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20 November 2013

Ref: 13-048-1

Manager
Corbett Constructions Pty. Ltd.
P.O. Box 354
Picton NSW 2571

Dear Sir,

RE: Lot 102 DP1092990 Coull Street, Picton

Site filling and Flood Impacts.

I refer to your request for this firm to assess the impacts of filling the above allotment to achieve a platform approximately 25metres wide from the front boundary to Coull Street.

The following is offered for your consideration prior to submission to Council:

1.0 Stonequarry Creek Floodplain Management Plan Flood Levels.

The site is located between the Floodplain Management Plan (FMP) nominated cross section 10 and 11. The site is approximately 72 metres long, downstream property boundary is 7 metres upstream of section 10 and the upstream boundary is approximately 13 meters downstream of section 11.

Design Flows used are;

- 1% AEP: 494 cubic metres per second.
- 5% AEP: 345 cubic metres per second.

The 1% AEP Flood levels are listed in Table 1.

Table 1 – 1% AEP flood levels.

FPMS X-Section No.	FPMS Channel Chainage (m)	HEC-RAS Channel Chainage (m)	Existing Conditions RL (AHD)	Vegetation Management Plan	Reduction in Flood Levels (m)
X – 11	861.1	807.1	157.45	156.95	0.50
X – 10	770.6	716.6	157.21	156.79	0.42

FMS – Stonequarry Creek Floodplain Management Plan, June 1996 by Willing & Partners Pty. Ltd. et al.

The 5% AEP event flood levels are listed in Table 2 below.

Table 2 – Existing 5% AEP flood levels.

FPMS X-Section No.	FPMS Channel Chainage	Existing Conditions
X - 11	861.1	156.43
X - 10	770.6	156.26

Determined from Department of Water Resources HEC-2 files

2.0 Hydraulic Impacts of Development.

The site is located between Cross-sections X10 and X11 the Stonequarry Creek Floodplain Management HEC data set.

The data set titled P100 used by the Department of Water Resources (DWR) and Willings & Partners (authors of the Floodplain Management Plan – FPMP) was used to determine the water surface profile for the subject water course.

This firm has purchased the data set from Council required for a previous assessment. This firm has previously been given the data sets used by the DWR in the Picton Flood Study, 1989.

The data has been converted from the HEC-2 format to run on the newer HEC-RAS version 3.1.3. The most current version is 4.1 however it has not been released in 64bit format as is currently required by this author's computing hardware.

The HEC-RAS Version 3.1.3 has been run using Geometric Mean Friction Slope method and conveyance calculation in HEC-2 style in an attempt to duplicate the previous Study generated flood levels. There will be differences and these differences are tabulated below.

Table 3 – Existing FPMP 1% AEP flood levels & HEC-RAS V 3.1.3 generated results.

FPMS X-Section No.	FPMS	HEC-RAS
9	157.12	156.10
10	157.21	157.23
Site		
11	157.45	157.50
12	157.68	157.74

The impacts of the development have been assessed on the HEC-RAS V 3.1.3 model by filling with increments of 10metres of fill up to 40metres and the final proposal as described on Plan 13048FA issue A. Results are shown in Table 4.

Table 4 – 1% AEP Flood Levels resulting from filling the flood zone.

FPMS X-Section No.	Flood Level (m. AHD)	*1% AEP Flood Levels (m. AHD)*				
	HEC-RAS Existing	10m	20m	30m	*40m*	*fill 30m at X10 10m at X11
9	156.10	156.10	156.10	156.10	156.10	156.10
10	157.23	157.23	157.23	157.23	157.23	157.23
Site						
11	157.50	157.50	157.51	157.52	157.54	157.52
12	157.74	157.74	157.74	157.78	157.80	157.76
13 (d/s bridge)	158.01	158.01	158.02	158.03	158.04	158.02

*fill – Proposed filling proposal

Table 5 lists the flow characteristics of the 1% AEP event for sections 9 through to 13. (Section 13 being immediately below Argyle Street Bridge).

Sections above the Argyle Street Bridge are unchanged and hence omitted from the summary. The changes in flow characteristics are included in Table 5 including the net numerical change.

Table 6 lists the existing and changed flow characteristics for the 5% AEP event.

Table 5 – 1% AEP Flood Levels & Flow Characteristics (494 cumecs)

FPMS X-Section No.	Flood Level (m. AHD)	Flow (cumecs)			Avg. Velocity (m/sec)			
		LOB	CH	ROB (Site)	LOB	CH	ROB	Total
9	157.10	88.2	234.84	170.74	0.54	1.12	0.73	0.81
***fill**	157.10	88.2	234.84	170.74	0.54	1.12	0.73	
10	157.23	29.73	357.67	106.59	0.80	1.79	0.92	1.40
***fill**	157.23	30.95	374.45	88.57	0.84	1.87	0.99	1.51
Change	0.0	1.22	16.81	-18.02	0.04	0.08	0.07	0.11
Site								
11	157.50	29.00	422.16	42.84	0.43	2.27	0.52	1.47
***fill**	157.52	29.95	420.42	43.63	0.43	2.25	0.54	1.46
Change	0.02	0.95	-1.74	0.79	0.00	-.02	0.02	-0.01
12	157.74	80.34	362.15	51.51	0.56	2.39	0.44	1.20
***fill**	157.76	82.15	359.33	52.52	0.56	2.36	0.44	1.18
Change	0.02	1.81	-2.82	1.01	0.00	-0.03	0.00	-.02
13	158.01	78.01	400.23	15.76	0.28	1.69	0.21	0.83
***fill**	158.02	78.87	399.18	15.95	0.28	1.68	0.21	0.82
Change	0.01	0.86	-1.05	0.19	0.00	-0.01	0.00	-0.01

*fill – Proposed filling proposal

LOB – Left Over Bank, ROB – Right Over Bank, CH – main Channel

Subject site is located on the ROB.

Table 6 – 5% AEP Flood Levels & Flow Characteristics (345 cumecs)

FPMS X-Section No.	Flood Level (m. AHD)	Flow (cumecs)			Avg. Velocity (m/sec)			
		LOB	CH	ROB (site)	LOB	CH	ROB	Total
9	156.47	45.64	202.66	96.70	0.47	1.12	0.86	0.81
***fill**	156.47							
10	156.63	2.67	308.75	33.57	0.46	1.77	0.63	1.46
***fill**	156.63	2.69	313.05	29.25	0.47	1.79	0.67	1.54
Change	0	0.02	4.30	-4.32	0.01	0.02	0.04	0.06
Site								
11	156.94	7.44	327.01	10.55	0.27	1.96	0.37	1.55
***fill**	156.94	7.60	326.62	10.78	0.27	1.95	0.37	1.54
Change	0	0.16	-0.39	0.23	0.00	-0.01	0.00	-0.01
12	157.13	27.50	303.75	13.75	0.47	2.28	0.29	1.44
***fill**	157.14	27.71	303.34	13.96	0.47	2.25	0.29	1.43
Change	0.01	0.21	-0.41	0.21	0.00	-0.01	0.01	-0.01
13	157.44	23.75	317.18	4.06	0.19	1.48	0.14	0.93
***fill**	157.44	23.94	316.95	4.10	0.19	1.48	0.14	0.93
Change	0	0.19	-0.23	0.04	0.00	0.00	0.00	0.00

3.0 Determination of Floodway Limits.

Council's current policy - Picton Local Flood Policy Updated: May 2000 defines a floodway as:

> "*those areas where a significant volume of water flows during floods. They are often aligned with obviously naturally defined channels. Floodways are areas which, even if partially blocked, would cause a significant redistribution of flood flow, which may in turn adversely affect other areas. Hey are often, but not necessarily, the areas of deeper flow or areas where higher velocities occur.* "

The NSW Government's Floodplain Management Manual; January 2001 defines *Floodway Areas* as:

> "*those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with obviously naturally defined channels. Floodways are areas that, even if only partially blocked, would*

cause a significant redistribution of flood flow, or a significant increase in flood levels. "

The NSW Government's Floodplain Development Manual, the management of flood liable land; April 2005 has maintained this definition.

The NSW Government Department of Environment & Climate Change issued in on the 25/10/2007 advice on Floodway Definition. 'This FRM guideline addresses the identification of floodways in the FRM Process as outlined in the NSW Floodplain Development Manual (2005). The 2005 definition provides a qualitative rather than a quantitative description of a floodway.

'*The definition does not relate to the velocity or depth of flow but to the significance of discharge (significance is relative to the total flow along an individual flowpath rather than the "hazard") and the hydraulic impacts of blockage (the impacts on both the floodplain as a whole and the flowpath in question).*
.'

The previous definitions were based on a generalised approach were flow paths had a region of deep flow with high velocities. These principles fell short in the flat western areas of NSW where there were wide plain flows and there was no formal main channel.

To assist in assessing where floodways exist, the following guidance is provided in relation to the characterisation of floodways and approaches to the assessment of floodways extents.

As floodways are primarily defined through hydraulic function their characterisation needs to be along the same lines. Hence floodways areas would be expected to have at least one of the following hydraulic characteristics which relate to impacts of works in these areas. Obstruction of the floodway can:

- Divert water to other existing flowpaths.
- Have a significant impact upon upstream flood levels in the planning level flood.
- Divert significant amounts of water away from existing flowpaths resulting in the development of new flowpaths and associated adverse impacts.

The areas general to Stonequarry Creek are viewed to be of the traditional style of a flow path where there is a central region of deep flow and higher velocities. It is considered that the tradition approach of determining floodway used in hydraulic calculation is applicable in this region.

The numerical determination of the floodways can be determined within HEC-RAS, published by the US Army Corps of Engineers. It is defined as that portion of the available flow cross section that cannot be obstructed without causing an increase in

the water-surface elevations resulting from a flood with a 100-year average return period of more than a given amount. This is termed 'Afflux'. The Federal Emergency Management Agency established the amount to be 1 foot (0.305m) to be adopted and is used to define floodways for risk benefit assessments.

HEC-RAS has the facility to determine the extent of encroachments that will cause an increase in afflux of flood levels.

Appendix 'A', figures 2 and 3 shows the model determined floodway.

Figures 4 and 5 places the proposed filling on to determined floodway.

At X11 the extent of filling is outside the extent of the flood way in the area considered as High Hazard Flood Fringe.

At X10 the proposed extent of filling is to line of the 'Floodway' – 'High Hazard Flood Fringe'.

4.0 Discussion of Hydraulic Impacts from HEC-RAS Modelling.

The assessment of filling has been undertaken by placing obstructions to flow at X-sections 10 & 11.

The creek centre line distance between the sections is 90.5 metres.

The subject property has a frontage length of 72.52 metres which represents the maximum length of filling between the cross sections.

The construction of the building platform has the effects of increasing the 1% flood level at the immediate upstream cross section X11 by a maximum of approximately 20 millimetres.

The 1% flood level will be increased upstream by this amount of 20mm to at Cross section X12 (45.3 main stream length).

At Cross section X13 (immediately downstream of Argyle street bridge0 the 1% flood level is increased by 10mm.

Upstream of the bridge crossing flood level remain unchanged.

The change in flow characteristics is described by the change in flow velocities in the Left, Right Overbanks and the main channel. The numerical change in the order of the second decimal place and is considered negligible to nil.

With respect to changes in flood levels to the 5% AEP event (1 in 20 year ARI), levels through the site remain unaltered however an increase of 10mm will occur at section X12. Flood levels return to and remain unaffected from X13 and upstream. Flow characteristics across the stream are considered to be effectively unchanged.

5.0 Compliance with Stonequarry Creek FPMP Guidelines for development.

The Picton Flood Map indicates that the site has a small portion on the corner of Coull Street and Krananthorpe Lane is flood free whilst the majority of the boundary fronting Coull Street is located on 'Low Hazard Flood Fringe'.

The extent of the proposed filling is located in 'Low Hazard Floodway'.

The Picton Local Flood Policy Updated: May 2000 states in section 7.5 (Subdivision of land) states that "In general, subdivision of land within the extent of the designated Flood is not favoured by Council because of the likelihood of increasing the future potential dor flood damage. However, subdivision of land which is classified Flood Fringe me be permitted provide the applicant satisfies Council thet the proposed subdivision:

(a) Fully complies with all relevant provisions of this policy; and

(b) Contains permanent, maintenance-free and fail-safe provisions for the evacuation such as continuously rising roads linking with high ground.

(c) Does not incorporate proposals for high-risk land uses such as hospitals, nursing homes or aged accommodation."

Items (a) & (b) are easily satisfied. Flood free access onto Could street will be provided by the proposed filling. The proposed us of the land is residential not including the listed high risk uses.

In section 7.3 Low Hazard Floodways< Council describes these that "contain flow paths where a significant volume of water flows during floods. In considering applications for development in these areas Council requires that the development be designed to maintain the operation of these flow paths."

Items (i) to (vii) are too be satisfied.

(i) "*New developments may be permitted provided adequate information is provided to Council by a competent engineer indicating that the proposed development will be unlikely to significantly increase the 5% AEP and 1% AEP flood levels of peak flood flow velocities on adjacent properties and that the proposed building can withstand the likely conditions experienced during the designated Flood without suffering significant damage.*"

The flow rate in the ROB for the 1% AEP in section X10 and X11 for the existing case are 106.6 and 42.8 cusecs respectively.

Filling reduces flows to 88.6 and 43.6 cusecs respectively.

Approximately 18 cusecs are redirected from section X10 and 0.8 cusecs are increased to X11. This represents 3.6 of the total flows across the section which is considered not significant.

At section X10 the flows are redirected to the main channel, increasing velocities by 0.08 metres per second. This increase is considered in significant.

At section X11, computer calculations indicate that flows in the ROB will be increased by 0.38 cusecs with is considered negligible.

The increased impacts on section X11 are insignificant.

The area affected is to be filled to a level of the flood level or at the level of the flood plus 0.5m freeboard.

The above assessment has shown that flood levels will be increased by approximately 20mm and 10mm for the for the 1% and 5% AEP events respectively.

These increases in flood levels are considered insignificant and the associated velocity increases are negligible.

For the 1% AEP event, the average velocities for the ROB for the existing case are 0.92 and 0.52 m/sec for cross sections X10 and X11 respectively. The proposed filling increases velocities to 0.99 and 0.54 m/sec respectively.

These velocities represent average velocities and the boundary velocities at the embankment will be significantly lesser approaching zero.

(ii) "*Any portion of a building or structure subject to inundation should be constructed of flood compatible (flood damage resistant) materials.*"

Buildings will be located above flood level on the fill platform and the platform will resist erosive effects.

(iii) "*In the Residential 2(a) zone the floor level of any development shall be erected at least 0.5 m above the Designated Flood Level and Council shall require the submission of a surveyor's certificate on forming up of the structure certifying that the level of the floor is not less than the required floor level.*"

Noted and can be complied with.

(iv) "*In the Commercial* ...."
Not applicable.

(v) "Minor extensions ...."
Not applicable.

(vi) "*Filling will only be permitted if compensatory works such as excavated floodways re provided to ensure that there is no adverse effect on flood levels."*
Council's flood maps has defined that area of the majority of filling as 'Low Hazard Floodway'

For reasons outlined in Section 6 above the subject area is not considered 'Low Hazard Floodway' but 'High' and 'Low Hazard Flood Fringe'.

Compliance with this requirement is now considered not applicable.

(vii) "*Fencing must comply with Council's guidelines for the erection of fencing.*" Noted and can be complied with.

6.0 Summary & Recommendations:

It is considered that the proposed extent of filling is achievable and it is considered that it will have has a negligible effect on flood levels.

Filling of the site at the downstream boundary (X10) for a width of 25 metres will result in a depth of fill of 1.15m approximately and 1.65m if filled to the freeboard level.

Filling at the upstream boundary (X11) will be approximately 10m wide to a depth of approximately 0.65m to flood level.

The main issue will be Council adopting my assessment that the site is located in a flood category described as 'High Hazard Flood Fringe' as distinct Council's current categorisation of 'Low Hazard Floodway'.

Under Council's categorisation and policy, compensatory excavation is to be to be undertaken. This requires that excavation will need to be undertaken adjacent to the fill and towards the creek, so that there are no adverse effects on flood levels.

The Area of fill is approximately 18 square metres at downstream X10 and 3 square metres at upstream X11.

As you do not own or have access to the parcel of land below the site compensatory excavation are not really possible.

If you are able to undertake compensatory excavations then reaching an agreement with Council will be easier.

Changing Council's flood category to negate the compensatory excavation requirements will be difficult but this has occurred on another site. The initial report on that site was commenced in 2005 and is now only likely to be approved in the immediate near future.

To finalise the report on this site you will need to obtain site specific survey to determine the required extent/depth of fill.

This assessment assumes filling from sections X10 to X11 and is considered a conservative. The actual filling may only be 75% of the length between sections. To include additional sections into the flood model, cross sectional stadia survey will need to be undertaken on both sides of the creek.

I trust this information is satisfactory.

Sincerely

Gary Murphy

Director

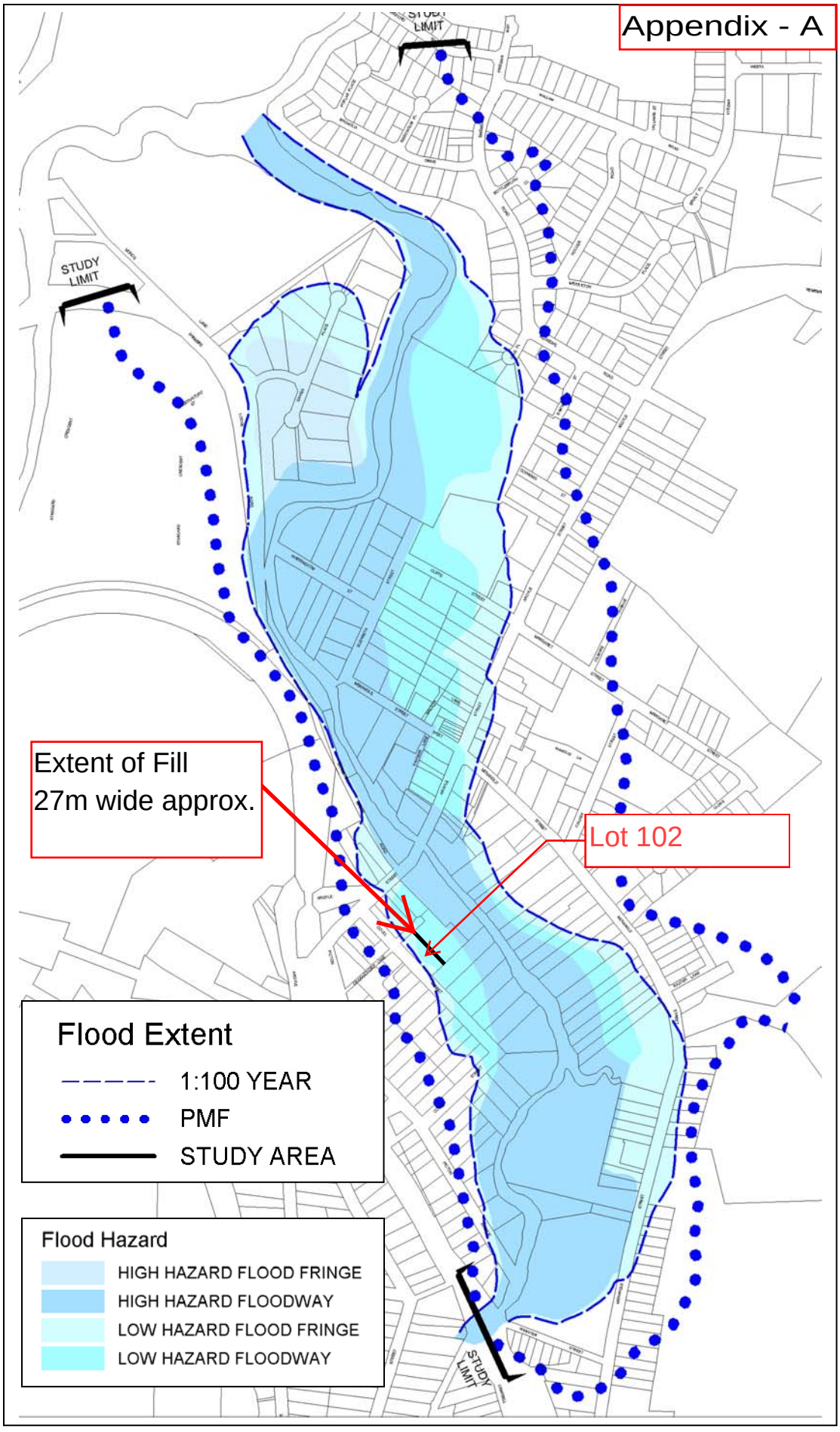
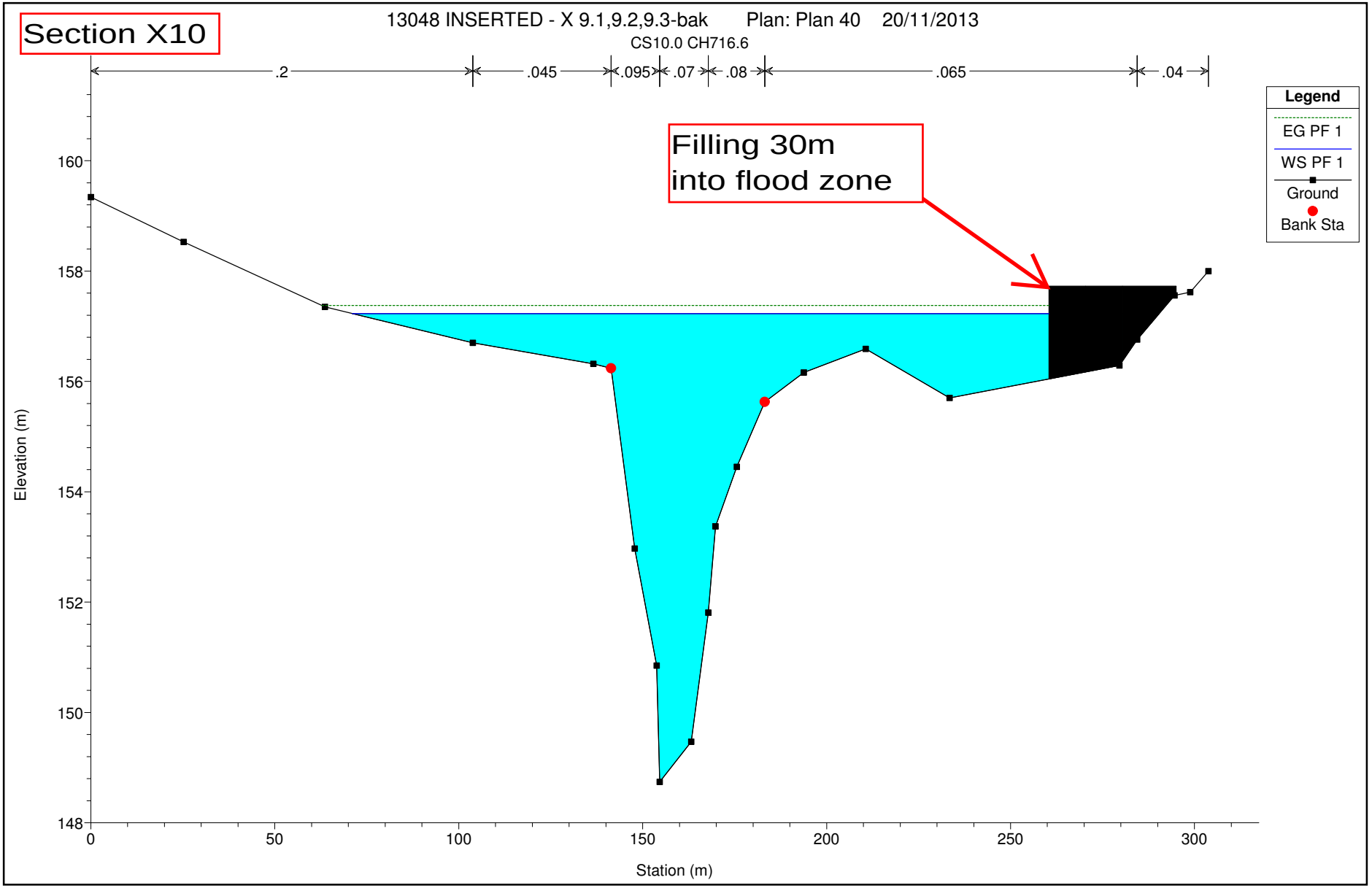


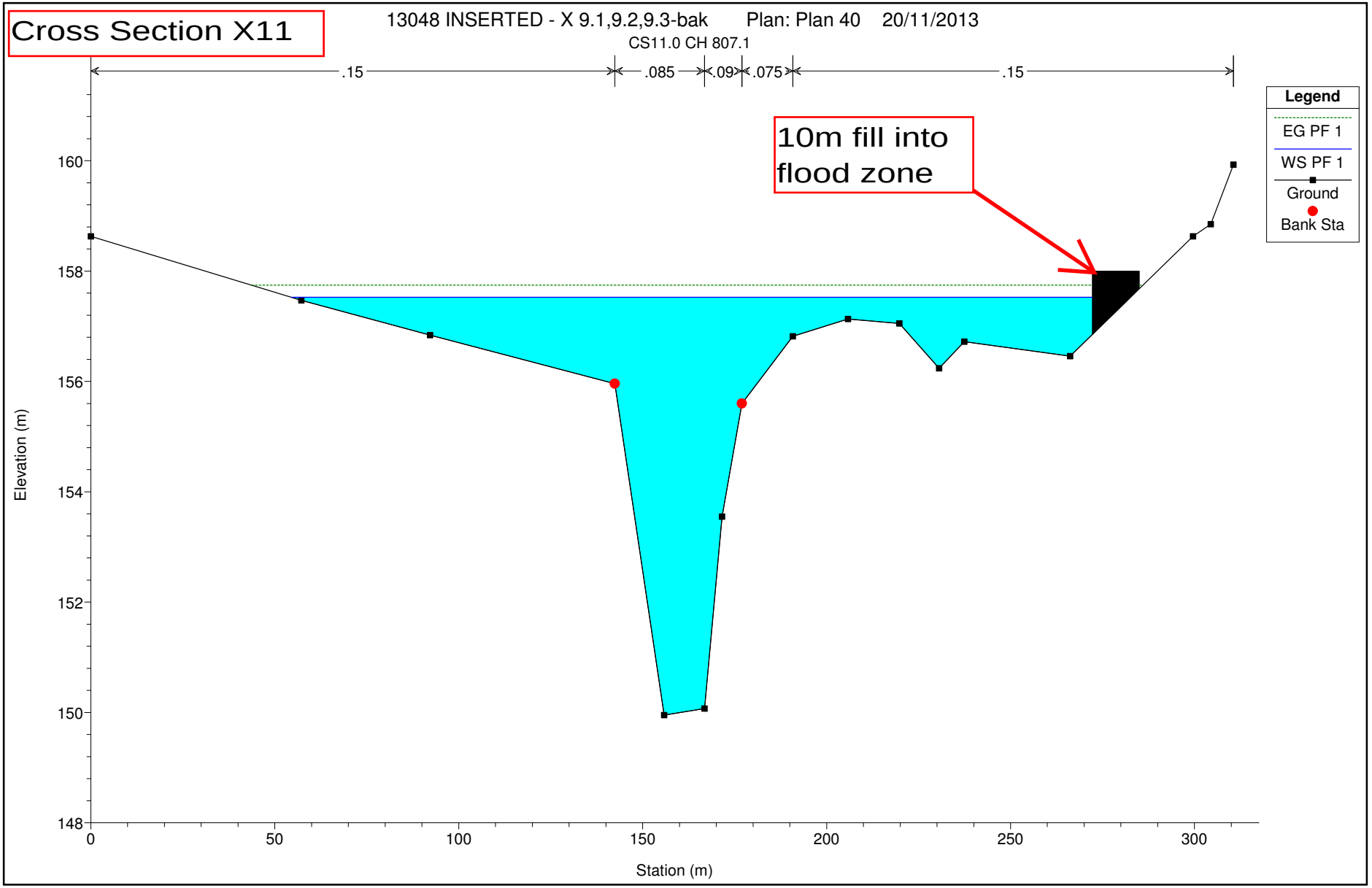
Figure 1: **Flood Extent and Hazard in Picton & Site Location**

Figure 2



1 cm Horiz. = 15 m 1 cm Vert. = 1 m

Figure 3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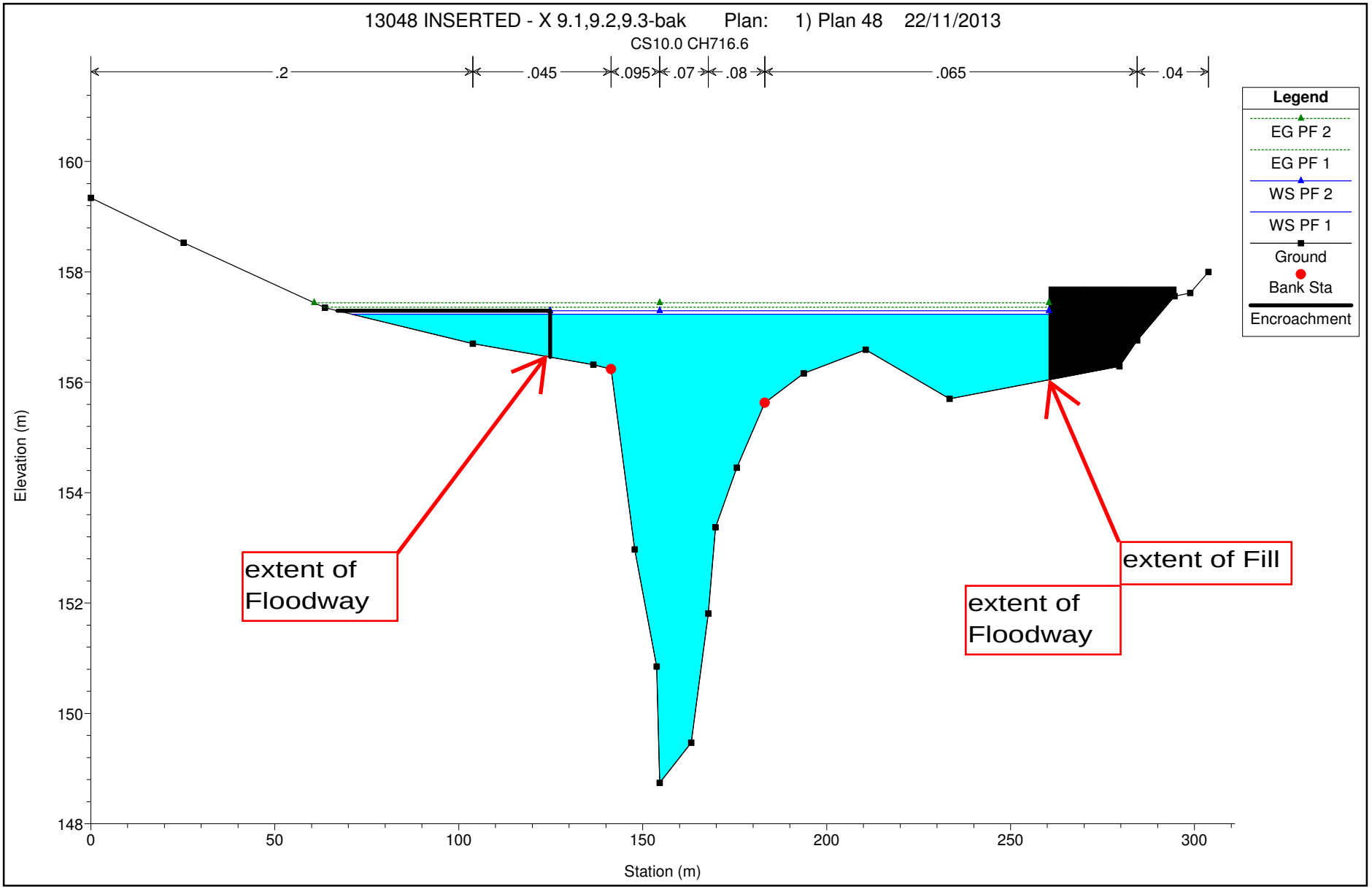
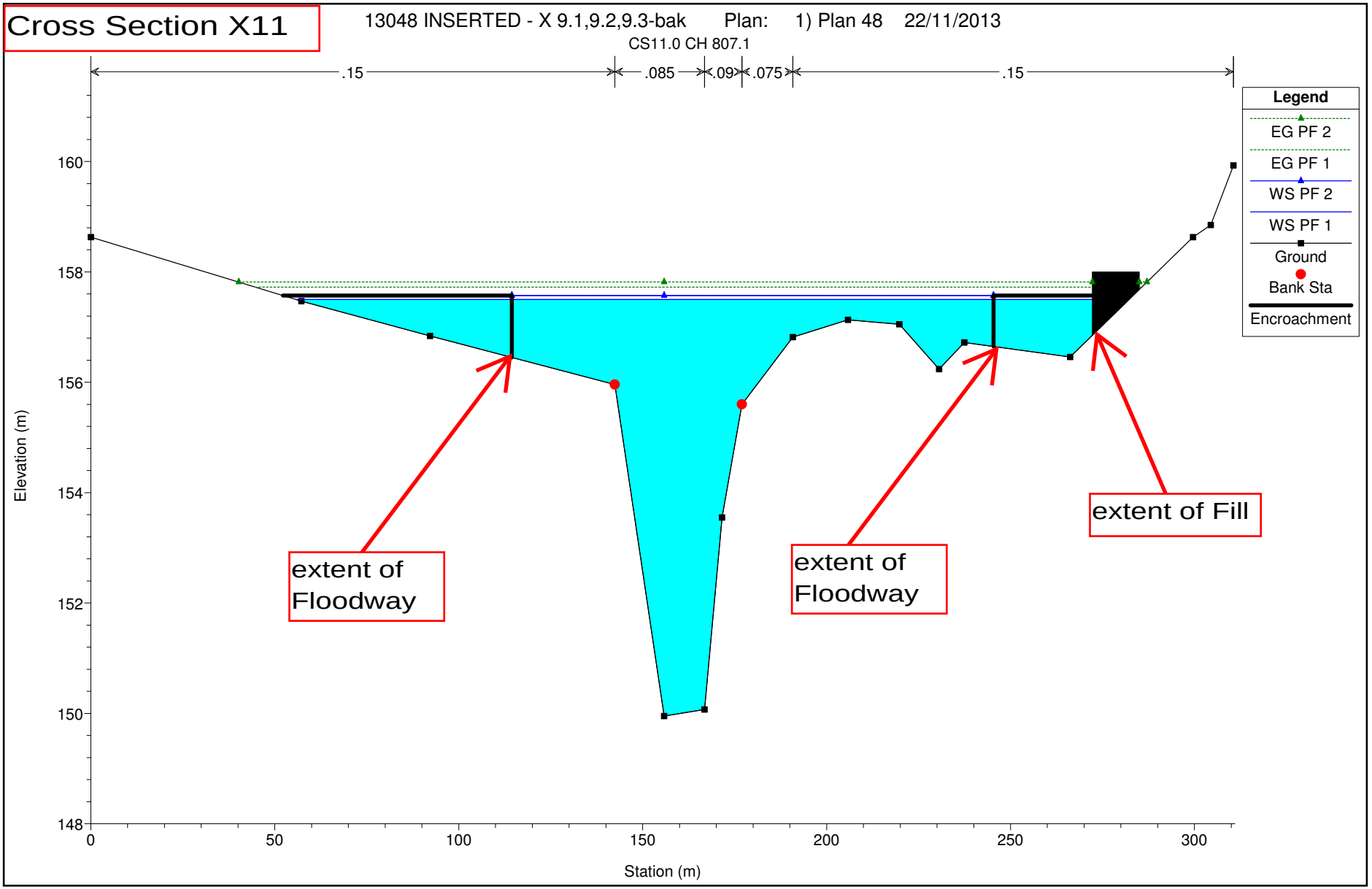
CS11.0 CH 807.1
.15
.085
.09
.075
.15
10m fill into flood zone
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (m)
160
158
156
154
152
150
148
0
50
100
150
200
250
300
Station (m)
1 cm Horiz. = 15 m 1 cm Vert. = 1 m

Figure 4



1 cm Horiz. = 15 m 1 cm Vert. = 1 m

Figure 5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.085
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Legend
EG PF 2
EG PF 1
WS PF 2
WS PF 1
Ground
Bank Sta
Encroachment
Elevation (m)
160
158
156
154
152
150
148
0
50
100
150
200
250
300
Station (m)
extent of Floodway
extent of Floodway
extent of Fill
1 cm Horiz. = 15 m 1 cm Vert. = 1 m

Figure 6 - 1% AEP Flow Characteristics - Existing Channel Conditions

HEC-RAS Plan: Plan 35 River: RIVER-1 Reach: Reach-1 Profile: PF 1

Reach	River Sta	Profile	W.S. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Vel Left	Vel Chnl	Vel Right	Vel Total	Area Left	Area Channel	Area Right	Area
			(m)	(m)	(m3/s)	(m3/s)	(m3/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m2)	(m2)	(m2)	(m2)
Reach-1	26	PF 1	162.39	63.76		157.00			0.97		0.97		161.22		161.22
Reach-1	25	PF 1	162.29	228.45	9.56	141.12	6.33	0.55	0.68	0.20	0.61	17.38	208.43	32.08	257.89
Reach-1	24	PF 1	162.22	275.12	19.59	128.25	9.16	0.37	0.57	0.19	0.48	52.89	225.41	48.10	326.40
Reach-1	23	PF 1	161.55	362.32	1.62	423.53	68.85	0.67	1.94	0.64	1.50	2.42	218.28	108.13	328.84
Reach-1	22	PF 1	160.50	259.45		440.85	53.15		1.93	0.67	1.61		228.33	78.85	307.19
Reach-1	21	PF 1	159.85	341.38		320.74	173.26		1.13	0.89	1.03		283.73	193.70	477.43
Reach-1	20	PF 1	159.60	440.84	34.63	210.07	249.29	0.33	1.05	0.79	0.80	104.24	200.22	316.34	620.80
Reach-1	19	PF 1	159.31	341.52	62.01	303.88	128.11	0.69	1.35	0.60	0.94	89.70	224.41	213.06	527.17
Reach-1	18	PF 1	158.86	454.04	153.63	310.35	30.02	0.54	1.67	0.89	0.98	283.96	185.63	33.64	503.23
Reach-1	17	PF 1	158.63	409.67	229.74	238.47	25.79	0.50	1.17	0.93	0.71	462.05	203.46	27.71	693.23
Reach-1	16	PF 1	158.51	340.82	312.96	181.04		0.73	1.29		0.87	426.52	140.05		566.58
Reach-1	15	PF 1	158.27	451.82	189.00	287.85	17.15	0.35	1.47	0.38	0.63	537.70	195.45	45.16	778.31
Reach-1	14	PF 1	158.20	483.45	88.75	327.32	77.92	0.27	1.44	0.78	0.75	334.35	227.19	99.95	661.49
Reach-1	13.5 BR U	PF 1	158.16	471.19	98.63	225.94	169.43	0.31	1.41	1.79	0.86	319.34	159.71	94.81	573.86
Reach-1	13.5 BR D	PF 1	158.00	443.91	110.80	339.54	43.66	0.39	2.04	0.60	0.95	281.38	166.15	73.00	520.53
Reach-1	13	PF 1	158.01	444.54	78.01	400.23	15.76	0.28	1.69	0.21	0.83	283.24	236.85	75.01	595.09
Reach-1	12	PF 1	157.74	327.92	80.34	362.15	51.51	0.56	2.39	0.44	1.20	142.59	151.54	117.50	411.63
Reach-1	11	PF 1	157.50	226.46	29.00	422.16	42.84	0.43	2.27	0.52	1.47	67.28	186.38	82.08	335.74
Reach-1	10	PF 1	157.23	219.51	29.73	357.67	106.59	0.80	1.79	0.92	1.40	36.99	200.11	115.30	352.40
Reach-1	9	PF 1	157.10	305.21	88.42	234.84	170.74	0.54	1.12	0.73	0.81	164.94	210.06	232.78	607.77
Reach-1	8	PF 1	156.98	355.34	83.45	235.69	174.86	0.56	1.06	0.83	0.85	149.79	223.37	210.73	583.88
Reach-1	7	PF 1	156.88	338.58	160.95	231.32	101.73	0.58	1.12	0.65	0.77	279.10	205.85	155.84	640.80
Reach-1	6	PF 1	156.79	298.39	239.89	241.44	12.67	0.69	1.02	0.66	0.82	347.73	237.73	19.09	604.54
Reach-1	5	PF 1	156.66	195.92	202.53	250.61	40.86	0.91	1.20	0.93	1.04	223.14	209.68	44.03	476.86
Reach-1	4	PF 1	156.27	54.87	6.56	417.95	69.49	0.80	2.40	1.78	2.23	8.15	174.35	39.06	221.56
Reach-1	3	PF 1	155.59	37.32		494.00			3.31		3.31		149.28		149.28
Reach-1	2	PF 1	155.10	33.97		494.00			3.74		3.74		132.02		132.02
Reach-1	1	PF 1	154.50	34.90		494.00			2.63		2.63		187.57		187.57

Figure 7 - 5% AEP Flow Characteristics - Existing Channel Conditions

HEC-RAS Plan: Plan 45 River: RIVER-1 Reach: Reach-1 Profile: PF 1

Reach	River Sta	Profile	W.S. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Vel Left	Vel Chnl	Vel Right	Vel Total	Area Left	Area Channel	Area Right	Area
			(m)	(m)	(m3/s)	(m3/s)	(m3/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m2)	(m2)	(m2)	(m2)
Reach-1	26	PF 1	161.78	34.53		109.00			0.82		0.82		133.22		133.22
Reach-1	25	PF 1	161.71	61.69	0.35	108.65		0.22	0.61		0.60	1.56	178.65		180.21
Reach-1	24	PF 1	161.65	118.50	4.18	104.82		0.27	0.55		0.53	15.43	190.77		206.20
Reach-1	23	PF 1	160.98	76.59		344.86	0.14		1.83	0.13	1.82		188.60	1.06	189.65
Reach-1	22	PF 1	160.06	155.58		344.25	0.75		1.66	0.14	1.62		207.75	5.26	213.01
Reach-1	21	PF 1	159.45	241.67		266.42	78.58		1.05	0.74	0.96		253.40	105.93	359.33
Reach-1	20	PF 1	159.18	399.67	9.41	184.33	151.26	0.21	1.03	0.68	0.77	44.36	179.02	222.18	445.56
Reach-1	19	PF 1	158.90	293.59	25.76	252.34	66.90	0.51	1.23	0.48	0.87	50.97	204.73	140.50	396.21
Reach-1	18	PF 1	158.36	367.16	38.48	293.71	12.81	0.35	1.80	0.70	1.18	111.23	163.27	18.41	292.91
Reach-1	17	PF 1	158.15	359.75	130.04	200.90	14.06	0.43	1.09	0.73	0.68	303.23	184.21	19.31	506.75
Reach-1	16	PF 1	158.02	291.03	180.14	164.86		0.63	1.30		0.84	284.52	127.30		411.82
Reach-1	15	PF 1	157.76	436.24	99.59	241.40	4.01	0.28	1.35	0.26	0.62	359.72	178.35	15.44	553.51
Reach-1	14	PF 1	157.70	373.32	36.58	270.22	38.19	0.20	1.30	0.63	0.77	180.12	207.64	60.69	448.46
Reach-1	13.5 BR U	PF 1	157.65	361.54	46.46	206.19	92.34	0.28	1.48	1.68	0.95	166.54	139.73	55.09	361.36
Reach-1	13.5 BR D	PF 1	157.42	321.76	39.28	293.91	11.81	0.32	2.06	0.43	1.18	123.57	142.58	27.24	293.40
Reach-1	13	PF 1	157.44	326.65	23.75	317.18	4.06	0.19	1.48	0.14	0.93	127.08	213.69	29.81	370.59
Reach-1	12	PF 1	157.13	214.57	27.50	303.75	13.75	0.47	2.26	0.29	1.44	58.77	134.55	47.09	240.41
Reach-1	11	PF 1	156.94	161.91	7.44	327.01	10.55	0.27	1.96	0.37	1.55	27.22	166.92	28.47	222.62
Reach-1	10	PF 1	156.63	173.16	2.67	308.75	33.57	0.46	1.77	0.63	1.48	5.81	174.93	52.99	233.73
Reach-1	9	PF 1	156.47	271.41	45.64	202.66	96.70	0.47	1.12	0.66	0.81	97.55	181.36	146.28	425.20
Reach-1	8	PF 1	156.30	250.85	41.10	214.85	89.05	0.59	1.13	0.75	0.91	69.76	190.15	119.24	379.15
Reach-1	7	PF 1	156.15	321.50	58.74	229.81	56.44	0.48	1.28	0.60	0.87	122.27	179.90	94.56	396.73
Reach-1	6	PF 1	156.00	273.68	95.43	244.95	4.63	0.58	1.21	0.57	0.92	163.19	202.43	8.16	373.77
Reach-1	5	PF 1	155.78	180.48	88.63	241.78	14.60	0.78	1.36	0.73	1.11	113.02	178.33	19.89	311.25
Reach-1	4	PF 1	155.49	46.58	1.18	307.41	36.41	0.47	2.01	1.37	1.89	2.53	153.27	26.64	182.44
Reach-1	3	PF 1	155.04	33.52		345.00			2.66		2.66		129.82		129.82
Reach-1	2	PF 1	154.81	32.51		345.00			2.82		2.82		122.46		122.46
Reach-1	1	PF 1	154.50	34.90		345.00			1.84		1.84		187.57		187.57

Figure 8 - 1% AEP Flow Characteristics - Fill between X10 & X11

HEC-RAS Plan: Plan 35 River: RIVER-1 Reach: Reach-1 Profile: PF 1

Reach	River Sta	Profile	W.S. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Vel Left	Vel Chnl	Vel Right	Vel Total	Area Left	Area Channel	Area Right	Area
			(m)	(m)	(m3/s)	(m3/s)	(m3/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m2)	(m2)	(m2)	(m2)
Reach-1	26	PF 1	162.39	63.76		157.00			0.97		0.97		161.22		161.22
Reach-1	25	PF 1	162.29	228.45	9.56	141.12	6.33	0.55	0.68	0.20	0.61	17.38	208.43	32.08	257.89
Reach-1	24	PF 1	162.22	275.12	19.59	128.25	9.16	0.37	0.57	0.19	0.48	52.89	225.41	48.10	326.40
Reach-1	23	PF 1	161.55	362.32	1.62	423.53	68.85	0.67	1.94	0.64	1.50	2.42	218.29	108.13	328.84
Reach-1	22	PF 1	160.50	259.46		440.85	53.15		1.93	0.67	1.61		228.34	78.86	307.20
Reach-1	21	PF 1	159.85	341.43		320.70	173.30		1.13	0.89	1.03		283.75	193.77	477.52
Reach-1	20	PF 1	159.60	440.88	34.66	210.03	249.32	0.33	1.05	0.79	0.80	104.30	200.24	316.44	620.99
Reach-1	19	PF 1	159.32	341.60	62.05	303.79	128.15	0.69	1.35	0.60	0.94	89.77	224.45	213.19	527.41
Reach-1	18	PF 1	158.86	454.32	154.09	309.84	30.06	0.54	1.67	0.89	0.98	284.88	185.75	33.73	504.36
Reach-1	17	PF 1	158.64	409.67	230.02	238.16	25.82	0.50	1.17	0.93	0.71	463.29	203.60	27.78	694.67
Reach-1	16	PF 1	158.52	341.32	313.35	180.65		0.73	1.29		0.87	427.88	140.16		568.05
Reach-1	15	PF 1	158.28	452.59	189.47	287.24	17.29	0.35	1.47	0.38	0.63	539.94	195.66	45.55	781.15
Reach-1	14	PF 1	158.21	487.45	89.25	326.56	78.19	0.26	1.44	0.78	0.74	336.87	227.47	100.52	664.86
Reach-1	13.5 BR U	PF 1	158.16	472.83	99.06	225.14	169.80	0.31	1.41	1.78	0.86	321.97	160.00	95.42	577.40
Reach-1	13.5 BR D	PF 1	158.02	445.11	111.69	338.19	44.12	0.39	2.03	0.60	0.94	284.85	166.59	73.96	525.41
Reach-1	13	PF 1	158.02	445.72	78.87	399.18	15.95	0.28	1.68	0.21	0.82	286.64	237.28	75.95	599.87
Reach-1	12	PF 1	157.76	329.23	82.15	359.33	52.52	0.56	2.36	0.44	1.18	146.37	152.12	120.00	418.49
Reach-1	11	PF 1	157.52	217.67	29.95	420.42	43.63	0.43	2.25	0.54	1.46	69.41	187.23	81.17	337.81
Reach-1	10	PF 1	157.23	189.31	30.95	374.48	88.57	0.84	1.87	0.99	1.51	36.78	199.99	89.81	326.59
Reach-1	9	PF 1	157.10	305.21	88.42	234.84	170.74	0.54	1.12	0.73	0.81	164.94	210.06	232.78	607.77
Reach-1	8	PF 1	156.98	355.34	83.45	235.69	174.86	0.56	1.06	0.83	0.85	149.79	223.37	210.73	583.88
Reach-1	7	PF 1	156.88	338.58	160.95	231.32	101.73	0.58	1.12	0.65	0.77	279.10	205.85	155.84	640.80
Reach-1	6	PF 1	156.79	298.39	239.89	241.44	12.67	0.69	1.02	0.66	0.82	347.73	237.73	19.09	604.54
Reach-1	5	PF 1	156.66	195.92	202.53	250.61	40.86	0.91	1.20	0.93	1.04	223.14	209.68	44.03	476.86
Reach-1	4	PF 1	156.27	54.87	6.56	417.95	69.49	0.80	2.40	1.78	2.23	8.15	174.35	39.06	221.56
Reach-1	3	PF 1	155.59	37.32		494.00			3.31		3.31		149.28		149.28
Reach-1	2	PF 1	155.10	33.97		494.00			3.74		3.74		132.02		132.02
Reach-1	1	PF 1	154.50	34.90		494.00			2.63		2.63		187.57		187.57

Figure 9 - 5% AEP Flow Characteristics - Fill between X10 & X11

HEC-RAS Plan: Plan 45 River: RIVER-1 Reach: Reach-1 Profile: PF 1

Reach	River Sta	Profile	W.S. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Vel Left	Vel Chnl	Vel Right	Vel Total	Area Left	Area Channel	Area Right	Area
			(m)	(m)	(m3/s)	(m3/s)	(m3/s)	(m/s)	(m/s)	(m/s)	(m/s)	(m2)	(m2)	(m2)	(m2)
Reach-1	26	PF 1	161.78	34.53		109.00			0.82		0.82		133.22		133.22
Reach-1	25	PF 1	161.71	61.69	0.35	108.65		0.22	0.61		0.60	1.56	178.66		180.21
Reach-1	24	PF 1	161.65	118.50	4.18	104.82		0.27	0.55		0.53	15.43	190.77		206.20
Reach-1	23	PF 1	160.98	76.60		344.86	0.14		1.83	0.13	1.82		188.60	1.06	189.66
Reach-1	22	PF 1	160.06	155.60		344.25	0.75		1.66	0.14	1.62		207.75	5.26	213.01
Reach-1	21	PF 1	159.45	241.69		266.41	78.59		1.05	0.74	0.96		253.41	105.94	359.35
Reach-1	20	PF 1	159.18	399.68	9.42	184.32	151.27	0.21	1.03	0.68	0.77	44.37	179.03	222.21	445.61
Reach-1	19	PF 1	158.90	293.62	25.77	252.32	66.91	0.51	1.23	0.48	0.87	50.99	204.74	140.54	396.27
Reach-1	18	PF 1	158.36	367.51	38.56	293.62	12.82	0.35	1.80	0.70	1.18	111.42	163.30	18.43	293.15
Reach-1	17	PF 1	158.15	359.85	130.11	200.83	14.07	0.43	1.09	0.73	0.68	303.49	184.25	19.33	507.07
Reach-1	16	PF 1	158.02	291.04	180.25	164.75		0.63	1.29		0.84	284.83	127.33		412.15
Reach-1	15	PF 1	157.77	436.41	99.73	241.23	4.04	0.28	1.35	0.26	0.62	360.35	178.41	15.54	554.29
Reach-1	14	PF 1	157.70	373.75	36.68	270.05	38.27	0.20	1.30	0.63	0.77	180.63	207.72	60.84	449.19
Reach-1	13.5 BR U	PF 1	157.65	362.04	46.57	205.93	92.50	0.28	1.47	1.67	0.95	167.10	139.81	55.26	362.17
Reach-1	13.5 BR D	PF 1	157.43	323.01	39.57	293.50	11.93	0.32	2.06	0.43	1.17	124.45	142.75	27.51	294.71
Reach-1	13	PF 1	157.44	327.85	23.94	316.95	4.10	0.19	1.48	0.14	0.93	127.94	213.85	30.08	371.87
Reach-1	12	PF 1	157.14	215.78	27.71	303.34	13.96	0.47	2.25	0.29	1.43	59.31	134.73	47.71	241.75
Reach-1	11	PF 1	156.94	161.47	7.60	326.62	10.78	0.27	1.95	0.37	1.54	27.65	167.19	28.95	223.79
Reach-1	10	PF 1	156.63	150.40	2.69	313.05	29.25	0.47	1.79	0.67	1.54	5.77	174.89	43.46	224.12
Reach-1	9	PF 1	156.47	271.41	45.64	202.66	96.70	0.47	1.12	0.66	0.81	97.55	181.36	146.28	425.20
Reach-1	8	PF 1	156.30	250.85	41.10	214.85	89.05	0.59	1.13	0.75	0.91	69.76	190.15	119.24	379.15
Reach-1	7	PF 1	156.15	321.50	58.74	229.81	56.44	0.48	1.28	0.60	0.87	122.27	179.90	94.56	396.73
Reach-1	6	PF 1	156.00	273.68	95.43	244.95	4.63	0.58	1.21	0.57	0.92	163.19	202.43	8.16	373.77
Reach-1	5	PF 1	155.78	180.48	88.63	241.78	14.60	0.78	1.36	0.73	1.11	113.02	178.33	19.89	311.25
Reach-1	4	PF 1	155.49	46.58	1.18	307.41	36.41	0.47	2.01	1.37	1.89	2.53	153.27	26.64	182.44
Reach-1	3	PF 1	155.04	33.52		345.00			2.66		2.66		129.82		129.82
Reach-1	2	PF 1	154.81	32.51		345.00			2.82		2.82		122.46		122.46
Reach-1	1	PF 1	154.50	34.90		345.00			1.84		1.84		187.57		187.57