CONSULTING ENGINEERS

PROPOSED DIEPSLOOT UPGRADE OF NGONYAMA ROAD

Flood Hydrology Report

PREPARED FOR:

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TITLE	**PROPOSED DIEPSLOOT UPGRADE NGONYAMA ROAD FLOOD HYDROLOGY REPORT**
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DATE	November 2012
REFERENCE NUMBER	6496/HLA
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Rev No	Date	Created/ Revised by	Approved by	Remarks

TABLE OF CONTENTS

Table of Figures

Table of Tables

Appendixes

FLOOD HYDRAULIC REPORT

1. BACKGROUND

1.1. BACKGROUND AND TERMS OF REFERENCE

Hlanganani Consulting Engineers & Project Managers appointed ARQ Consulting Engineers to design a bridge. The bridge is part of the Diepsloot upgrade of Ngonyama road and spans over the stream running through Diepsloot.

ARQ performed a Flood Hydraulic study in order to be able to make an informed decision on the size of the bridge. The stream is well populated on its banks by informal houses and is therefore sensitive regarding the flood levels of the stream. Any additional backwater caused by the bridge could lead to potential flooding of the informal houses and leave these people homeless.

This report serves to provide more detail on the optimal sizing of the bridge to cause the smallest backwater effect.

1.2. THE SITE

The Ngonyama road upgrade is situated in the South-Western part of Diepsloot. Figure 1 indicates the locations of the bridge.

Figure 1: Site location of bridge

2. FLOOD HYDROLOGY

In February 2009 F&B Consulting Agricultural & Civil Engineering Services prepared a flood level analysis report (Ref No FB0221/HLA) for Hlanganani of the stream passing through Diepsloot. The flow values obtained by F&B Consulting were adopted by ARQ during the calculation of backwater. The flows and other critical parameters are indicated in **Table 1** below.

Table 1: Catchment parameters and flows.

CATCHMENT CHARACTERISTICS			
Size of catchment:		9.21	km^2
Longest water course length:		5.142	km
Length to catchment centroid along longest river course:		2.024	km
Average river course slope:	Equal area =	0.022	m/m
	1085 =	0.0253	m/m
Mean Annual Rainfall:		551	mm/year
FLOW'S AT BRIDGE SITE			
1 in 50 years		108	m^3/s
1 in 100 years		168	m^3/s

3. FLOOD LEVELS

3.1. SITE INVESTIGATION

On 31 October 2012 two members of the ARQ bridge office went to do a site inspection. The site inspection was mainly to determine the Manning n values for the stream. Only the section of the stream between the proposed bridge site and the footbridge upstream were inspected. On this section a waste dump was encountered and also a leaking sewer pipe that disperse raw sewer water straight into the stream. The lower part of the stream is a wetland with thick reeds and an undefined water course. It was observed that the locals cross the river close to the proposed bridge site. This river crossing comprise out of stepping stones to get the people from one side to the other side. A photo of this crossing is included in **Appendix A**.

3.2. SURVEY DATA

A survey was done for the stream from where it enters Diepsloot up to the proposed bridge site. A DTM (Digital Terrain Model) was created from this survey. Cross sections through the stream, at intervals between 25m and 35m, were extracted from the DTM for use in the river profile analyses.

3.3. ROUGHNESS PARAMETERS

In some places, the stream is an incised stream and in others it is a flattish wetland. The stream was modelled 800m upstream and 120m downstream. The stream was divided into three sections: Upper, Middle and Lower. The Upper section is from chainage 0m-

475m the Middle section is from 475m-617m and the Lower section from 617m-920m. As per Chow, 1959, a representative Manning's roughness value of n=0.035 was allowed for the incised stream course of the Upper section and n=0.04 for the overbanks. No bank flow for the Middle and Lower sections were anticipated because of the wetland located in these sections. The representative Manning roughness value of n=0.055 were assumed for the middle section and 0.11 for the lower section.

The lower section had a high Manning n value because of the thick and high reeds located on this section. Reeds up to 4m high were observed in the lower section. In **Appendix A** Photos of each section is included.

The hydraulic effects of the tributary joining the stream from the East just before the bridge site were not taken in to account in this study. This tributary is a small stream and the effects that it will have on the backwater of the bridge is negligibly small.

3.4. FLOODLEVELS

The United States Army Corps of Engineers River Analysis software HEC-RAS was employed in the determination of flood levels. This software program utilises the gradients between discrete cross-sections across the river course to establish the water level in the stream.

Flood levels without the bridge were determined utilising 33 cross sections of the stream. The flood levels were found to be lower than that stated in report No FB0221/HLA prepared by F&B Consulting. On average it is about ±0.5m lower. More in detail cross section in smaller intervals lead to less interpolation of the cross sections. This was the main reason for this lower flood level analysis.

According to *SANRAL Drainage Manual 5th Edition,* the NGONYAMA Road will be a class 2 road and need to clear the 1:50 year flood level with a minimum freeboard of 0.3m. A bridge were placed on the centre line of the road at the appropriate level to clear the 1:50 year flood level with at least 0.3m. The critical cross sections were investigated to determine the backwater. Cross section -29.1 is 5m upstream of the proposed bridge site. Section -28 is 36m upstream from the bridge and -27 is 68m upstream. These sections are included in **Appendix B**. **Table 2-4** indicate the levels at critical cross sections.

Table 2: Flood levels for cross section -27

CROSS SECTION -27 WITHOUT BRIDGE				
Recurrence Interval	**Flow(m^3/s)**	**Energy level (El)(m)**	**Velocity (m/s)**	**Flow depth (m)**
1:50 yrs.	108	1373.47	3.13	2.55
1:100 yrs.	168	1373.8	3.27	2.88
CROSS SECTION -27 WITH BRIDGE				
Recurrence Interval	**Flow(m^3/s)**	**Energy level (El)(m)**	**Velocity (m/s)**	**Flow depth (m)**
1:50 yrs.	108	1373.47	3.13	2.55
1:100 yrs.	168	1373.8	3.27	2.88

Table 3: Flood levels for cross section -28

CROSS SECTION -28 WITHOUT BRIDGE				
Recurrence Interval	Flow(m^3/s)	Energy level (El)(m)	Velocity (m/s)	Flow depth (m)
1:50 yrs.	108	1372.73	1.05	2.07
1:100 yrs.	168	1373.17	1.18	2.51
CROSS SECTION -28 WITH BRIDGE				
Recurrence Interval	Flow(m^3/s)	Energy level (El)(m)	Velocity (m/s)	Flow depth (m)
1:50 yrs.	108	1372.94	0.87	2.28
1:100 yrs.	168	1373.41	1	2.75

Table 4: Flood levels for cross section -29.1

CROSS SECTION -29.1 WITHOUT BRIDGE				
Recurrence Interval	Flow(m^3/s)	Energy level (El)(m)	Velocity (m/s)	Flow depth (m)
1:50 yrs.	108	1372.63	1.07	2.13
1:100 yrs.	168	1373.06	1.26	2.56
CROSS SECTION -29.1 WITH BRIDGE				
Recurrence Interval	Flow(m^3/s)	Energy level (El)(m)	Velocity (m/s)	Flow depth (m)
1:50 yrs.	108	1372.87	1	2.37
1:100 yrs.	168	1373.33	1.26	2.83

4. CONCLUSION AND RECOMMENDATIONS

4.1. BRIDGE DIMENSIONS

Taking into account the flood level analysis it was decided to go for a 3 span bridge spanning 60m in total. Two end spans of 17m and one main span of 26 m were adopted based on structural considerations. The approximate depth of the bridge deck from top of asphalt to the beam soffits is 1.61m.

4.2. FREEBOARD

It was calculated that there is more than the required minimum of 0.3m freeboard available. The given road geometry was used as base line for the top of asphalt. The minimum freeboard for the bridge is 1.13m.

4.3. BACKWATER

The bridge cause 0.24m of backwater at cross section -29.1 (5m upstream) and 0.21m at cross section -28 (36m upstream). No backwater affects were noted at section -27 (68m upstream). This study proves that a bridge in this specific location with the dimensions specified above will have a small influence on the flood levels of the stream.

4.4. BRIDGE PROTECTION WORKS

Although the hydraulic effect of the tributary joining the stream from the East just before the bridge is neglactably small, protection works is required on the side of the approach road embankment to prevent scouring. Scouring could be prevented in two ways. One is to construct a channel upstream as far as necessary to keep the water away from the road approach embankment. The second is to use embankment protection to prevent scouring.

5. REFERENCES

Chow VT. 1959 Open Channel Hydraulics. International Student Edition. McGraw-Hill. Tokyo.

F&B Consulting, February 2009. *Determination of the 1:50 & 1:100 years Floodlines at Diepsloot Development (Watercourse pre-clearing stage)*. F&B Consulting. Summary Report No. FB0221/HLA/01.

SANRAL. (2006). Drainage Manual. 5th revised edition, The South African National Road Agency Limited, Pretoria.

APPENDIX A
SITE PHOTOS

Photo 1: People crossing the stream

Photo 2: People crossing the stream

Photo 3: Stepping stone crossing

Photo 4: Vegetation for Upper section of stream

Photo 5: Vegetation for Upper section of stream

Photo 6: Vegetation for Middle section of stream

Photo 7: Vegetation for Lower section of stream

Photo 8: Vegetation for Lower section of stream

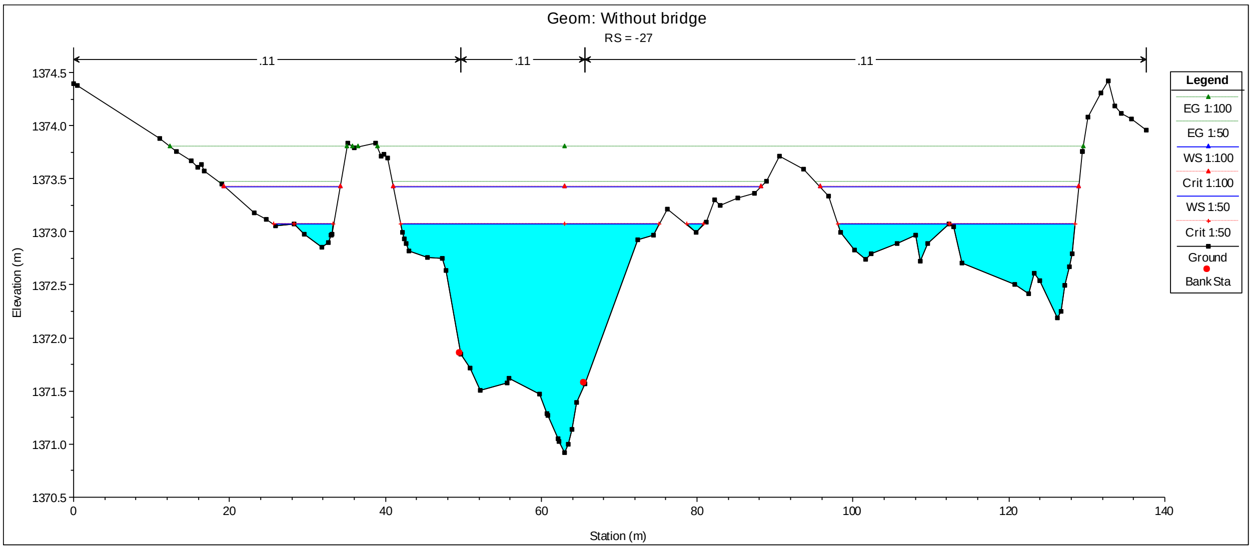
Photo 9: Dump site located next to river

Photo 10: Sewer leaking into the stream

Photo 11: Tributary joining from the East just before the bridge

Photo 12: Footbridge Upstream

APPENDIX B
STREAM CROSS SECTIONS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Station (m)
Legend
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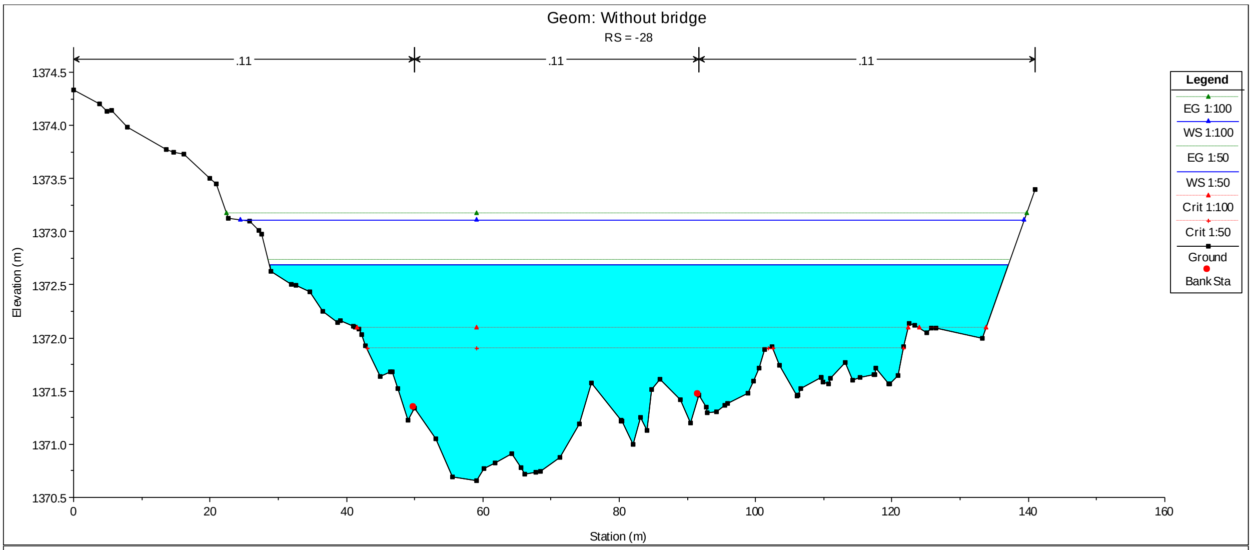
WS 1:100
Crit 1:100
WS 1:50
Crit 1:50
Ground
Bank Sta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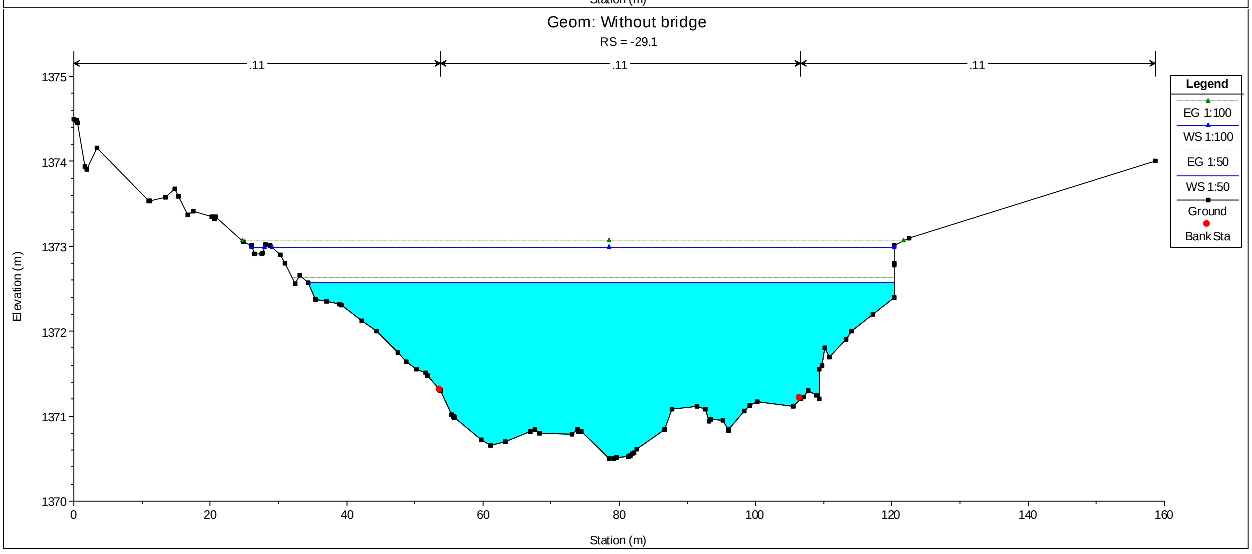
Crit 1:50
Ground
Bank Sta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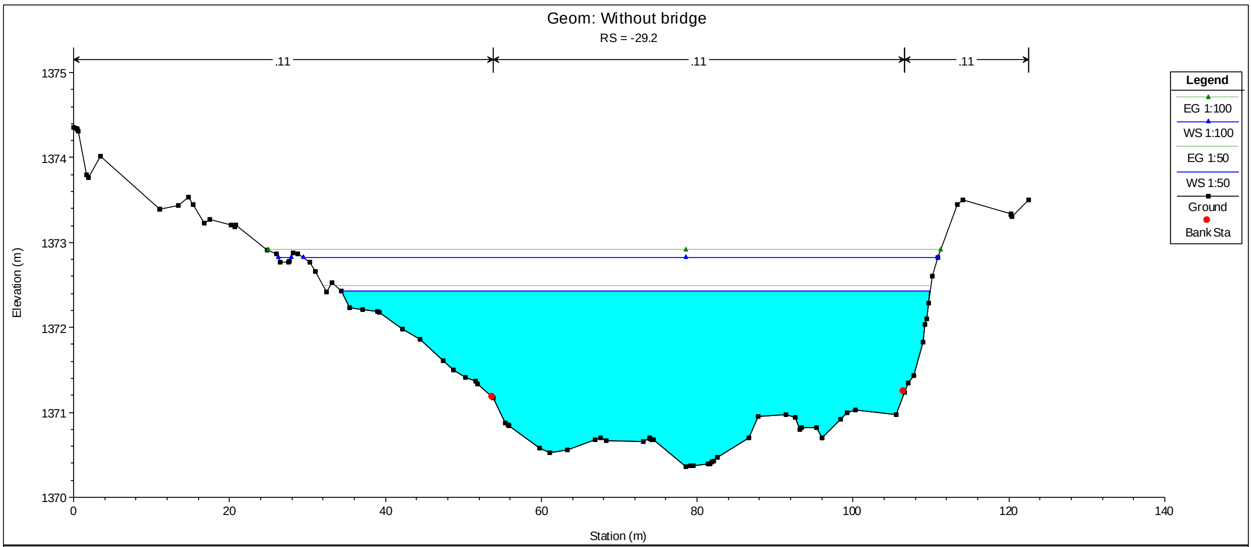
EG 1:50
WS 1:50
Ground
Bank Sta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Station (m)
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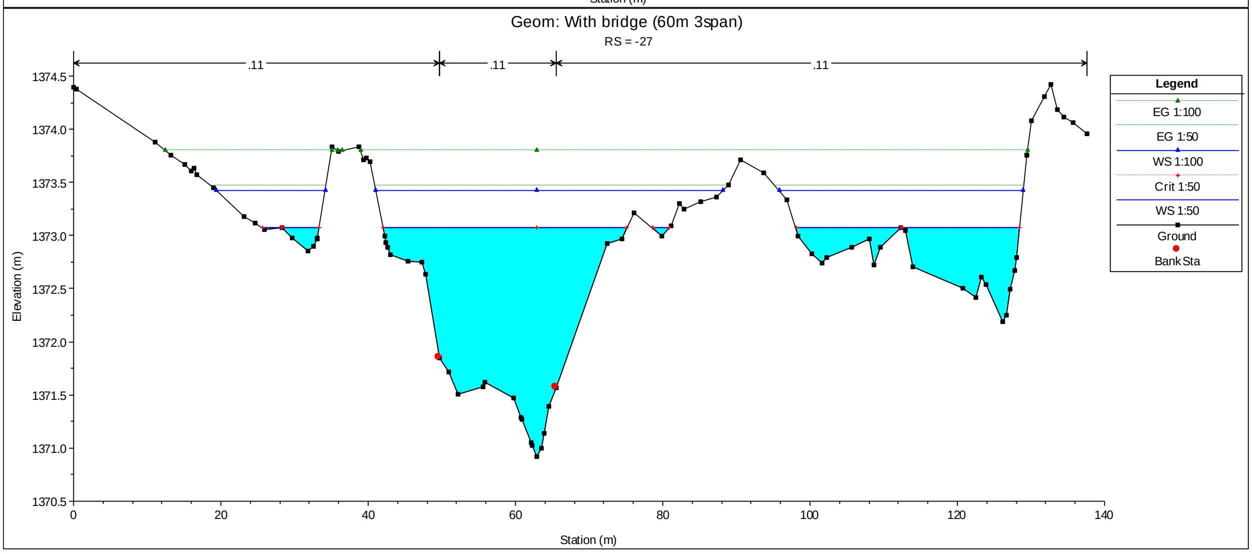
WS 1:50
Ground
Bank Sta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.11
.11
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Station (m)
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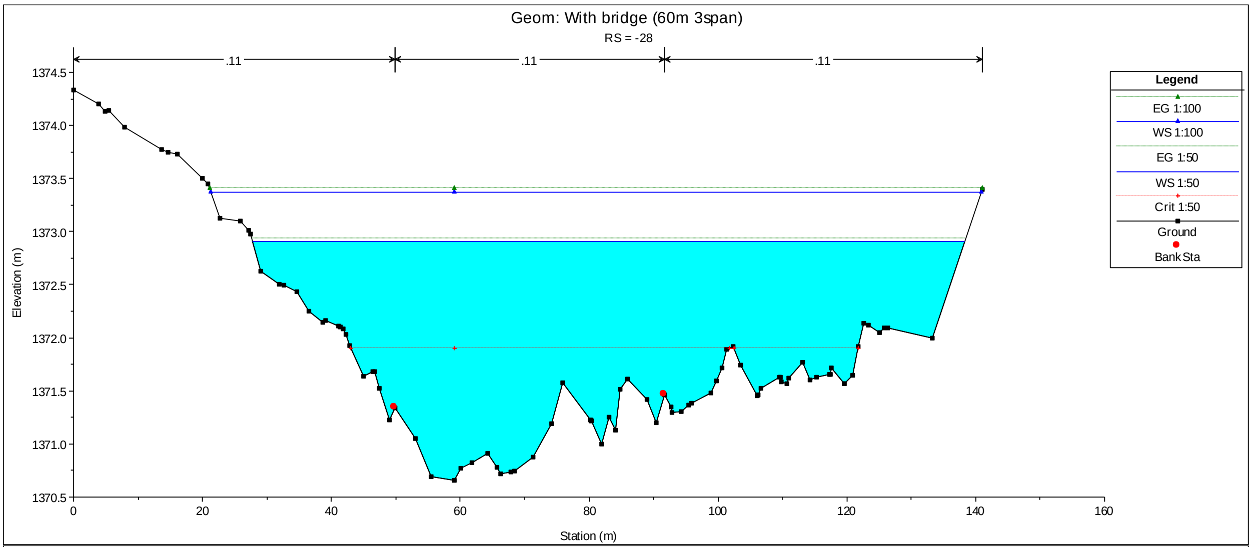
WS 1:100
Crit 1:50
WS 1:50
Ground
Bank Sta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WS 1:50
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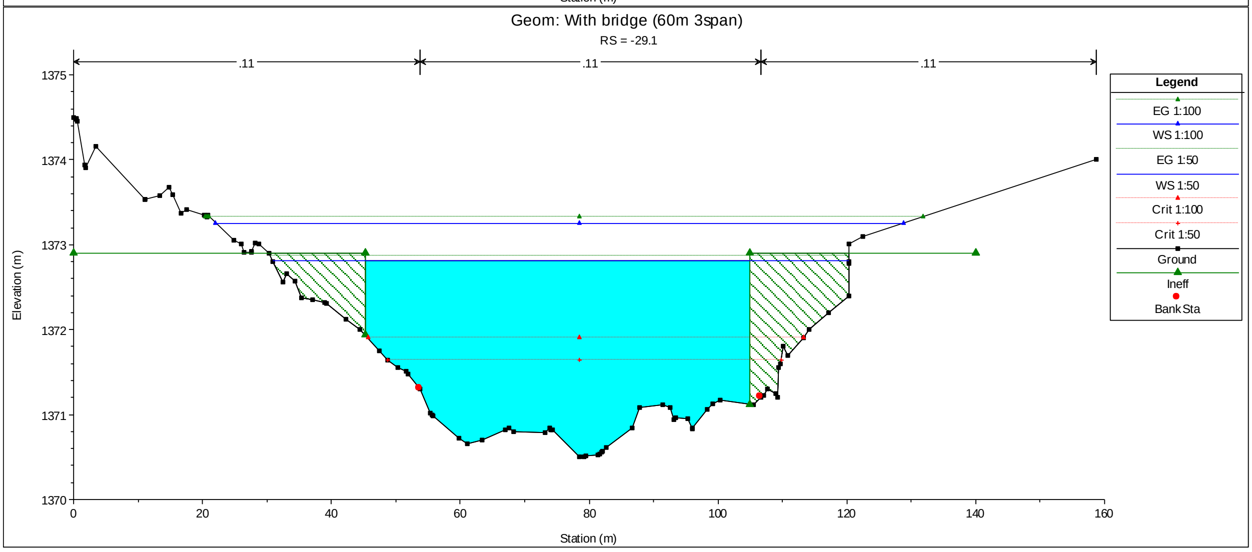
Ground
Bank Sta
Elevation (m)
Station (m)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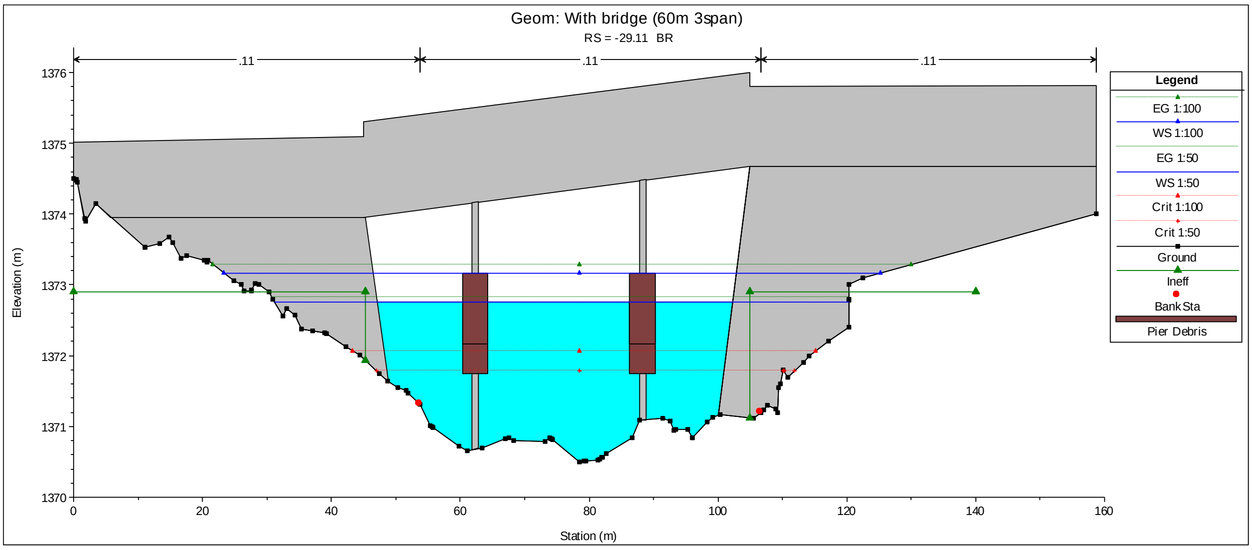
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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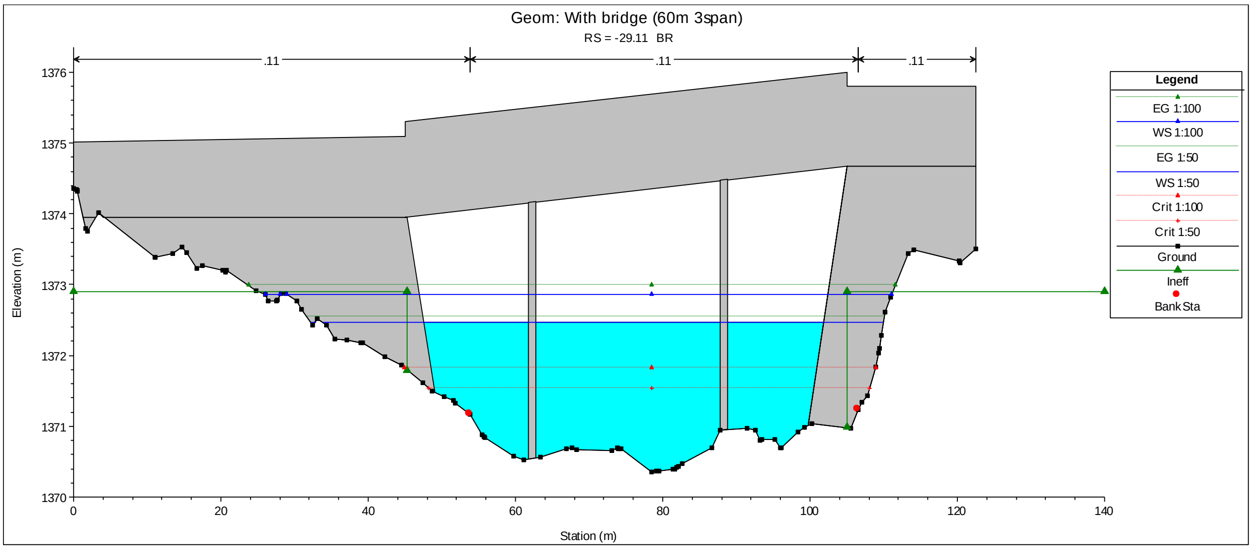
Ineff
Bank Sta
Pier Debris
Elevation (m)
Station (m)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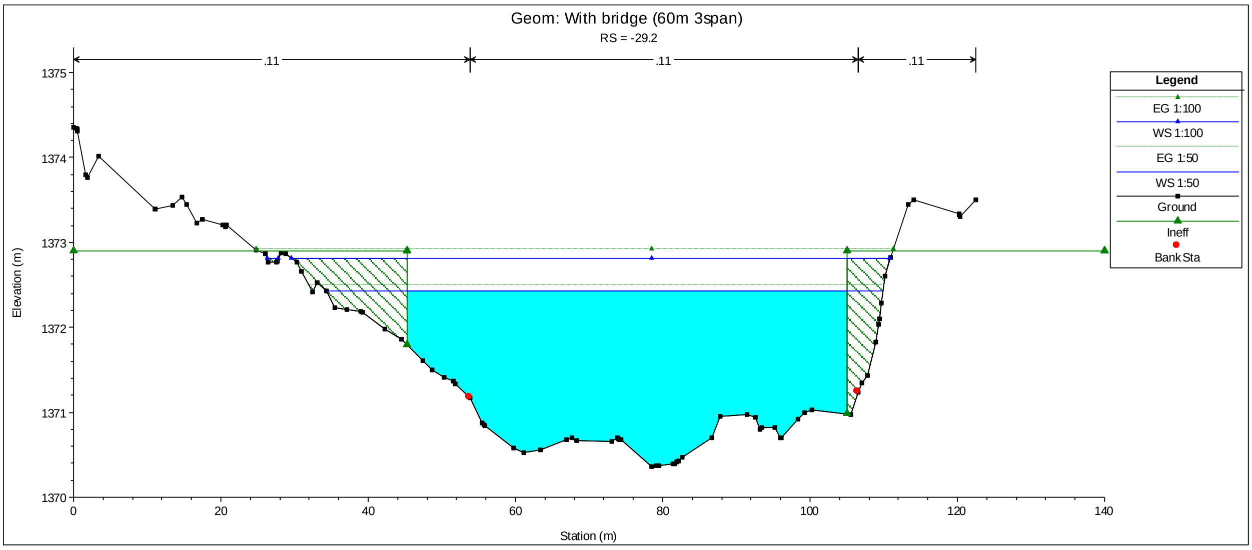
Crit 1:50
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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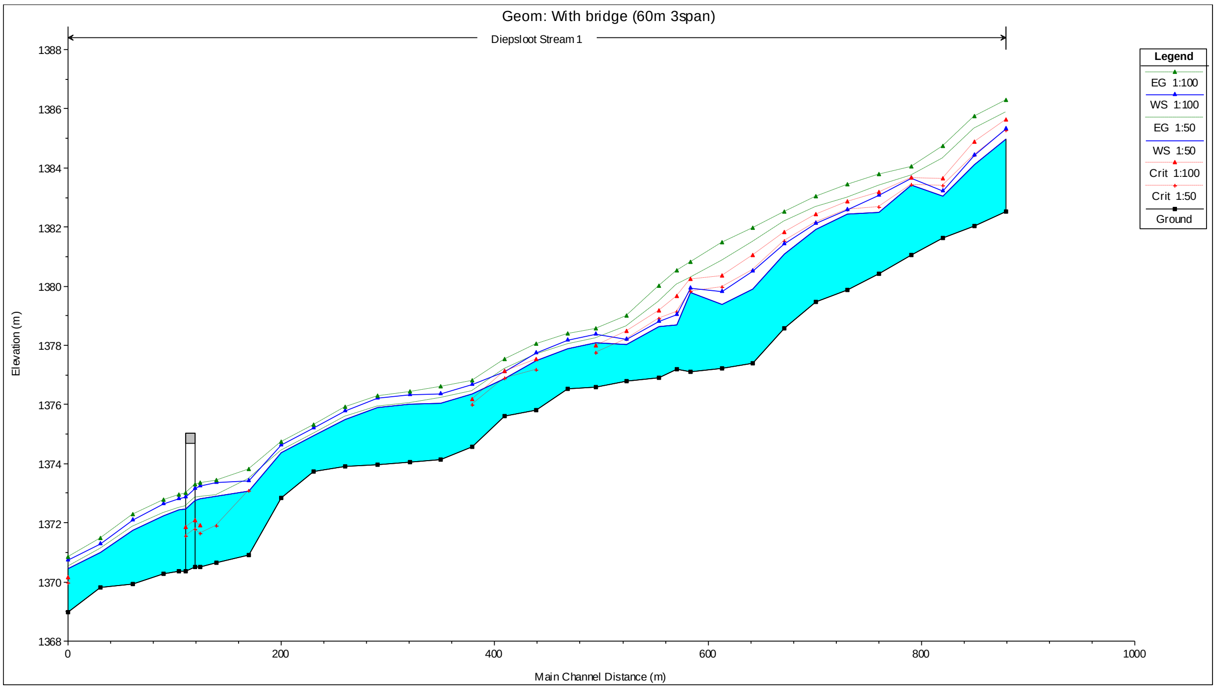
EG 1:50
WS 1:50
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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Diepsloot Stream 1
Legend
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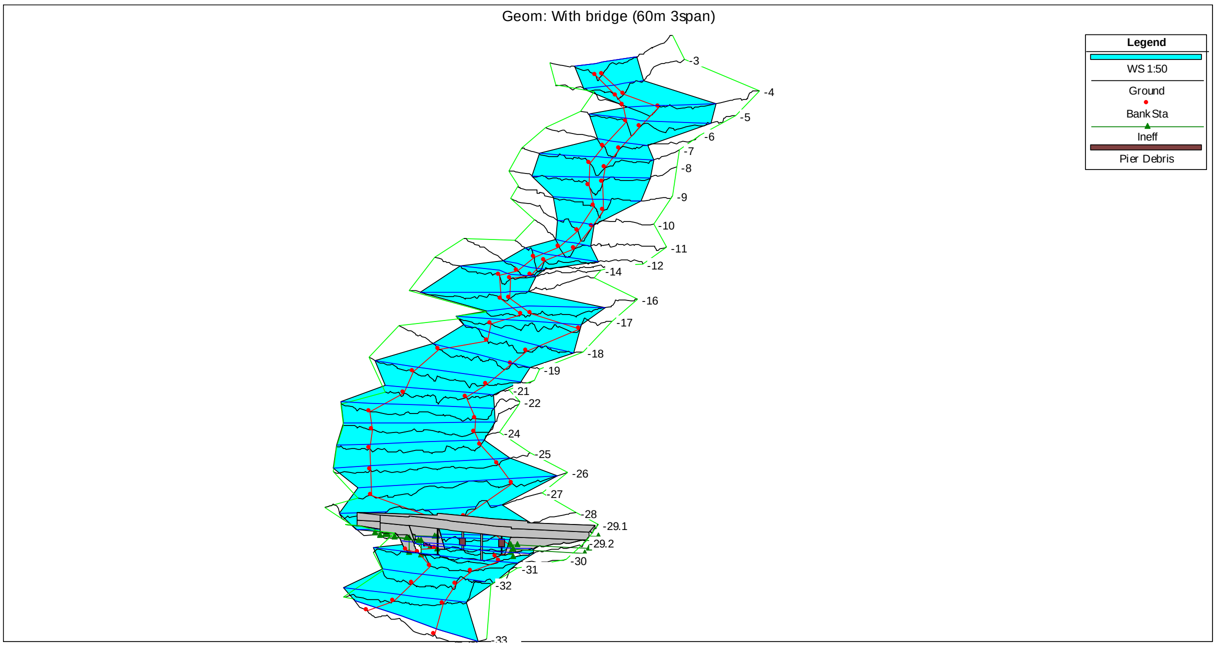
EG 1:50
WS 1:50
Crit 1:100
Crit 1:50
Ground
Elevation (m)
Main Channel Distance (m)


Geom: With bridge (60m 3span)
Legend
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Ground
Bank Sta
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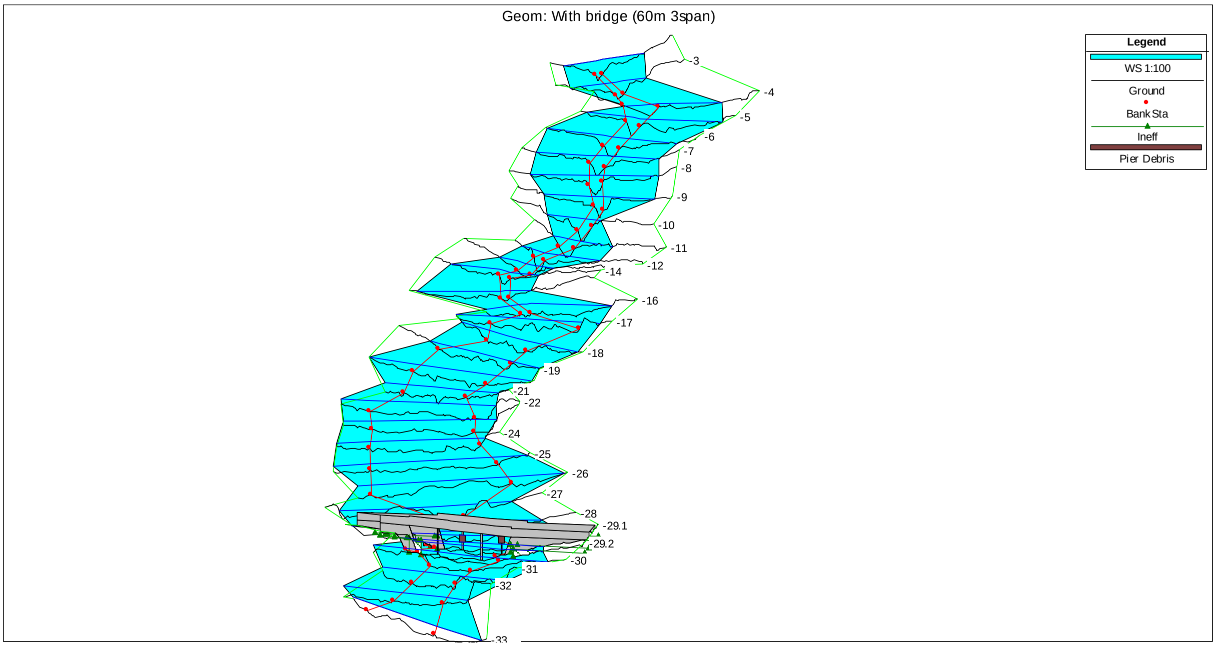
Geom: With bridge (60m 3span)
Legend
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Ground
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BRIDGES

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