width:	*4m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:3, RB 1:3*
Channel Banks: Bank stability was poor and convex in shape. The banks are grassed with a scatter of small trees.	
Substrate Type: The bed substrate is packed, unarmoured which is matrix dominated (>60% fine sediment, interstitial spaces virtually absent). The bed was fairly muddy. The predominate particle size is silt/clay.	
Channel Bed: Little vegetation was found within the channel bed. The bed was severely eroded with the presence of debris (log jams across the channel).	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*92km^2*		
Channel Slope:	*6 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling, with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	14mm	20mm	31mm
Flow	88m^3/s	206m^3/s	491m^3/s
Depth	1.4m	2.1m	3.0m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**23**
Location Name	**Bell Creek**
Easting:	260,134
Northing:	7,324,137
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees and dense scrubs on the banks.*	
Channel Depth:	*<0.5m*
Channel Width:	*2m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:2, RB 1:2*
Channel Banks: The moderately stable banks are concave in shape and contain a large amount of lantana and scarred riparian vegetation.	
Substrate Type: The bed substrate is packed, unarmoured, which is matrix dominated (>60% fine sediment, interstitial spaces virtually absent). The predominate particle size is sand.	
Channel Bed: The stable bed is 2m wide, with a sand dominated particle size.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*91km^2*		
Channel Slope:	*6.5 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Flat, with slopes of 0 – 1.5%			
	Q2	Q10	Q100
Intensity	14mm	20mm	31mm
Flow	87m^3/s	203m^3/s	484m^3/s
Depth	2.5m	3.1m	3.9m

Photo: Looking Upstream

Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**26**
Location Name	**Bell Creek**
Easting:	260,885
Northing:	7,325,276
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees and grasses on the banks.*	
Channel Depth:	*Stage 1- Shallow, Stage 2 – 1m, Stage 3- 8 to 10m*
Channel Width:	*Stage 1- 1m, Stage 2 – 25m, Stage 3- 45m*
Floodplain Width:	*>100m*
Bank Slope:	*Approximately 1:10*
Channel Banks: The multi staged channel has concave shaped banks. These banks are fairly stable and are grassed with a scattering of mature trees.	
Substrate Type: Water was present therefore the bed compaction and sediment matrix of the bed was unable to be identified. The predominate particle size is silt/clay.	
Channel Bed: The multi stage channel has a silt/clay substrate and is fairly stable. Grasses were found within the bed.	
Water Quality: Water had moderate sediment oils and a water sheen. No water or sediment odours were detected. The water was slightly turbid, however fairly clear, with the presence of vegetation and algae.	
Floodplain: Grazed bushland.	

Catchment Size:	*89km^2*		
Channel Slope:	*7.5 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	14mm	20mm	31mm
Flow	84m^3/s	197m^3/s	468m^3/s
Depth	0.5m	0.8m	1.4m


Photo: Looking Upstream


Photo: Looking Downstream

GLNG Supplementary EIS–Surface Water Assessment-Pipeline	
Location No.	**28**
Location Name	**Bell Creek**
Easting:	267,862
Northing:	7,326,744
Site Description: *Bell Creek is located to the south west of Gladstone. The ephemeral stream is heavily vegetated with mature larger trees and grasses on the banks.*	
Channel Depth:	*LB 3m, RB 1.5m*
Channel Width:	*6m*
Floodplain Width:	*>100m*
Bank Slope:	*LB 1:1, RB 1:1*
Channel Banks: Both left and right banks appear fairly stable, with only small evidence of erosion. Both banks are convex in shape. The banks are grassed with small and large trees.	
Substrate Type: The bed substrate is low compaction, which is matrix dominated (>60% fine sediment, interstitial spaces virtually absent). The predominate particle size is gravel and sand.	
Channel Bed: Moderate deposition was evident within the sand and gravel dominated bed.	
Water Quality: No water present.	
Floodplain: Grazed bushland.	

Catchment Size:	*89km²*		
Channel Slope:	*7.5 m/km*		
Catchment Storage: Poorly defined and meandering stream.			
Catchment Relief: Rolling with slopes of 1.5 – 4%			
	Q2	Q10	Q100
Intensity	15mm	22mm	35mm
Flow	$56m^3/s$	$131m^3/s$	$35m^3/s$
Depth	0.6m	1.0m	1.6m

URS Australia Pty Ltd
Level 16, 240 Queen Street
Brisbane, QLD 4000
GPO Box 302, QLD 4001
Australia
T: 61 7 3243 2111
F: 61 7 3243 2199

www.ap.urscorp.com