APPENDIX 5

Validation of Stream Design

URS 2008

REPORT

Validation of Stream Diversion Design at Iluka Gingin Deposit

Prepared for

Iluka Resources Ltd

Level 23, 140 St. Georges Terrace, Perth WA 6000

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Project Manager:	.... Boon Eow Senior Hydrologist/Water Engineer	URS Australia Pty Ltd	
Project Director:	.... Bas Wijers Principal Water Engineer	Level 3, 20 Terrace Road East Perth WA 6004 Australia Tel: 61 8 9326 0100 Fax: 61 8 9326 0296	
Author: *(Optional)*	.... Boon Eow Senior Hydrologist/Water Engineer on behalf of the Surface Water Group	Date: Reference: Status:	2 July 2008 42906853.W0009 Draft
Reviewed by:	.... Bas Wijers Principal Water Engineer	Date: Reference: Status:	2 July 2008 42906853.W0009 Draft

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Section 1 Introduction

1.1 Background

URS has provided a conceptual design for the diversion of watercourse at the Iluka Gingin Deposit (URS, 2003). It consists of a diversion channel along the eastern fringe of the minesite which intercepts several watercourses draining towards the mine and diverts the surface runoff around the northern and southern ends of the mine site, cross some culverts along Dewar Road and rejoin the downstream watercourses. At the completion of the mining, the diversion channels and associated bunding will be removed and the original watercourses reinstated to a condition and route similar to what existed prior to mining.

The mining activities are currently at a stage that both the Southern and Northern streams can be reinstated. Iluka are planning to reinstate these streams. Engineering designs for both the Southern and Northern streams have been prepared, according to the original stream sections prior to mining. Iluka is seeking services from URS to validate the adequacy of these designs for a minimum 20 years ARI flow and to suggest improvement to increase the stability and naturalness of the streams.

1.2 Scope of Works

The aim of this Project is to validate the adequacy of the engineering designs of the Southern and Northern stream reinstatement and to suggest improvement to the designs. The scope of work consists of the following work tasks:

Task 1: Data Review:

- Assessment of updated climatic and stream flow data.
- Review of design criteria and methodology used in previous design report (URS, 2003).
- Review of the plan to reinstate the Southern and Northern streams by Iluka, which include the design sections by the surveyor.

Task 2: Validation of Original Engineering Design for a minimum 20 yr ARI flow:

- Determine the 20 years ARI peak discharge rates for the Southern and Northern streams reinstatement using AR&R Rational Method.
- Hydraulic computations to validate the adequacy of the engineering design of the stream channels for the 20 years ARI peak discharge rates.

Task 3: Suggestions of Improvement to Engineering Design to increase stability and naturalness of stream

This report presents the findings from above work tasks.

Section 2 Data Review

For the background knowledge and the requirement of this project, the following information made available to URS has been reviewed.

2.1 Design Report of Stream Diversion (2003)

This report presents a conceptual design for the diversion of streams around Iluka's proposed mine site at Gingin, 80 km north of Perth. Amongst other things, it includes a conceptual engineering design of two temporary drains with flood protection bunds constructed across the eastern side, or upslope, of the mine area, draining into the culverts NS2 and SS3. These diversion channels were designed for a 1:50 yr ARI storm. Peak discharge for a 1:50 year ARI event is predicted to be 22.1 m^3/s for the NS2 catchment and 10.4 m^3/s for the SS3 catchment.

The North Stream Diversion is a trapezoidal drain, grassed, 5 to 10 m bottom width, up to 1.15 m deep, 0.15% slope, 1.5 km long; design discharge = 25 m^3/s, design velocity = 1.6 m/s.

The South Stream also takes the form of a trapezoidal drain, grassed, 1 to 25 m wide, up to 1.1 m deep, 0.15 to 1% slope, 3.2 km long; design discharge = 15 m^3/s, design velocity = 1.6 m/s.

After mining is completed, the drains and bunds would be removed and the original streamlines reinstated to a condition and route similar to what existed prior to mining.

2.2 Extract from draft Closure Plan on Streams Reinstatement

Iluka has provided an extract on the reinstatement of streams from the draft closure plan. The following paragraphs describe the hydraulics aspects of the stream reinstatement plan:

> *"……The North and South streams will both be re-created in locations closely following the original alignments. The recreated streams will have low and high flow zones and incorporate gentle meanders consistent with the flow alignments of similar sized streams in the district. Erosion control measures will include grassing of the watercourse and use of geo-textile matting and velocity control structures where required. The streams will be designed to ensure the sustainability of the streams in the long-term, consistent with the requirements of the Permit to Obstruct or Interfere granted by the Department of Water……."*

> *"……The material that the stream will be constructed of is approximately 70% sand and 30% clay with a metre of overburden on top. Overburden consists of 30% clay and the remainder is rock with a maximum 200mm diameter……."*

2.3 Stream Design by Iluka

Digital Elevation Models (DEM) of the engineering design to reinstate both South Stream and North Stream has been provided to URS, in the form dxf drawings. A longitudinal section profiles and cross-sections at 100 m intervals have been extracted from the DEM.

Section 2 Data Review

South Stream

The design section for the South Stream is a trapezoidal section with 5 m bottom width and a side slope of 1V:2H. The average channel slope is about 1.8%.

North Stream

The design section for the North Stream is a 0.5 m deep triangular section with a 3 m top width (side slope 1V:3H). The average channel slope is about 1%.

The main aim of Task 2 of this project is to validate the adequacy of these design section to carry a 1:20 yr ARI flood flow.

Section 3 Validation of Stream Design

With the knowledge from the data review, this section aims at validating the design of the stream reinstatement for a 1:20 year ARI storm event.

3.1 Runoff Catchments

In the URS 2003 report, the South Stream catchment has been defined as a whole catchment, because the proposed diversion channel receives water from this entire catchment. However for this exercise, the South Stream will be reinstated into it original form which consists of two tributaries SS1 and SS2 which merge into a single stream SS3 before crossing the Dewar Road culvert. (Note: the channels and catchments adopt the name of the stream flow monitoring station such as SS1, SS2, SS3 and NS2). Therefore it would be necessary to sub-divide the South Stream catchment into sub-catchments for the SS1, SS2 and SS3 channels respectively, as shown in Figure 3-1.

Figure 3-1 Sub-catchments of South Stream

The ratio of SS1:SS2 catchment area is about 40:60 with comparable channel slopes. The basic characteristics of the sub-catchments such as catchment areas, stream lengths, stream slopes were determined and summarised in Table 3-1 below.

Table 3-1 Pre-project Sub-catchments

Description	Catchment area, A (m2)	Stream Length, L (km)	Mainstream slope, S (m/km)
Pre-project Sub-catchments:			
Catchment SS1	1,086,980	2.532	35.55
Catchment SS2	1,599,267	3.493	40.08
Catchment SS3	2,704,727	3.647	39.76
Catchment NS2	4,170,000	3.300	28.00
Total:	**6874727.00**		

3.2 Predicted Peak Discharge Rate

To validate the adequacy of the stream design by Iluka to carry a 1:20 yr ARI rainfall event, it would be necessary to determine the peak discharge rate related to this rainfall event. The AR&R method has been used for this purpose.

Methodology

The Rational Method in Chapter 4 of "Australian Rainfall and Runoff - a Guide to Flood Estimation (1987 Edition)" has been used to determine the peak flows from the individual sub-catchments. The Rational Method is a universally accepted simplistic method to calculate the peak flood flows of selected Average Recurrence Intervals (ARI) from an average rainfall intensity of the same ARI. The Rational Method incorporates the intensity of the rainfall, the area of the catchment and a coefficient of runoff.

The coefficient of runoff for a catchment depends on the following inter-related factors:

- Soil type and permeability;
- Land vegetation type, density and slope; and
- Intensity of rainfall.

Section 3 Validation of Stream Design

The Rational Formula used for the estimation of the peak discharge is:

$Q = 0.278\ C\ I_{tc,Y}\ A$

Where

Q = Peak discharge (in $m^3 s^{-1}$);

C = A dimensionless run-off coefficient;

I = Mean rainfall intensity (mm hr^{-1}) of a storm of the design ARI and duration equal to the time of concentration, t_c;

A = Catchment area (ha);

Design Rainfall

First and foremost, the average rainfall intensities of various durations and average return intervals (ARI) are generated in accordance with Chapter 2 of "Australian Rainfall and Runoff - a Guide to Flood Estimation (1987 Edition)". The peak rainfall intensity data for 1 hour, 12 hour and 72-hour durations for 2 and 50-year ARI's, geographical factors for 2- and 50-year ARI's, and average regional skewness were obtained from AR&R (1987). The rainfall intensities (mm $hour^{-1}$) for different durations and ARI's between 1 and 100 years were then computed for the minesite (Table 3-2).

Table 3-2 Average Rainfall Intensities - Gingin

	***Average Rainfall Intensity, $I_{d,Y}$* for ARI (yr), (mm/h)**						
Duration (hr)	**1 Yr**	**2 Yr**	**5 Yr**	**10 Yr**	**20 Yr**	**50 Yr**	**100 Yr**
0.5	22.6	29.7	38.9	45.4	54	68	79
1	14.7	19.2	24.8	28.7	34.2	42.3	49.1
6	4.73	6.09	7.54	8.52	9.93	11.9	13.6
12	3.04	3.89	4.74	5.31	6.13	7.3	8.26
24	1.89	2.42	2.95	3.3	3.81	4.54	5.14
48	1.15	1.47	1.79	2	2.31	2.75	3.11
72	0.83	1.06	1.3	1.45	1.67	1.99	2.25

Peak Discharge Rates

The Rational Method as outlined above is used to estimate the 1:20 years ARI peak discharge rates of the sub-catchments at the critical duration equal to the time of concentration (t_c). Design parameters for the "Loamy soil catchments 75-100% cleared" for the Wheatbelt Region have been adopted, with some extrapolation to the catchment runoff coefficient, C factor.

The peak flow rate from a 1:20 years ARI and t_c duration rainfall event for the pre-project sub-catchments were computed and summarised in Table 3-3 below.

Table 3-3 Peak Discharge Rates for 1:20 yr ARI - Gingin

Sub-Catchment	Catchment area, A (m2)	Stream length, L (km)	Mainstream slope, S (m/km)	Time of concentration tc (min)	Itc,Y for ARI (years), (mm/h)	QY for ARI (years), (m3/s)
Catchment SS1	1,086,980	2.532	35.55	47	42	**4.5**
Catchment SS2	1,599,267	3.493	40.08	55	39	**5.4**
Catchment SS3	2,704,727	3.647	39.76	67	34	**8.0**
Catchment NS2	4,170,000	3.300	28.00	78	30	**11.0**

3.3 South Streams (SS1, SS2 and SS3)

The design section for the South Stream provided by Iluka (hereafter called the original design) is a trapezoidal section with 5 m bottom width and a side slope of 1V:2H. The average channel slope is about 1.8%. Figure 3-2 and Figure 3-3 shows the general layout, longitudinal profiles and cross-sections of the three channel stretches SS1, SS2 and SS3 respectively.

Figure 3-2 SS1, SS2 & SS3: General layout

Figure 3-3 SS1, SS2 & SS3: Long Section Profiles & Cross Sections

With the design inputs extracted from the DEM, the flow capacity of the original design was checked against the required flow capacity, using the Manning n open-channel flow formula, and the results of the computations are summarised in Table 3-4 below:

Table 3-4 Summary of Channel Design Sections - SS1, SS2 & SS3

Channel	SS1	SS2	SS3
Design Input:			
1:20 yr Peak Q (m^3/s)	4.5	5.4	8
Design Q (rounded up) (m^3/s)	**6**	**6**	**8**
Channel slope (m/m)	0.018	0.018	0.018
Channel Manning's n	0.07	0.07	0.07
Design Section:			
Side slope (1H:xV)	2	2	2
Channel bottom width (m)	5	5	5
Flow depth (m)	0.75	0.75	0.85
Flow Area (m^2)	4.88	4.88	5.70
Flow Capacity (m^3/s)	**6.52**	**6.52**	**8.17**

Channels SS1 & SS2

The two tributaries SS1 and SS2 have comparable characteristics in terms of catchment area, stream length, channel slope and peak discharge rates. Therefore it is suggested to adopt the same design for both channels. The design discharge rate has been rounded up to 6 m^3/s. With the designed side slope of 1:2 and a bottom width of 5 m, the flow depth will be 0.75 m deep at the design discharge rate. This will be well contained in the design channel except at Ch. 355 m of channel SS2, where it will spill the bank. Some bunding or deepening/widening may be necessary at this location.

Section 3 Validation of Stream Design

Channels SS3

Channels SS1 and SS2 merge into a single stream SS3 which has a length of 160 m. The design discharge rate is 8 m^3/s. The original design section is similar to that of SS1 and SS2. The flow depth will be 0.85 m at the design discharge rate.

In general, the original design for the South Stream is adequate, except at Ch. 355 in channel SS2 which may need some bunding to contain the 1:20 yr ARI flow.

3.4 North Stream (NS2)

The original design section for the North Stream is a 0.5 m deep triangular section with a 3 m top width (side slope 1V:3H). The average channel slope is about 1% measured from the long sectional profile. Figure 3-4 shows the general layout, longitudinal profiles and cross-sections of the North Stream NS2. It can be seen that the flood plains on both side of the channel are having irregular profiles. Assuming the cross-section at Ch. 100 is representative of the channel, the flood plain has a 1:60 slope towards the channel.

Figure 3-4 General Layout North Stream, Long Section Profiles & Cross Sections

Similarly, the flow capacity of the original design was checked against the required flow capacity. The section is considered as a composite section consists of a triangular low-flow section with a top width of 3m and a trapezoidal flood-flow section with a bottom width of 3 m. The results of the computations are summarised in Table 3-5 below:

Table 3-5 Design Sections (original & recommended) - NS2

Channel	NS2 Original Design			NS2 Proposed Alternative
	Triangular	Trapezoidal	Total Composite	
Design Input:				
1:20 yr Peak Q (m^3/s)			11	11
Design Q (rounded up) (m^3/s)			**12**	**12**
Channel slope (m/m)	0.01	0.01	0.01	0.01
Channel Manning's n	0.07	0.07	0.07	0.07
Design Section:				
Side slope (1H:xV)	3	60		2
Channel bottom width (m)	0	3		5
Flow depth (m)	0.5	0.53	1.03	1.25
Flow Area (m^2)	0.75	18.44	19.19	9.38
Flow Capacity (m^3/s)	0.41	11.19	**12.31**	**12.35**

It seems from the result that the triangular low-flow section is insufficient for the 1:20 yr ARI peak discharge of 11 m^3/s (rounded up to 12 m^3/s for design purpose). The flood flow will inundate to the adjacent flood plain. The flood flow width will be approximately 60 m wide based on the typical section at Ch. 100m. The flow area required is about double compared to a case where the flood flow is contained in the stream channel. This is due to the much longer wetted perimeter of the flow section on the flat flood plain.

To avoid this low-efficiency flood flow regime, it is recommended to have a larger trapezoidal section with a 5 m bottom width as an alternative to the triangular section in the original design (see cross section at Ch. 100 in Figure 3-4). The flow characteristics of this alternative trapezoidal section are shown in the last column of the Table 3-5.

Section 4 Suggestions for Improvement

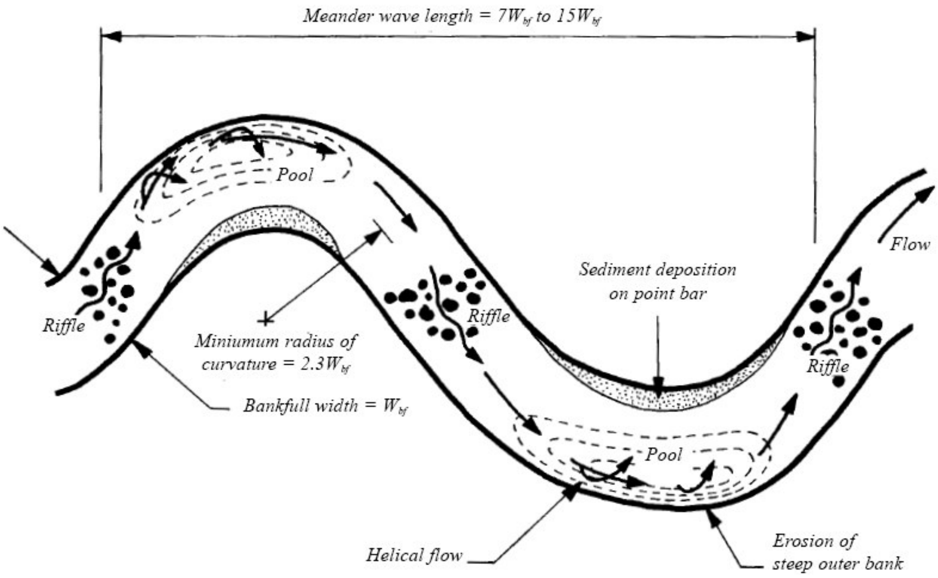
Based on the River Restoration Guidelines published by Department of Environment / Water and River Commissions, and other relevant guidelines of good practices, the following "good practices", which will potentially improve the naturalness and stability of the reinstated streams, are recommended for consideration:

Meandering

- Since the flow capacities are quite ample, there is some leeway to incorporate stream meandering to slow down the flow for erosion control. Most of the channel stretches of the original design already have some meandering except SS1 which is unnaturally straight.
- According to the recommendation of the Water and River Commission, a full meander wavelength (the distance between two similar points along the channel between which the waveform is complete) is found to occur between 7 and 15 times the bankfull width (Note: Bankfull width is the width of the channel at water level during an average 1 to 2 year peak follow event). Generally, a natural creek line forms a series of regular sinusoidal curves with an average radius range of 2.3 to 2.7 times the bankful width (Fig 4-1). Base on the above guideline, theoretically the meander should have the following characteristics:
  - Meander wave length = 15 X Width of bankfull flow (upper limit) = 50 m
  - Radius of curvature = 2.3 X width of bankfull flow = 7 m
- It is also recommended in the guideline that meanders should be consistent with the flow alignments of similar sized streams in the same district. It has been found that the other tributary, Channel SS2 has a similar setting as SS1 in terms of catchment area, channel slope and landform. Measuring from the survey plan, the meandering in this SS2 channel has the following characteristics (Fig 3-2):
  - Meander wave length = 200 m
  - Radius of curvature = 75 m
- It is suggested to adopt the same meandering features of SS2, as shown in Fig 3-2.

Section 4 Suggestions for Improvement

Figure 4-1 Meandering stream channel form



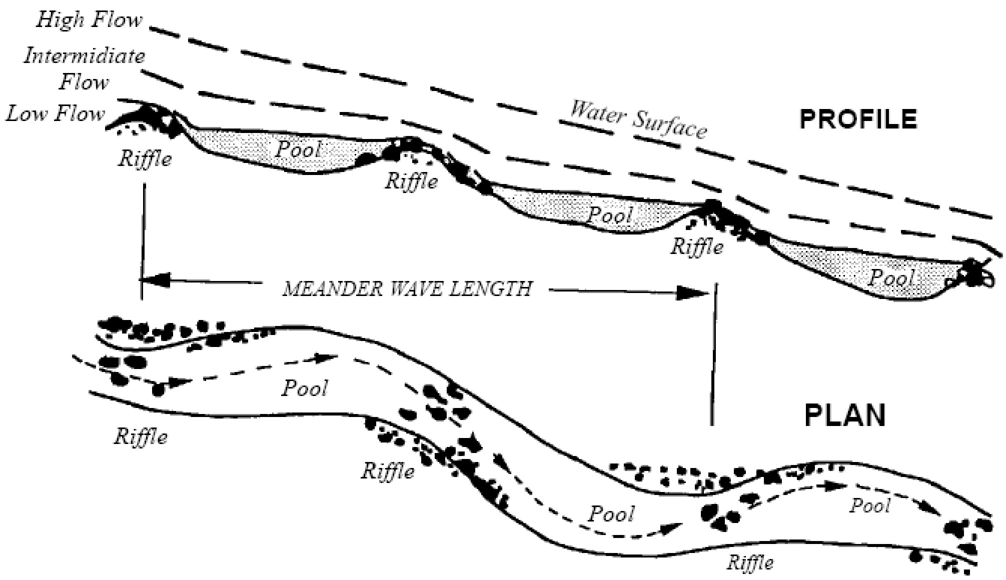
(Adapted from Report RR 10: Stream Stabilization, Water and River Commission, WA)

Pools and Riffles system

- It is recommended to incorporate some riffle and pool system for the streams. Pool-riffle sequences contribute to channel stability by controlling the velocity of flow and reducing the downstream movement of sediments into the river. The riffle reduces the flow velocity by creating a pool that backfloods the upstream section and reduces the power of the downstream flow. It can also serve as a livestock watering or crossing point.
- According to the guideline by Water and River Commission, the pool-riffle sequence is generally 5-7 times the width of the bankfull channel, i.e. about half of the meander wavelength (Fig 4-2). The riffles should be constructed along a straight section of the river or at the crossover (inflexion) point in the middle of a meander.

Suggestions for Improvement

Figure 4-2 Riffle and Pool for stream

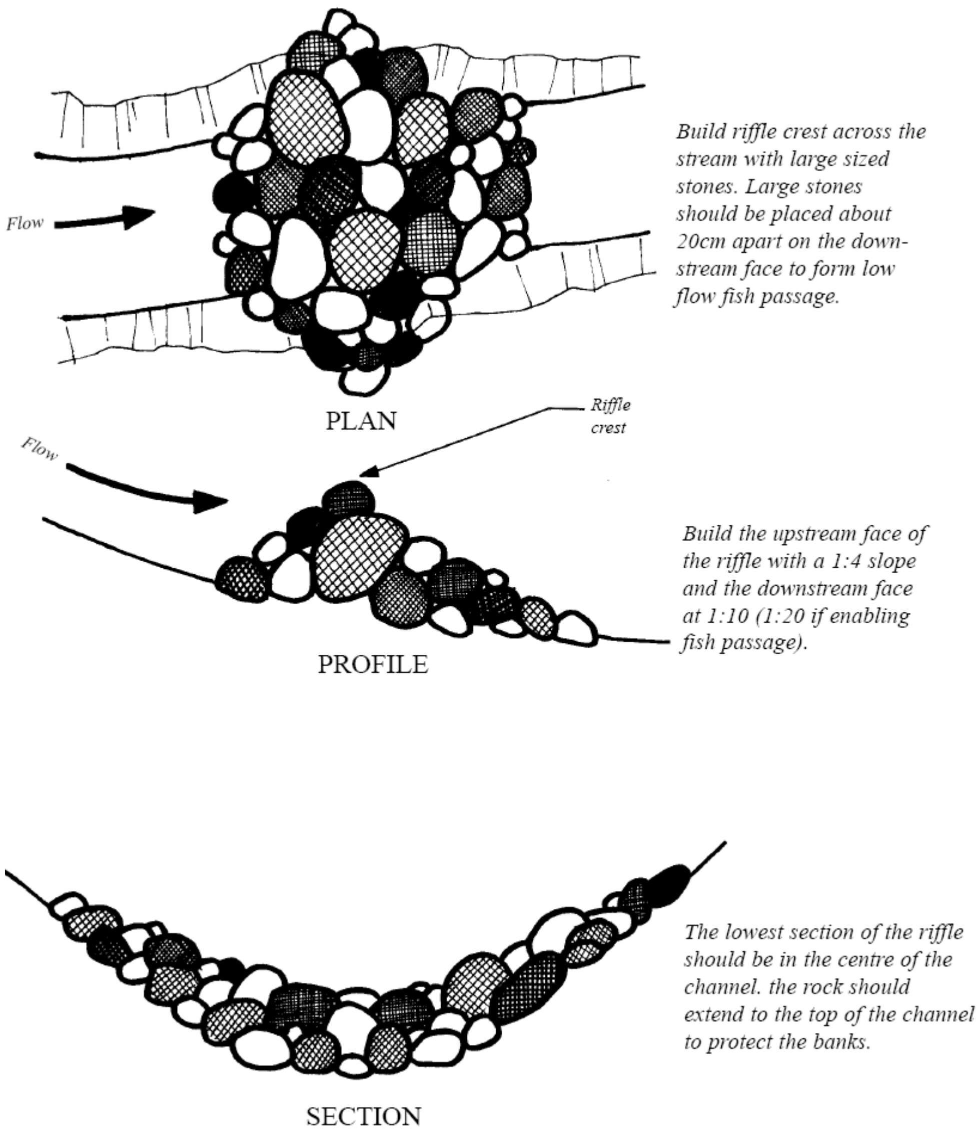


(Adapted from Report RR 10: Stream Stabilization, Water and River Commission, WA)

- The riffle sequence should be constructed to cater to the natural meanders and profile of the river rather than strictly conforming to the riffle spacing determined. For instance, it should be constructed at natural high point on the bed profile to create a deeper and longer pool.
- The riffles should be designed to obstruct less than 10% of the cross-sectional area of the channel, so that it will not adversely affect the flood capacity of the channel.
- The crest of the riffle should be built with a shallow 'V' shaped cross-section. The lowest point of the riffle should be in the centre of the channel to direct flows away from the banks. The sides of the riffle should typically extend to the top of the channel. The crest of the riffle may need to be dug in to below the bed level and into the bank in highly erosive soils to prevent undermining of the structure. A schematic diagram of a riffle is shown in Fig 4-3.
- The riffles can be constructed by placing rock of across the river section at the suitable locations. A mix of rock sizes is required for the riffle to become interlocking and thus achieve greater strength. Hard, clean, angular-shaped rock is preferred. Larger stones or boulders should be placed on the surface of the riffle and spaced about 20-30 cm apart on the downstream face to break up the flow of water and assist in fish passage.
- Some rock movement may occur during initial high flows and maintenance and possibly addition of more rock may be required following the first few big floods.

Section 4 Suggestions for Improvement

Figure 4-3 Schematic diagram for Riffle Construction



Freeboard

It is good practice to provide some freeboard for the designed channel section to take a higher ARI flood flow. It is recommended to provide the following freeboard to cater for an approximately 1:50 year ARI flood flow:

- 150 mm freeboard for SS1 and SS2; and
- 300 mm freeboard for SS3 and NS2 respectively.

Low Flow Section

- Provision of a low-flow section is to help keeping the base flow of the stream at the middle of the channel bed away from the side slopes, hence reduces erosion risk.

Section 4 Suggestions for Improvement

- The flow capacity of this low flow section is relatively small and can be ignored in the derivation of the design flood flow section.
- It is recommended to adopt the dimension of low-flow sections in nearby streams of similar catchment area, like the example in SS1 shown in Plate 4-1 below. The top widths and depths of the low flow sections can be measured on site at a few locations and adopt the average of these measurements.
- It can be constructed by excavating a near rectangular cross section at the centre of the finished channel bed, using a backhoe with suitable bucket size. The steeper than usual side slopes will naturally gain its stable form following future flood flows.

Plate 4-1 Example of Low Flow Section in SS1

Other General Considerations

- When planning to restore channel stability, the current and possible future characteristics of the catchment must be considered. Designs should be developed to restore stability to a waterway, rather than attempt to replicate the original natural system.
- The theoretical designs provide a reference only. Some judgement based on observations on site is required when implementing these designs. For instance, the types and sizes of materials occurring naturally in the waterway can be used as a guide to selecting appropriate materials to construct in-stream structures.

Section 4 Suggestions for Improvement

- The protective measures for stream reinstatement recommended in the Iluka Mine Closure Plan (Ref 2) should be adopted. This includes grassing of the water course and use of geo-textile matting to stabilize the bank/bed before the full establishment of revegetation.

Section 5 Conclusions and Recommendations

Conclusions

The outcomes of the channel design validation can be summarised as follows:

- The design sections for the South Stream are generally adequate, except at Ch. 355 in channel SS2 which may need some bunding, or deepened/widened to contain the 1:20 yr ARI flow.
- The triangular design section for the North Stream can not contain the 1:20 yr ARI flow. An alternative trapezoidal design section with a 5 m bottom width is recommended.

Recommendations

Based on the River Restoration Guidelines published by Department of Environment / Water and River Commissions, and other relevant guidelines, the following “good practices”, which will potentially improve the naturalness and stability of the reinstated streams, are recommended for consideration:

- Incorporate stream meandering (especially for SS1), taking advantage of the ample flow capacity.
- Incorporating Pool-riffle system in all channels, where appropriate.
- Provision of freeboard to take a 1:50 yr ARI flood flow – 150 mm for the smaller SS1 and SS2 channel and 300 mm for the larger SS3 and NS2.
- Provision of a low-flow section to confine the baseflow in the middle of the channel.
- Adopting the recommendations for stream reinstatement stipulated in Iluka Mine Closure Plan (Ref 2).

Section 6 References

1) Report No. 44047-048-562 : Diversion of Streams at the Iluka Gingin Deposit, URS Australia Pty. Ltd, 17 October 2003.
2) Extract of Iluka Mine Closure Plan on Stream Reinstatement (through email dated 19/05/2008).
3) Australian Rainfall and Runoff (1987), IEAustralia.
4) River Restoration Manual Report No. RR 19, Stream and Catchment Hydrology, 2003, Department of Environment.
5) River Restoration Manual Report No. RR 9, Stream Channel Analysis, 2001, Water and Rivers Commission.
6) River Restoration Manual Report No. RR 10, Stream Stabilisation, 2001, Water and Rivers Commission.

Section 7 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Iluka Resources Ltd and only those third parties who have been authorised in writing by URS to rely on the report. 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 26th May 2008.

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 26th May 2008 and 30 May 2008 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 or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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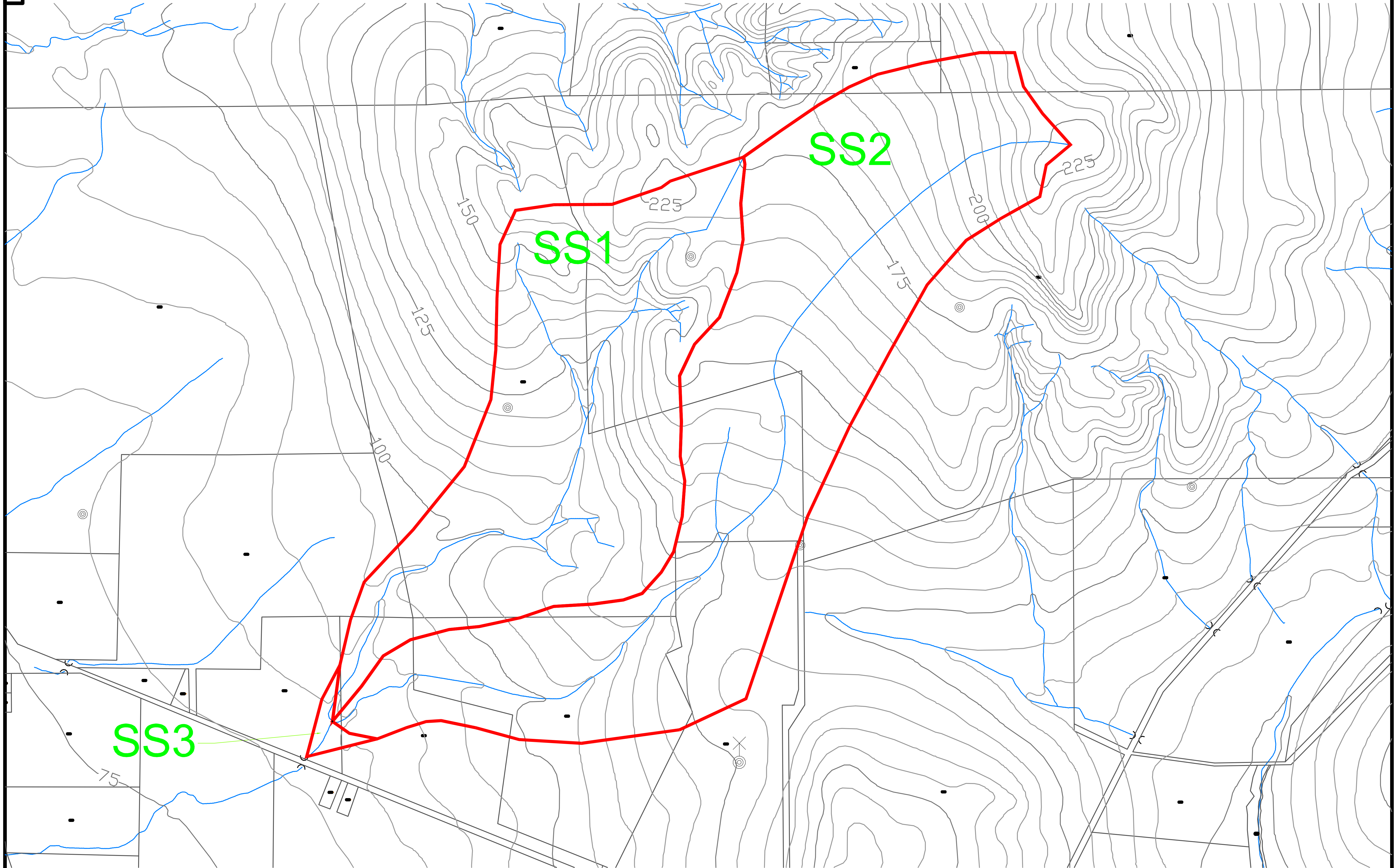

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URS

URS Australia Pty Ltd.
Level 3
20 Terrace Road
East Perth, WA 6004
Tel. 08 9326 0100
Fax.08 9326 0296

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Designed	B E / F vd L
Drawn	F vd L
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Scales	N.T.S.

Client: ILUKA RESOURCES LTD

Project Title: VALIDATION OF STREAM DIVERSION DESIGN ILUKA GINGIN DEPOSIT

Drawing Title: SUB CATCHMENTS FOR SOUTH STREAM

Status: **FINAL**

Datum:

Date: 30/05/2008

CAD File Number: Figure 3.1

Job Number: 42906853

Drawing Number: **Figure 3.1**

Rev: **A**

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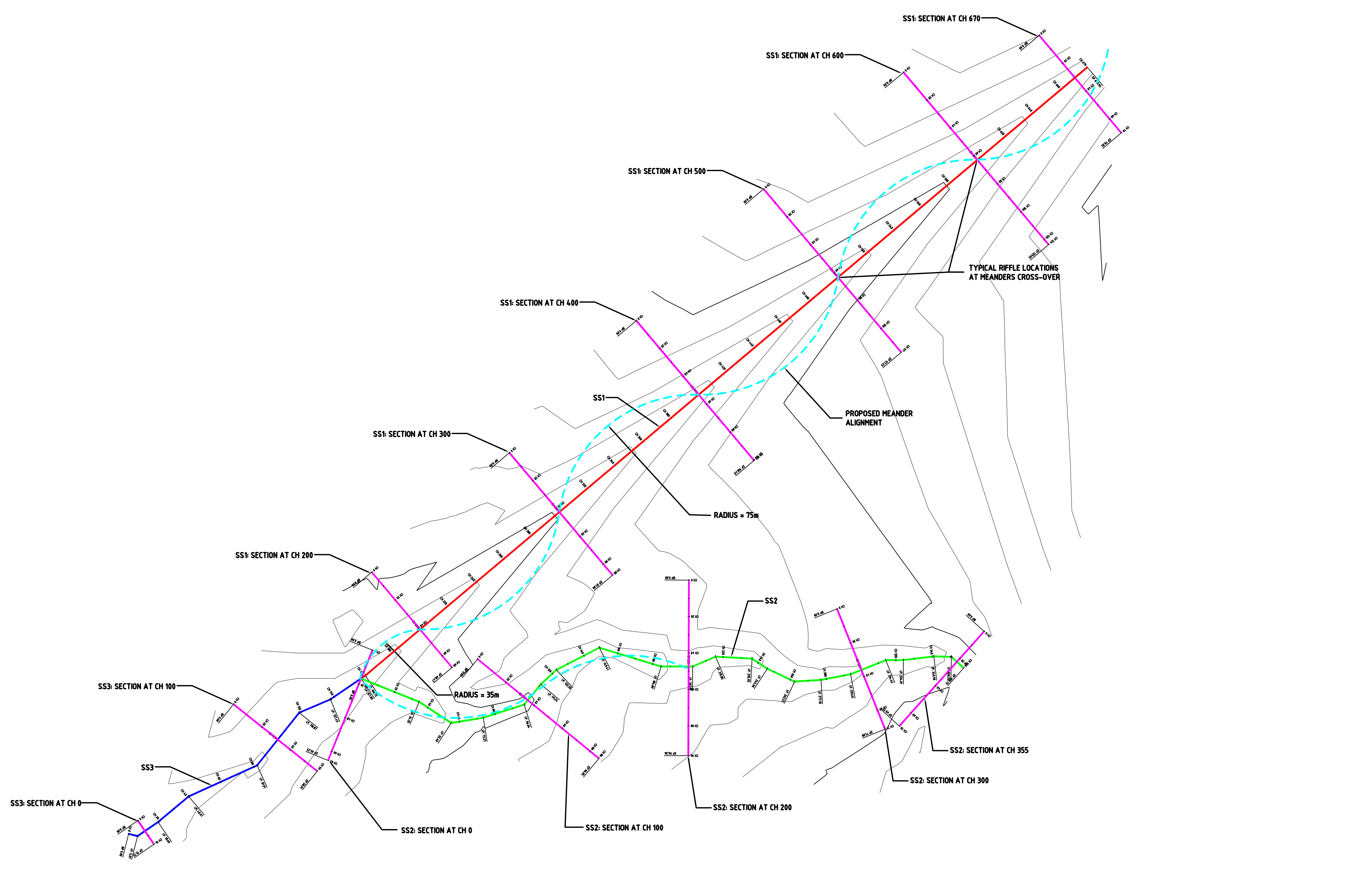

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URS Australia Pty Ltd.
Level 3
20 Terrace Road
East Perth, WA 6004
Tel. 08 9326 0100
Fax.08 9326 0296

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Client: ILUKA RESOURCES LTD

Project Title: VALIDATION OF STREAM DIVERSION DESIGN ILUKA GINGIN DEPOSIT

Drawing Title: SS1, SS2 & SS3: GENERAL LAYOUT

Status: **FINAL**

Datum:

Date: 03/07/2008

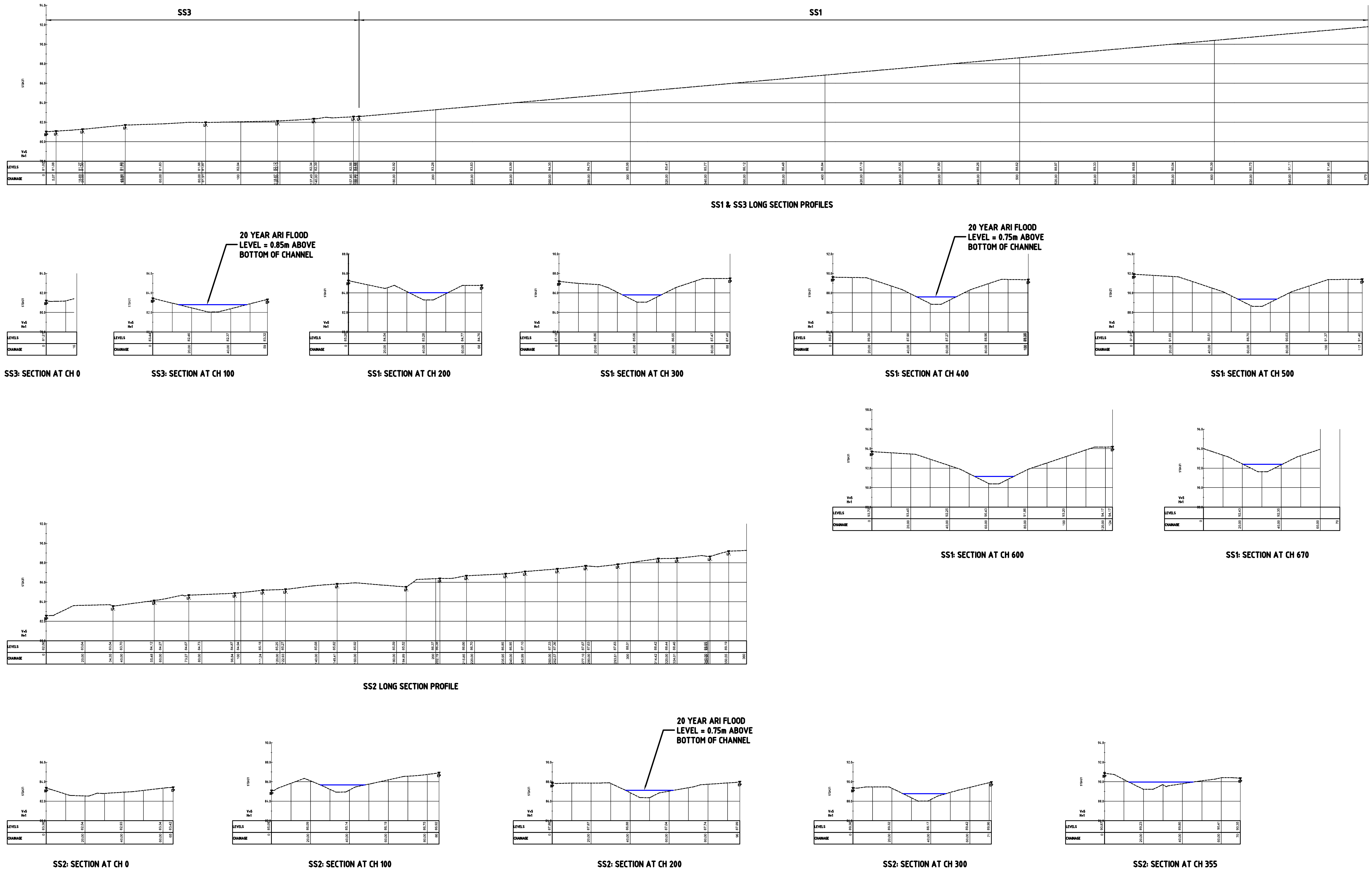
CAD File Number: Figure 3.2

Job Number: 42906853

Drawing Number: **Figure 3.2**

Rev: **B**

A1 THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET INCLUDING THE SPECIFICATIONS.



ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

URS Australia Pty Ltd.
Level 3
20 Terrace Road
East Perth, WA 6004
Tel. 08 9326 0100
Fax.08 9326 0296

Rev	By	Appd	Date	REVISION RECORD

Designed	B E / F vd L
Drawn	F vd L
Checked	B E
Approved	B W
Scales	1 : 1 500

Client: ILUKA RESOURCES LTD

Project Title: VALIDATION OF STREAM DIVERSION DESIGN ILUKA GINGIN DEPOSIT

Drawing Title: SS1, SS2 & SS3: LONG SECTION PROFILES & CROSS SECTIONS

Status: FINAL

Datum:

Date: 30/05/2008

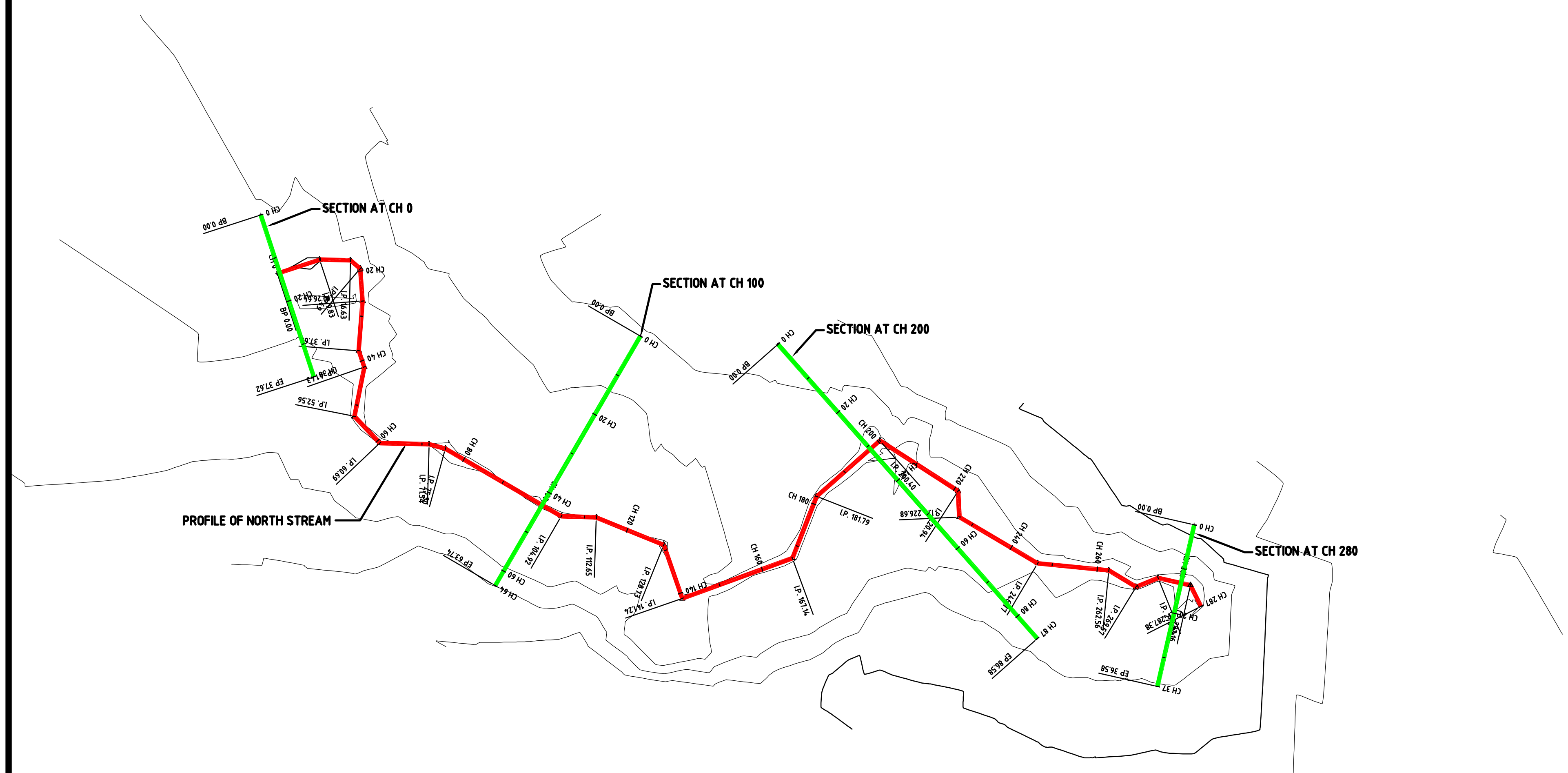
CAD File Number: Figure 3.3

Job Number: 42906853

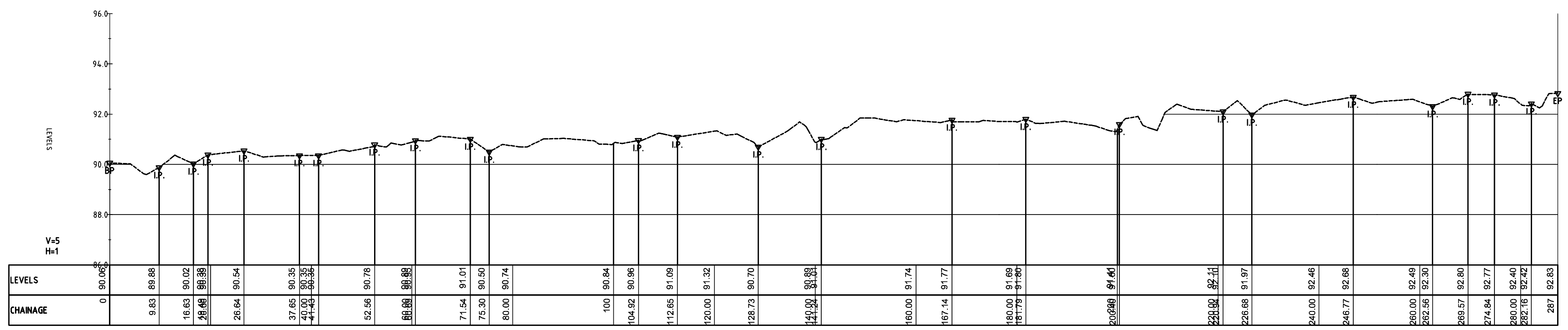
Drawing Number: **Figure 3.3**

Rev: **A**

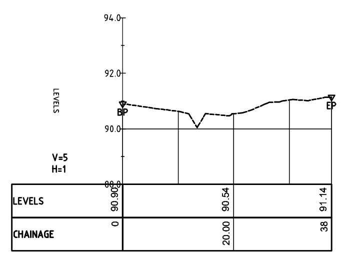
A1 THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET INCLUDING THE SPECIFICATIONS.



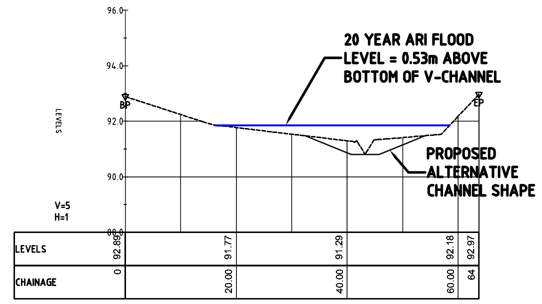
GENERAL LAYOUT



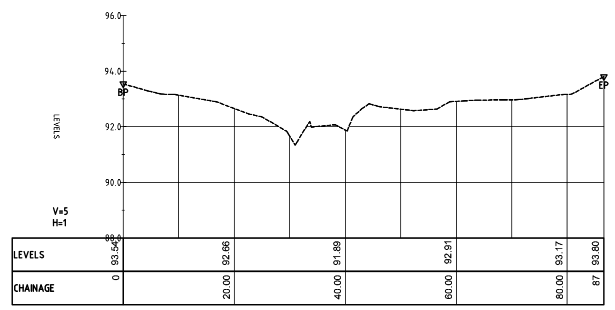
LONG SECTION PROFILE OF NORTH STREAM



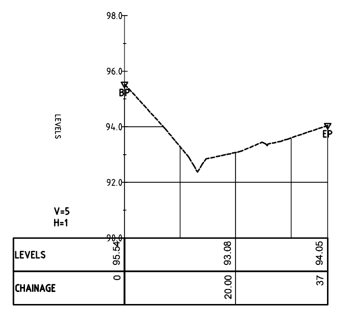
SECTION AT CH 0



SECTION AT CH 100



SECTION AT CH 200



SECTION AT CH 280

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Level 3
20 Terrace Road
East Perth, WA 6004
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Designed	B E / F vd L
Drawn	F vd L
Checked	B E
Approved	B W
Scales	1 : 1 500

Client: ILUKA RESOURCES LTD

Project Title: VALIDATION OF STREAM DIVERSION DESIGN ILUKA GINGIN DEPOSIT

Drawing Title: GENERAL LAYOUT OF NORTH STREAM, LONG SECTION PROFILES & CROSS SECTIONS

Status: FINAL

Datum:

Date: 30/05/2008

CAD File Number: Figure 3.4

Job Number: 42906853

Drawing Number: Figure 3.4

Rev: A