Appendix G

Flood Study

ANALYSIS ON THE IMPACT OF FLOODING IN COCKLE CREEK FOR PROPOSED

CONSTRUCTION WASTE RECYCLING FACILITY

The Weir Road, Teralba

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Cover Photo: Piers of disused Rail Bridge, Cockle Creek, NSW

1. INTRODUCTION

This flooding assessment has been prepared by Lake Macquarie City Council (LMCC) and relates to a proposed recycling facility to be located on a 7-hectare site off The Weir Road, Teralba, (Figure 1).

The proposed recycling facility will be a crushing grinding and separating operation for hard waste/ construction and demolition materials including concrete, bricks, asphalt, soils, green waste and tiles. The operation will process up to 200,000 tonnes of material per annum.

CiviLake, a business unit of Lake Macquarie City Council, will operate the facility on behalf of the Council. CiviLake carry out road maintenance and construction, building and demolition and parks and gardens maintenance.

In order to protect the facility from flooding inundation it is proposed to fill the site and provide a flood protection embankment around the site. These works have the potential to then effect flooding levels in the vicinity. This report analyses and discusses any changes to flood levels that may result if the recycling facility is constructed.

2. BACKGROUND

a. LOCATION

The proposed development site is within the floodplain of Cockle Creek. Cockle Creek is a waterway that discharges in to Lake Macquarie at its north western extent. The catchment for Cockle Creek is approximately 106 square kilometres and includes urban development to the north and east (Suburbs include Edgeworth, Cameron Park, Glendale, Cardiff & Charlestown among others) and vast undeveloped areas to the west (Barnsley, West Wallsend, Wakefield, Killingworth).

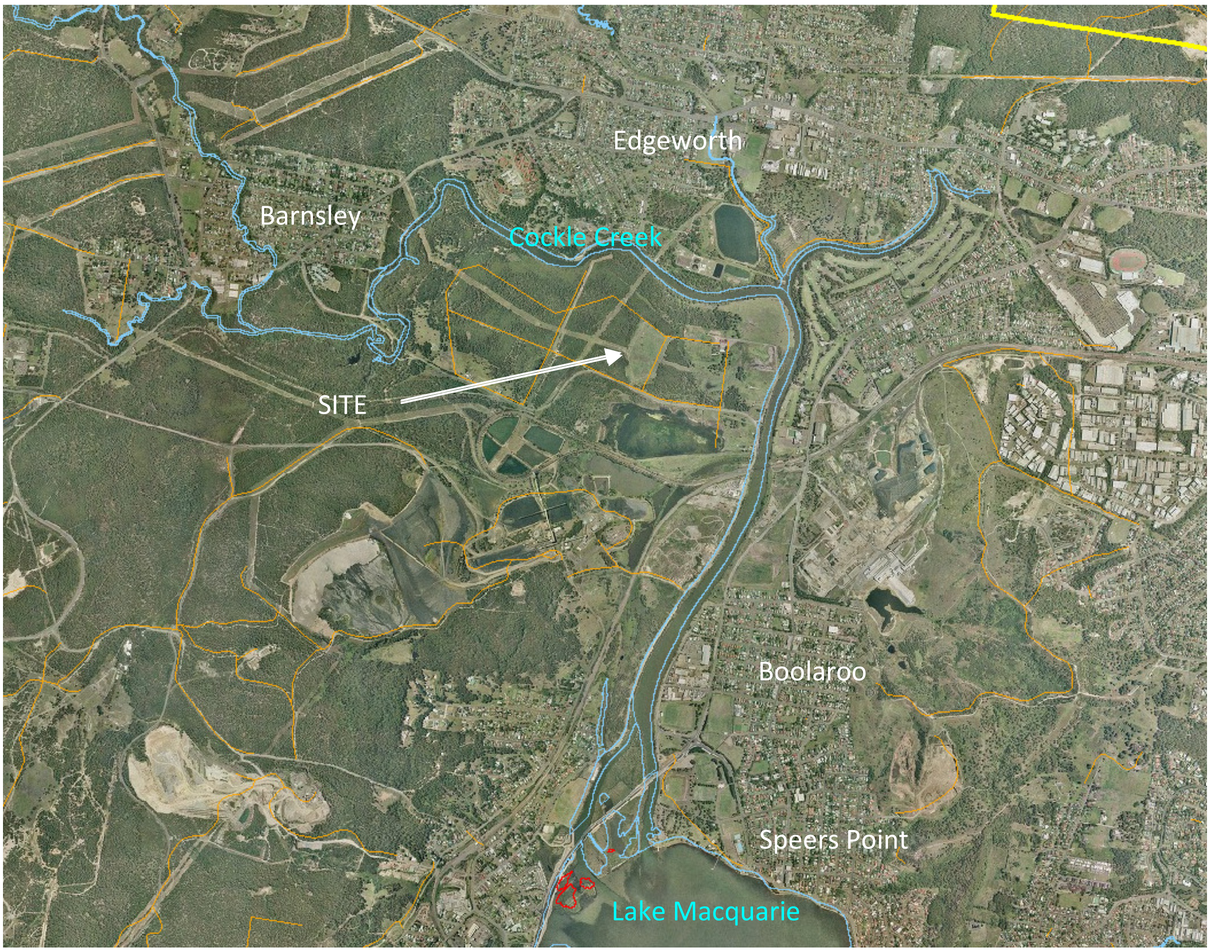


Figure 1 – Location Aerial Photo

b. PREVIOUS REPORTS / STUDIES ON COCKLE CREEK

Two major studies on the flooding within the Cockle Creek catchment have been undertaken. Both of these studies were undertaken by the Public Works Department NSW. The first study was undertaken in 1986 and titled "COCKLE CREEK FLOOD STUDY". The flood study was carried out for LMCC to assess the nature and extent of the flood hazard within the catchments of Cockle Creek, Cocked Hat Creek, Brush Creek and Winding Creek. A catchment area of approximately 106 square kilometres.

The second study was also carried out by the Public Works Department NSW in 1993 as the next stage of assessment. This study was called the "COCKLE CREEK FLOODPLAIN MANAGEMENT STUDY". The intention of this study was to build on the assessment of the flooding that was derived in the 1986 study and to investigate various mitigation options to reduce flood hazard and damage.

Both of the studies indicated that the site of the proposed development was within the floodplain / storage of Cockle Creek.

3. SITE DESCRIPTION

The development proposed is located on The Weir Road, Teralba (Lot 42/43 & 53/54 DP 16062, H/No. 80 The Weir Road, Teralba). The site has dimensions of approximately 200m x 350m (7ha) and is generally at a level of RL 2 – 3 m (AHD). A portion of the site in the South Eastern corner is lower at approximately RL 0.5m (AHD).

Appendix A includes survey of the existing site levels.

The site appears to be been slightly filled in the past and is generally level and only vegetated with grass. The site is currently used for grazing. Photo 1 below shows the site as viewed from the street frontage on The Weir Road. The tree line in the distance indicates the northern extremity of the site.

Photo 1 Site as Viewed from Street Frontage (The Weir Road)

4. PROPOSED DEVELOPMENT

The development proposed is a materials recycling facility for construction type materials such as concrete, road base, gravel etc. The intention is to process these waste materials into products that can be reused in road and other similar construction.

To ensure that the operation can maximise its operations, the intention is to import fill to construct mounds around the perimeter of the site. The bunding serves the dual purpose of keeping the site flood free and to allow containment, treatment and reuse of stormwater that directly falls on the site.

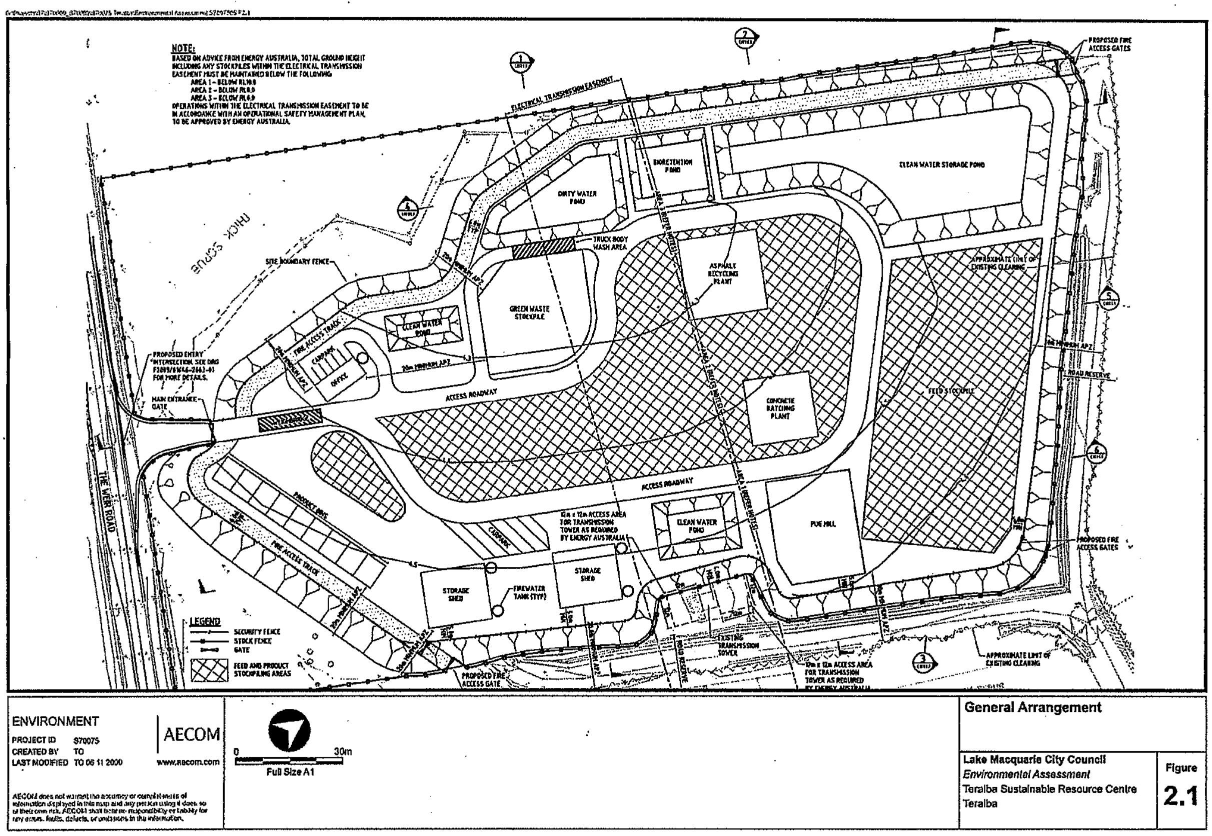


Figure 2 – Plan Schematic of Proposed Recycling Facility

5. APPROACH ADOPTED

a. EXPLANATION OF SURVEY

The likely extent of survey was derived using existing topographic survey maps with 2 metre contour intervals.

Field survey of the reach of Cockle Creek, adjacent to the site, was taken to establish the cross sectional information of the base and sides of the creek proper. This gave nine cross sections of the creek channel over a length of the stream of approximately 1.5km.

To gain survey of the floodplain, on either side of the creek, for each creek channel section, existing survey was used. This survey was obtained using aerial laser survey data (LiDAR) supplied to LMCC by the NSW Department of Planning.

What is lidar?

Light detection and ranging (lidar) is a technology that uses laser pulses to generate large amounts of data about the physical layout of terrain and landscape features.

The data can be analysed and used in diverse applications such as:

- *mapping areas for building and structures in the construction industry*
- *generation of digital terrain maps for use in geographic information systems*
- *generation of digital vegetation maps for use in the forestry and land management industries.*

How does it work?

All varieties of lidar operate using the same basic principle.

The lidar instrument fires rapid pulses of light (laser pulses) at the landscape and a sensor mounted on the instrument measures the amount of time taken for each light pulse to bounce back.

Because light moves at a constant and known speed, the lidar instrument can then calculate the distance between itself and the target with high accuracy.

By rapidly repeating the process, the lidar instrument builds up a complex 'picture' of the terrain it is measuring. (Source CSIRO)

This LiDAR survey data of the floodplain was added to the creek channel survey to form complete cross sections for use in the flood modelling. These cross sections are provided in Appendix B at the end of this report.

6. HYDRAULIC MODELLING

a. DISCUSSION ON ADOPTED MODEL HEC-RAS

The HEC-RAS River Analysis System (Version 4 - 2008) model was developed by the U.S. Army Corps of Engineers. The software performs one-dimensional steady and unsteady flow river hydraulic calculations. Full details of the software capabilities are available via the internet at www.hec.usace.army.mil/. This software is freely available, is widely used and industry accepted by the engineering profession in Australia.

b. SURVEY DATA

As discussed previously cross section data was obtained from two sources of survey. The locations of the cross sections were chosen at strategic locations . Some cross section locations were chosen to corresponded with those adopted in the previous flood studies. Others were chosen due to their relative proximity to the development site. For instance, at the upstream and downstream boundary of the site.

Survey Data with creek and floodplain profiles are contained within Appendix B.

c. FLOW DATA

Flow information for 100yr and 20yr ARI storm events was adopted from the 1986 "COCKLE CREEK FLOOD STUDY".

Adopted flows are as follows:-

100 year ARI event – 416 cubic metres / sec
20 year ARI event – 291 cubic metres / sec

d. MANNING ROUGHNESS

The Manning roughness (*n*) factors that were used in the HEC-RAS model were similar to those used in the previous studies. To confirm the values used the creek system and floodplains were inspected by small boat and site visit. Photo 2 shows the typical grassed floodplain that exists for the majority of the southern side of Cockle Creek in the vicinity of the development site. Photo 3 shows the densely vegetated stream banks on the northern side of Cockle Creek and on the southern side of the creek, upstream of the development site.

Adopted Manning *n* values are as follows:-

Manning *n* of Channel – 0.05
Manning *n* of overbank areas – 0.1

Photo 2 Typical Grassed Flood Plain

Photo 3 Densely Vegetated Streambank

e. ADOPTED WATER SURFACE LEVELS

The HEC-RAS software allows the user to include a known water level at the downstream end of the section of stream being analysed. In this instance the known flood level from previous studies at the confluence of the three major streams (Cockle Creek, Cocked Hat Creek & Brush Creek) was adopted . The level at this point was extracted from the 1993 Cockle Creek Floodplain Management Study.

Tail Water Levels adopted were as follows:-

100 year ARI Event – RL 2.66m (AHD)
20 year ARI Event – RL 2.38m (AHD)

7. FLOOD MODELLING RESULTS

a. EVALUATION OF EXISTING FLOOD REGIME

The majority of the proposed development site is inundated by flooding in the 100yr ARI event. The 100yr flood level at the site is approximately 2.7m AHD. Backwater effects from, the confluence of Cockle Creek, Cocked Hat Creek and Brush Creek are the governing factor contributing to flooding at the development site and downstream to the confluence.

The effect of climate change has been considered in Section 8, and it has been found that the 100yr ARI flood level may rise to approximately RL 2.9m AHD. This equates to an increase of 0.2m and has no impact on the proposed development, as filling is proposed well above this level.

Refer to the Tables below for flood level results and Appendix B for cross section locations.

b. EVALUATION OF IMPACT OF DEVELOPMENT ON FLOOD REGIME AND ADJACENT PROPERTIES

It has been found that the proposed development has negligible impact on the flooding regime of Cockle Creek and as a result does not adversely effect adjacent properties. An increase in flood level of 0.01m occurs at the upstream boundary of the site, but quickly transitions back to predevelopment levels within 20 metres upstream of the site. The flood levels of the creek further upstream and downstream of this point are unaffected by the proposed development. Refer to the Tables below for details.

In regards to loss of storage volume as a result of the proposed filling, it has been calculated that a maximum 0.01m increase in flood level may result in the immediate flood plain. This increase is deemed insignificant in this location, given the area of flooding will hardly increase as flood waters are vast and are bounded by road embankments. Refer to Section 9 in the below Tables for details.

NOTE: See Appendix B for Cross Section locations.

20 Year Flood Levels Comparison			
Profile / Section No.	Pre – Development m (AHD)	Post – Development m (AHD)	% Change
1	2.87	2.87	No Change
2	2.55	2.55	No Change
3	Not Used	Not Used	-
4	2.44	2.44	No Change
5	2.43	2.43	No Change
6	2.41	2.41	No Change
7	2.41	2.41	No Change
8	2.41	2.41	No Change
9	2.40	2.40	No Change
10	2.38	2.38	No Change

100 Year Flood Levels Comparison			
Profile / Section No.	Pre – Development m (AHD)	Post – Development m (AHD)	% Change
1	3.28	3.28	No Change
2	2.86	2.86	No Change
3	Not Used	Not Used	-
4	2.73	2.73	No Change
5	2.72	**2.73**	**0.4% increase**
6	2.70	2.70	No Change
7	2.69	2.69	No Change
8	2.69	2.69	No Change
9	2.68	2.68	No Change
10	2.66	2.66	No Change

8. SENSITIVITY & IMPACT OF CLIMATE CHANGE ANALYSIS RESULTS

a. SEA LEVEL RISE

The document "Lake Macquarie Sea Level Rise Preparedness Adaption Policy" adopts a recommended maximum 100 year ARI event level for Lake Macquarie, for the year 2100 AD, of RL 2.35m (AHD). This would only have an impact, on the modelling undertaken with this report, if the level was higher than the downstream water level adopted. The level adopted was RL 2.66m (AHD) therefore a rise in lake level would not change the results of the modelling. However a higher tail water level of RL 2.85m (AHD) was adopted in the Sensitivity Analysis, which represents 100 year ARI lake level in the year 2100 AD plus 500mm freeboard.
It was found that the adopted increased flow and tailwater level had minimal effect on the flooding regime. The flood level at the site increased 0.2 m from RL2.7m AHD to RL2.9m AHD. Similarly to previous results an increase of 0.01m occurred in the post development scenario at the upstream boundary of the site and transitioned back to zero by profile 6 (20m upstream of the site). This rise is deemed negligible. Refer to the table below for detailed results.

b. INCREASE IN RAINFALL INTENSITY

Lake Macquarie City Council's policy discusses possible increases in the intensity of rainfall and storm events of the order of 30%. This figure was from taken from DECC *Practical Consideration of Climate Change (2007).*
A 30% increase in rainfall intensity does not necessarily mean that there will be a corresponding 30% increase in stormwater flows. Losses such as infiltration, catchment storages etc would typically mean that the increase in flows would be less. In this analysis, to be conservative, a direct 30% increase in creek flows has been adopted.

As such the 100 year creek flow used to test the impact of a increase in rainfall intensity was 1.3 x 416 = 541 cubic metres / sec.

100 Year Flood Levels Comparison

(with increased rainfall and tail water level due to Climate Change)			
Profile / Section No.	Pre – Development m (AHD)	Post – Development m (AHD)	% Change
1	3.61	3.61	No Change
2	3.08	3.08	No Change
3	Not Used	Not Used	-
4	2.94	2.94	No Change
5	2.93	**2.94**	**0.34% increase**
6	2.90	2.90	No Change
7	2.90	2.90	No Change
8	2.89	2.89	No Change
9	2.88	2.88	No Change
10	2.85	2.85	No Change

9. VOLUMETRIC ANALYSIS

As discussed previously in Section 1 and 4, it is proposed to fill the site to an appropriate level in excess of the 100yr ARI flood level to provide protection against flooding and also to allow containment, treatment and reuse of stormwater that directly falls on the site.

The proposed filling results in a loss of flood storage equating to approximately 20,000 cubic metres.

Previous modelling data used in the study undertaken by the Public Works 'Cockle Creek Flood Study June 1986' indicates that the site is located in an area of flood storage of approximately 1,350,000 m^2. Calculations have found that an increase of 0.01m occurs over this storage area as a result of the proposed filling. Refer to Appendix F for details.

10. DISCUSSION AND RECOMMENDATIONS

Modelling has shown that the proposed waste recycling facility has an insignificant impact on the existing flooding regime in cockle creek which is governed by a backwater phenomenon created at the confluence of Cockle Creek, Cocked Hat Creek and Brush Creek.

An increase in flood level of 0.01m occurs at the upstream boundary of the site as a result of the proposed filling required for the development. This increase is negligible, given the vast extent of flooding in the area and is probably within the accuracy of the model.

Due consideration has been given to the effect of climate change by conservatively increasing flows and downstream tail water controls. Modelling indicates that an increase in flood level, as a result of climate change, would be approximately 0.2m from RL2.7m AHD to RL 2.9m AHD at the site. It was also found that filling to the site in this scenario also resulted in a negligible increase of 0.01m at the upstream boundary of the site in comparison to predeveloped flood levels at that location.

It can be concluded that the proposed waste recycling facility has negligible effect to the flooding regime of Cockle Creek and would not adversely effect upstream or downstream properties.

11. REFERENCES

a. COCKLE CREEK FLOOD STUDY – Public Works Department NSW, June 1986. Ref PWD 86008

b. COCKLE CREEK FLOODPLAIN MANAGEMENT STUDY Hydraulic Analysis of Flood Mitigation and Development Options – Public Works Department NSW, September 1993. Ref 93080

c. Lake Macquarie Sea Level Rise Preparedness Adaption Policy – Lake Macquarie City Council, September 2008

d. Practical Consideration of Climate Change – Department of Environment & Climate Change, 2007

12. APPENDICES

APPENDIX A – Contour Survey of Site

APPENDIX B - Cross Section Survey of Cockle Creek and Associated Floodplain

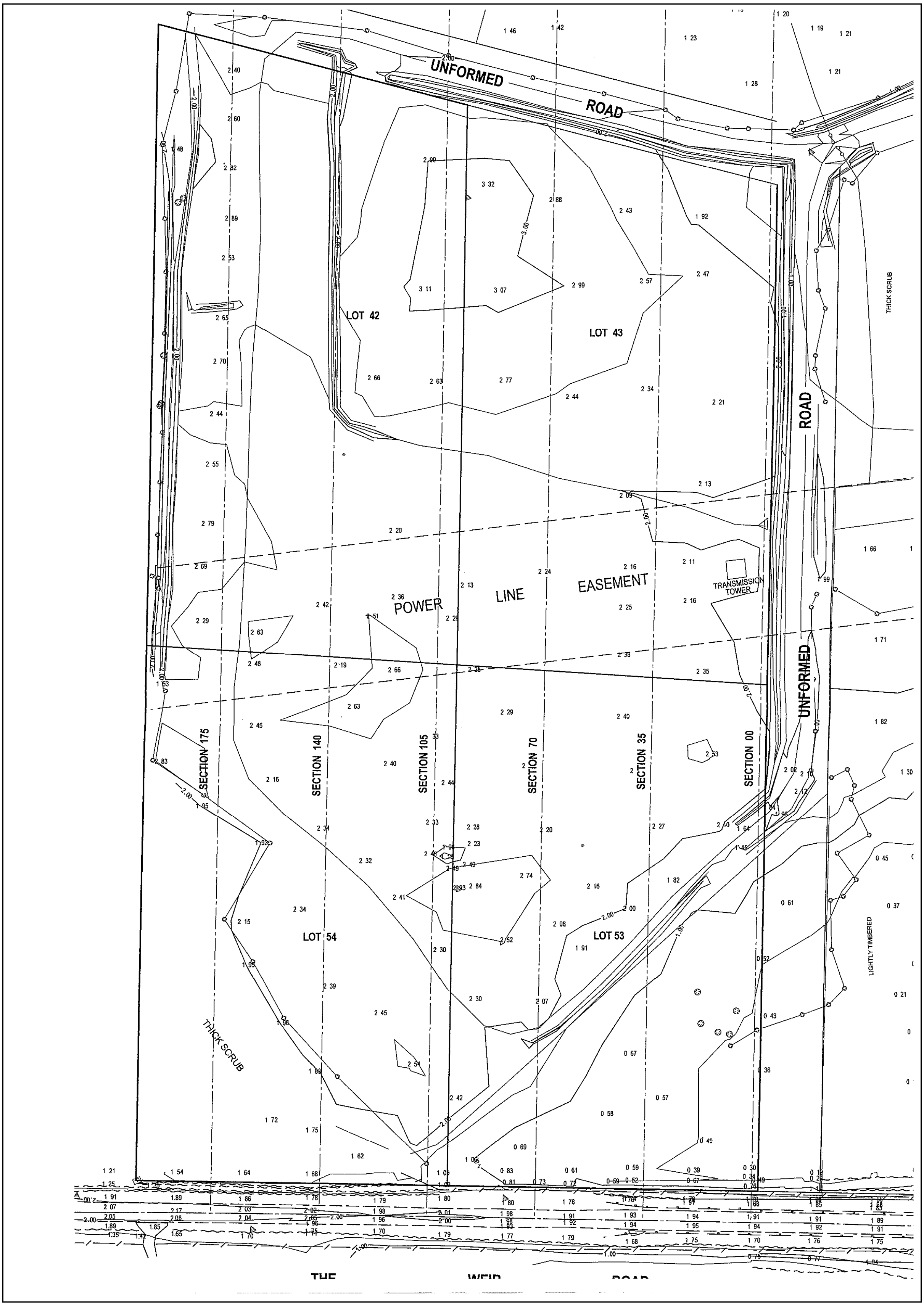
APPENDIX C -HEC-RAS Output Data 20 year ARI Event

APPENDIX D - HEC-RAS Output Data 100 year ARI Event

APPENDIX E - HEC-RAS Output Data 100 year ARI Event with Climate Change Considered

APPENDIX F – Impact of Loss of Flood Storage

APPENDIX A – Contour Survey of Site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SECTION 105
SECTION 70
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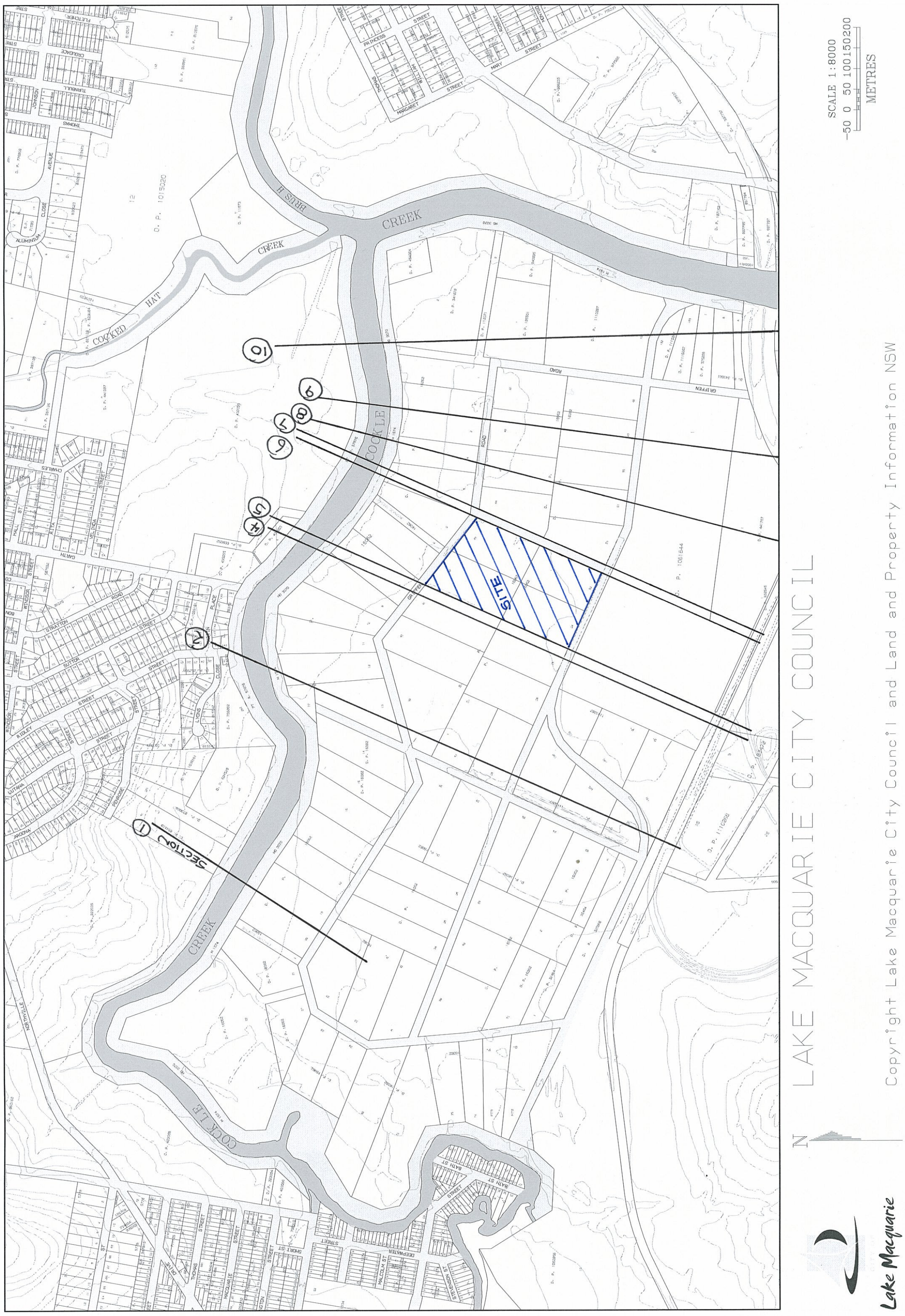
THE
WEIR

APPENDIX B - Cross Section Survey of Cockle Creek and Associated Floodplain


LAKE MACQUARIE CITY COUNCIL
Copyright Lake Macquarie City Council and Land and Property Information NSW
SCALE 1:8000
METRES
SITE
COCKLE CREEK
COCKED HAT CREEK
Lake Macquarie


PROFILE 1
Level (m AHD)
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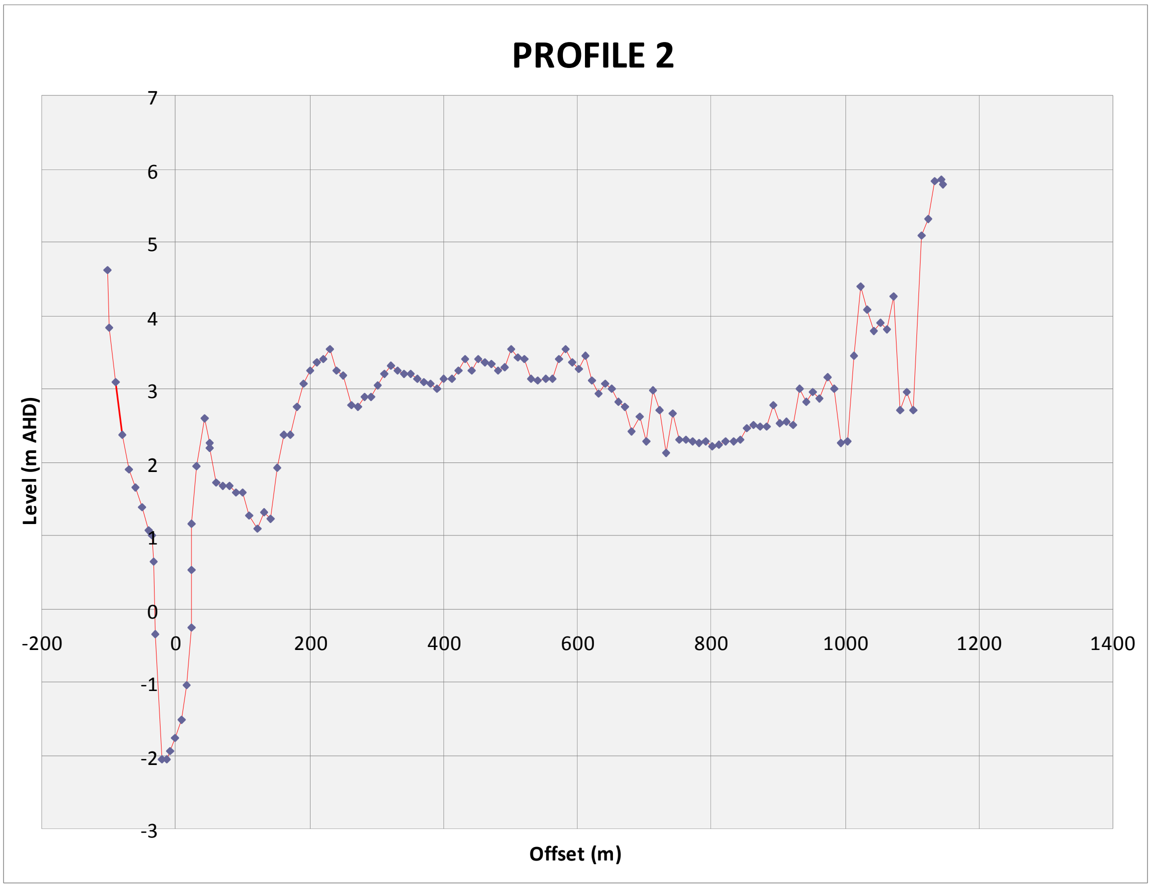
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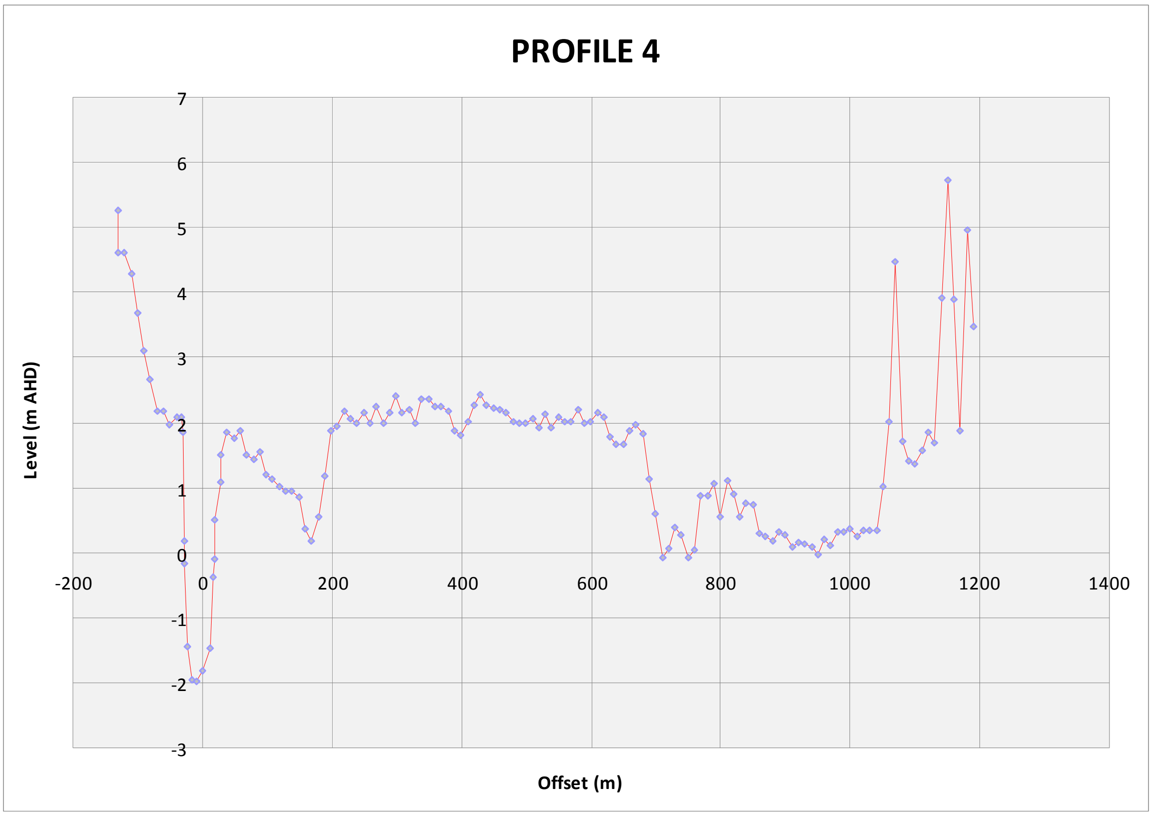
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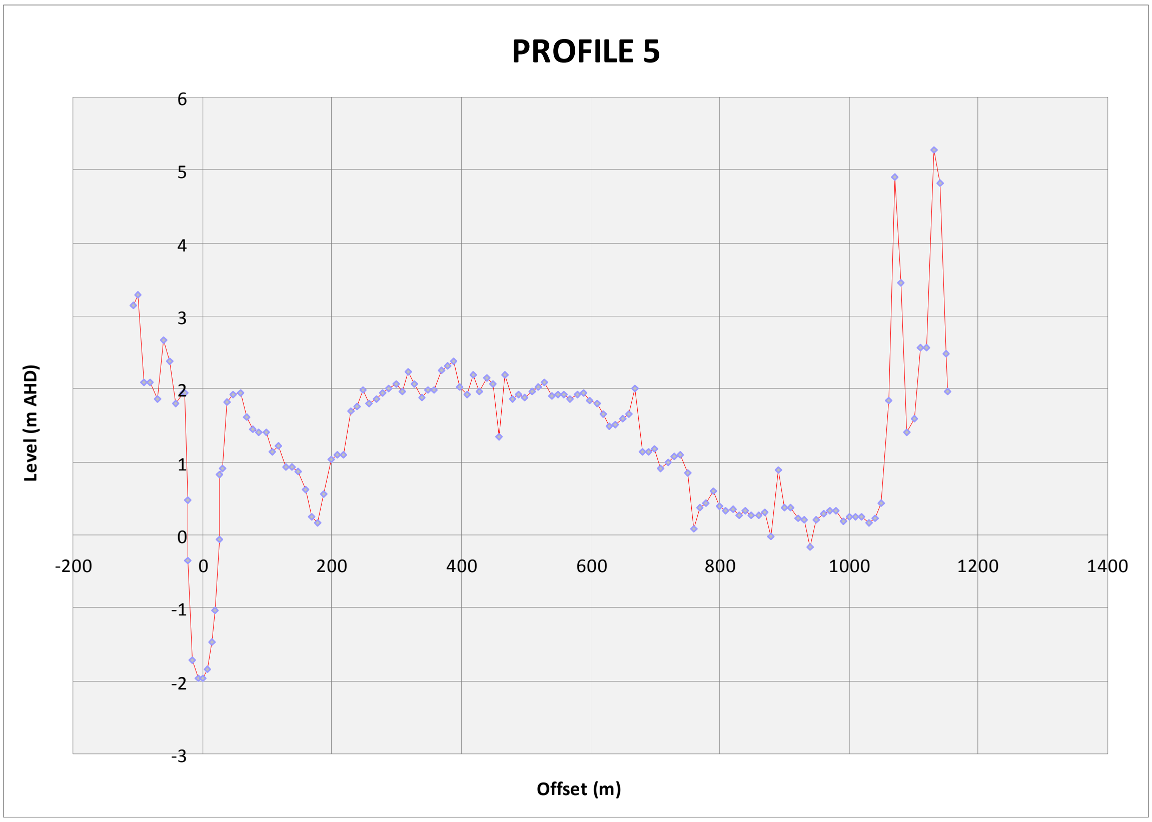
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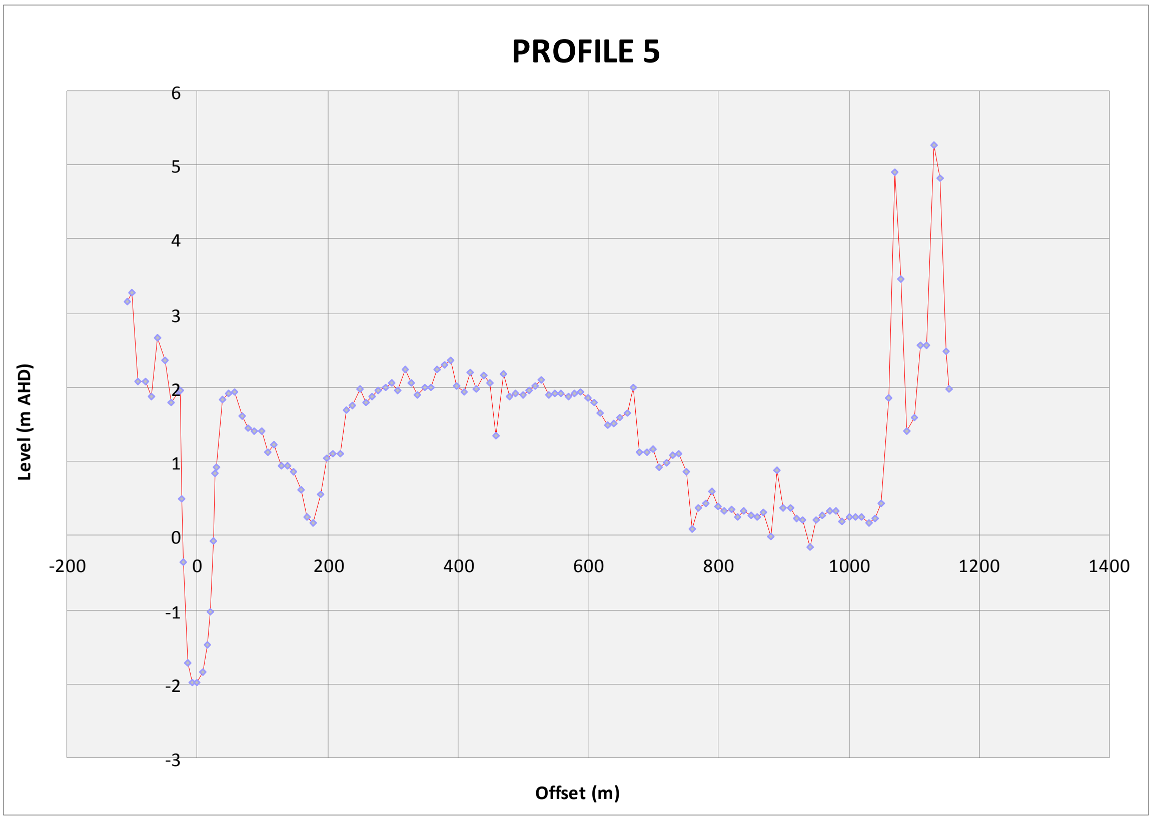
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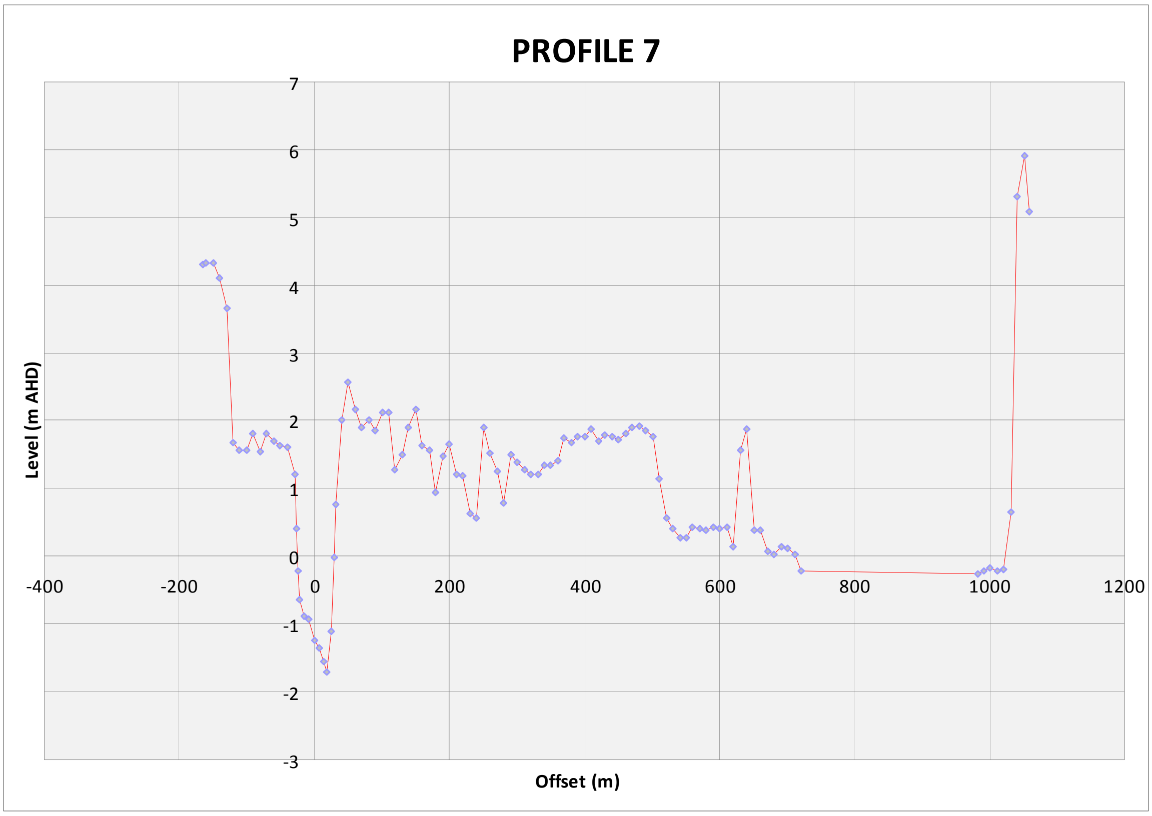
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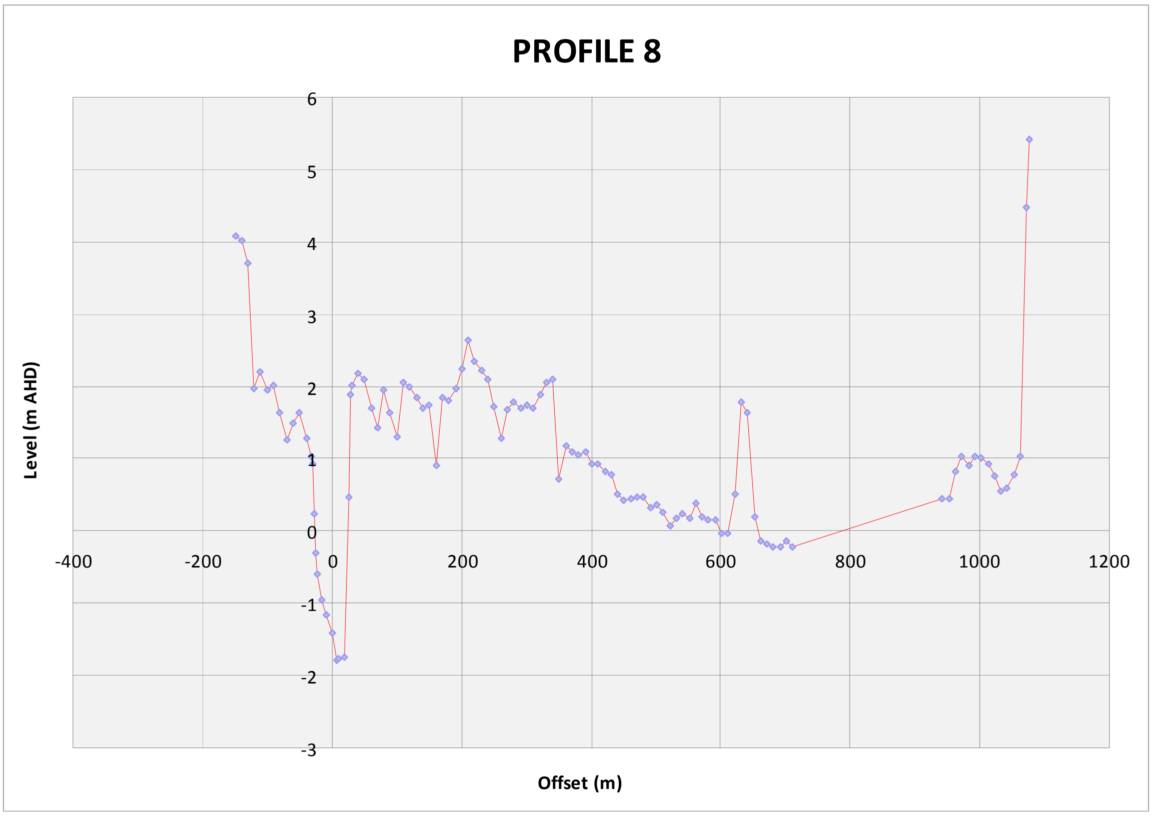
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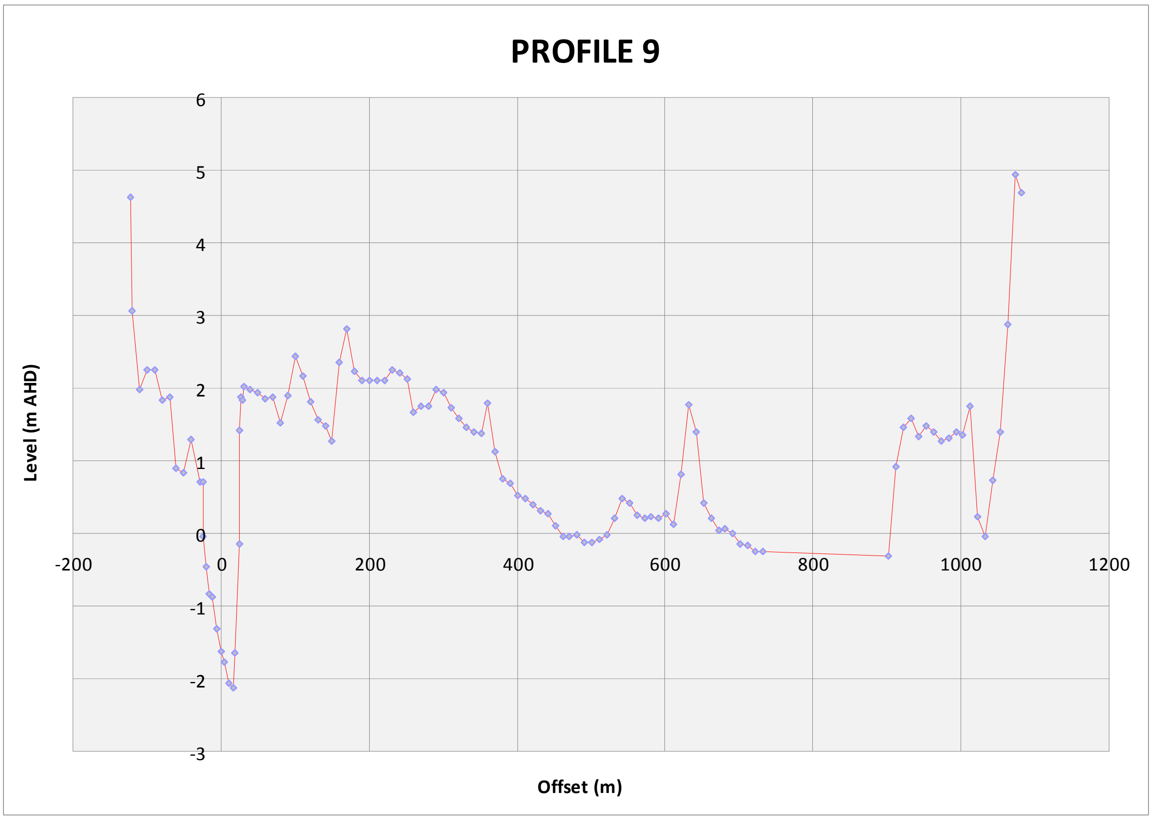
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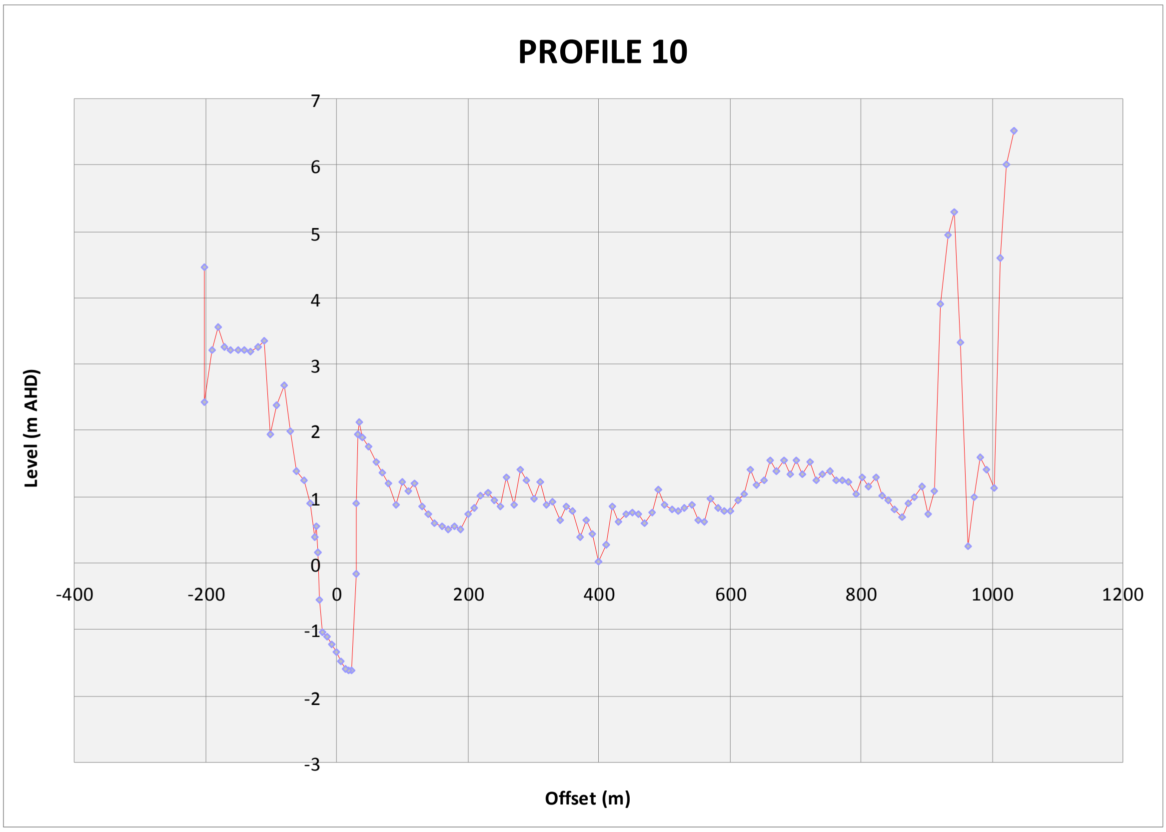

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Offset (m)

APPENDIX C -HEC-RAS Output Data 20 year ARI Event

HEC-RAS Plan: 20yr ARI Pre River: Cockle Creek Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	1442	PF 1	291.00	-1.18	2.87	0.47	2.90	0.000320	0.85	688.46	404.36	0.14
1	841	PF 1	291.00	-2.06	2.55		2.60	0.000634	1.07	394.88	257.29	0.19
1	509	PF 1	291.00	-1.97	2.44		2.44	0.000187	0.56	1411.20	1198.30	0.10
1	487	PF 1	291.00	-1.98	2.43		2.44	0.000162	0.51	1479.92	1171.15	0.10
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1	225	PF 1	291.00	-1.79	2.41		2.41	0.000085	0.34	1885.14	1175.73	0.07
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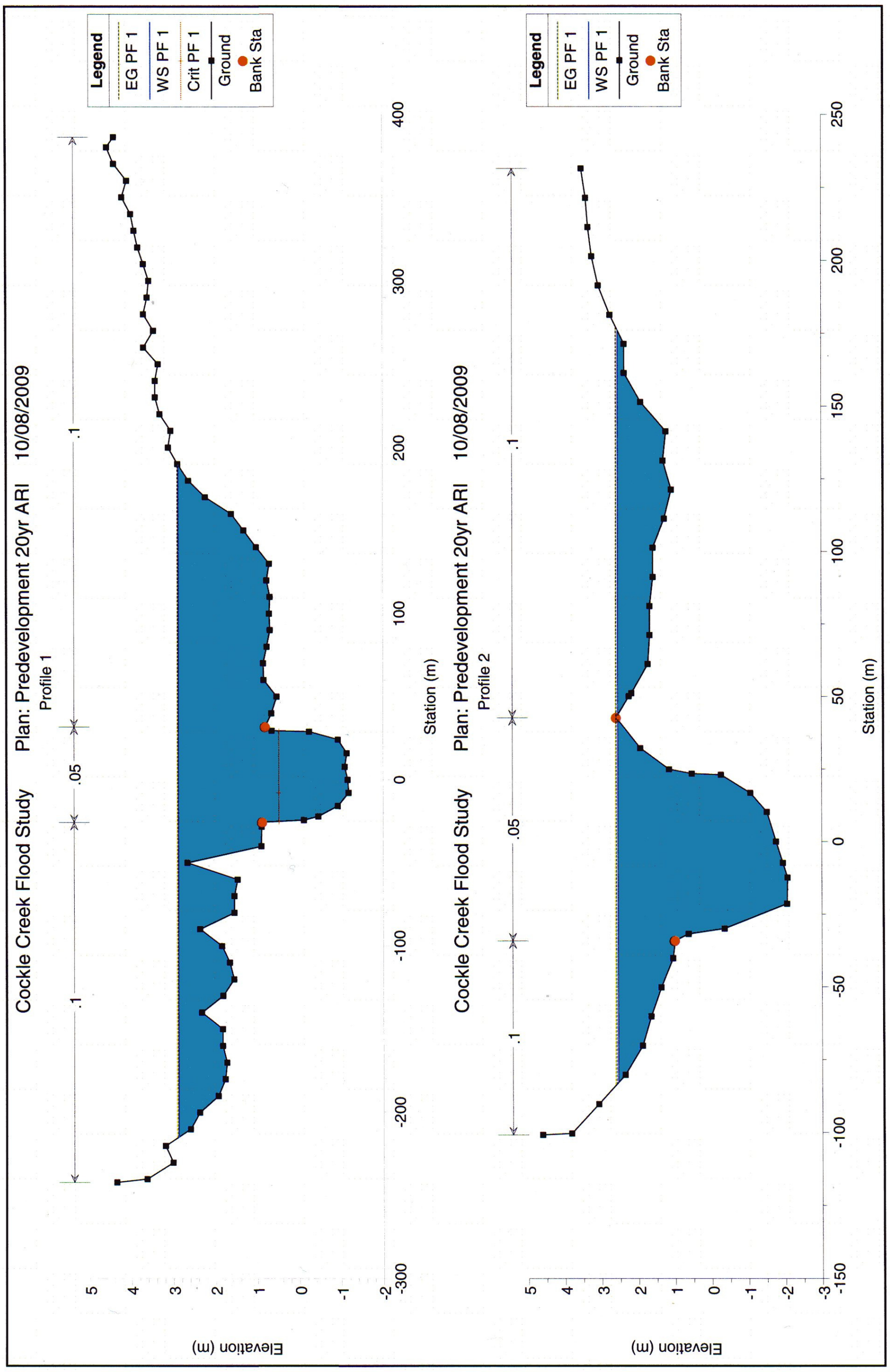
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WS PF 1
Crit PF 1
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Elevation (m)
Station (m)
Cockle Creek Flood Study   Plan: Predevelopment 20yr ARI   10/08/2009
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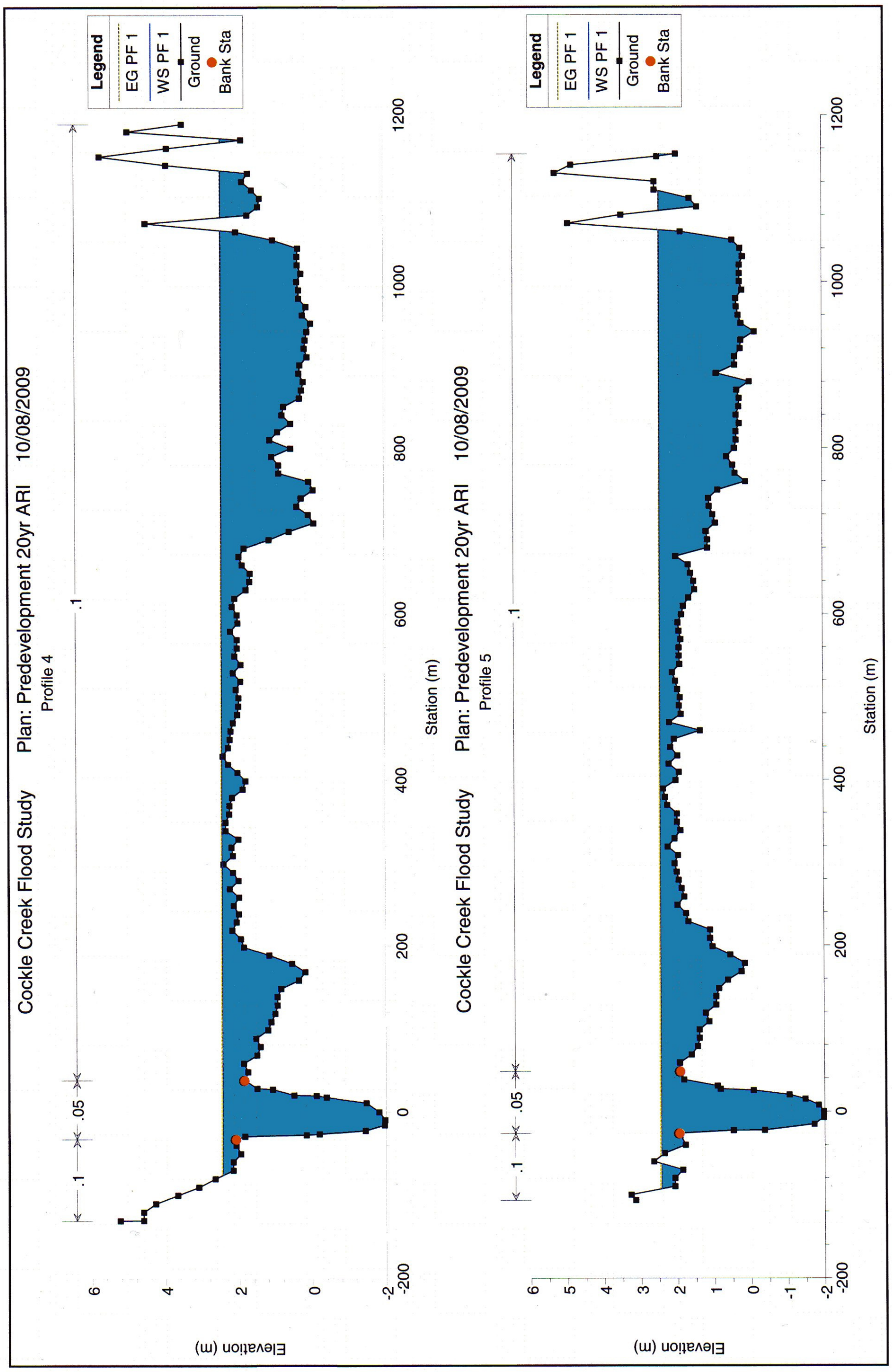
Station (m)



Cockle Creek Flood Study Plan: Predevelopment 20yr ARI 10/08/2009
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Legend
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WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
Cockle Creek Flood Study Plan: Predevelopment 20yr ARI 10/08/2009
Profile 5
Legend
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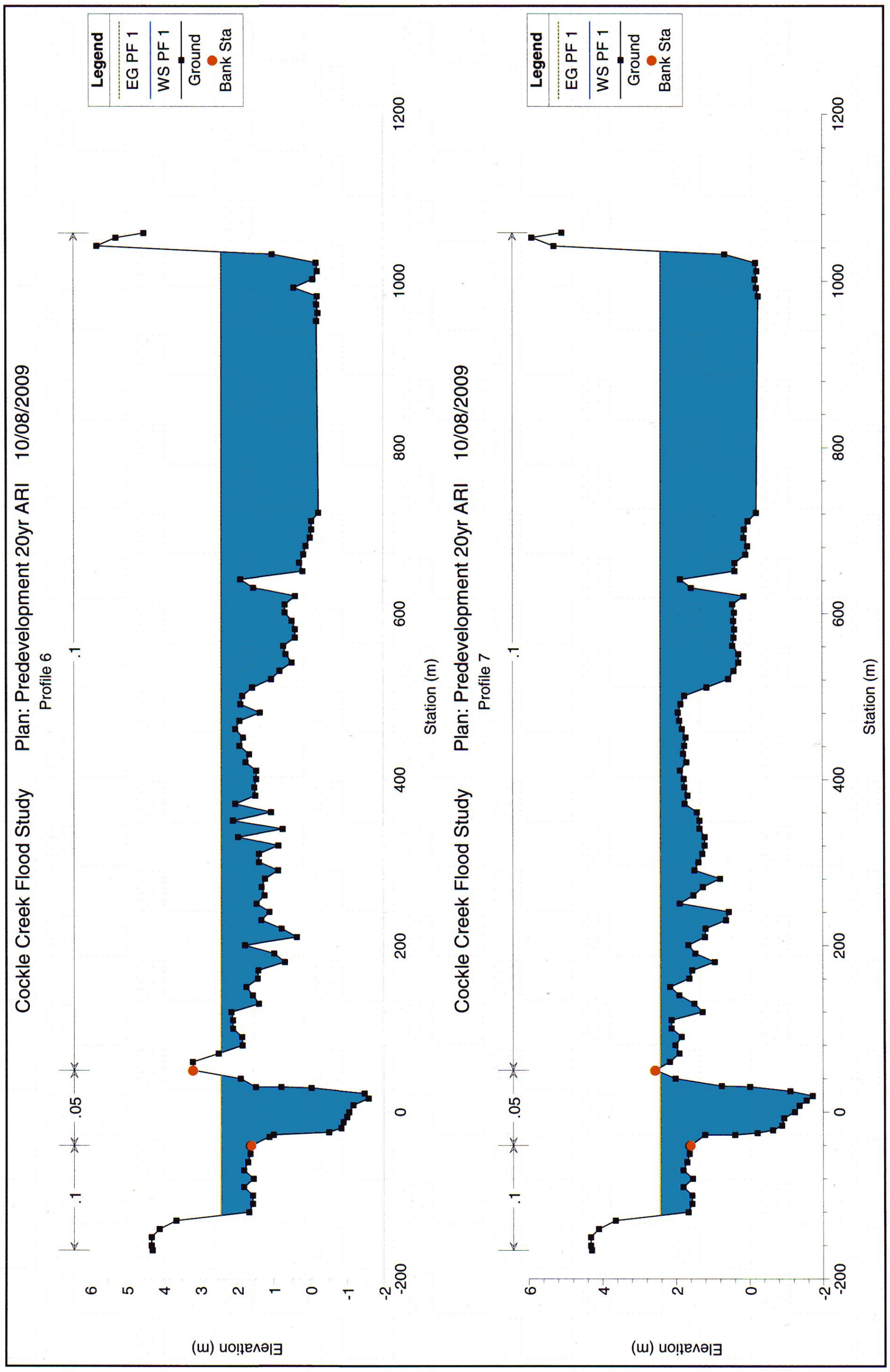
Ground
Bank Sta
Elevation (m)
Station (m)



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Cockle Creek Flood Study   Plan: Predevelopment 20yr ARI   10/08/2009
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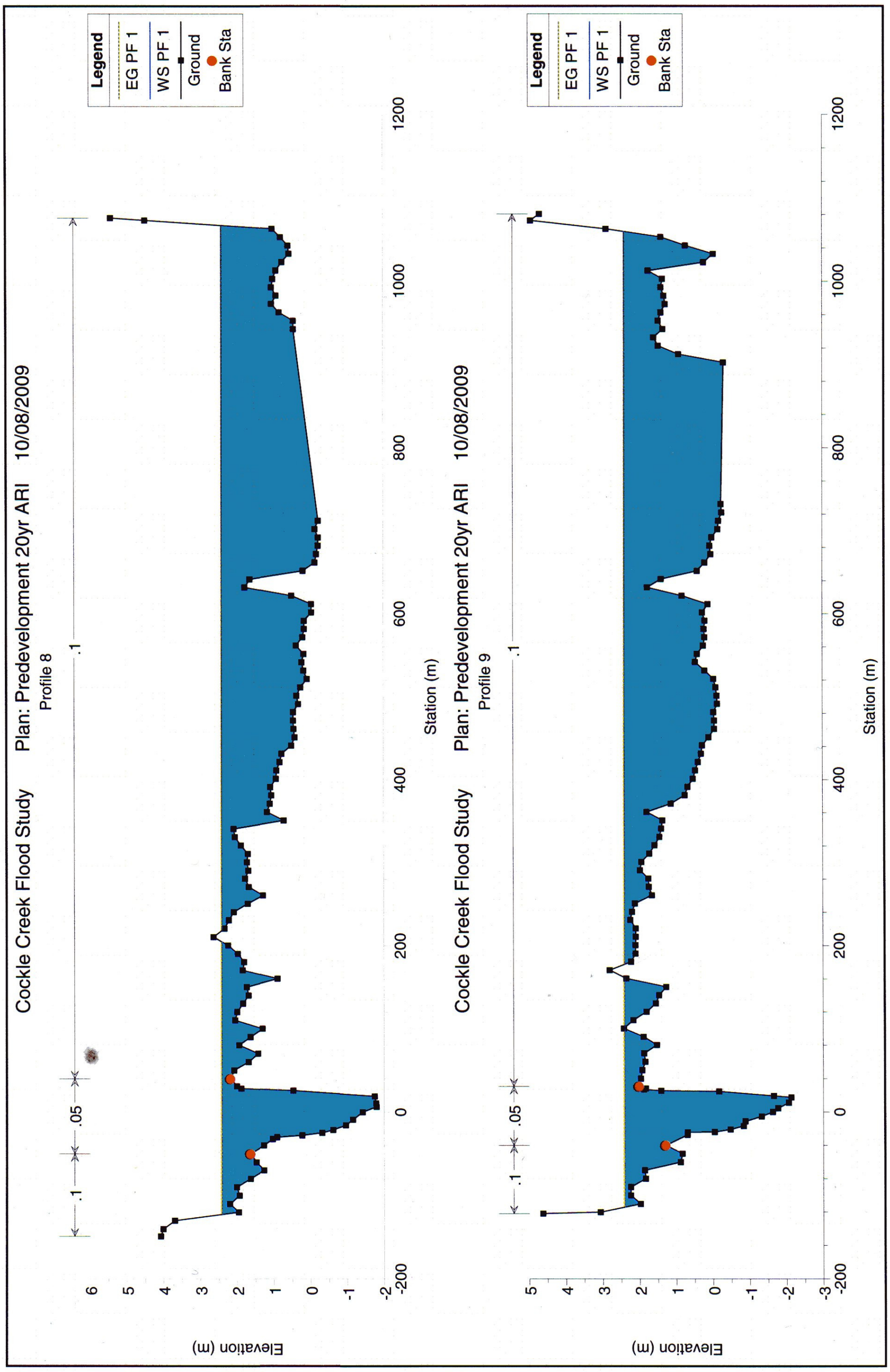
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Cockle Creek Flood Study Plan: Predevelopment 20yr ARI 10/08/2009
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Elevation (m)
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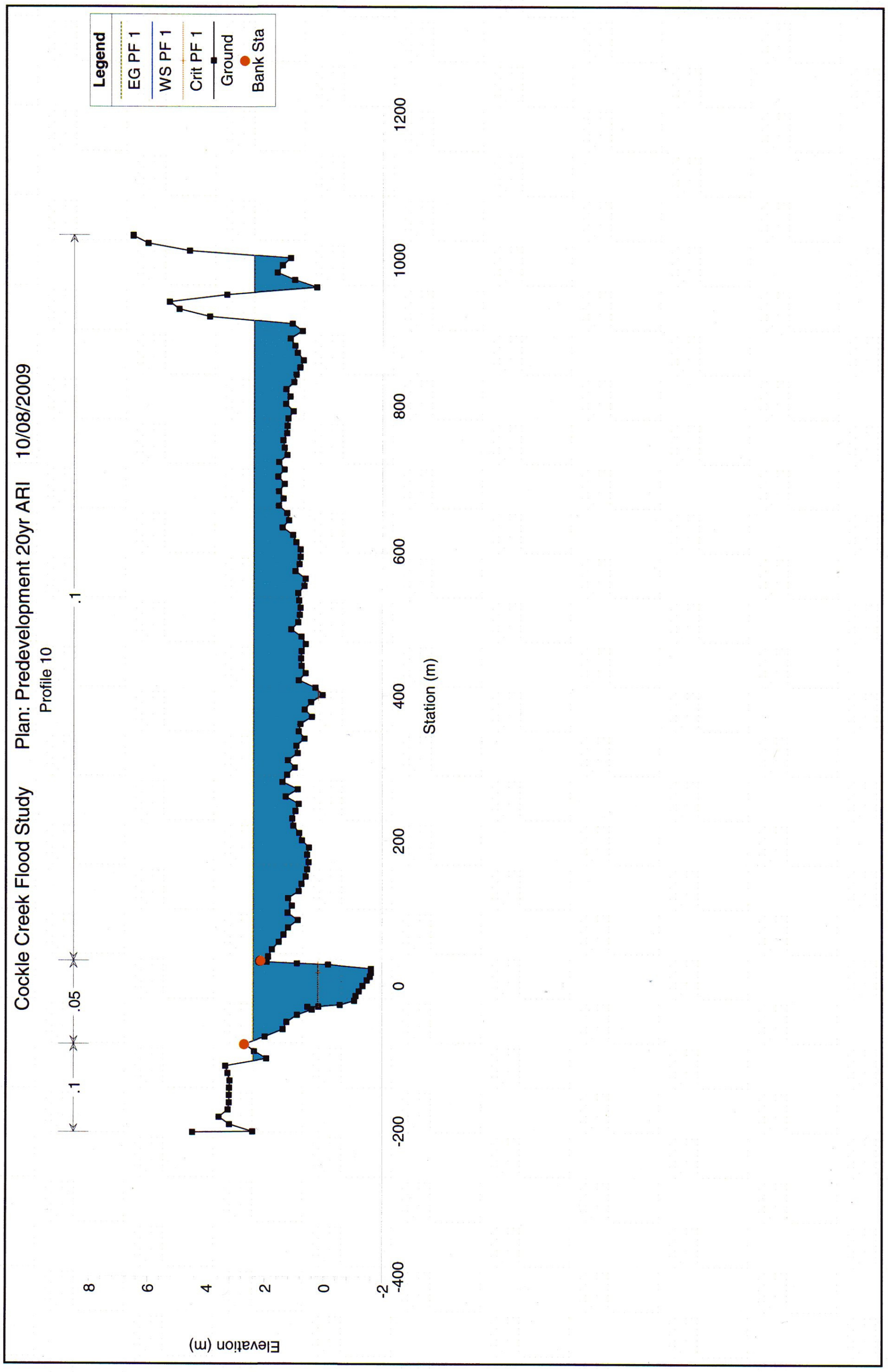
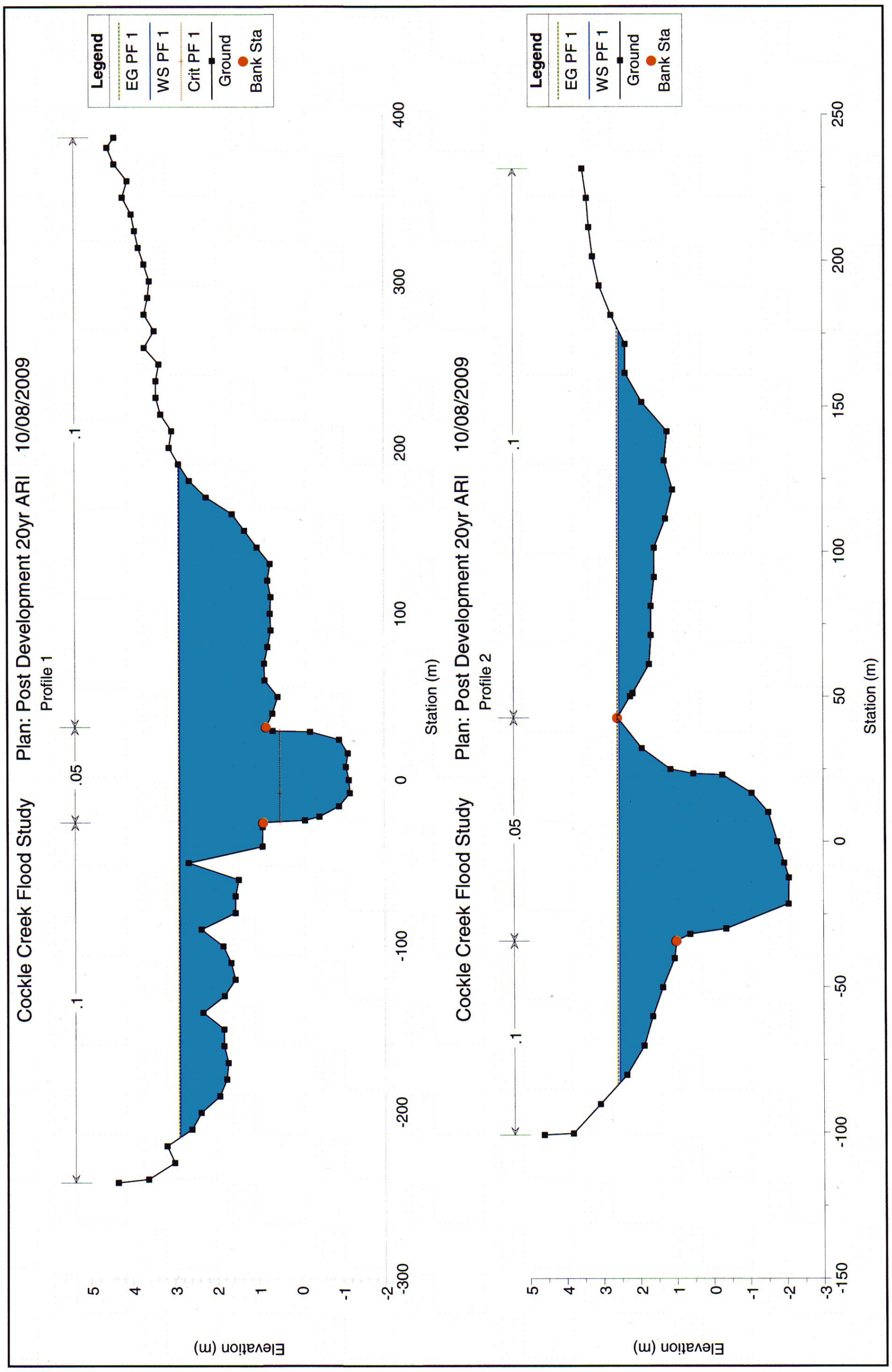


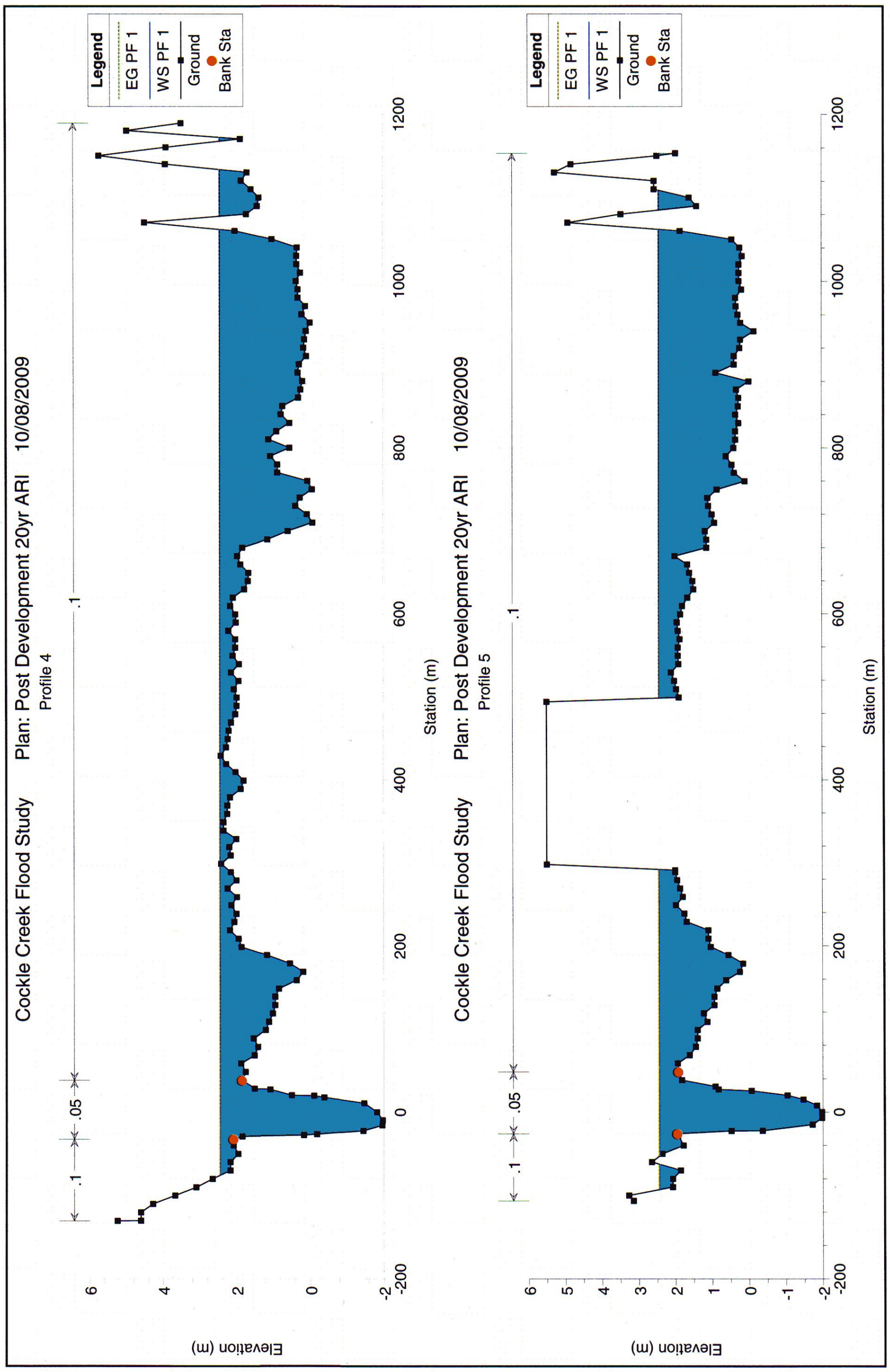
Cockle Creek Flood Study Plan: Predevelopment 20yr ARI 10/08/2009
Profile 10
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
.1
.05
.1
Elevation (m)
Station (m)
-2
0
2
4
6
8
-400
-200
0
200
400
600
800
1000
1200

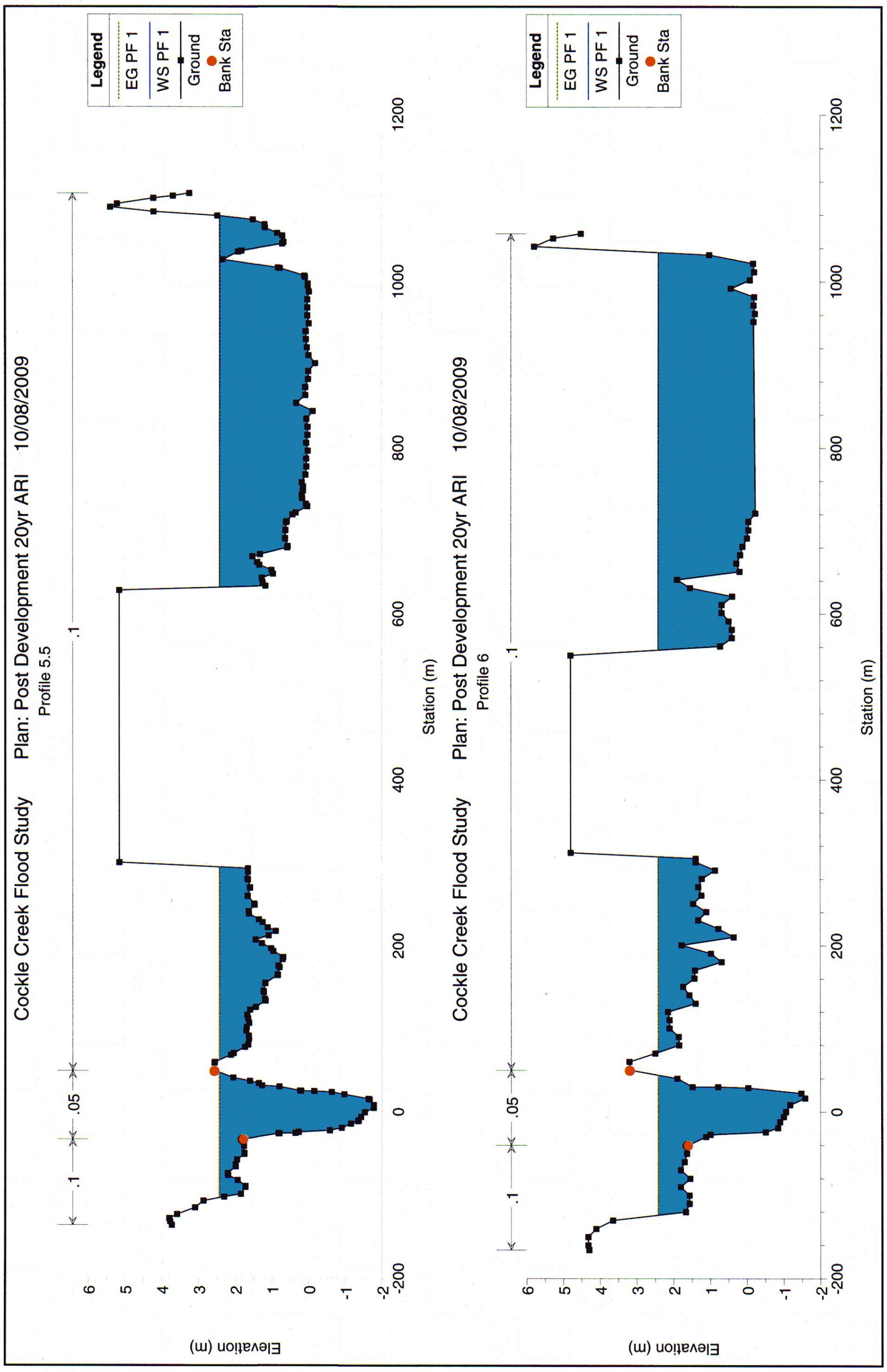
HEC-RAS Plan: 20yr Post River: Cockle Creek Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	1442	PF 1	291.00	-1.18	2.87	0.47	2.90	0.000321	0.85	688.31	404.34	0.14
1	841	PF 1	291.00	-2.06	2.55		2.60	0.000634	1.07	394.88	257.29	0.19
1	509	PF 1	291.00	-1.97	2.44		2.44	0.000187	0.56	1411.37	1198.30	0.10
1	487	PF 1	291.00	-1.98	2.43		2.44	0.000154	0.50	1397.74	964.63	0.09
1	385	PF 1	291.00	-1.78	2.42		2.43	0.000134	0.44	1384.19	829.18	0.09
1	283	PF 1	291.00	-1.58	2.41		2.41	0.000091	0.35	1629.82	882.01	0.07
1	272	PF 1	291.00	-1.72	2.41		2.41	0.000087	0.35	1899.21	1153.12	0.07
1	225	PF 1	291.00	-1.79	2.41		2.41	0.000085	0.34	1885.11	1175.72	0.07
1	143	PF 1	291.00	-2.13	2.40		2.40	0.000086	0.38	1857.91	1155.61	0.07
1	0	PF 1	291.00	-1.62	2.38	0.17	2.38	0.000132	0.41	1551.78	1057.08	0.08

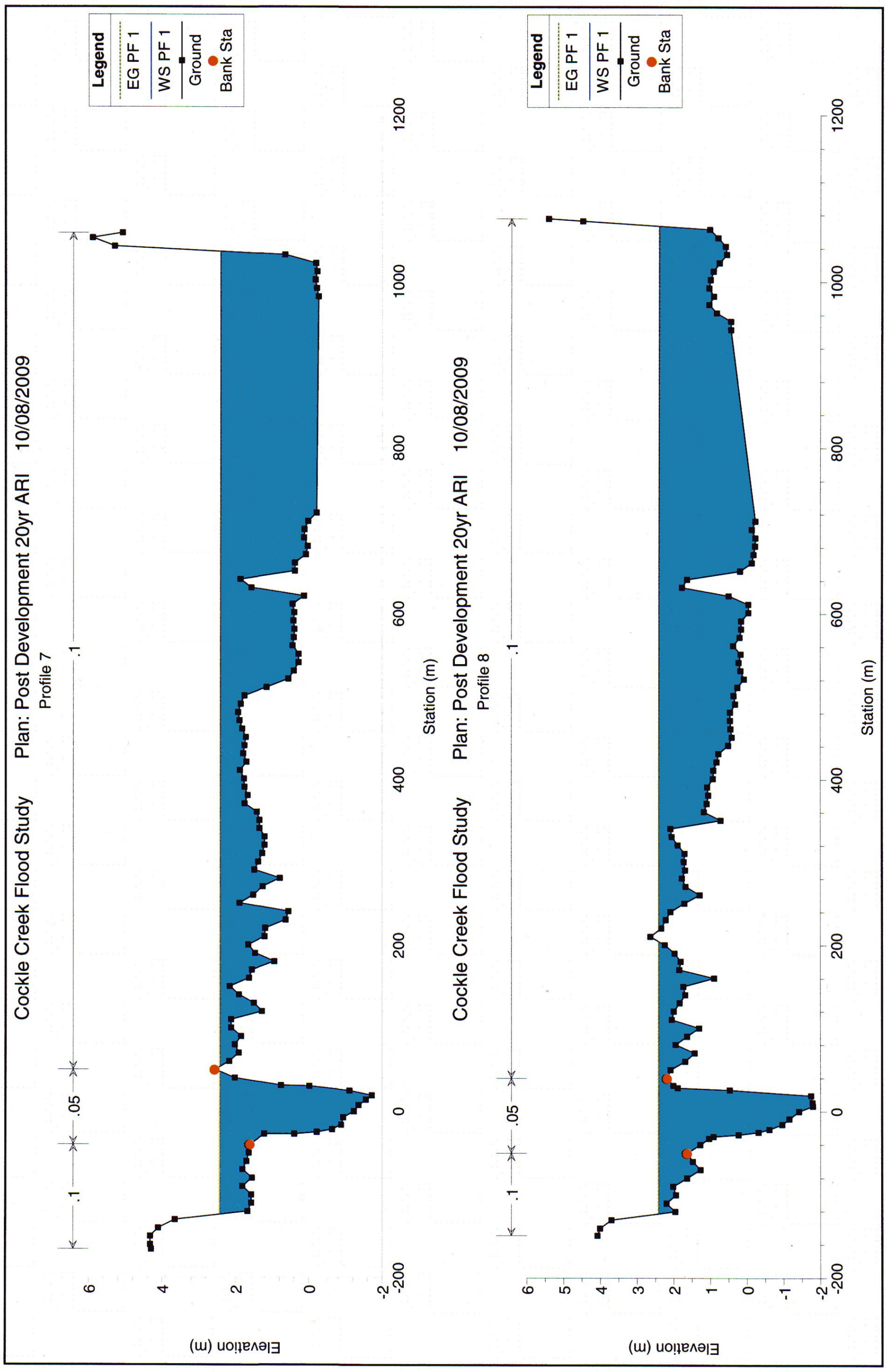


Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 1
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
.1
.05
.1
Elevation (m)
Station (m)
Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 2
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
.1
.05
.1
Elevation (m)
Station (m)

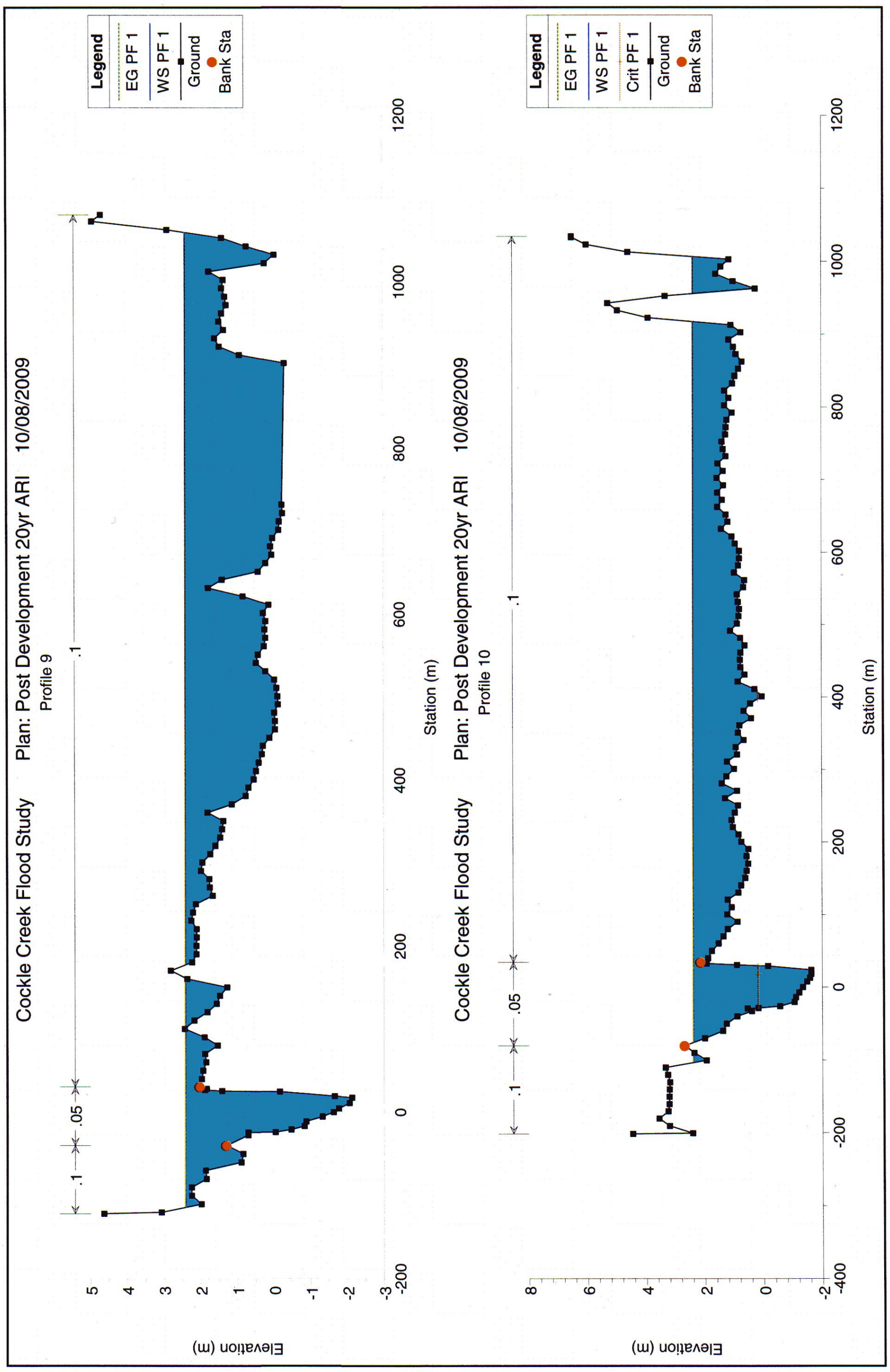

Cockle Creek Flood Study   Plan: Post Development 20yr ARI   10/08/2009
Profile 4
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
Cockle Creek Flood Study   Plan: Post Development 20yr ARI   10/08/2009
Profile 5
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)



Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 5.5
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 6
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)



Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 7
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
Cockle Creek Flood Study Plan: Post Development 20yr ARI 10/08/2009
Profile 8
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

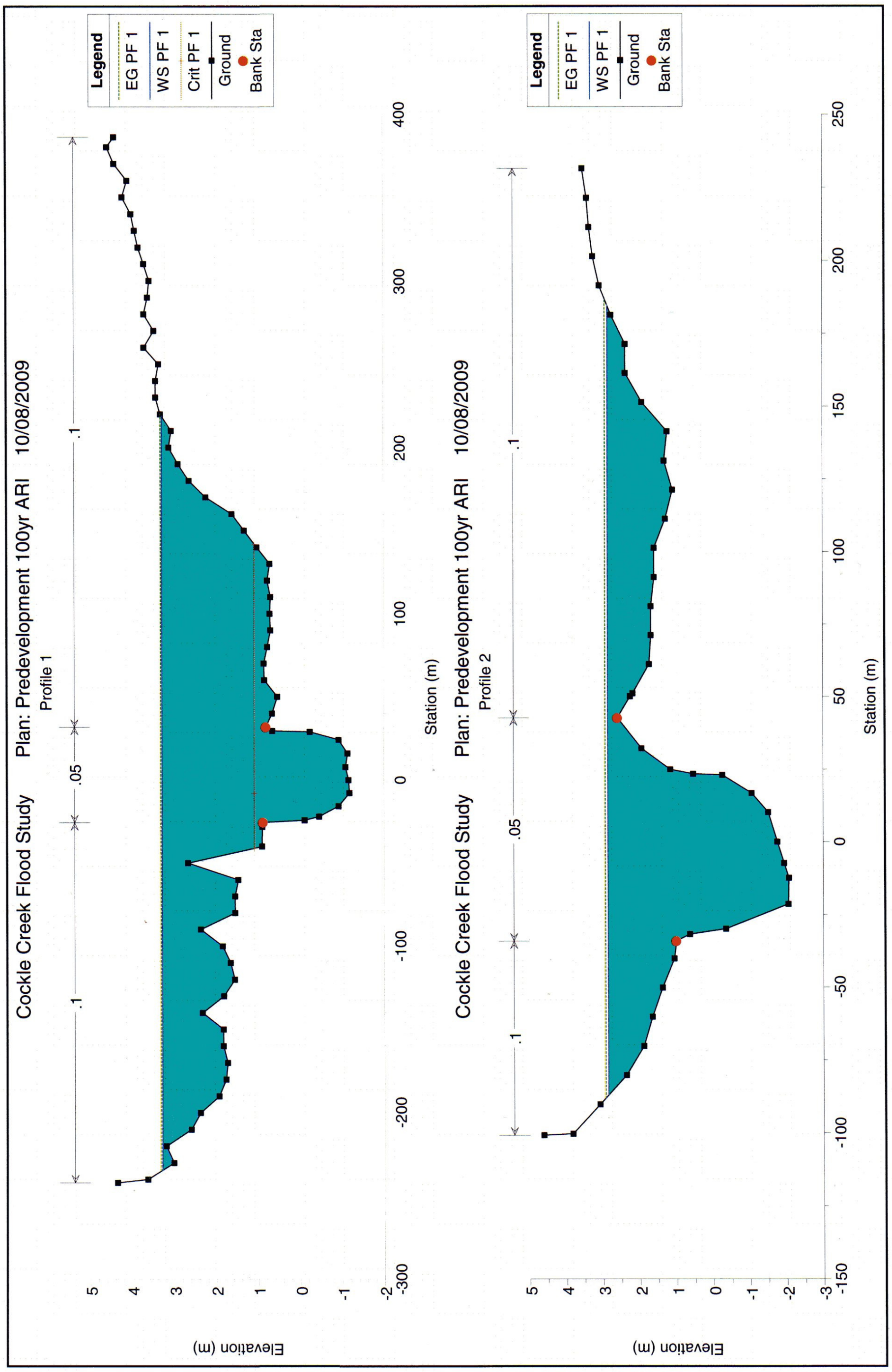


Cockle Creek Flood Study   Plan: Post Development 20yr ARI   10/08/2009
Profile 9
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
.1
.05
Cockle Creek Flood Study   Plan: Post Development 20yr ARI   10/08/2009
Profile 10
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

APPENDIX D - HEC-RAS Output Data 100 year ARI Event

HEC-RAS Plan: 100yr Pre River: Cockle Creek Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	1442	PF 1	416.00	-1.18	3.28	1.08	3.31	0.000403	1.02	862.67	453.57	0.16
1	841	PF 1	416.00	-2.06	2.86		2.93	0.000877	1.33	475.56	271.68	0.23
1	509	PF 1	416.00	-1.97	2.73		2.74	0.000208	0.62	1760.74	1210.31	0.11
1	487	PF 1	416.00	-1.98	2.72		2.73	0.000185	0.58	1824.01	1199.83	0.10
1	283	PF 1	416.00	-1.58	2.70		2.70	0.000113	0.42	2191.97	1139.84	0.08
1	272	PF 1	416.00	-1.72	2.69		2.70	0.000109	0.41	2229.21	1161.83	0.08
1	225	PF 1	416.00	-1.79	2.69		2.69	0.000113	0.42	2221.03	1192.06	0.08
1	143	PF 1	416.00	-2.13	2.68		2.68	0.000110	0.45	2185.57	1173.07	0.08
1	0	PF 1	416.00	-1.62	2.66	0.79	2.66	0.000162	0.48	1847.48	1077.94	0.09



Cockle Creek Flood Study   Plan: Predevelopment 100yr ARI   10/08/2009
Profile 1
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
.1
.05
.1
Elevation (m)
Station (m)
Cockle Creek Flood Study   Plan: Predevelopment 100yr ARI   10/08/2009
Profile 2
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
.1
.05
.1
Elevation (m)
Station (m)

ERROR: stackunderflow
OFFENDING COMMAND: ~

STACK: