

POTENTIAL RESIDENTIAL DEVELOPMENT,  
OAK MILLS, CLIFF HOLLINS LANE,  
OAKENSHAW, BRADFORD

FLOOD RISK ASSESSMENT  
ADDENDUM

*Prepared for*

FMB Investments Limited

February 2017  
Ref:116/02/OMFRA/ADD/0217

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<b>Document Revisions</b>		
Rev:	Details	Date
1		20/02/2017

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# POTENTIAL RESIDENTIAL DEVELOPMENT, OAK MILLS, CLIFF HOLLINS LANE, OAKENSHAW, BRADFORD

## FLOOD RISK ASSESSMENT ADDENDUM

*Prepared for*

**FMB Investments Limited**

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### **1. Introduction and background**

- 1.1 A Flood Risk Assessment (FRA) for proposed residential development on land at Oak Mills, Oakenshaw, Bradford was prepared by S M Foster Associates Limited in July 2016 (Ref: 116/01/fmb/fra/0716) to support an application for outline planning permission for the development. Following submission of the FRA comments were received from Kirklees Council and the Environment Agency with a request for further information. Meetings were held with both organisations (Kirklees Council 21<sup>st</sup> November 2016; Environment Agency 23<sup>rd</sup> September 2016). The issues raised by each organisation are as follows:

#### Kirklees Council

- (i) Further detail of the proposed surface water drainage strategy, including exceedance routes should be provided;
- (ii) Confirmation required of existing site drainage any current discharge to receptors other than Hunsworth Beck;
- (iii) Climate change allowance to be increased to 30%; and
- (iv) Further consideration of historic flood events.

#### Environment Agency

- (i) Provide a drawing to show all proposed flood risk mitigation works;
- (ii) Provide additional hydraulic modelling results to confirm and justify proposed finished floor levels at the site;
- (iii) Provide a drawing to indicate the configuration of the proposed new bridge in relation to modelled flood levels;
- (iv) Provide further details of proposed surface water management strategy for the site, including management of excess flow from Cliff Hollins Lane; and
- (v) Provide further details related to historic flooding in the area.

- 1.2 This FRA Addendum has been prepared to provide all the additional information requested by Kirklees Council and the Environment Agency. This Addendum should be considered as supplementary to the original FRA as only information related to the specific request for additional information is contained in the Addendum. The requested information is primarily related to proposals for surface water management at the site and definition/justification for the proposed flood risk mitigation measures at the site. This Addendum has therefore been structured accordingly. The Addendum is supported by additional drawings and datasets as necessary to respond fully to all issues raised.

## 2. Flood mitigation scheme

- 2.1 Flood risk at the site has been investigated through preparation of a detailed hydraulic model for the site and surrounding area. Full details of the model, modelling programme and results are included in the FRA.
- 2.2 Modelling studies have demonstrated that the primary source of flood risk at the site is out of bank flow from the Hunsworth Beck at the existing culvert across the site. The culvert has inadequate capacity to convey the 1 in 100 year flood flow in the beck. The proposed development includes provision for removal of the culvert and minor reprofiling of beck banks to increase the capacity of the watercourse through the site. Removal of the culvert and channel reprofiling are intended to fully mitigate fluvial flood risk at the site. It is noted that, at the request of the Environment Agency, flood risk modelling has been undertaken with all existing walls and buildings removed to avoid reliance on informal flood defence structures.
- 2.3 Whilst the proposed flood mitigation works are designed to mitigate risk of the site flooding from Hunsworth Beck, it will be necessary to raise ground levels at the site to achieve a finished floor level (FFL) that provides an adequate freeboard above predicted flood level. In summary therefore, flood mitigation and flood protection measures proposed for the development are as follows.
- (i) Removal of the existing site culvert and replacement with a raised deck bridge;
  - (ii) Reprofiling of Hunsworth Beck banks to increase on-site hydraulic capacity in the beck channel; and
  - (iii) Raising site levels to achieve FFL's with an acceptable standard of protection.

The proposed mitigation works are shown on Drawing 116/02/A1

### **Culvert removal and channel reprofiling**

- 2.4 Hydraulic modelling results included in the FRA (Drawing 116/01/04 and associated tables) demonstrated that with the culvert in place the eastern side of the site is at risk of flooding during a 1 in 100 year flood event. The FRA included model results for the proposed mitigation scheme i.e. culvert removed and banks reprofiled, and demonstrated that the proposed measures would ensure that the 1 in 100 year and the 1 in 1,000 year flood flow would remain in-bank through the site with no adverse impact on water levels upstream or downstream of the site. In this context the proposed flood mitigation works would remove the site fully from Flood Zones 2 and 3 and support a change to the current Environment Agency flood zone designation.
- 2.5 The FRA modelling work did not include allowance for climate change in flood flow prediction as the objective was to produce a present day flood extents map. Climate change was accounted for in the FRA in discussion of FFL's (FRA Section 6) and by noting that the 1 in 1,000 year flood flow, which remained in-bank, represented a 23% increase over the 1 in 100 year flood flow and therefore was representative of a 20% climate change allowance. Since the original FRA modelling work was undertaken, new Government guidance<sup>1</sup> on climate change has provided updated information on appropriate climate change allowances

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<sup>1</sup> Environment Agency. 2016. Flood risk assessment: climate change allowances. 19<sup>th</sup> February 2016.

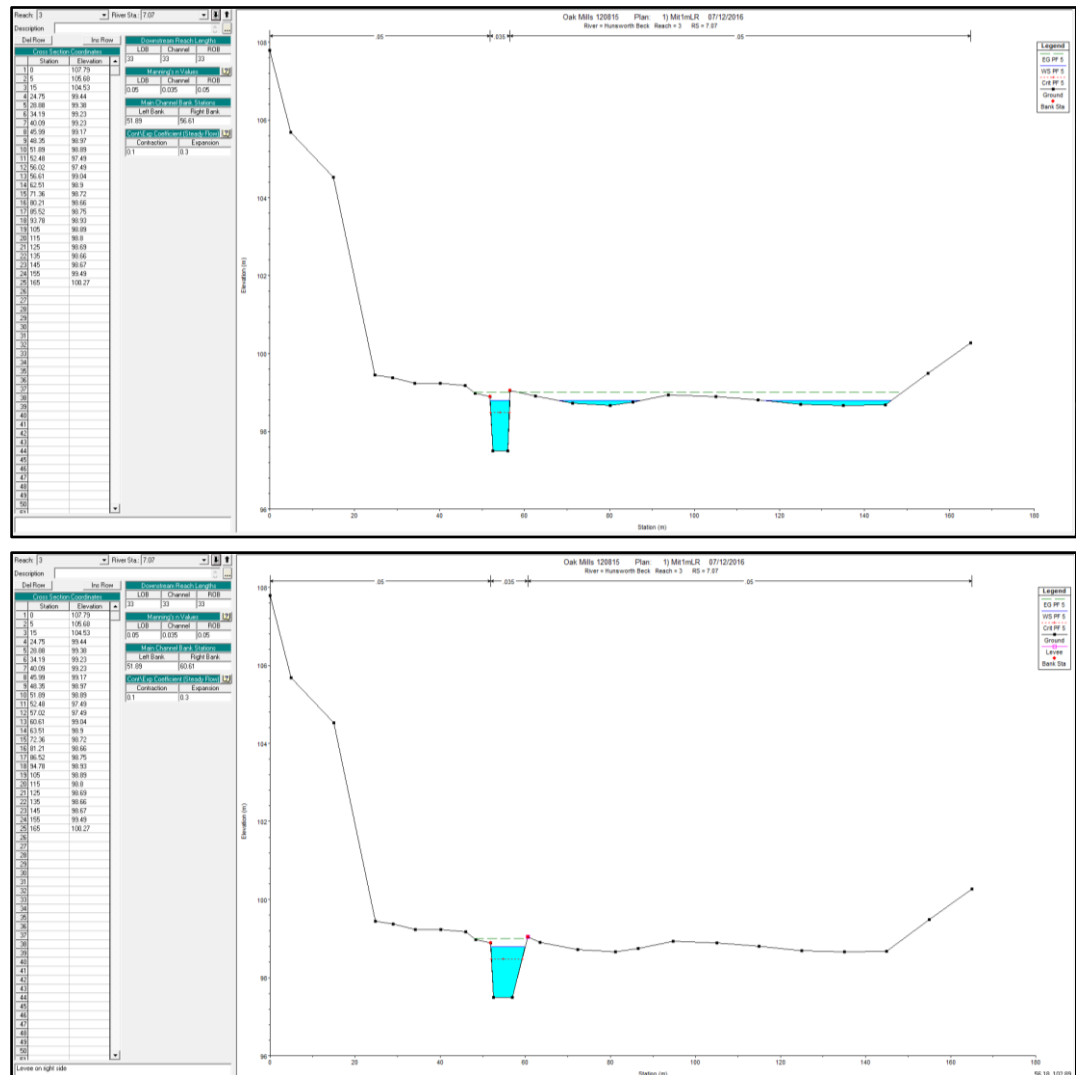
for incorporation in flood risk assessment. For sites designated Flood Zone 3a, the highest current designation at the site, the appropriate allowance for 'more vulnerable' development is 30% with a requirement to undertake sensitivity analysis with an allowance of up to 50%. In practice, the proposed flood mitigation works would lead to re-designation of the site as Flood Zone 1. However, it is considered appropriate to update flood risk assessment to accommodate a 30% increase in flood flow as the basis for consideration of flood protection measures and to undertake sensitivity analysis with a 50% increase in flood flow to confirm that such a change would not lead to an unacceptable increase in development flood risk.

2.6 As indicated at Section 6 of the FRA, the hydraulic model has been developed as follows to represent the proposed flood mitigation measures.

- (i) The existing culvert deck between model sections 7.08 and 7.07 removed; and
- (ii) Right bank of Hunsworth Beck realigned by widening the channel bed by 1m and grading banks to 3m from bank foot to improve stability.

All other aspects of the hydraulic model geometry remain unchanged. A graphical indication of the changes in the model is presented for example section 7.07 as Figure A1 below. Full model sections for the mitigation scheme are included at Appendix AA of this Addendum.

**Figure A1: Channel section 7.07 showing channel profile changes for flood mitigation**



- 2.7 Flood flows used in the model have been increased to account for climate change allowances at both 30% and 50%. Modelled flood flows are presented in Table A1 below.

**Table A1: Modelled flood flows (mitigation scheme)**

	1:100 year (m <sup>3</sup> /sec)	1:100 year + 30% (m <sup>3</sup> /sec)	1:100 year + 50% (m <sup>3</sup> /sec)
Toad Holes Beck	1.09	1.417	1.635
Hunsworth Beck	6.92	8.996	10.380
High Royds Beck	4.12	5.356	6.180
Cockleshaw Beck	1.01	1.313	1.515
Totals	13.14	17.082	19.71

- 2.8 Modelling results for the mitigation scheme, including climate change allowance, are presented graphically as Drawing 116/02/A2, with cross sections and tabular results at Appendix AA. The model confirms that, with current ground levels, the 1 in 100 year flood flow, including 30% allowance for climate change, would remain in-bank through and around the Oak Mills site. Predicted flood levels in the beck are shown on Drawing 116/02/02.
- 2.9 Predicted flood levels upstream and downstream of the site for the 1 in 100 year flood flow, following flood mitigation works at the site, are included in the FRA at Table 6. The analysis has been repeated for the 1 in 100 year + 30% climate change allowance with results presented as Table A2 below.

**Table A2: Predicted flood water levels pre and post mitigation (1:100yr + 30% flow)**

Model section	Location	Pre-development	Post development
11.0	Upstream HRB	99.98	99.98
10.0	Upstream HRB confluence	100.37	100.41
9.0	HRB confluence	100.37	100.42
8.7	Upstream CHL bridge	100.36	100.41
8.0	Downstream-CHL Bridge	99.63	98.57
7.12	Upstream boundary	99.28	99.26
7.11	Western site	99.45	99.43
7.10	Western site	99.43	98.90
7.9	Upstream channel	99.06	99.00
7.8	Culvert entry	99.18	98.95
7.7	Culvert exit	99.03	98.78
7.5	Central site	98.40	98.33
7.4	Central site	98.29	98.02
7.3	Eastern site	98.00	97.81
7.2	Downstream boundary	97.69	97.59
7	Downstream	97.08	97.08

- 2.10 As with the 1 in 100 year flood flow reported in the FRA, the model results for the 1 in 100 year + 30% climate change allowance indicates that the proposed mitigation works would have negligible impact on flood levels or extents upstream or downstream of the site but would reduce water levels by around 10-15cms through the site.

### **Ground raising**

- 2.11 The FRA confirms that FFL's for the development would be established at 600mm above the 1 in 100 year flood level plus allowance for climate change. With model flood level data for the 1 in 100 year + 30% flood flow, FFL's can be more accurately specified. With reference to the highest predicted flood level at the upstream end of the western and eastern sides of the site, FFL's can be specified as follows:

Western side – max flood level – 99.60; FFL – 100.20; Ground level – 99.90mAOD

Eastern side – max flood level – 98.95; FFL – 99.55; Ground level – 99.25mAOD

- 2.12 As confirmed in the FRA, ground raising within the site will have no adverse impact on upstream or downstream flood risk as the proposed mitigation works act to take the entire site out of Flood Zone 2 and 3.

### **Bridge configuration**

- 2.13 The existing culvert will be replaced by a new road deck to connect the two sides of the site. The road bridge will be established to ensure no obstruction of flood flow during the 1 in 100 year + 30% climate change conditions. The proposed bridge configuration is shown on Drawing 116/02/A3.

- 2.14 Predicted 1 in 100 year + 30% climate change flood level at the proposed bridge crossing is 98.86mAOD. Raised ground level to the west is expected to be approximately 99.90mAOD and expected ground level to the east will be 99.25mAOD. The minimum freeboard to flood water level is therefore 0.38m below ground level. As discussed in subsequent sections of this Addendum, the proposed surface water drainage scheme for the site includes provision for drainage across the beck in conjunction with the proposed bridge deck. With a requirement to allow a minimum 600mm depth to drain crown elevation it is apparent that ground level on the eastern side of the bridge will need to be established above the minimum elevation of 99.25mAOD referenced above. Ground level in this area will therefore be locally increased to 99.70mAOD as shown on Drawing 116/02/A3. Bridge soffit elevation will be above the 100 year + 30% climate change allowance elevation of 98.86mAOD.

### **Sensitivity analysis**

- 2.15 The hydraulic model has been further developed to incorporate the proposed new bridge and the ground raising. The model has been re-run to investigate flood flow response with climate change allowance at both 30% and 50%. The results are presented in full at Appendix AB. The model confirms that, following mitigation and ground raising works, flood flow under both climate change scenarios, would remain in-bank without risk of flooding of the site.
- 2.16 The information provided in Section 2 of this Addendum covers all the information requested at items (i), (ii) and (iii) of the Environment Agency request for additional information.

### 3. Surface water management scheme

- 3.1 The FRA confirms that the proposed development will be served by a Sustainable Drainage System (SUDS) designed in accordance with national and local SUDS policy & practice. The FRA confirms that all excess surface water generated from the site will be directed to a stormwater detention basin to be established at the eastern end of the site. The basin will discharge to Hunsworth Beck via a restricted outfall. The SUDS scheme for the site consists of the following components.
- (i) A northern perimeter swale to collect runoff from higher ground to the north with direct discharge to Hunsworth Beck;
  - (ii) Channel and kerb drains across the site entrance and along the proposed footpath on Cliff Hollins Lane to collect runoff from Cliff Hollins Lane and direct it to Hunsworth Beck;
  - (iii) Internal pipe drainage system to collect roof and road water from within the site and direct to the on-site detention basin;
  - (iv) Detention Basin established to attenuate surface water runoff rates to a maximum of existing runoff rates mins 30%; and
  - (v) New outfall to Hunsworth Beck at the eastern site boundary.

The proposed surface water drainage scheme is shown on Drawing 116/02/A4.

#### Conceptual design

- 3.2 Justification for the general SUDS approach and the intention to discharge excess surface water to Hunsworth Beck is included in the FRA and not repeated here.

#### *Northern swale*

- 3.3 At the north western boundary of the site ground levels rise steeply at the edge of a densely wooded area. Whilst not considered to be a major source of surface water there is potential for excess runoff from this area to drain onto the site. At present surface water from this area drains informally to Hunsworth Beck via a local valley and backwater. The proposed installation of a shallow swale at the foot of rising ground will provide greater control over drainage in this area whilst maintaining the natural flow of water to the beck.

#### *Site entrance and Cliff Hollins Lane*

- 3.4 Hydrological analysis has identified the potential for surface runoff from Cliff Hollins Lane to drain in a southerly direction towards the existing site entrance and a low point at the entry to Cliff Hollins Lane Bridge. At present excess surface water in this area drains informally to Hunsworth Beck via a breach in the bridge wall, with risk of excess surface water overflow onto the site via the existing south western access road.
- 3.5 Entry of surface water from Cliff Hollins Lane to the proposed development will be prevented by the installation of a gridded open channel drain across the site entrance. If necessary, this could be accompanied by a local rise entrance road level to increase containment. The existing south western access road will be removed and local kerb drainage systems will be

designed to intercept excess surface water in this area for direct conveyance to Hunsworth Beck.

- 3.6 It is proposed that the new footpath along the site frontage will be established with kerb drains that will allow containment and drainage of any surface water accumulating at the low point on Cliff Hollins Lane. The site entrance drain will connect to the kerb drainage system which will discharge to Hunsworth Beck by formalisation of the existing informal discharge through establishment of a new pipe outfall. The predicted 100 year + 30% climate change flood water level at this location is approximately 1m below ground level allowing adequate freeboard for a drainage outfall.
- 3.7 The presence of a positive drainage system in this area should improve local flood management and reduce surface water flood risk at Cliff Hollins Lane Bridge generally. The volume of surface water that would be discharged to Hunsworth Beck with the proposed drainage scheme is already fully accounted for in the hydraulic model, as Cliff Hollins Lane is within the catchment of the beck and the adjacent High Royds Beck, and therefore would not introduce any additional flood risk to modelled flood flows.

#### *Internal pipe drain*

- 3.8 The internal spine drain will consist of a subsurface pipe established at typical depth of 600-700mm as appropriate. The drain will be designed to accommodate all roof and road water from the site and to convey it to the eastern detention basin. Definition of the downstream outfall elevation, required detention basin freeboard and post development ground levels has allowed confirmation that it should be possible to drain the site at acceptable gradients, typically 1:100, across the site. An indication of the potential drainage invert levels is shown on Drawing 116/01/A4 to confirm scheme feasibility.
- 3.9 The drain will have to cross Hunsworth Beck via the proposed new bridge structure. As discussed above, ground levels at the site can be engineered to allow adequate depth for installation of drains within or at the side of the bridge at the required depth.
- 3.10 Although not shown on Drawing 116/02/A4, there is potential for the inclusion of filter trenches along the proposed parking areas. Filter trenches would provide a second level of water treatment, in addition to settlement in the detention basin, and would be connected to the main spine drain. There is also scope for use of permeable surfacing in parking and turning areas, although with adequate space for a detention basin there may be no advantage to provision of additional storage beneath permeable surfaces.

#### *Detention Basin*

- 3.11 The detention basin will consist of a shallow landscaped depression at the eastern end of the site. The area will be surfaced with grass cover and will be dry for the majority of the time. During rainfall events the site stormwater drainage system will discharge to the basin from where there will be discharge to Hunsworth Beck. As discussed in subsequent sections of this Addendum, the basin is required to provide storage capacity of up to 155m<sup>3</sup>. This will need to be achieved with a maximum water depth of 1m, indicating a basin area of approximately 155m<sup>2</sup>.

- 3.12 The basin outfall will have restricted capacity in order to achieve the requirement for a 30% reduction in the current peak rate of surface water discharge from the site. This will be achieved by installation of a restricted capacity outfall pipe or installation of a hydrobrake, or similar flow control structure.

*Outfall to Hunsworth Beck*

- 3.13 The new outfall to Hunsworth Beck will consist of an outfall pipe established in a concrete headwall and apron in accordance with current local authority/Environment Agency guidance. It is proposed that the outfall is established with an invert level above the 1 in 25 year modelled flood level, including 30% allowance for climate change. The outfall will be equipped with a non-return flap valve and therefore during more extreme flooding in the river the outfall would be submerged and ineffective and excess surface water would be temporarily stored within the detention basin.

**Hydrological design basis**

- 3.14 The FRA includes baseline information related to greenfield runoff rates at the site and potential post-development runoff rates. As the site layout/design has been updated since preparation of the FRA, hydrological analysis has been updated and included in the following sections of this Addendum which supersedes paras 6.18 - 6.27 of the FRA.

- 3.15 Following consultation response, and subsequent discussion with Kirklees Council it has been confirmed that the site drainage system should aim to achieve a 30% reduction in peak runoff rate when compared to the current site configuration. Climate change allowance must be included in post development rainfall runoff analysis.

- 3.16 Kirklees Council has confirmed that analysis of existing site runoff rates should not include areas of hardstanding that are not positively drainage. Areas of the site that drain to other receptors than Hunsworth Beck should also be excluded. Reference to the site topographic survey, included with the FRA, confirms that the eastern and south western areas of the site are 'unsurfaced' i.e. surfaced with compacted hardcore with no positive drainage system. The central and north western areas of the site are surfaced with asphalt and concrete and are positively drained to Hunsworth beck via outfalls in the beck channel.

- 3.17 Yorkshire Water has been consulted to establish whether there are any public sewers serving the site. A copy of the local sewer plan is attached at Appendix AC. The plan confirms that the site is not served by any sewer system. It is therefore assumed that all surface water drainage from the site is directed to Hunsworth Beck, but that only positively drained areas should be included in existing runoff calculations.

- 3.18 The impermeable areas of the existing site are therefore as follows:

Building roof area – 1,095m<sup>2</sup>

Positively drained hardstanding – 1,650m<sup>2</sup>

**Total impermeable area – 2,745m<sup>2</sup>**

- 3.19 The impermeable area of the proposed development is as follows:

Building roof area – 900m<sup>2</sup>  
 Parking areas – 370m<sup>2</sup>  
 Roads and turning areas – 1,170m<sup>2</sup>  
**Total impermeable area – 2,440**

- 3.20 As reported in the FRA, the proposed development will result in a net reduction in the total impermeable area of the site. The reduction is approximately 12%. Although there will be reduction in impermeable area the requirement to take account of climate change and to achieve a net 30% reduction in the current discharge rate creates a requirement for on-site stormwater attenuation capacity i.e. the detention basin.
- 3.21 Kirklees Council has advised that the allowable discharge rate from the site should be restricted to the current QBAR discharge rate, minus 30%, and should not be increased for lower frequency, higher magnitude storm events. Analysis undertaken in the FRA indicates that the critical storm duration for the site is 2 hours. The 2 year 2 hr rainfall depth for the site is 14.5mm. Application of the Rational Method results in a predicted peak runoff rate for the site in its current configuration of 5.6l/s. If reduced by 30% this would become approximately 4.0l/s. It is therefore concluded that the allowable off-site discharge rate should be restricted to 4.0l/s for all storm events.
- 3.22 Post development peak runoff rate has been calculated by the same procedure for the impermeable areas referred to above. Peak runoff rates for a range of storm frequencies, including a 30% allowance for climate change, are provided in Table A3.

**Table A3: Post-development peak runoff rates (2-hr duration)**

Storm frequency (yrs)	Peak runoff (l/s)	Peak runoff incl. 30% cc allowance (l/s)	Total runoff volume
QBAR	5.0	6.5	46.8
30	11.7	15.2	109.4
100	16.5	21.5	154.8

- 3.23 In accordance with current local and national guidance, as stated in the FRA, the SUDS drainage scheme for the site is designed to ensure off-site discharge of surface water is restricted to 4l/s for storm events up to the 1 in 100 year event, including 30% allowance for climate change. On this basis, the on-site storage requirement is approximately 125m<sup>3</sup>.
- 3.24 As noted above, high water level in Hunsworth Beck could lead to submergence of the proposed detention basin outfall and hence loss of outflow from the site. The detention pond should therefore have capacity to store all water generated during the design storm event. Without off-site discharge the required storage capacity would be approximately 155m<sup>3</sup>.
- 3.25 The FRA includes a calculation of the current greenfield runoff rate for the site, assuming no previous development. The calculated rate is 1.6l/s. It is noted that to limit off-site discharge to the greenfield rate for the site, the preferred objective of current Government guidance, would require on-site storage capacity of approximately 145m<sup>3</sup>. This is lower than the 'no-discharge' capacity calculated above. Given the land area available at the eastern end of the site it is considered that the proposed SUDS scheme has the capacity to reduce off-site

runoff rates to pre-development greenfield rates. A proposed detention pond capacity of 155m<sup>3</sup> is therefore specified.

- 3.26 In accordance with current policy and practice, the site drainage systems will be designed to accommodate surface water generated from a 1 in 30 year storm event. During more extreme events, any excess surface water would be retained on-site, within boundary kerbs or by overland flow to the detention pond, without risk to properties. For storm events of magnitude greater than 1 in 100 years, additional surface water would tend to drain down topographic gradient to the eastern end of the site and the detention basin area without risk of flooding of properties.
- 3.27 The information contained in Section 3 of this Addendum covers all the information requested by Kirklees Council items (i), (ii) and (iii) and the Environment Agency item (iv).

#### 4. Evidence of historic flooding

- 4.1 As detailed in the FRA a search for historic flood data for the site included reference to the following:
- (i) EA Historic Flood Map
  - (ii) Local Authority SFRA
  - (iii) Internet historic flooding search.

No evidence has been identified to indicate that the Oak Mills site has suffered from historic flooding. Anecdotal evidence from the current occupants of the site suggests that, whilst there is no history of fluvial flooding, the site may have experienced inflow of surface water from Cliff Hollins Lane in the past. There are no records to support this view.

- 4.2 Kirklees Council has provided photographic evidence to confirm that land immediately upstream of Cliff Hollins Lane Bridge, outside the site boundary, has flooded in the recent past. Reference to the hydraulic modelling results presented in the FRA confirms that the extent of historic flooding upstream of the site is entirely consistent with model results which indicate risk of fluvial flooding in the same area. It is therefore apparent that risk of upstream flooding has been fully accounted for in the hydraulic modelling work that supports the FRA.
- 4.3 As discussed at section 3 of this Addendum, the proposed sustainable drainage scheme for the site will include provision for positive drainage of surface water from Cliff Hollins Lane to prevent overland flow onto the site. Modelling studies have confirmed that this can be achieved with no adverse impact on flood risk at the site or in the surrounding area.
- 4.4 The information included in Section 4 of this Addendum covers all the information requested by Kirklees Council at item (v) and the Environment Agency at item (v).

For S M Foster Associates Limited



Stephen M Foster

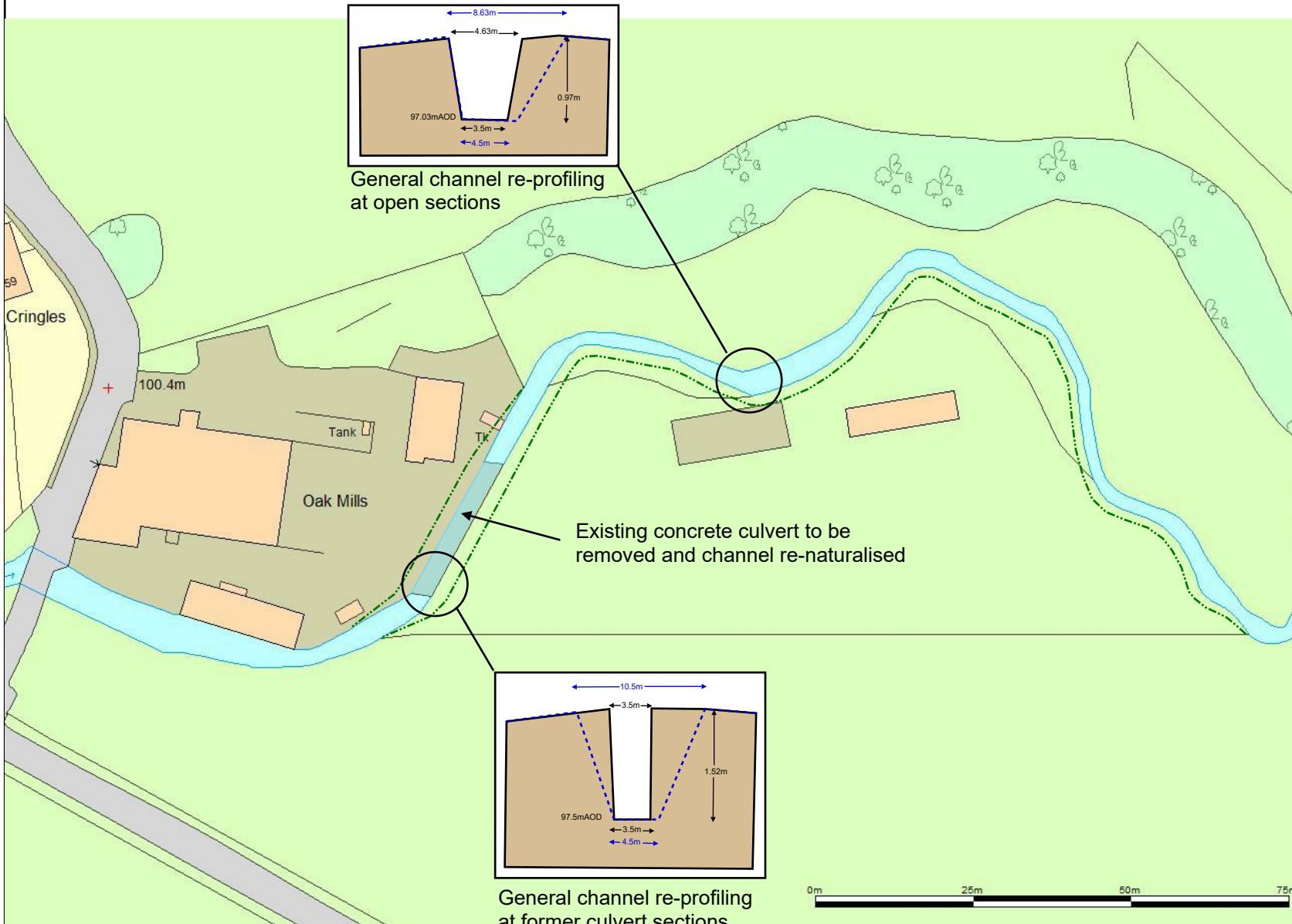
BSc MSc CGEOL MCIWEM CSi CEnv FIQ

**Principal Consultant**

## Drawings

**NOTES:**

Hunsworth Beck channel to be widened at base by 1m on southern side and right bank re-graded at approximately 1:2 with new bank top approximately 3m from bank foot. Central culvert to be removed and both banks re-profiled to re-naturalise the channel with both banks graded at approximately 1:2. No change to channel bed elevation throughout.



..... Approximate location of bank top

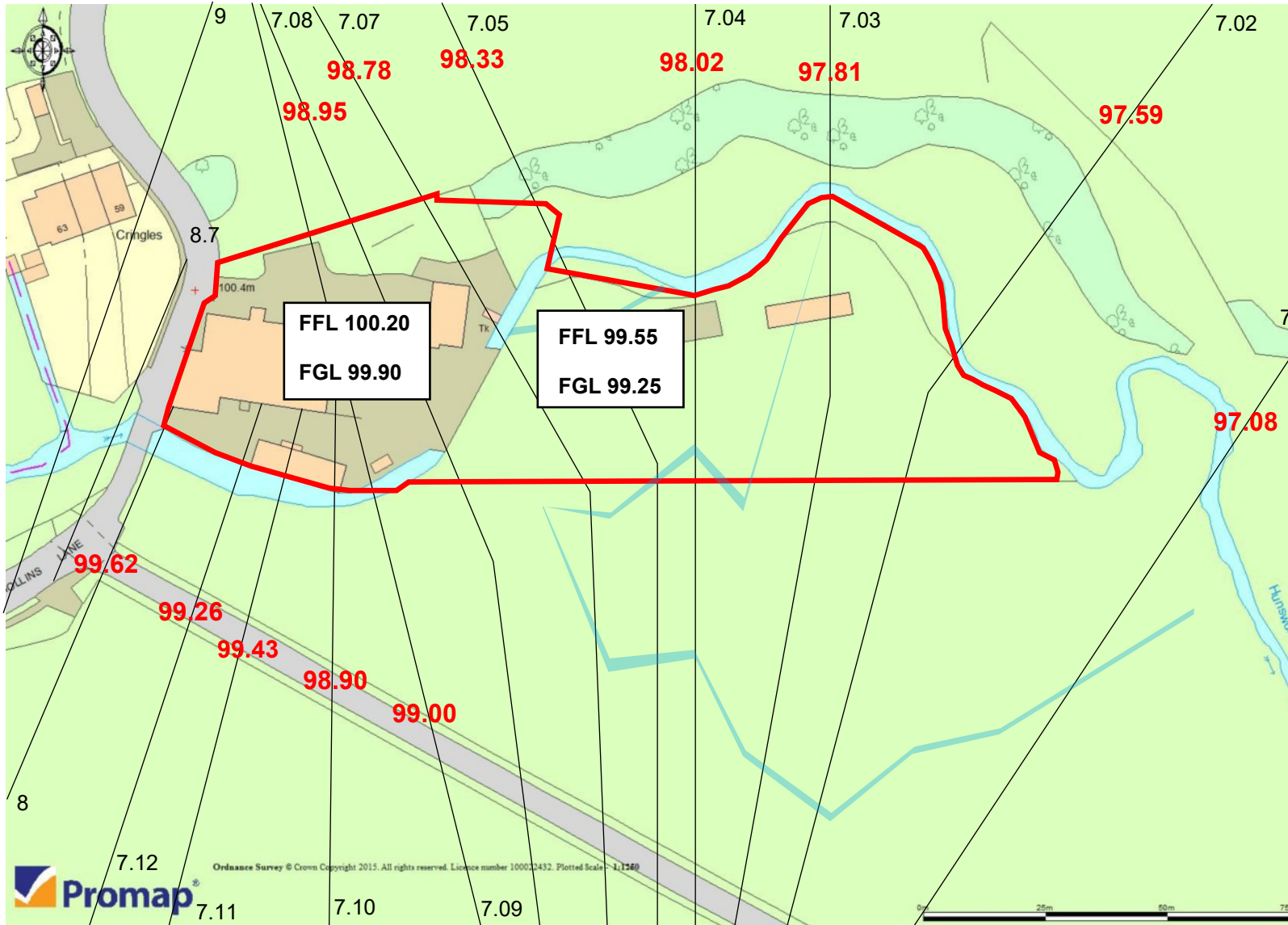
**CLIENT:**  
FMB Investments Limited

**PROJECT:**  
LAND OFF CLIFF HOLLINS LANE  
OAKENSHAW  
FLOOD RISK ASSESSMENT

Ref: 116/02/11/1015 Date: February 2017

Approved: smf Scale: as indicated

**DRAWING 116/02/A1**  
**PROPOSED CHANNEL**  
**RE-PROFILING WORKS**



— Section line

□ Approximate site boundary

**99.08** Modelled flood level  
100yr + 30% cc

**CLIENT:**  
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**PROJECT:**  
LAND OFF CLIFF HOLLINS LANE  
OAKENSHAW

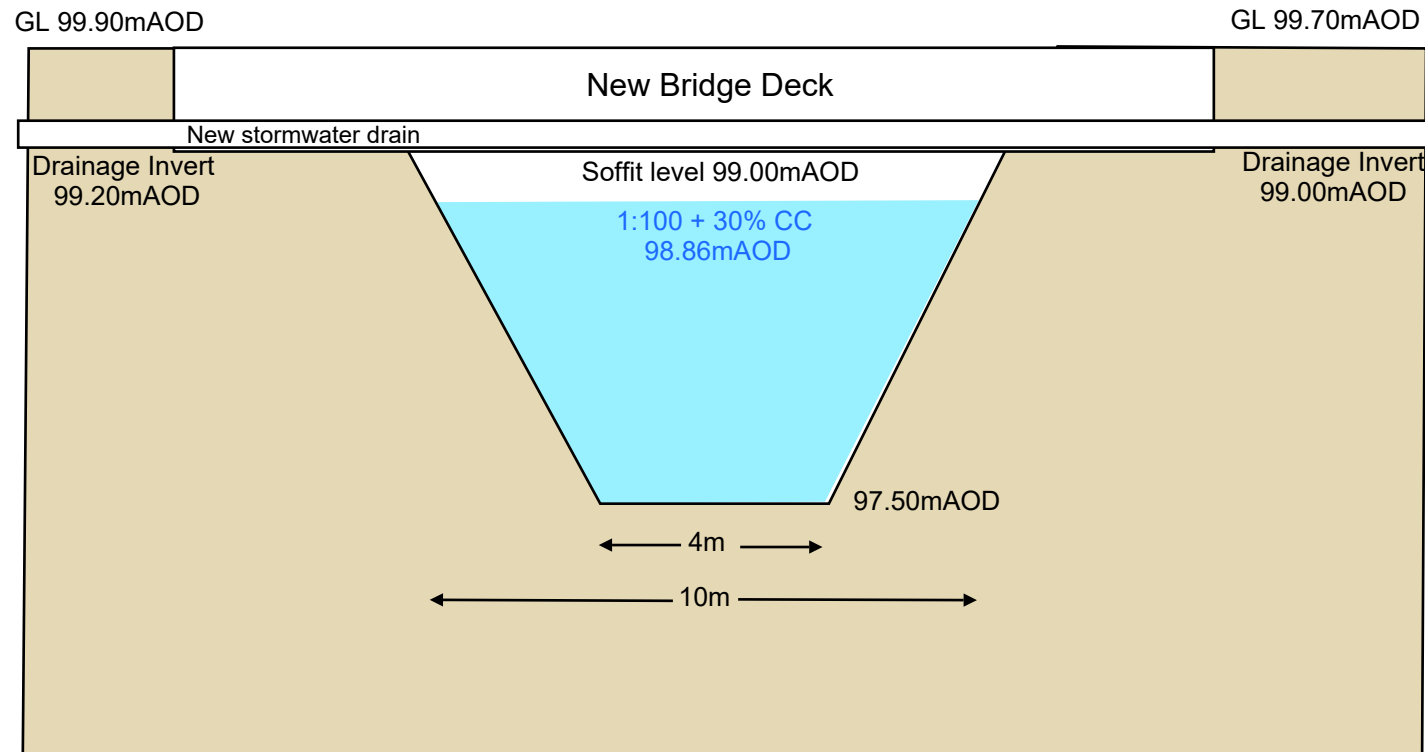
FLOOD RISK ASSESSMENT  
HYDRAULIC MODELLING

Ref: 116/02/11/0217 Date: February 2017

Approved: smf Scale: as indicated

**DRAWING 116/02/A2**  
**MODELLLED FLOOD LEVELS**

## INDICATIVE NEW BRIDGE CONFIGURATION IN RELATION TO DESIGN FLOOD LEVEL



Note: Drawing provided to show relationship between flood level and bridge elevations. This drawing should not be used for detailed design or construction purposes.

**CLIENT:**

FMB Investments Limited

**PROJECT:**

LAND OFF CLIFF HOLLINS LANE  
OAKENSHAW

FLOOD RISK ASSESSMENT

Ref: 116/02/11/1015

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Approved: smf

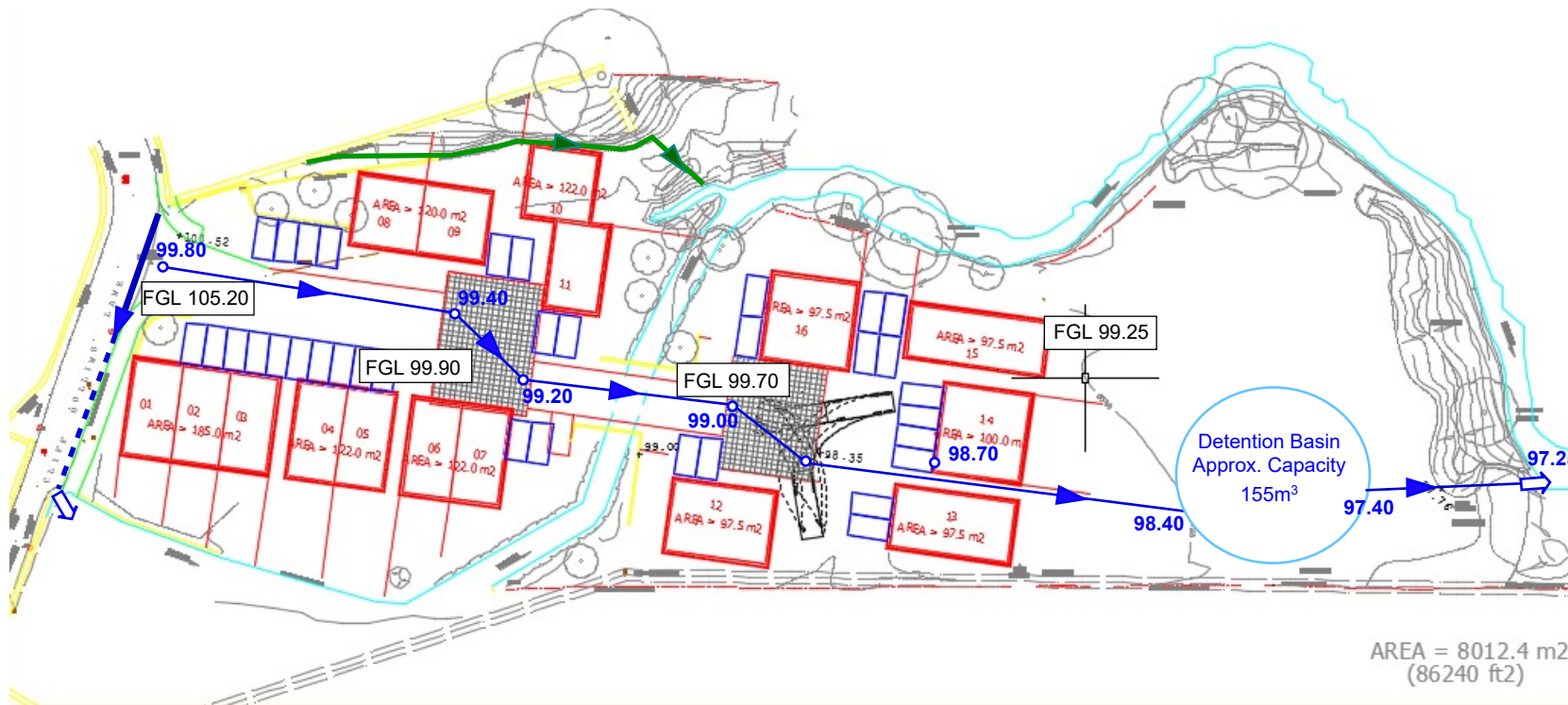
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**DRAWING 116/02/A3  
INDICATIVE BRIDGE  
CONFIGURATION**

**NOTES**

Design flood level derived from hydraulic model for 1:100 year flood flow including 30% allowance for climate change  
Bridge deck soffit level designed to accommodate stormwater drainage elevations. Alternative options for cross-beck drainage may allow reduction in deck depth.

- Pipe Drain
- Swale
- Gridded drainage channel
- - - Kerb drain
- ⇨ Drainage outfall
- 98.70 Drainage invert (AOD)
- FGL 99.25 Average finished ground elevation (mAOD)



**NOTES:**

1. Runoff from Cliff Hollins Lane prevented from entering site by gridded open drainage channel across site entrance and kerb drains along new footpath to direct water to formalised outfall to Hunsworth Beck.
2. Northern boundary swale to collect runoff from high ground to the north and convey to Hunsworth Beck
3. Surface water from roof and roads to be directed to central spine drain running west to east to eastern Detention Basing. Drain to be Routed along new bridge deck.
4. Drainage system to be specified at 1:30 year capacity. Excess surface water to 1:100 year storm event to be temporarily retained on-site.
5. Ground levels to be graded to ensure that surface water in excess of 1:100 year storm event directed away from properties to Hunsworth Beck and/or Detention Pond.

**CLIENT:**  
FMB Investments Limited

**PROJECT:**  
LAND OFF CLIFF HOLLINS LANE  
OAKENSHAW  
FLOOD RISK ASSESSMENT

Ref: 116/02/11/1015      Date: February 2017

Approved: smf      Scale: as indicated

**DRAWING 116/02/A4**  
**INDICATIVE SURFACE WATER**  
**DRAINAGE SCHEME**

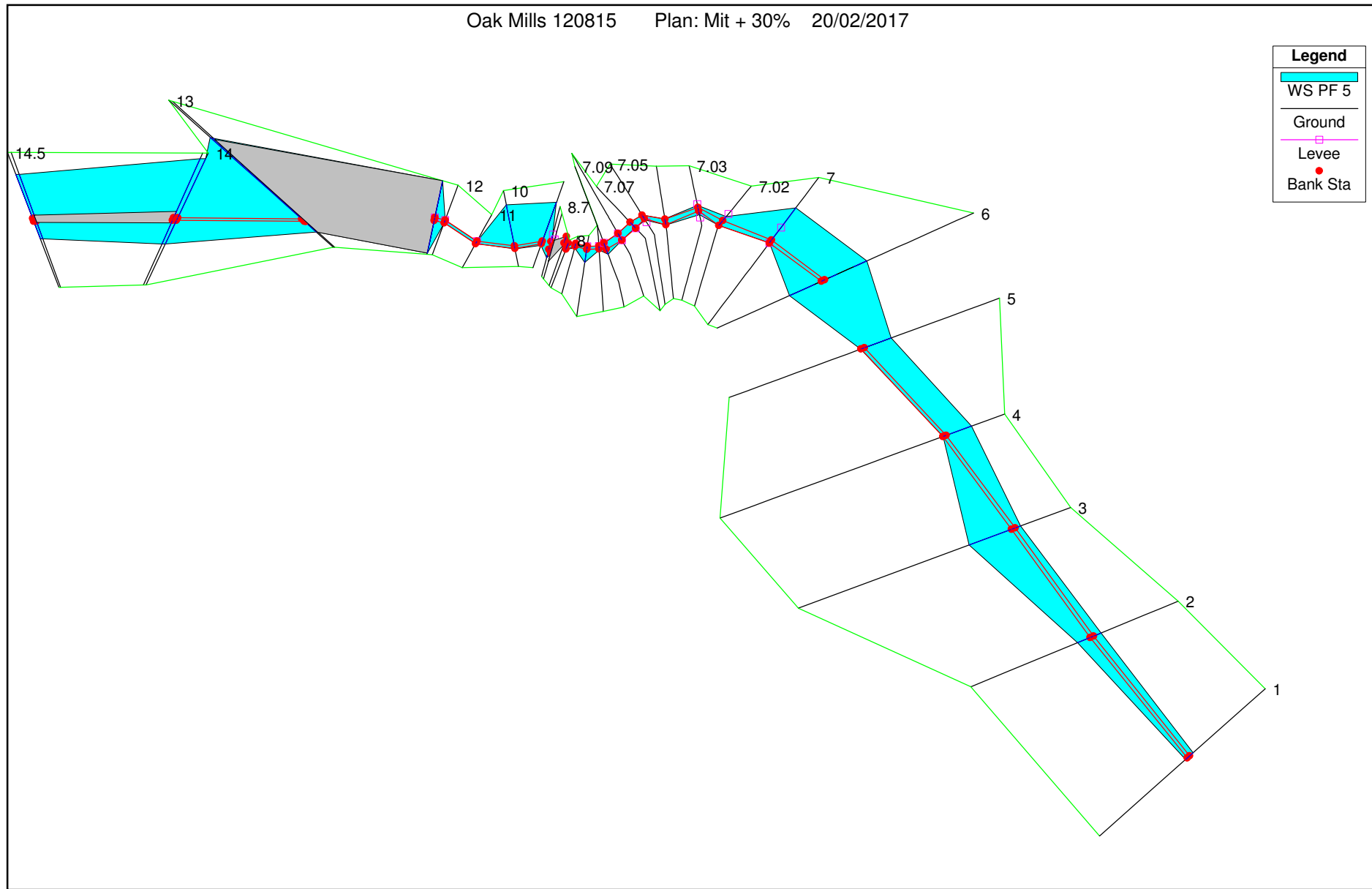
## Appendix AA

Model results – Channel re-profile with climate change allowance

Oak Mills 120815 Plan: Mit + 30% 20/02/2017

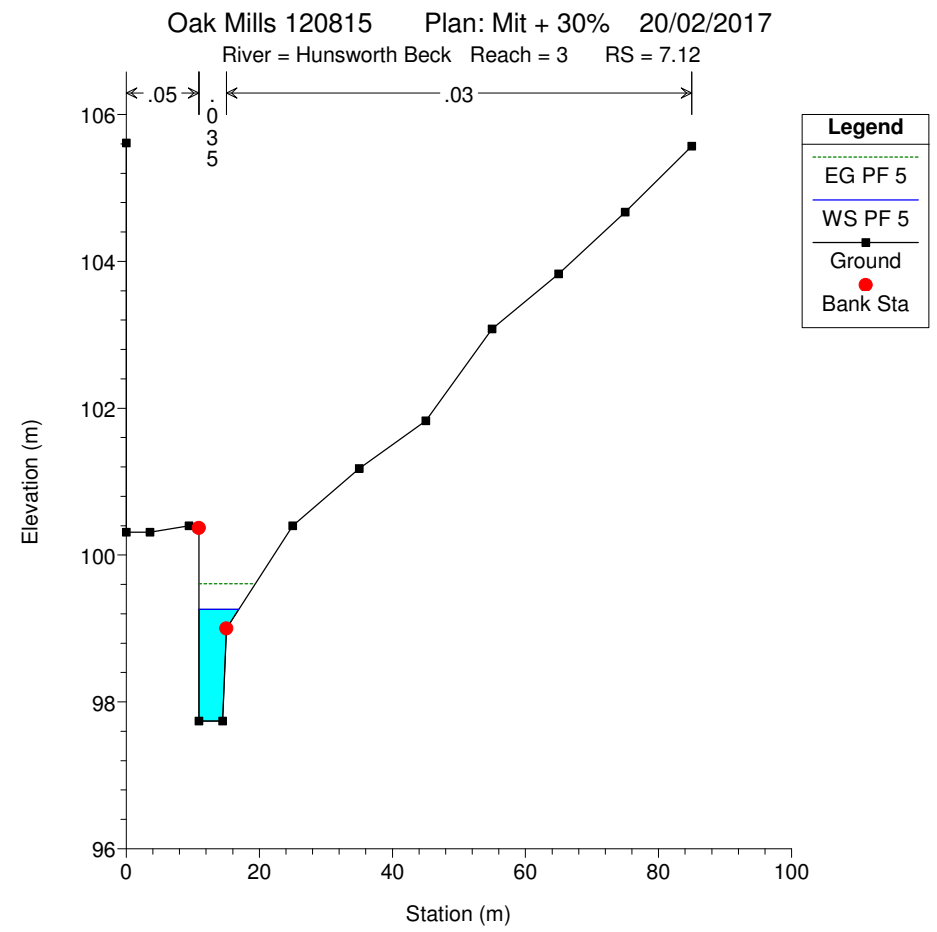
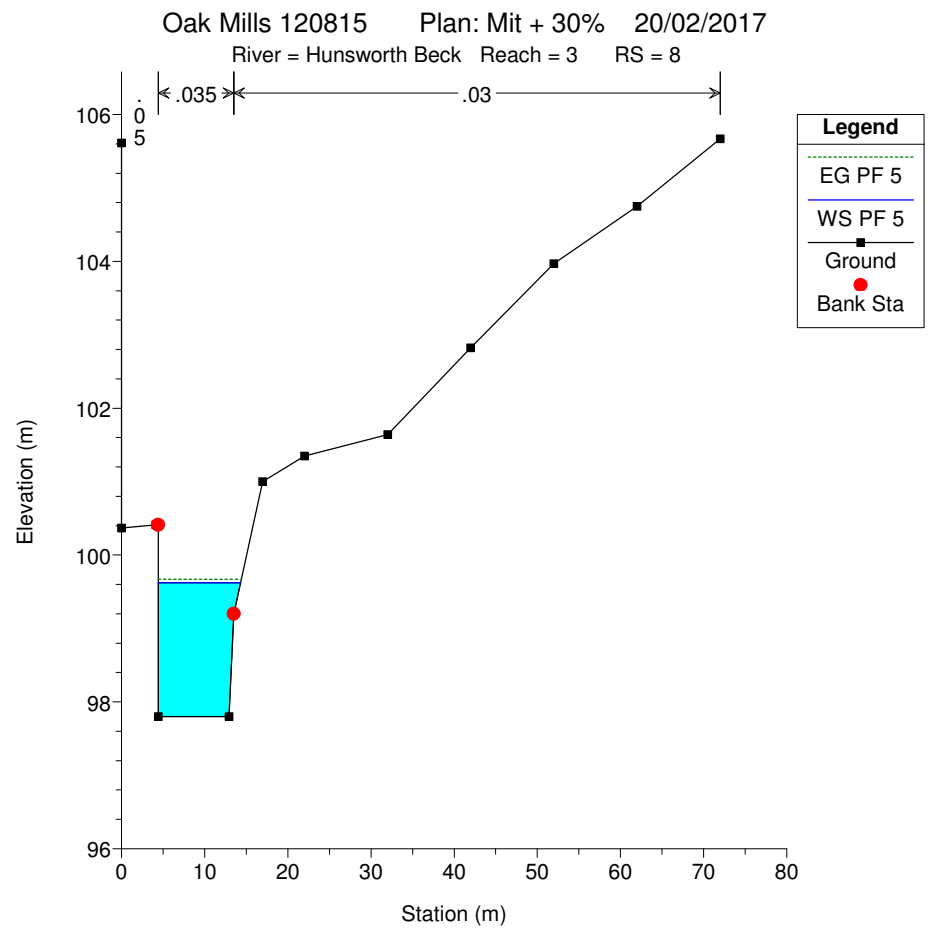
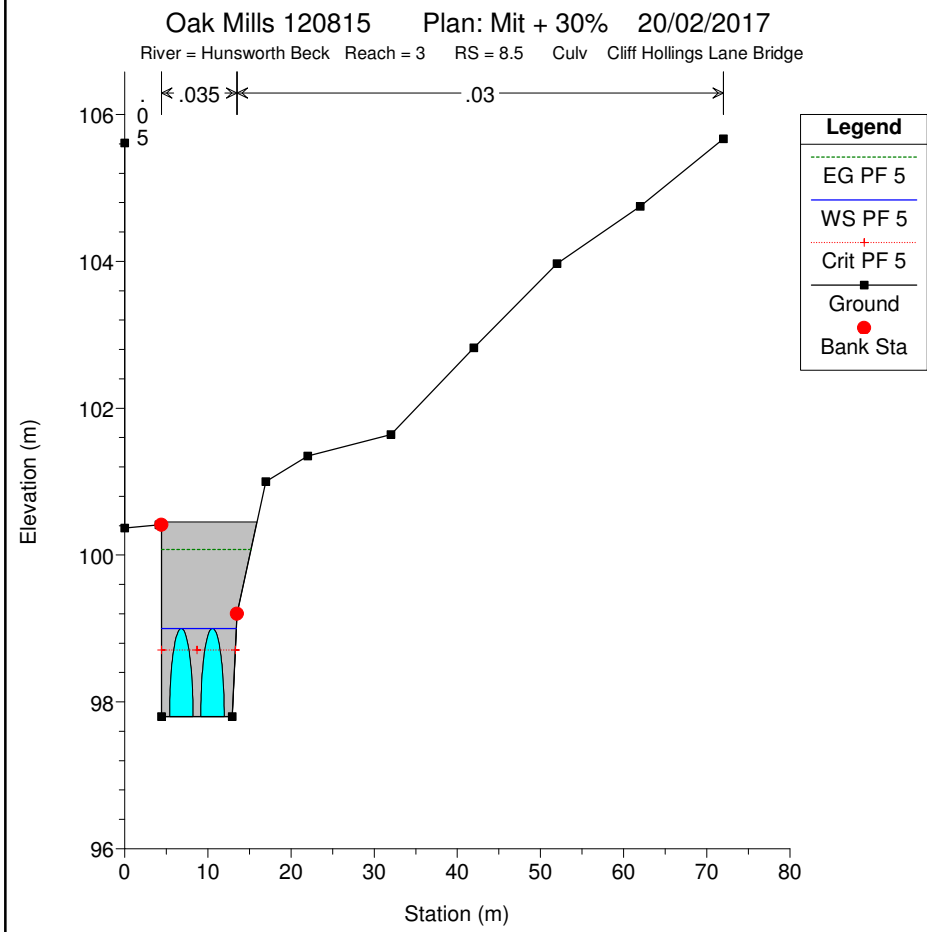
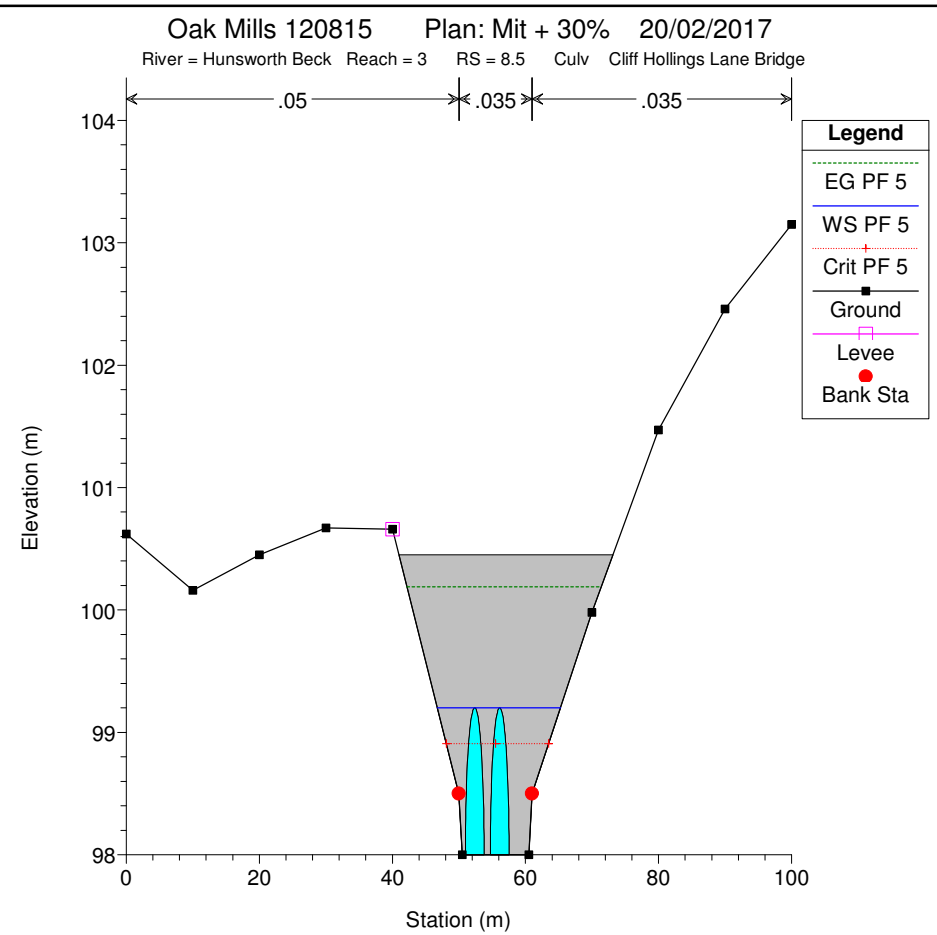
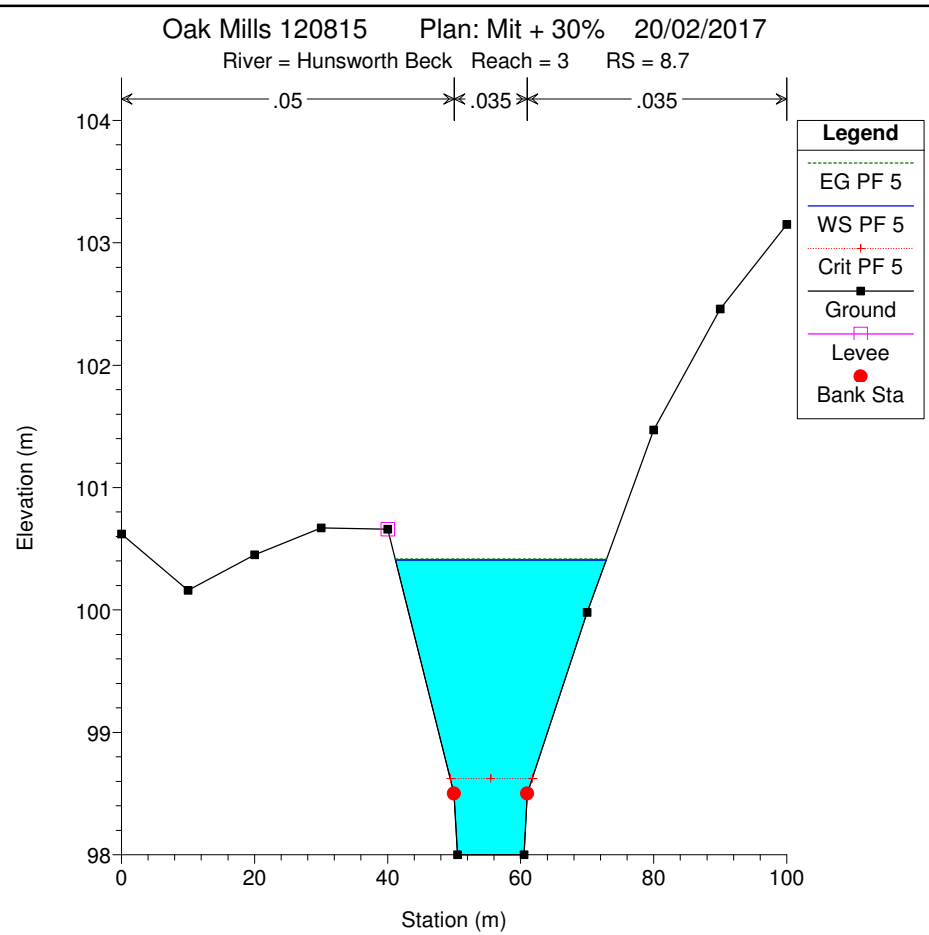
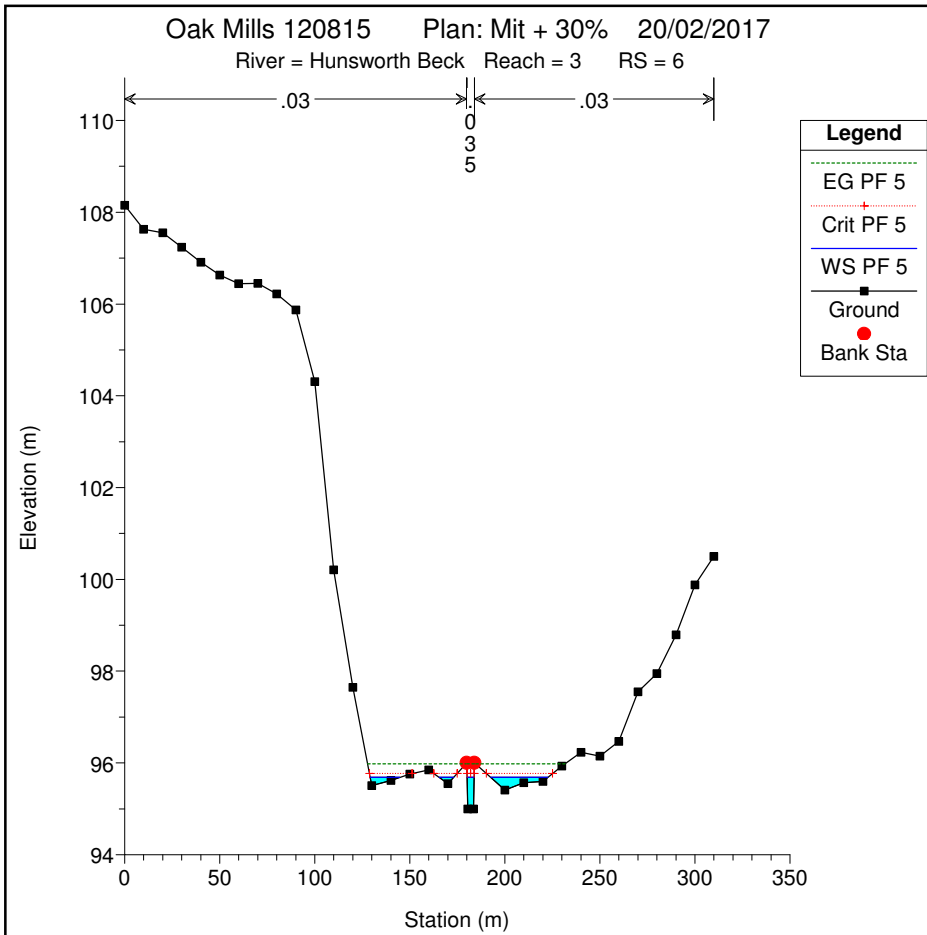
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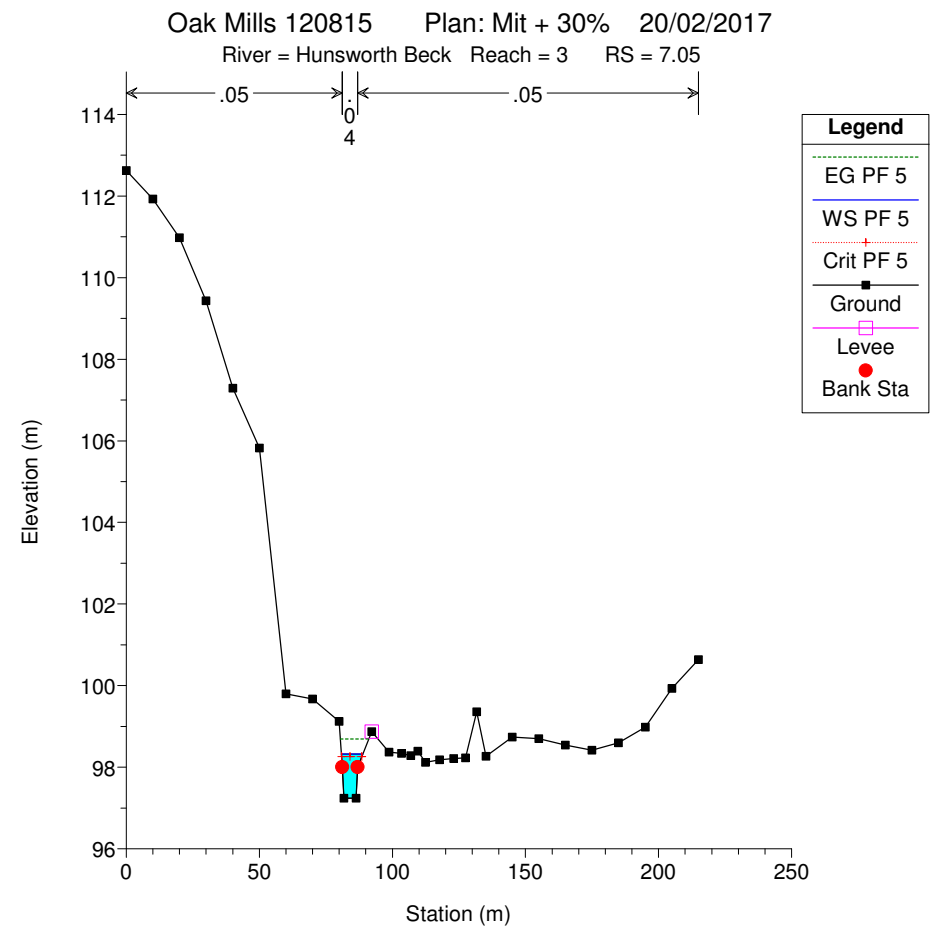
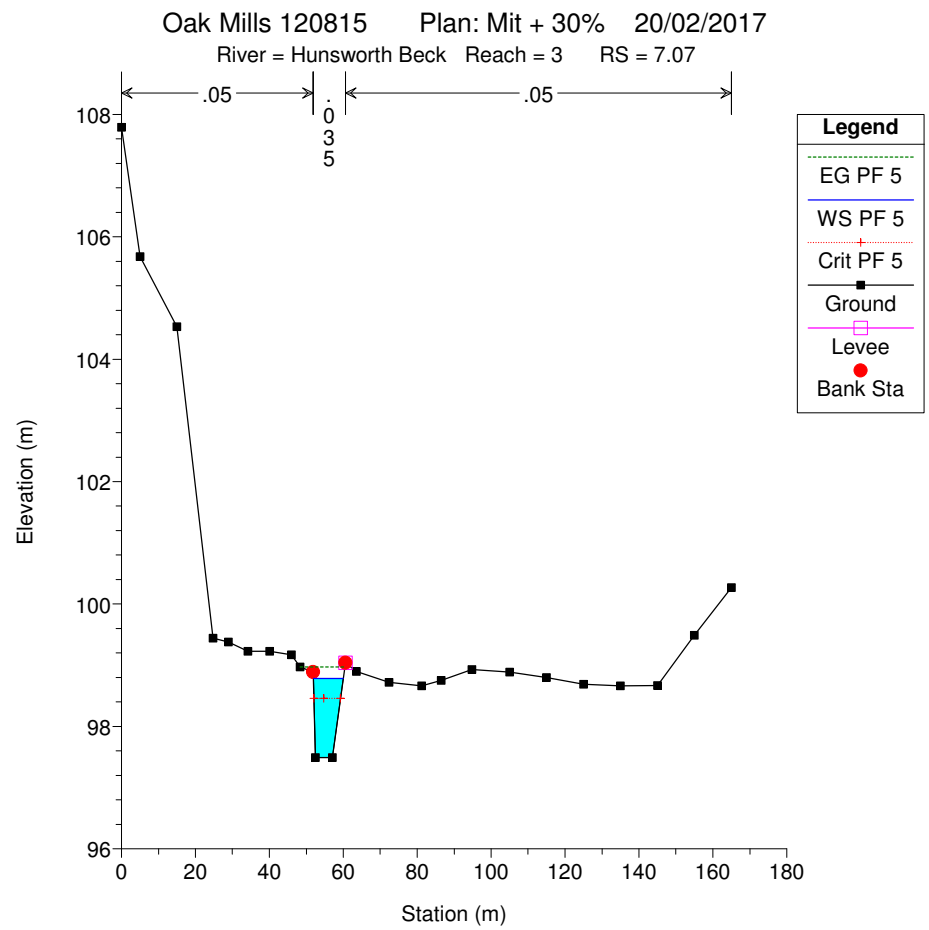
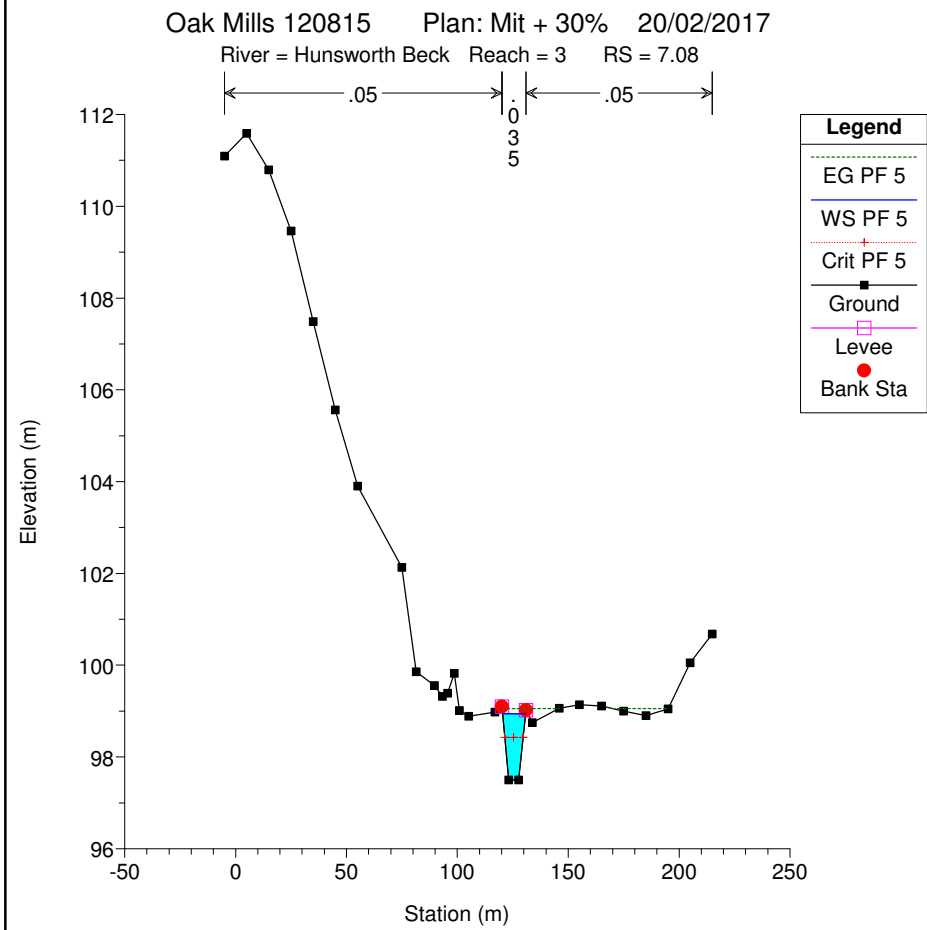
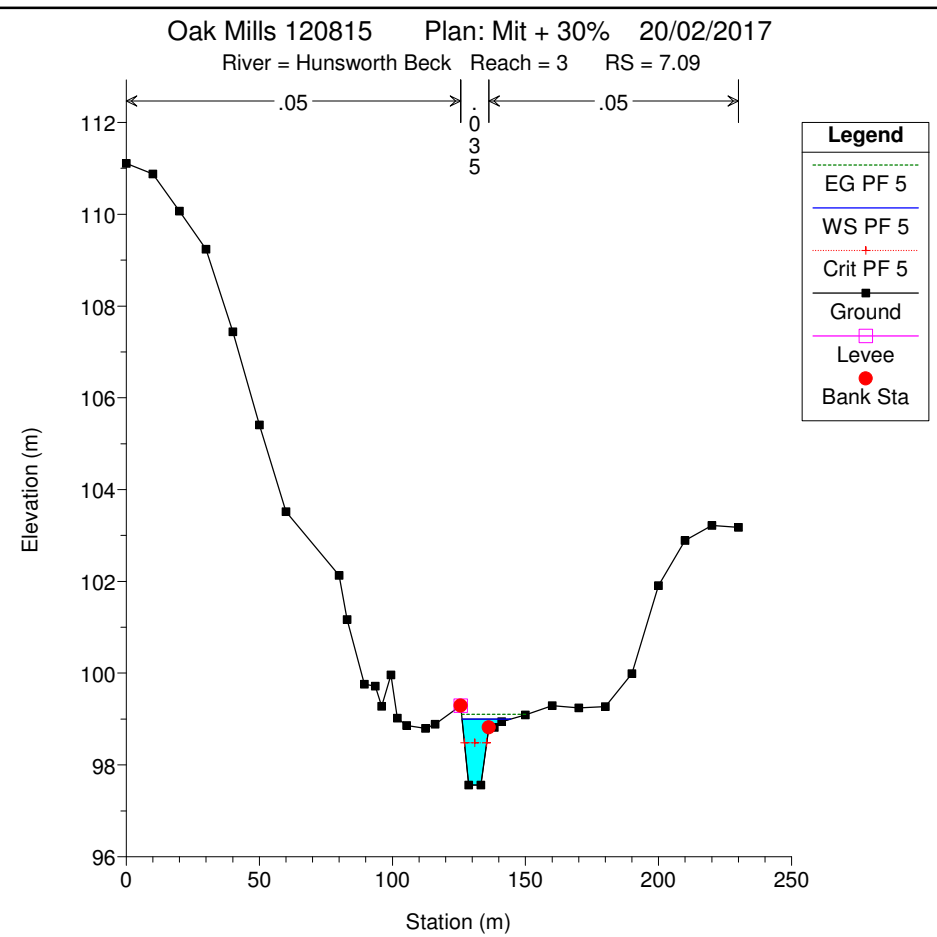
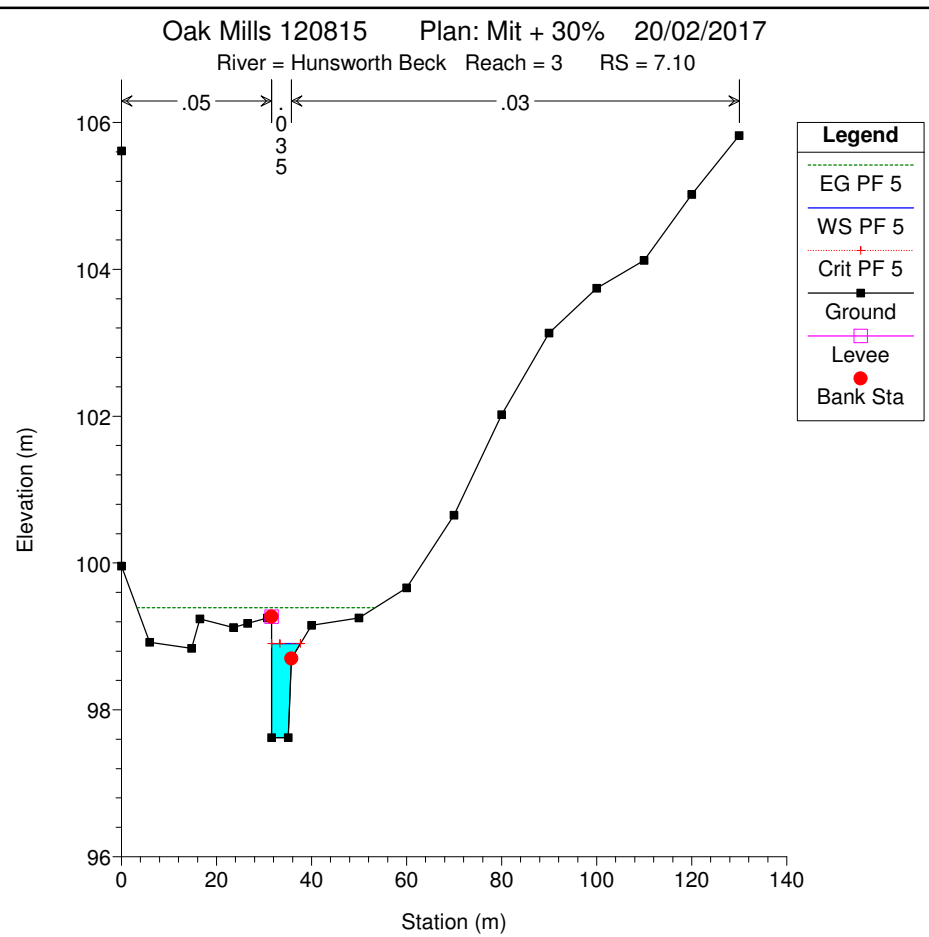
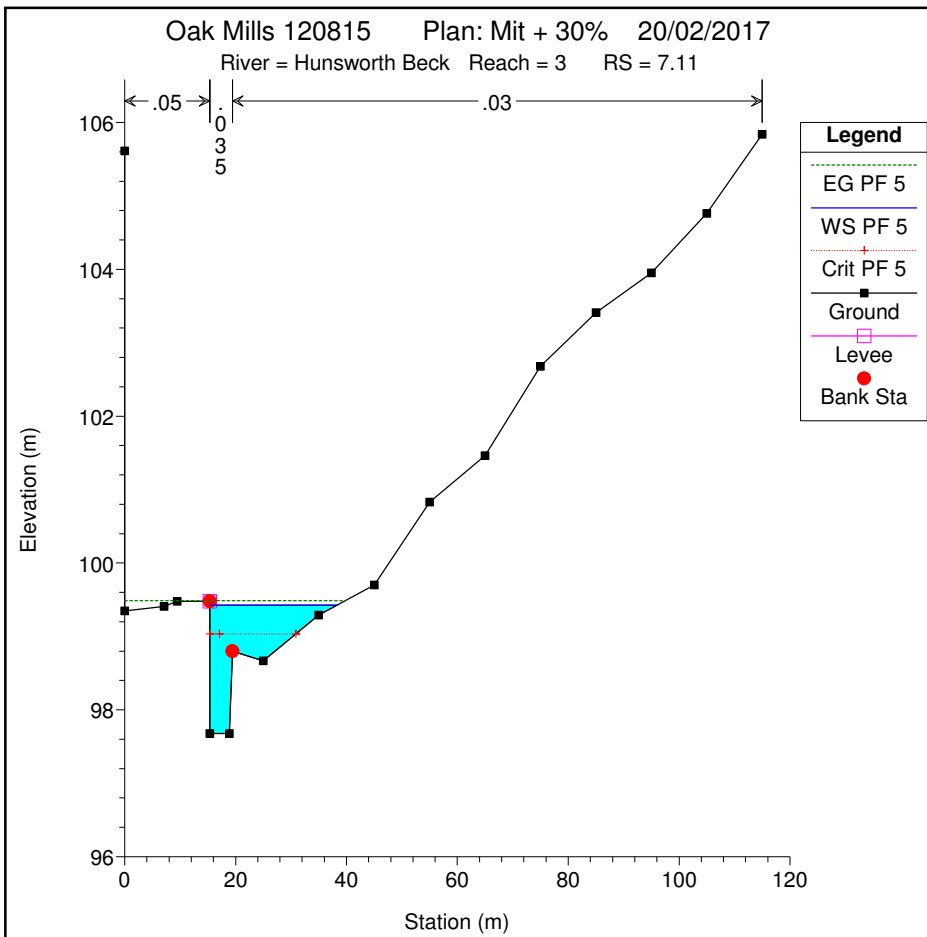
- WS PF 5
- Ground
- Levee
- Bank Sta

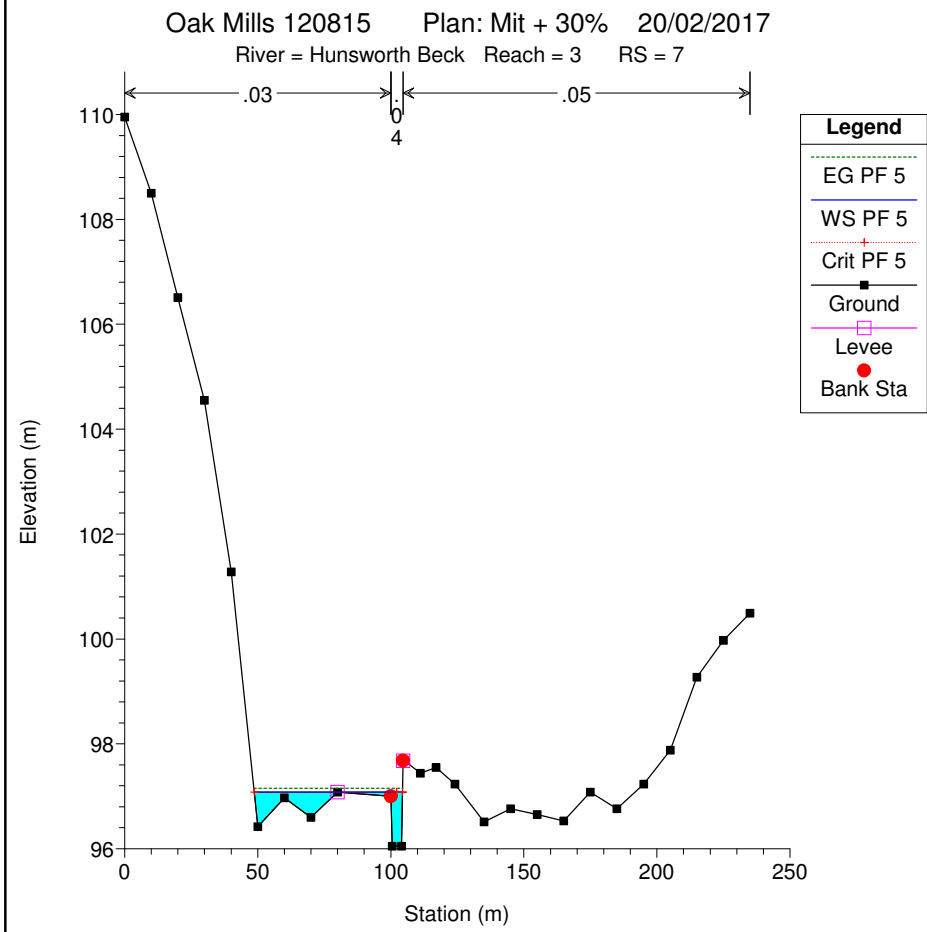
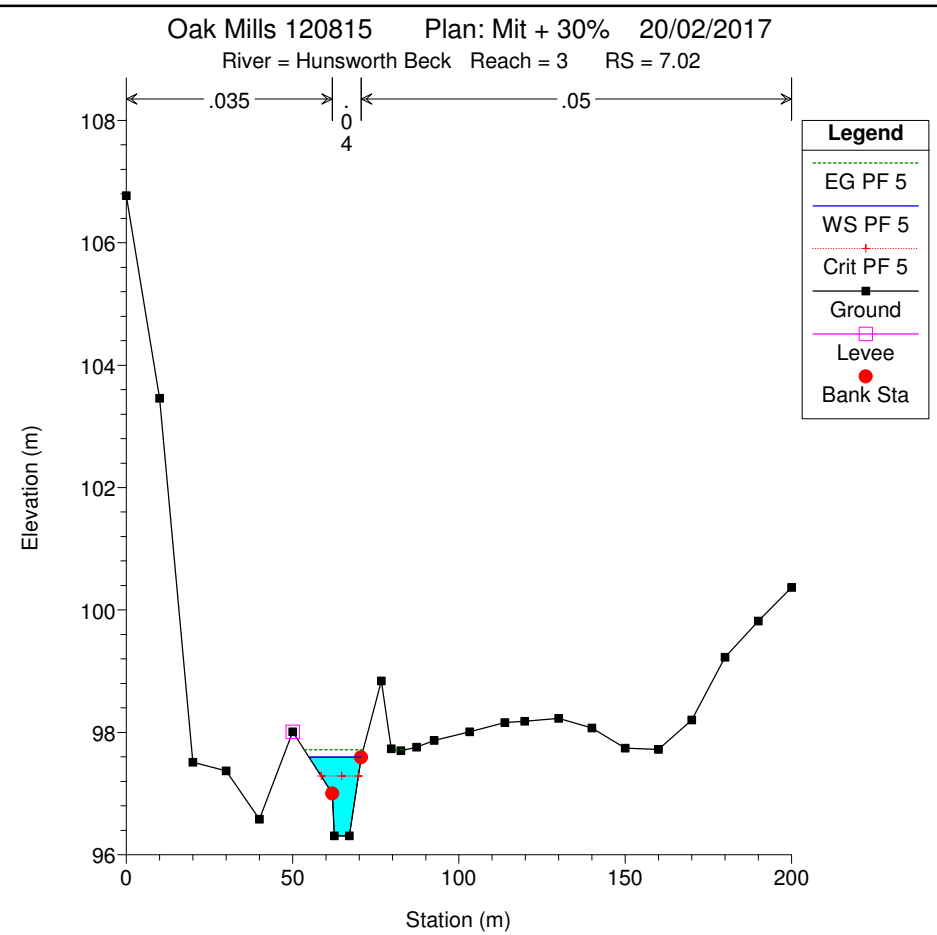
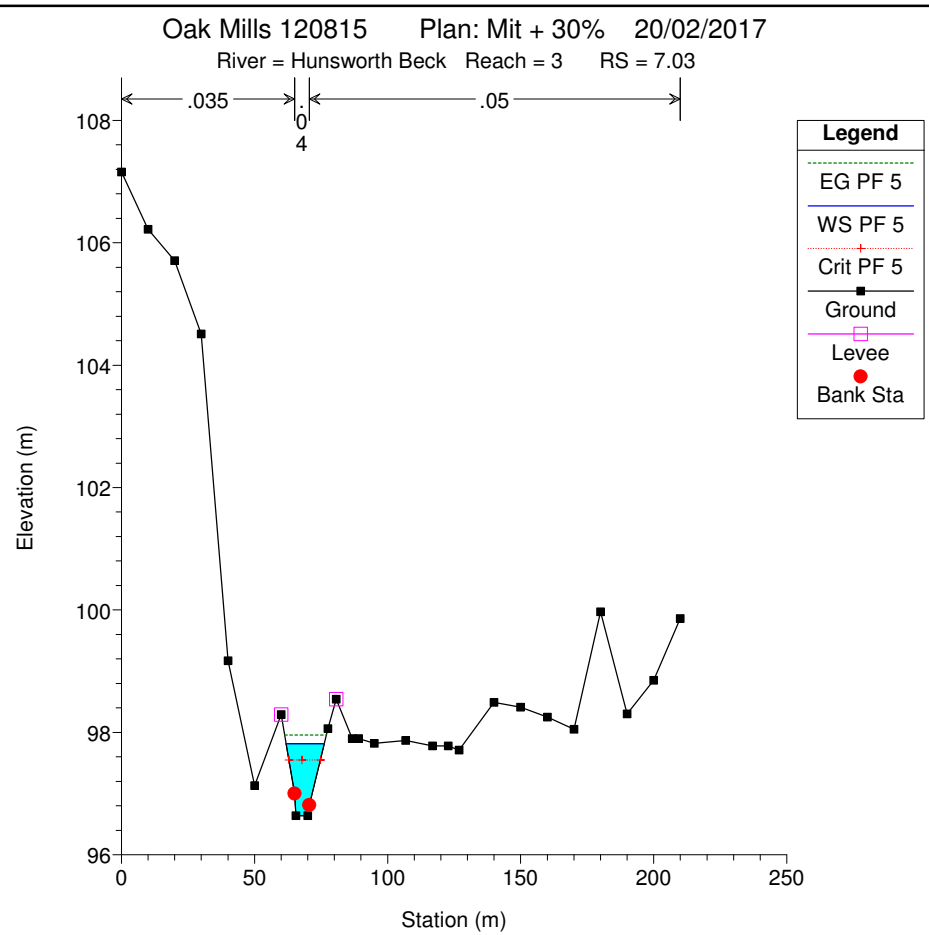
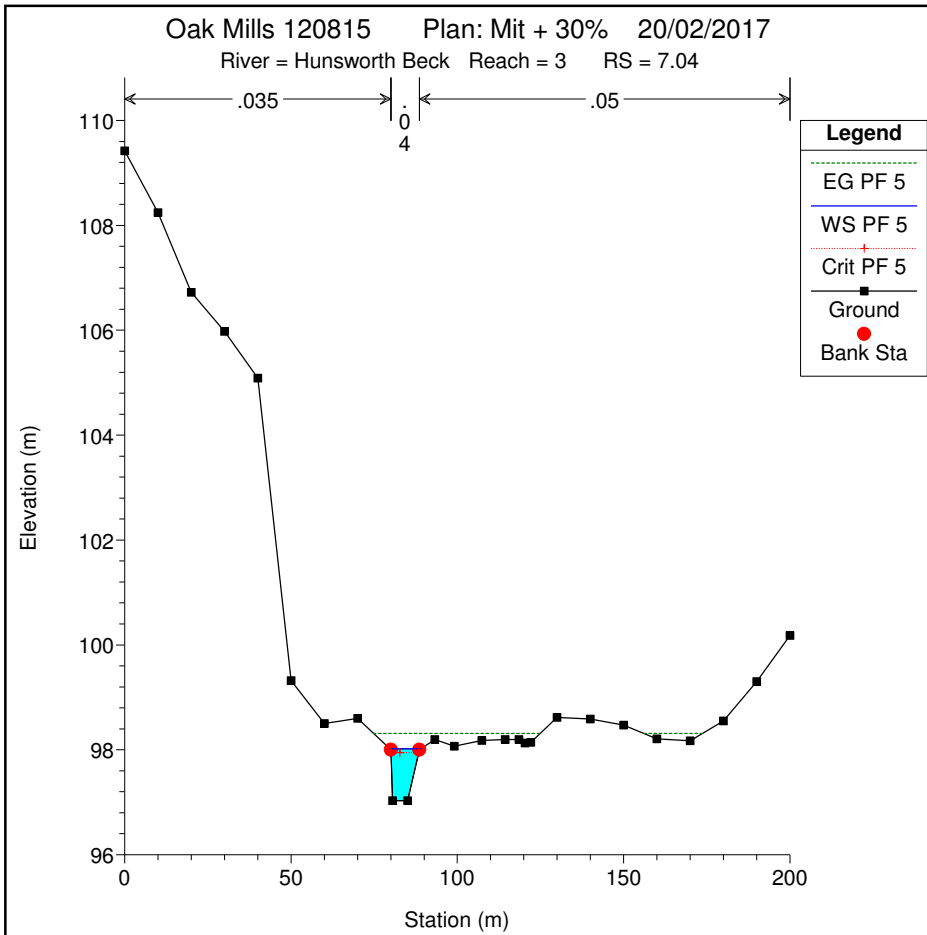


HEC-RAS Plan: MIT30 Profile: PF 5

River	Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Toad Holes Beck	0.5	5	PF 5	1.42	114.00	114.25	114.49	115.30	0.242477	4.54	0.31	1.50	3.17
Toad Holes Beck	0.5	4	PF 5	1.42	113.50	113.99	113.99	114.18	0.022194	1.94	0.73	1.98	1.02
Toad Holes Beck	0.5	3	PF 5	1.42	112.60	114.09	113.09	114.09	0.000093	0.30	8.79	14.32	0.08
Toad Holes Beck	0.5	2.5		Culvert									
Toad Holes Beck	0.5	2	PF 5	1.42	112.50	112.99	112.99	113.18	0.021821	1.92	0.74	1.99	1.01
Toad Holes Beck	0.5	1	PF 5	1.42	111.50	112.00	112.03	112.16	0.018694	1.80	1.65	232.07	0.94
Hunsworth Beck	1	17	PF 5	9.00	113.00	113.50	113.92	115.06	0.129808	5.54	1.62	3.50	2.59
Hunsworth Beck	1	16	PF 5	9.00	108.00	110.08	108.92	110.10	0.000286	0.63	25.43	35.35	0.14
Hunsworth Beck	1	15	PF 5	9.00	106.00	110.09	106.92	110.09	0.000005	0.14	127.31	76.27	0.02
Hunsworth Beck	1	14.9		Culvert									
Hunsworth Beck	1	14.8	PF 5	9.00	105.25	110.08		110.08	0.000002	0.09	190.68	94.79	0.01
Hunsworth Beck	2	14.5	PF 5	10.41	105.25	110.08	106.28	110.08	0.000004	0.11	173.95	97.28	0.02
Hunsworth Beck	2	14.2		Culvert									
Hunsworth Beck	2	14	PF 5	10.41	104.00	110.08		110.08	0.000001	0.06	316.82	132.15	0.01
Hunsworth Beck	2	13.5	PF 5	10.41	104.00	110.08	104.06	110.08	0.000000	0.02	604.50	167.55	0.00
Hunsworth Beck	2	12.5		Culvert									
Hunsworth Beck	2	12	PF 5	10.41	101.50	102.50	102.50	102.51	0.000185	0.30	30.55	35.94	0.10
Hunsworth Beck	2	11	PF 5	10.41	99.50	99.98	100.56	102.25	0.196479	6.68	1.56	3.48	3.18
Hunsworth Beck	2	10	PF 5	10.41	98.60	100.41	99.35	100.42	0.000175	0.47	36.91	63.86	0.11
Hunsworth Beck	2	9	PF 5	10.41	98.20	100.42		100.42	0.000013	0.15	84.31	65.17	0.03
Hunsworth Beck	3	8.7	PF 5	15.77	98.00	100.41	98.62	100.42	0.000080	0.44	45.79	31.71	0.09
Hunsworth Beck	3	8.5		Culvert									
Hunsworth Beck	3	8	PF 5	15.77	97.80	99.62		99.67	0.000768	0.97	16.31	9.90	0.23
Hunsworth Beck	3	7.12	PF 5	15.77	97.74	99.26		99.61	0.009602	2.64	6.14	5.97	0.70
Hunsworth Beck	3	7.11	PF 5	15.77	97.68	99.43	99.03	99.49	0.001813	1.26	15.41	22.99	0.31
Hunsworth Beck	3	7.10	PF 5	15.77	97.62	98.90	98.90	99.39	0.015428	3.12	5.19	6.07	0.91
Hunsworth Beck	3	7.09	PF 5	15.77	97.56	99.00	98.48	99.10	0.002573	1.45	11.50	18.20	0.45
Hunsworth Beck	3	7.08	PF 5	15.77	97.50	98.95	98.43	99.06	0.002701	1.46	10.80	10.38	0.46
Hunsworth Beck	3	7.07	PF 5	15.77	97.49	98.78	98.46	98.97	0.005369	1.93	8.16	8.08	0.61
Hunsworth Beck	3	7.05	PF 5	15.77	97.24	98.33	98.26	98.69	0.013554	2.69	6.14	8.06	0.86
Hunsworth Beck	3	7.04	PF 5	15.77	97.03	98.02	97.95	98.31	0.014882	2.41	6.56	9.39	0.88
Hunsworth Beck	3	7.03	PF 5	15.77	96.64	97.81	97.55	97.96	0.004741	1.86	10.55	14.39	0.55
Hunsworth Beck	3	7.02	PF 5	15.77	96.31	97.59	97.28	97.72	0.004602	1.62	10.70	15.71	0.52
Hunsworth Beck	3	7	PF 5	15.77	96.05	97.08	97.08	97.15	0.006037	1.56	14.57	55.77	0.52
Hunsworth Beck	3	6	PF 5	15.77	95.00	95.69	95.77	95.98	0.030422	3.16	8.34	56.81	1.28
Hunsworth Beck	4	5	PF 5	17.08	94.00	95.06	95.06	95.20	0.008617	2.11	11.41	36.25	0.70
Hunsworth Beck	4	4	PF 5	17.08	93.00	93.43	93.45	93.63	0.018202	1.91	8.68	28.35	0.96
Hunsworth Beck	4	3	PF 5	17.08	91.00	92.86	92.44	92.88	0.000664	0.89	29.22	55.70	0.22
Hunsworth Beck	4	2	PF 5	17.08	91.00	92.45	92.45	92.64	0.006074	2.24	10.70	28.00	0.62
Hunsworth Beck	4	1	PF 5	17.08	89.00	90.31	90.48	90.80	0.014876	3.26	6.16	13.25	0.96
High Royds Beck	1	7	PF 5	5.36	119.25	119.50	120.08	124.48	0.970994	9.89	0.54	2.33	6.55
High Royds Beck	1	6	PF 5	5.36	107.25	108.44	108.07	108.56	0.003875	1.58	3.68	5.20	0.49
High Royds Beck	1	5	PF 5	5.36	105.43	106.11	106.11	106.26	0.009445	1.95	3.80	13.63	0.79
High Royds Beck	1	4	PF 5	5.36	103.15	104.28	104.35	104.54	0.013972	2.44	2.81	9.03	0.82
High Royds Beck	1	3	PF 5	5.36	100.00	100.48	100.43	100.52	0.007809	1.37	8.33	48.87	0.67
High Royds Beck	1	2.5		Culvert									
High Royds Beck	1	2	PF 5	5.36	99.78	100.42		100.43	0.001888	0.82	14.03	48.94	0.34
High Royds Beck	1	1	PF 5	5.36	99.45	100.41		100.42	0.000297	0.45	28.82	67.06	0.15
Cockleshaw Beck	1	3	PF 5	1.31	114.50	114.80	115.01	115.55	0.148238	3.83	0.34	1.29	2.37
Cockleshaw Beck	1	2	PF 5	1.31	104.50	105.01	105.01	105.23	0.026279	2.06	0.64	1.49	1.01
Cockleshaw Beck	1	1	PF 5	1.31	94.50	94.82	95.01	95.46	0.119074	3.55	0.37	1.31	2.13





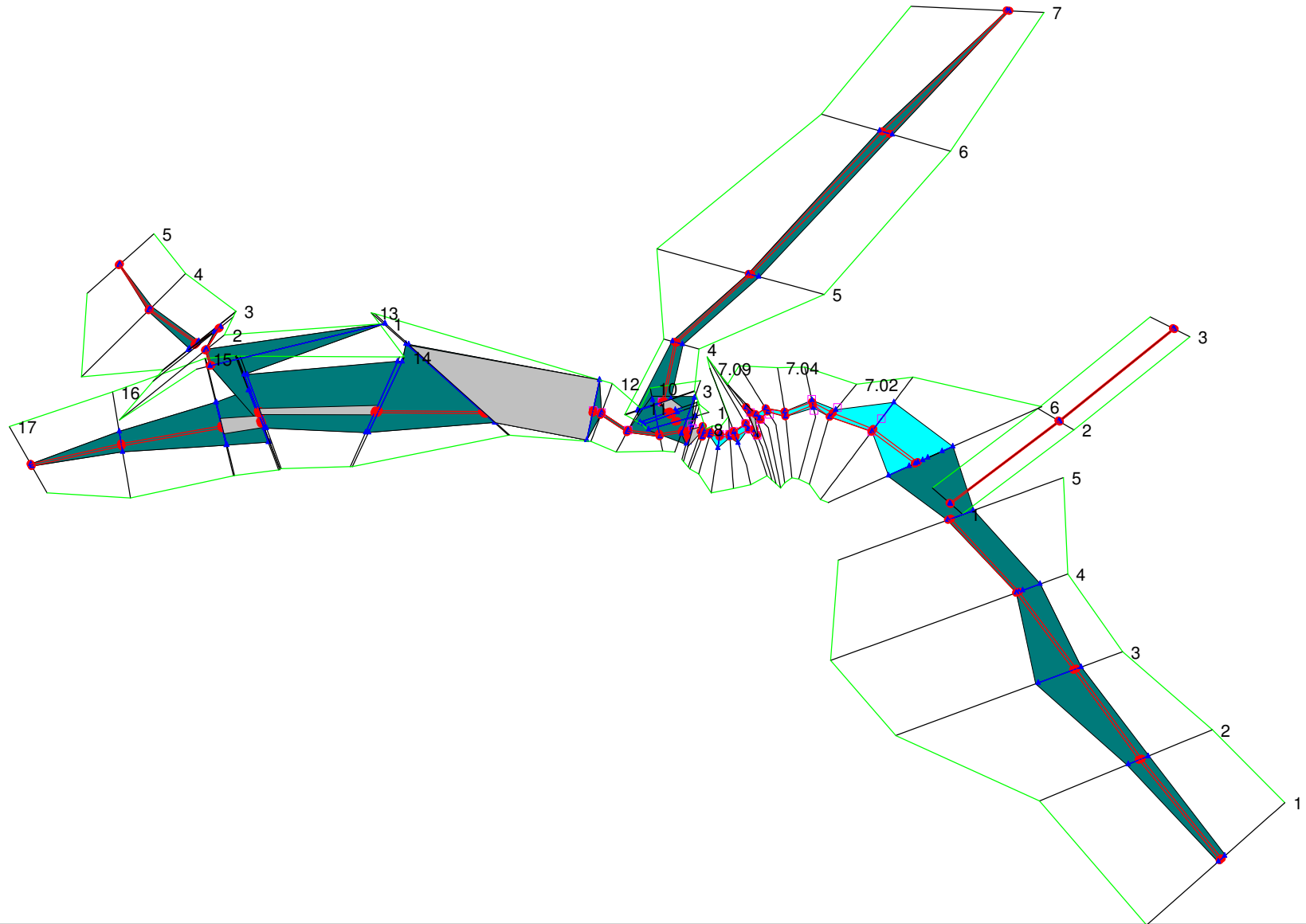


## Appendix AB

Model results – Mitigation scheme with climate change allowance

**Legend**

- WS PF 4
- WS PF 5
- Ground
- Bank Sta
- Levee

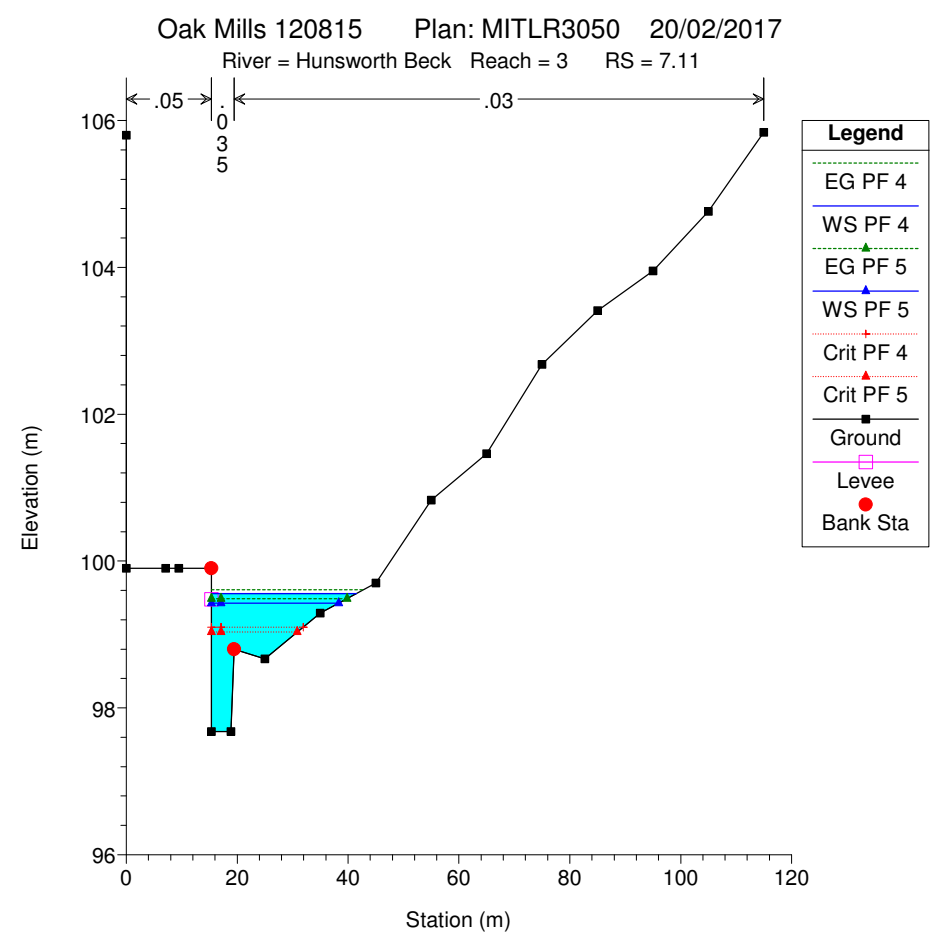
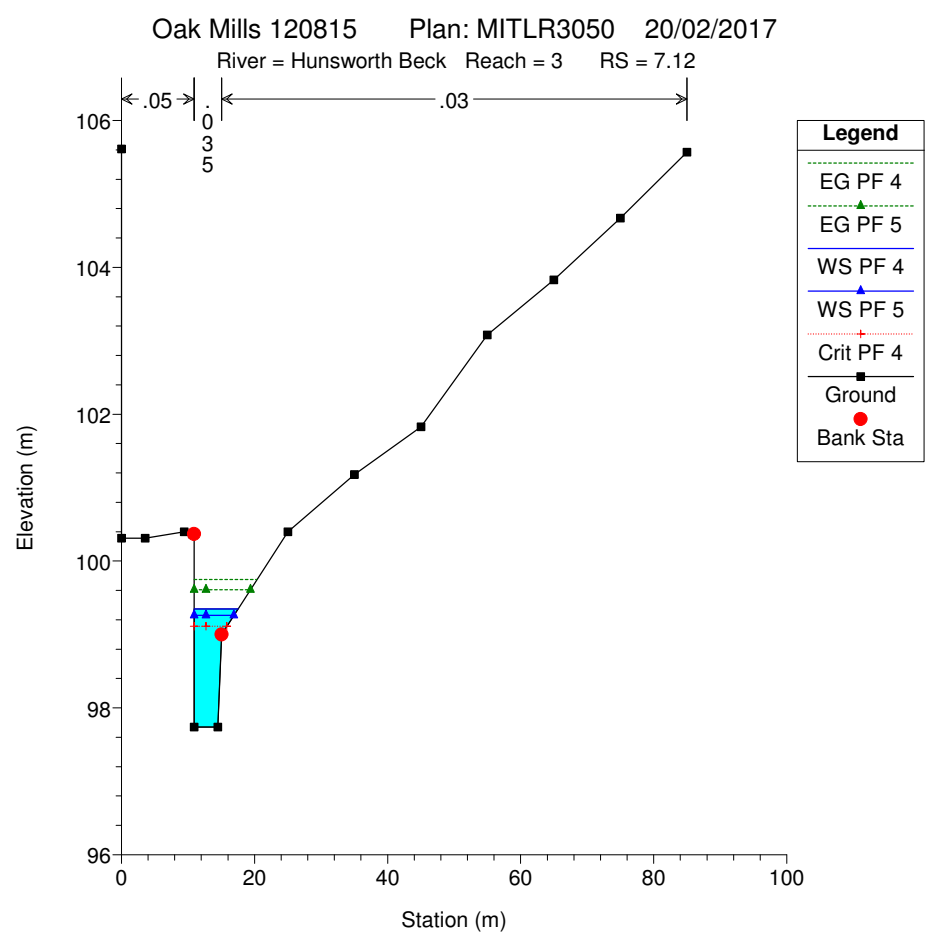
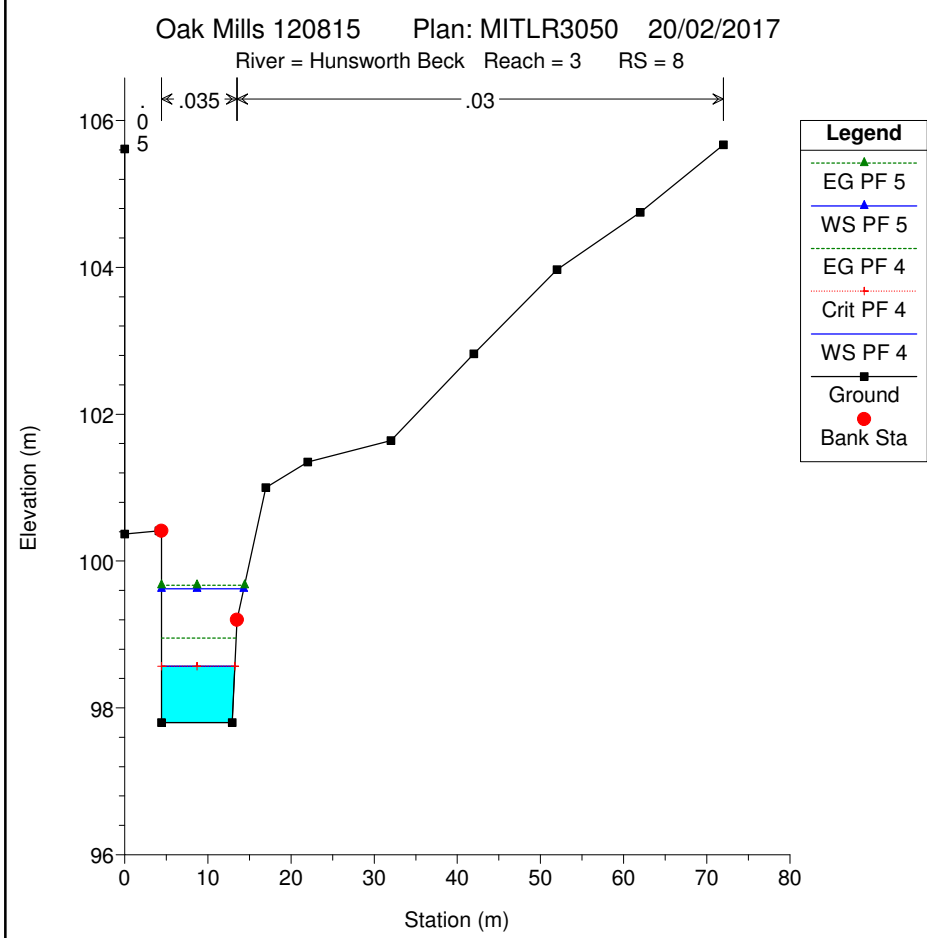
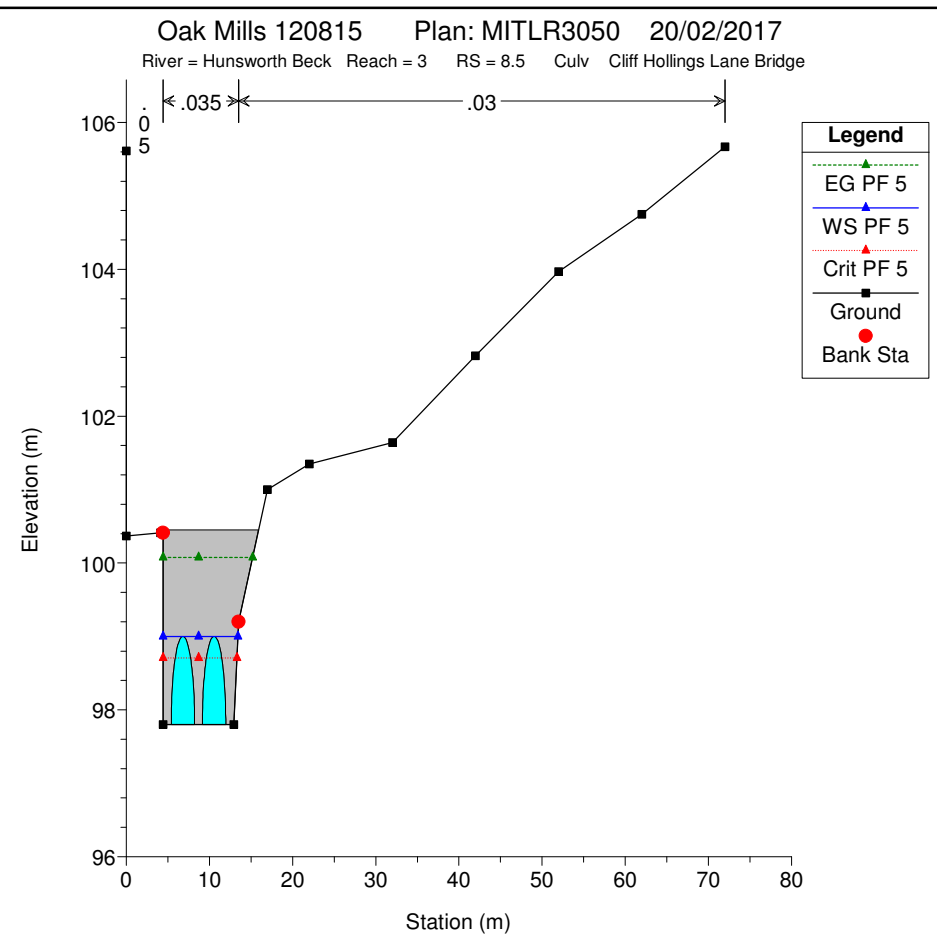
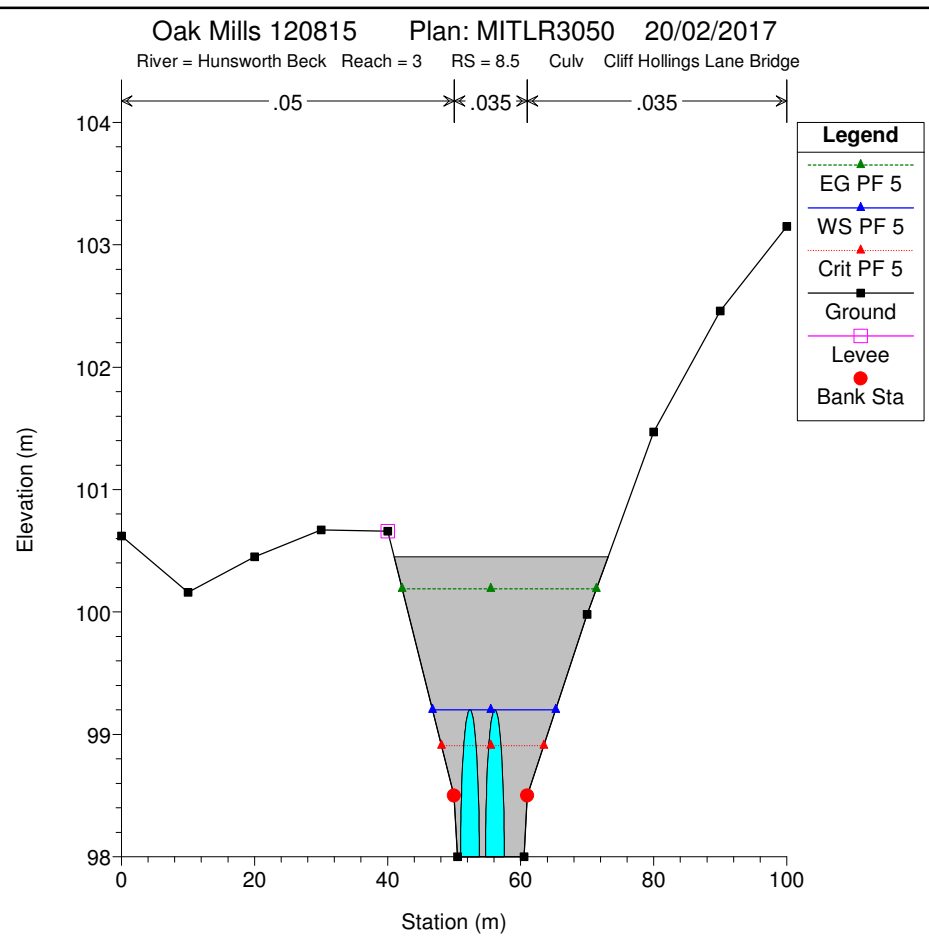
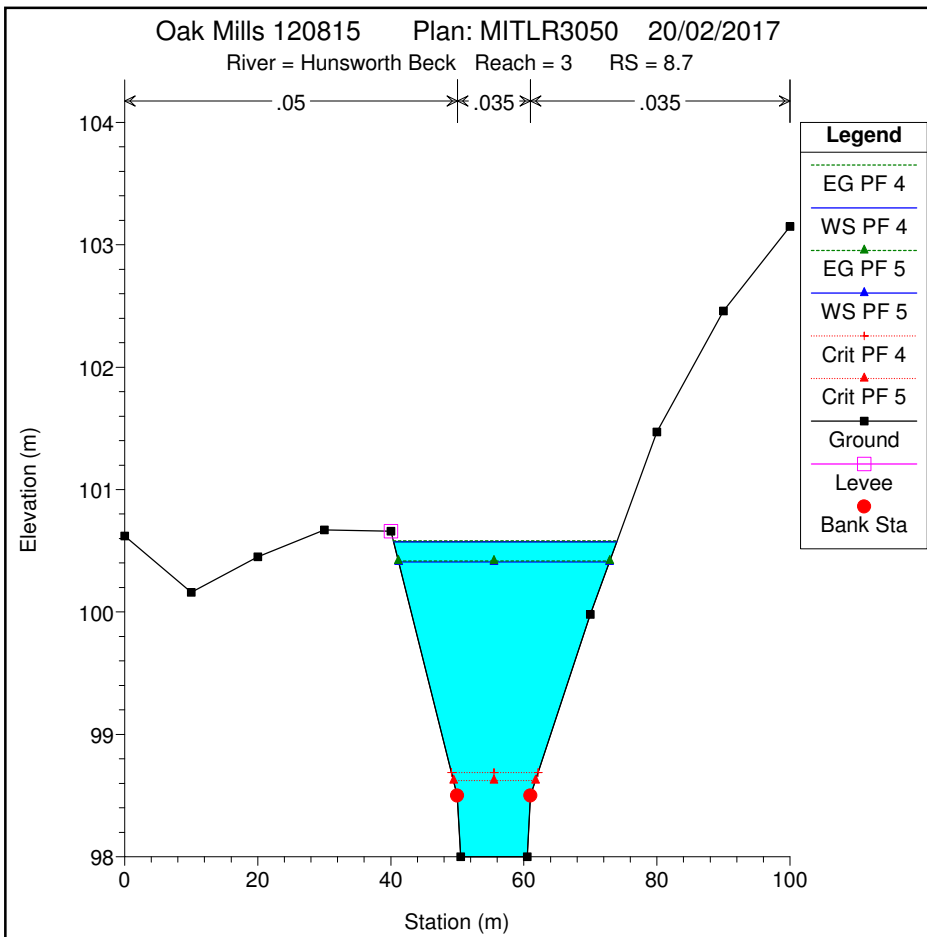


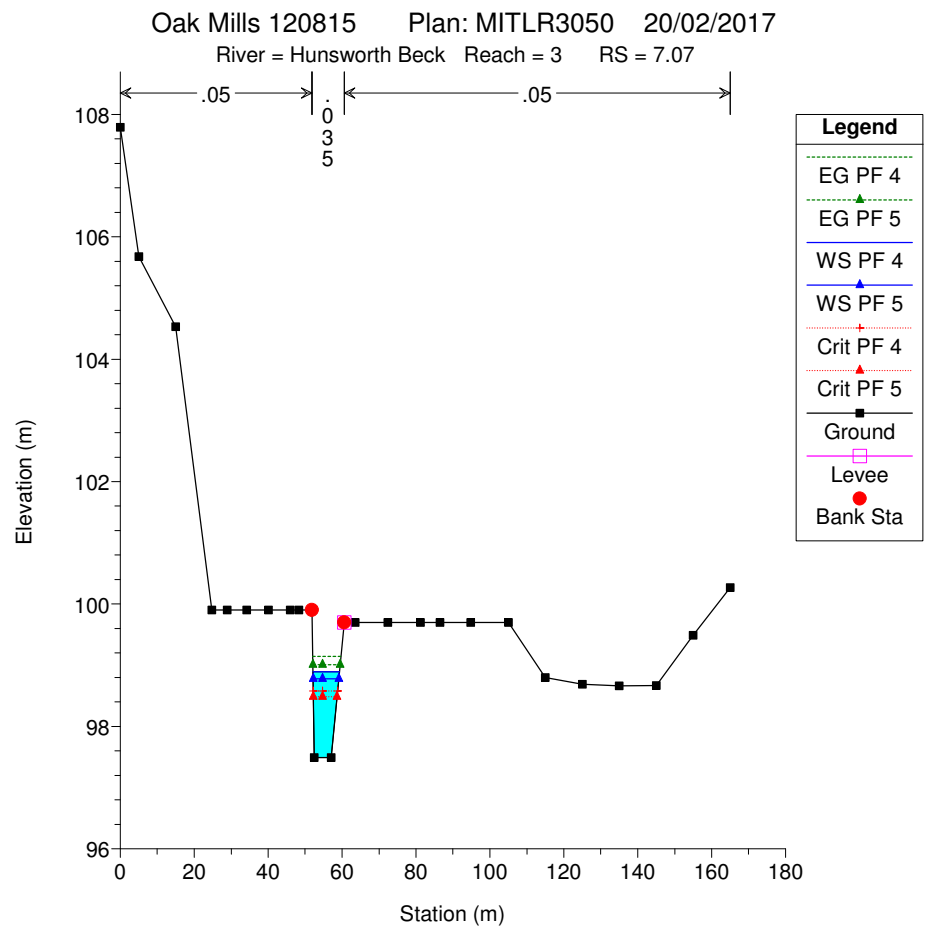
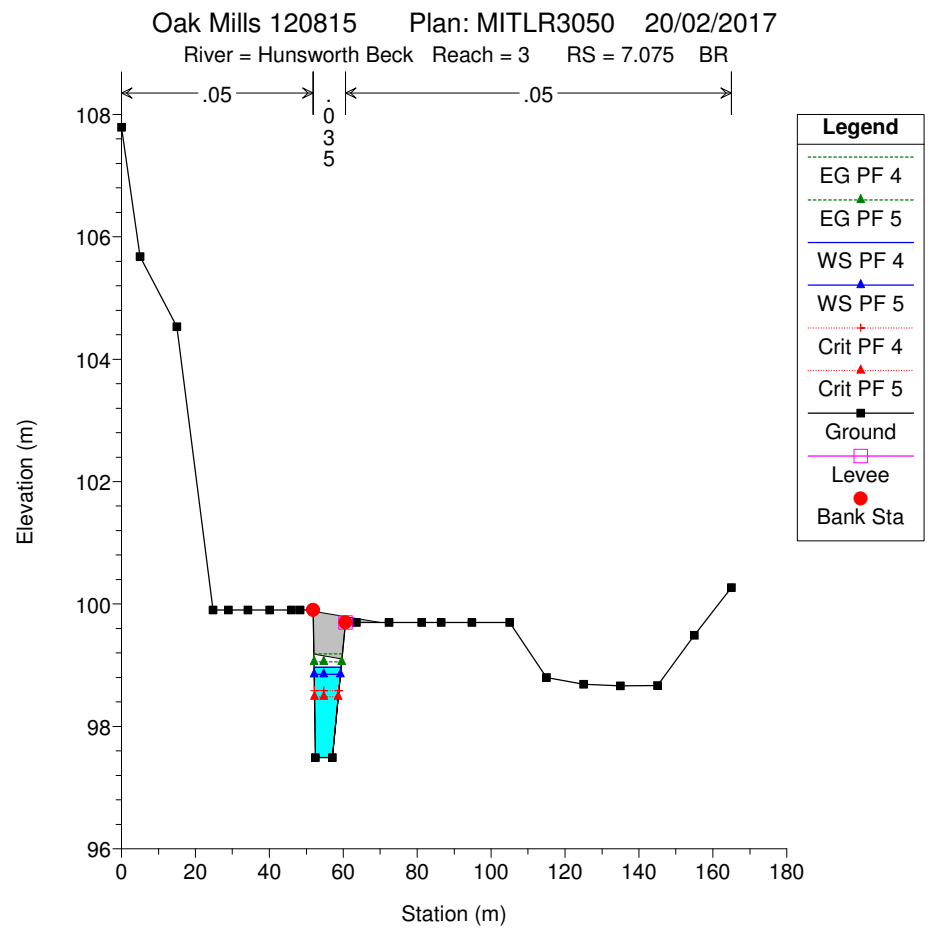
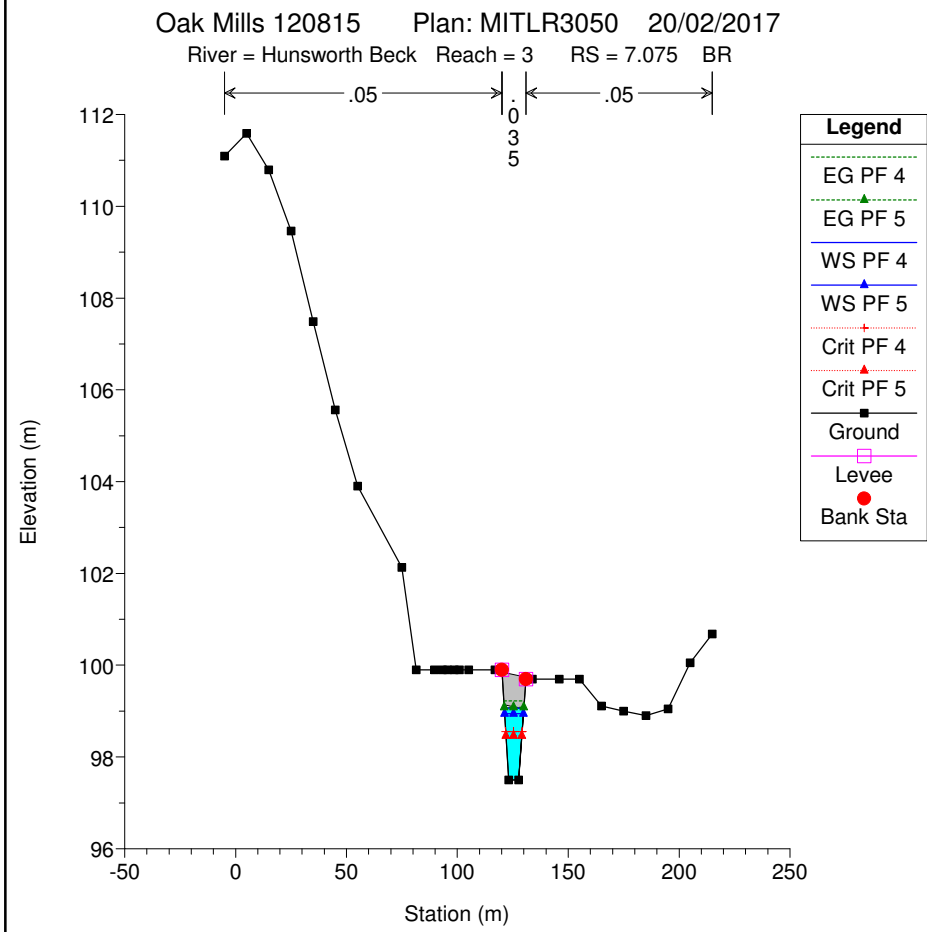
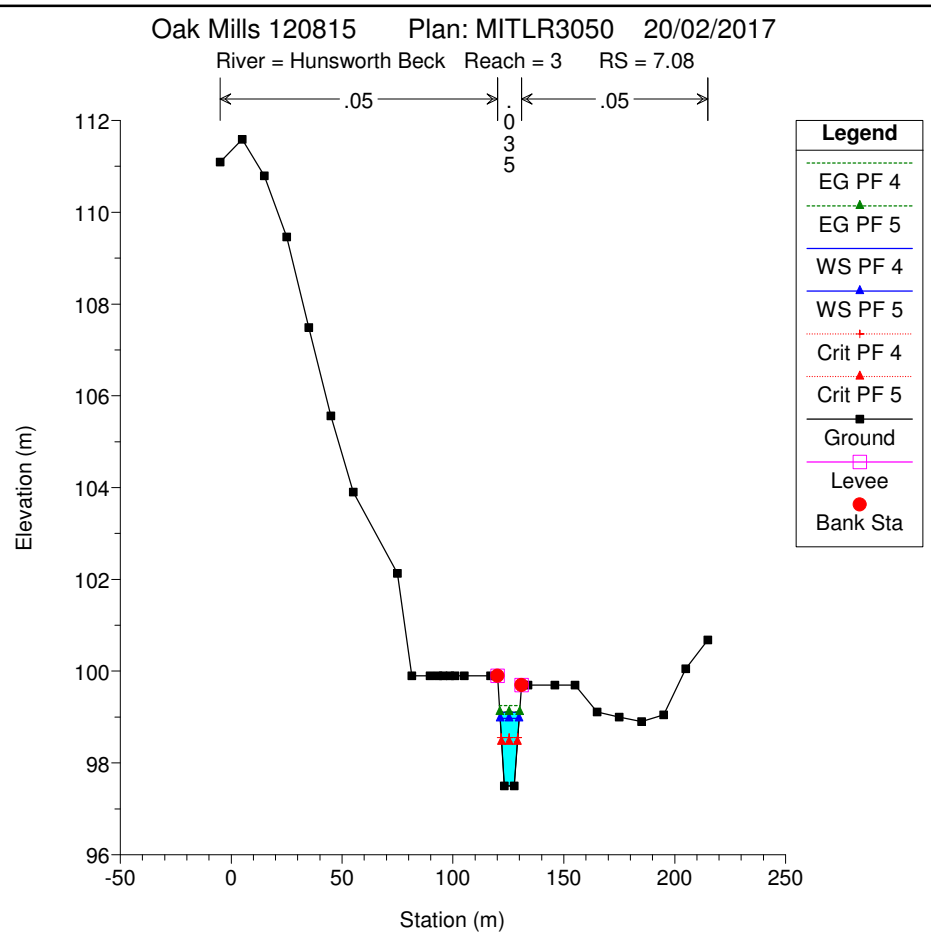
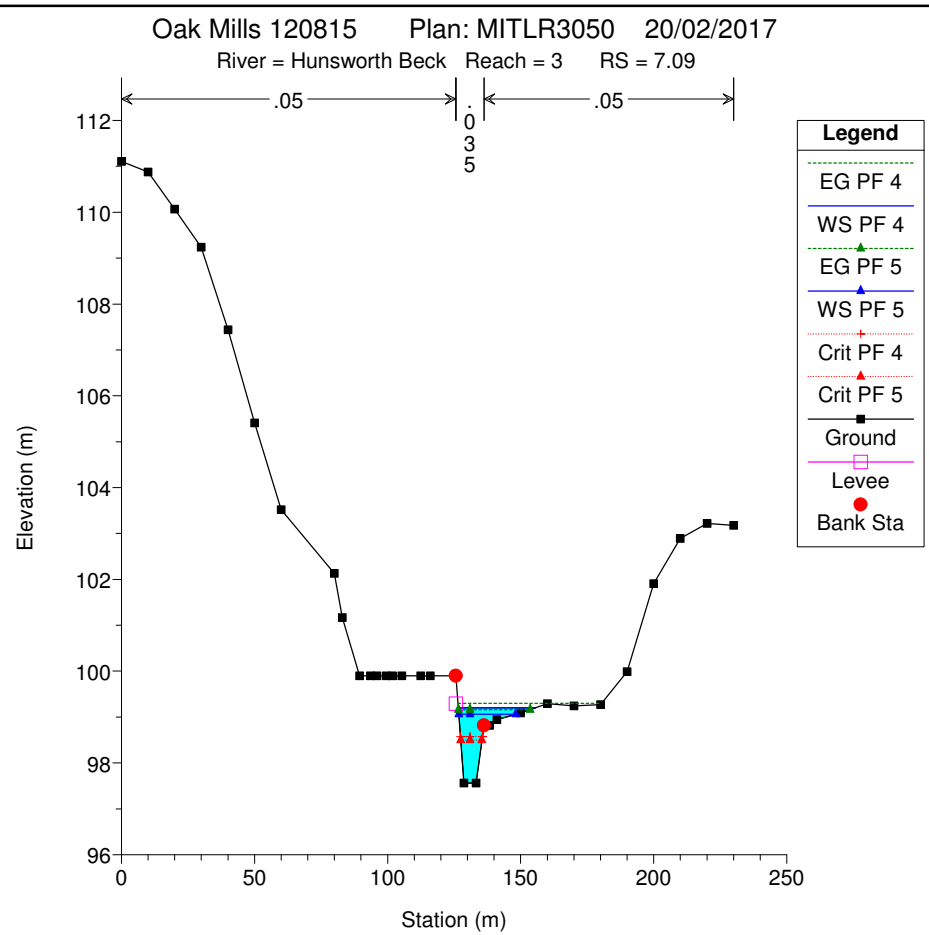
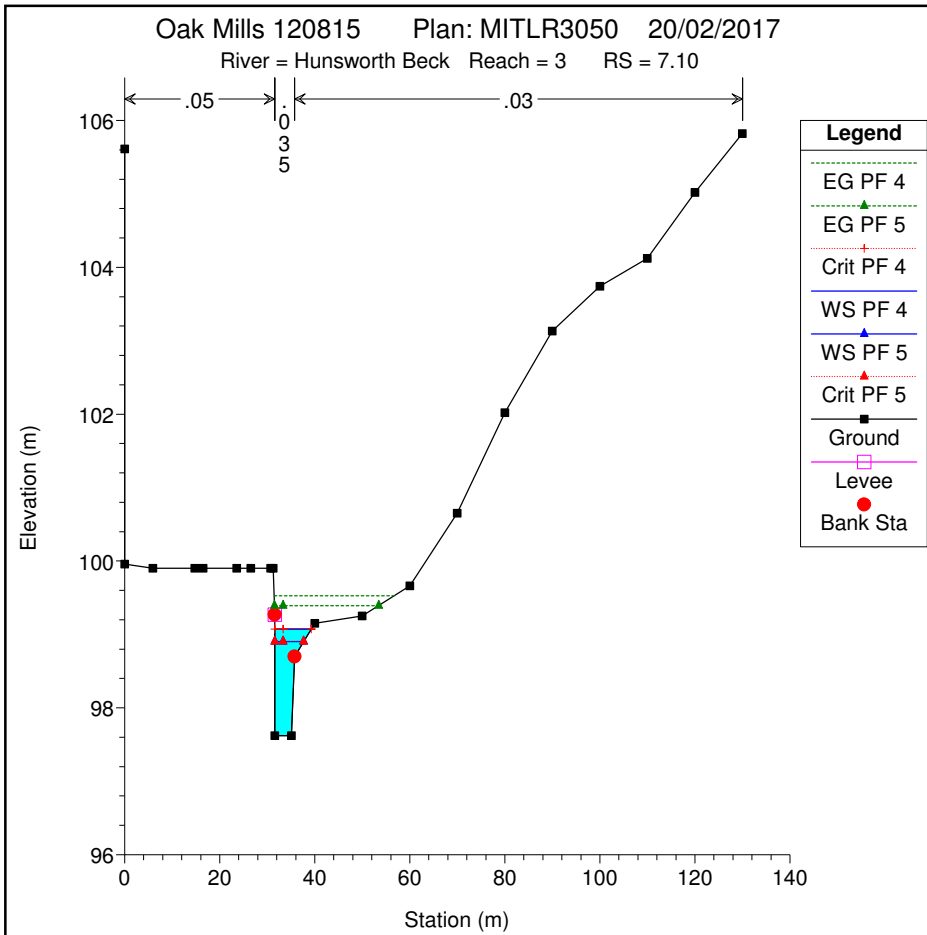
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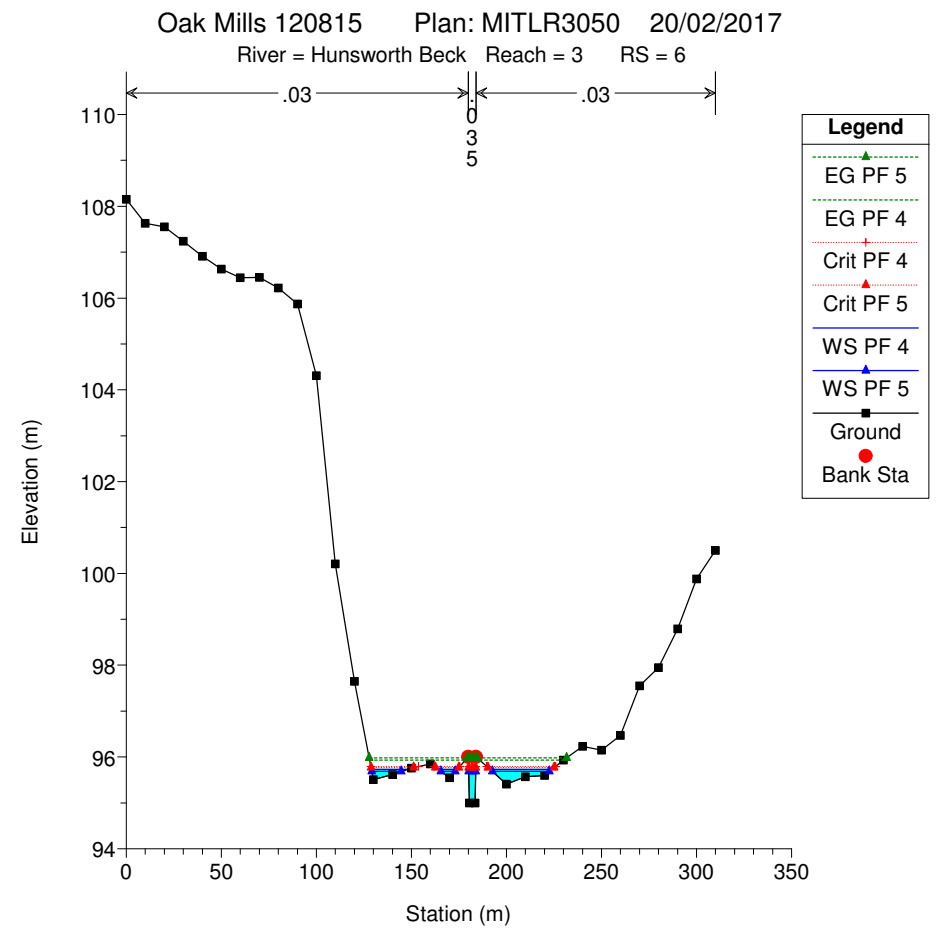
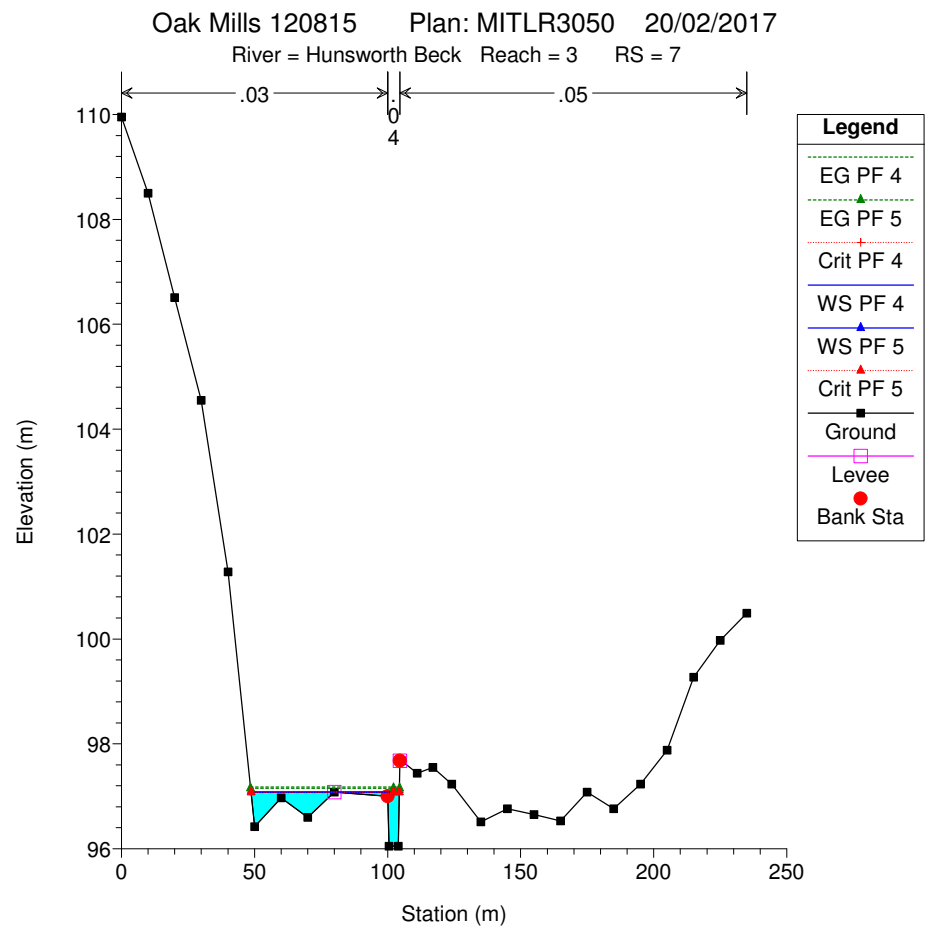
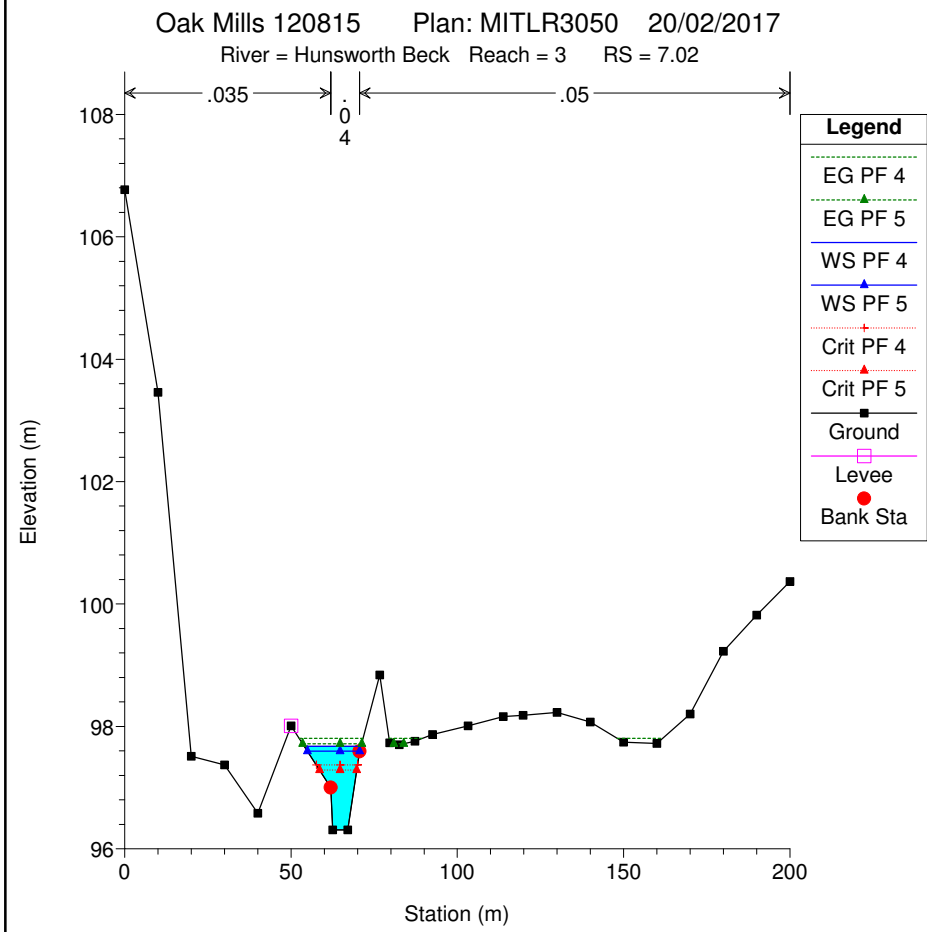
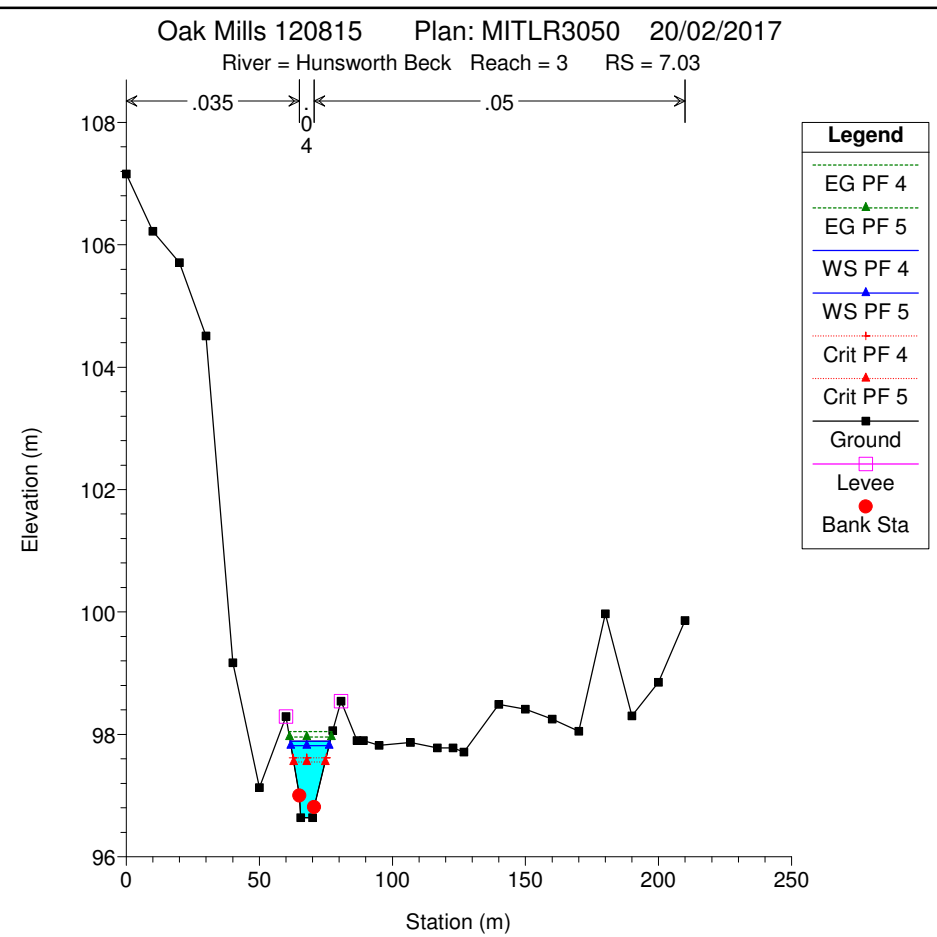
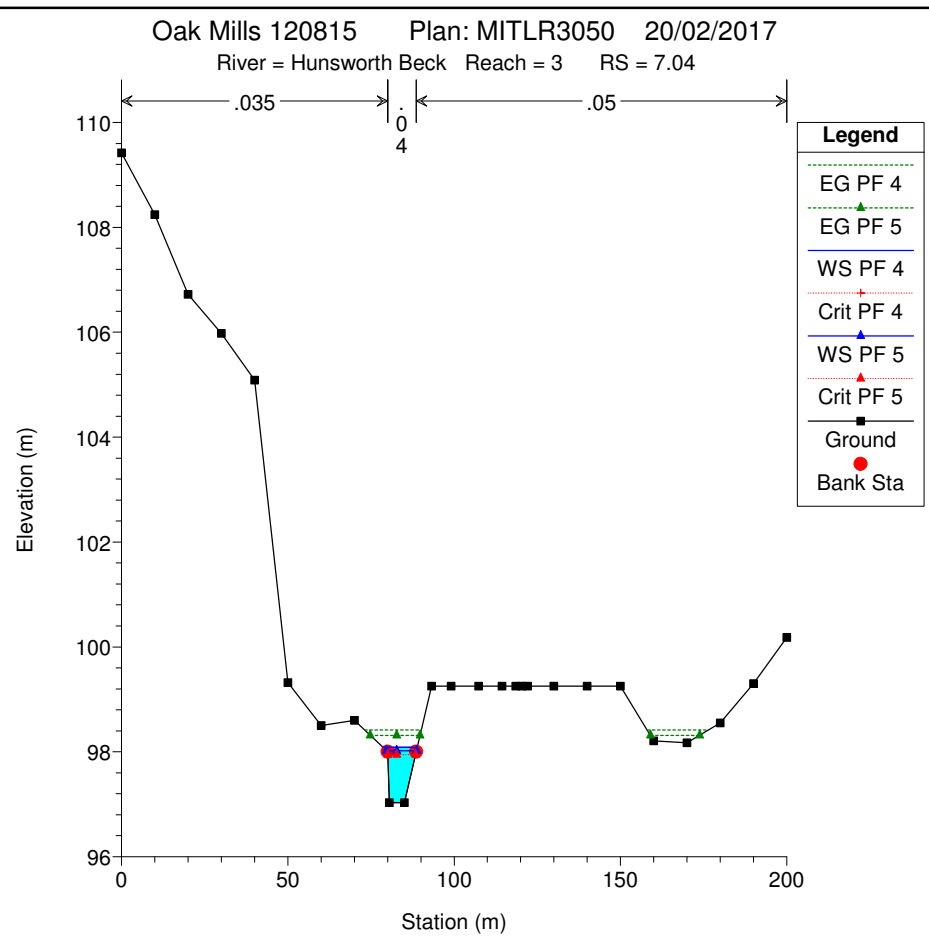
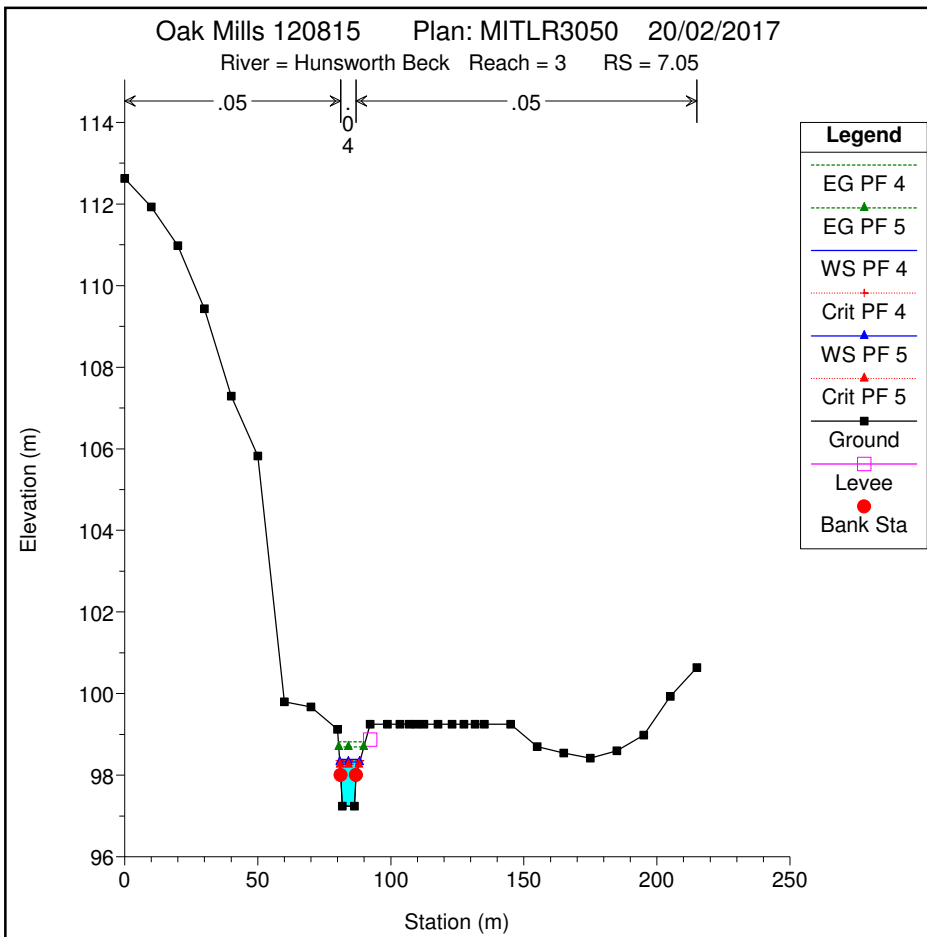
River	Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Toad Holes Beck	0.5	5	PF 4	1.64	114.00	114.25	114.62	115.65	0.322824	5.23	0.31	1.50	3.66
Toad Holes Beck	0.5	5	PF 5	1.42	114.00	114.25	114.49	115.30	0.242477	4.54	0.31	1.50	3.17
Toad Holes Beck	0.5	4	PF 4	1.64	113.50	114.10	114.10	114.23	0.011144	1.62	1.31	9.11	0.75
Toad Holes Beck	0.5	4	PF 5	1.42	113.50	113.99	113.99	114.18	0.022194	1.94	0.73	1.98	1.02
Toad Holes Beck	0.5	3	PF 4	1.64	112.60	114.11	113.14	114.11	0.000115	0.33	9.12	14.60	0.09
Toad Holes Beck	0.5	3	PF 5	1.42	112.60	114.09	113.09	114.09	0.000093	0.30	8.79	14.32	0.08
Toad Holes Beck	0.5	2.5		Culvert									
Toad Holes Beck	0.5	2	PF 4	1.64	112.50	113.04	113.04	113.24	0.020487	1.99	0.83	2.40	0.99
Toad Holes Beck	0.5	2	PF 5	1.42	112.50	112.99	112.99	113.18	0.021821	1.92	0.74	1.99	1.01
Toad Holes Beck	0.5	1	PF 4	1.64	111.50	112.01	112.04	112.18	0.021333	1.94	2.44	232.13	1.00
Toad Holes Beck	0.5	1	PF 5	1.42	111.50	112.00	112.03	112.16	0.018694	1.80	1.65	232.07	0.94
Hunsworth Beck	1	17	PF 4	10.38	113.00	113.50	114.01	115.58	0.172822	6.39	1.62	3.50	2.99
Hunsworth Beck	1	17	PF 5	9.00	113.00	113.50	113.92	115.06	0.129808	5.54	1.62	3.50	2.59
Hunsworth Beck	1	16	PF 4	10.38	108.00	110.10	109.00	110.12	0.000363	0.72	25.95	35.59	0.16
Hunsworth Beck	1	16	PF 5	9.00	108.00	110.08	108.92	110.10	0.000286	0.63	25.43	35.35	0.14
Hunsworth Beck	1	15	PF 4	10.38	106.00	110.11	107.01	110.11	0.000007	0.16	128.56	76.68	0.03
Hunsworth Beck	1	15	PF 5	9.00	106.00	110.09	106.92	110.09	0.000005	0.14	127.31	76.27	0.02
Hunsworth Beck	1	14.9		Culvert									
Hunsworth Beck	1	14.8	PF 4	10.38	105.25	110.09		110.09	0.000002	0.11	191.80	95.08	0.02
Hunsworth Beck	1	14.8	PF 5	9.00	105.25	110.08		110.08	0.000002	0.09	190.68	94.79	0.01
Hunsworth Beck	2	14.5	PF 4	12.02	105.25	110.09	106.38	110.09	0.000005	0.13	175.10	97.61	0.02
Hunsworth Beck	2	14.5	PF 5	10.41	105.25	110.08	106.28	110.08	0.000004	0.11	173.95	97.28	0.02
Hunsworth Beck	2	14.2		Culvert									
Hunsworth Beck	2	14	PF 4	12.02	104.00	110.09		110.09	0.000001	0.07	318.89	132.59	0.01
Hunsworth Beck	2	14	PF 5	10.41	104.00	110.08		110.08	0.000001	0.06	316.82	132.15	0.01
Hunsworth Beck	2	13	PF 4	12.02	104.00	110.09	104.09	110.09	0.000000	0.03	607.11	167.79	0.00
Hunsworth Beck	2	13	PF 5	10.41	104.00	110.08	104.06	110.08	0.000000	0.02	604.50	167.55	0.00
Hunsworth Beck	2	12.5		Culvert									
Hunsworth Beck	2	12	PF 4	12.02	101.50	102.50	102.50	102.51	0.000246	0.34	30.55	35.94	0.12
Hunsworth Beck	2	12	PF 5	10.41	101.50	102.50	102.50	102.51	0.000185	0.30	30.55	35.94	0.10
Hunsworth Beck	2	11	PF 4	12.02	99.50	100.06	100.58	102.25	0.161814	6.56	1.83	3.56	2.92
Hunsworth Beck	2	11	PF 5	10.41	99.50	99.98	100.56	102.25	0.196479	6.68	1.56	3.48	3.18
Hunsworth Beck	2	10	PF 4	12.02	98.60	100.58	99.41	100.58	0.000116	0.41	48.10	70.68	0.09
Hunsworth Beck	2	10	PF 5	10.41	98.60	100.41	99.35	100.42	0.000175	0.47	36.91	63.86	0.11
Hunsworth Beck	2	9	PF 4	12.02	98.20	100.58		100.58	0.000012	0.16	95.37	67.94	0.03
Hunsworth Beck	2	9	PF 5	10.41	98.20	100.42		100.42	0.000013	0.15	84.31	65.17	0.03
Hunsworth Beck	3	8.7	PF 4	18.20	98.00	100.57	98.69	100.58	0.000080	0.46	51.19	33.58	0.09
Hunsworth Beck	3	8.7	PF 5	15.77	98.00	100.41	98.62	100.42	0.000080	0.44	45.79	31.71	0.09
Hunsworth Beck	3	8.5		Culvert									
Hunsworth Beck	3	8	PF 4	18.20	97.80	98.57	98.57	98.95	0.015989	2.73	6.65	8.82	1.01
Hunsworth Beck	3	8	PF 5	15.77	97.80	98.62		98.67	0.000768	0.97	16.31	9.90	0.23
Hunsworth Beck	3	7.12	PF 4	18.20	97.74	99.35	99.11	99.75	0.010397	2.83	6.69	6.60	0.73
Hunsworth Beck	3	7.12	PF 5	15.77	97.74	99.26		99.61	0.009602	2.64	6.14	5.97	0.70
Hunsworth Beck	3	7.11	PF 4	18.20	97.68	99.56	99.10	99.61	0.001536	1.20	18.60	26.16	0.29
Hunsworth Beck	3	7.11	PF 5	15.77	97.68	99.43	99.03	99.49	0.001813	1.26	15.41	22.99	0.31
Hunsworth Beck	3	7.10	PF 4	18.20	97.62	99.07	99.07	99.53	0.012752	3.04	6.37	7.70	0.83
Hunsworth Beck	3	7.10	PF 5	15.77	97.62	98.90	98.90	99.39	0.015428	3.12	5.19	6.07	0.91
Hunsworth Beck	3	7.09	PF 4	18.20	97.56	99.20	98.58	99.30	0.001958	1.40	15.88	29.02	0.40
Hunsworth Beck	3	7.09	PF 5	15.77	97.56	99.06	98.50	99.16	0.002292	1.42	12.26	21.41	0.42
Hunsworth Beck	3	7.08	PF 4	18.20	97.50	99.10	98.55	99.25	0.003130	1.68	10.80	8.94	0.49
Hunsworth Beck	3	7.08	PF 5	15.77	97.50	98.97	98.47	99.11	0.003209	1.63	9.66	8.58	0.49
Hunsworth Beck	3	7.075		Bridge									
Hunsworth Beck	3	7.07	PF 4	18.20	97.49	98.89	98.58	99.14	0.006466	2.22	8.21	7.16	0.66
Hunsworth Beck	3	7.07	PF 5	15.77	97.49	98.78	98.49	99.01	0.006517	2.13	7.40	6.95	0.66
Hunsworth Beck	3	7.05	PF 4	18.20	97.24	98.39	98.36	98.82	0.014734	2.92	6.52	7.79	0.90
Hunsworth Beck	3	7.05	PF 5	15.77	97.24	98.32	98.26	98.69	0.013744	2.71	6.03	7.45	0.86
Hunsworth Beck	3	7.04	PF 4	18.20	97.03	98.08	98.03	98.42	0.014996	2.55	7.19	10.35	0.90
Hunsworth Beck	3	7.04	PF 5	15.77	97.03	98.02	97.95	98.31	0.014879	2.41	6.56	9.02	0.88
Hunsworth Beck	3	7.03	PF 4	18.20	96.64	97.89	97.62	98.05	0.004852	1.96	11.67	15.10	0.57
Hunsworth Beck	3	7.03	PF 5	15.77	96.64	97.81	97.55	97.96	0.004741	1.86	10.55	14.39	0.55
Hunsworth Beck	3	7.02	PF 4	18.20	96.31	97.67	97.37	97.80	0.004522	1.69	11.99	17.02	0.52

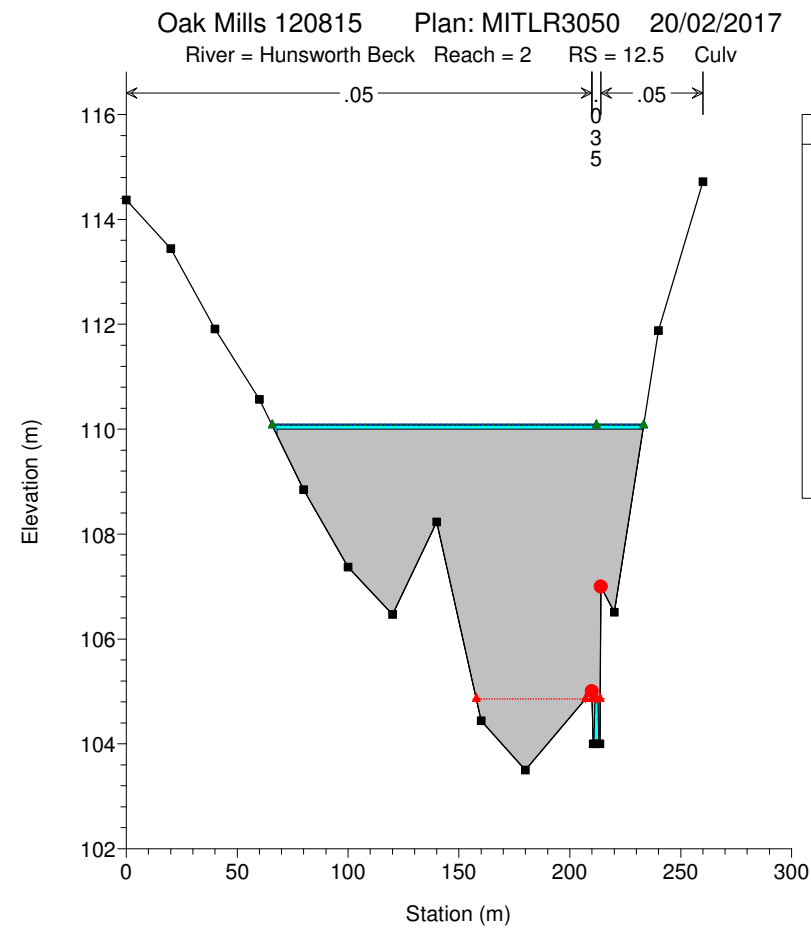
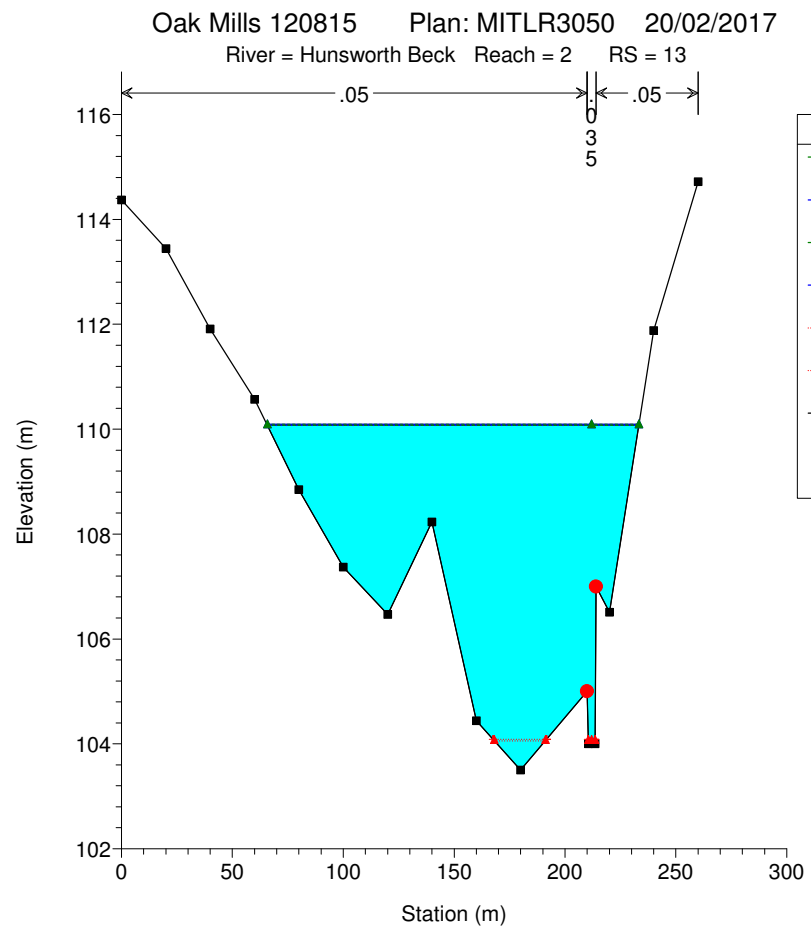
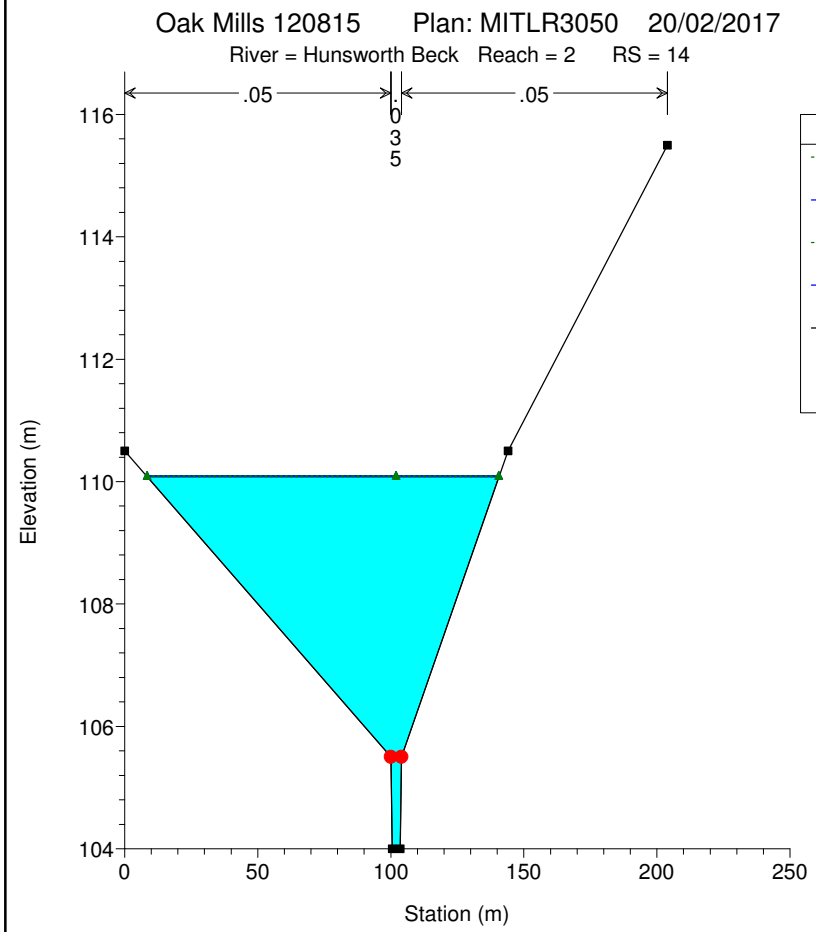
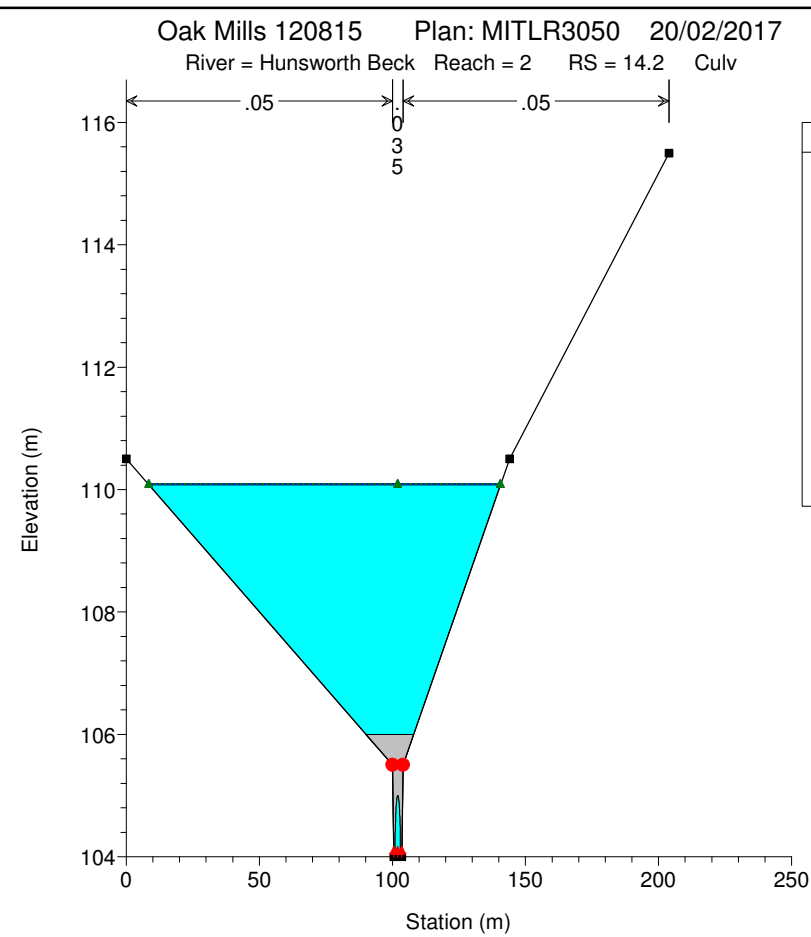
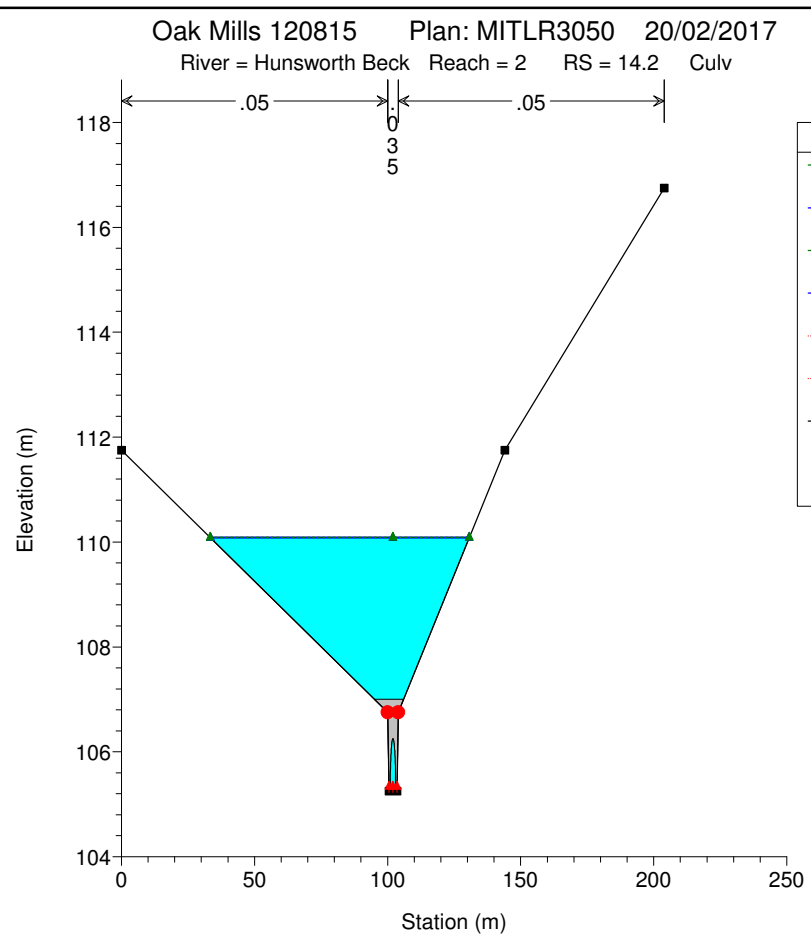
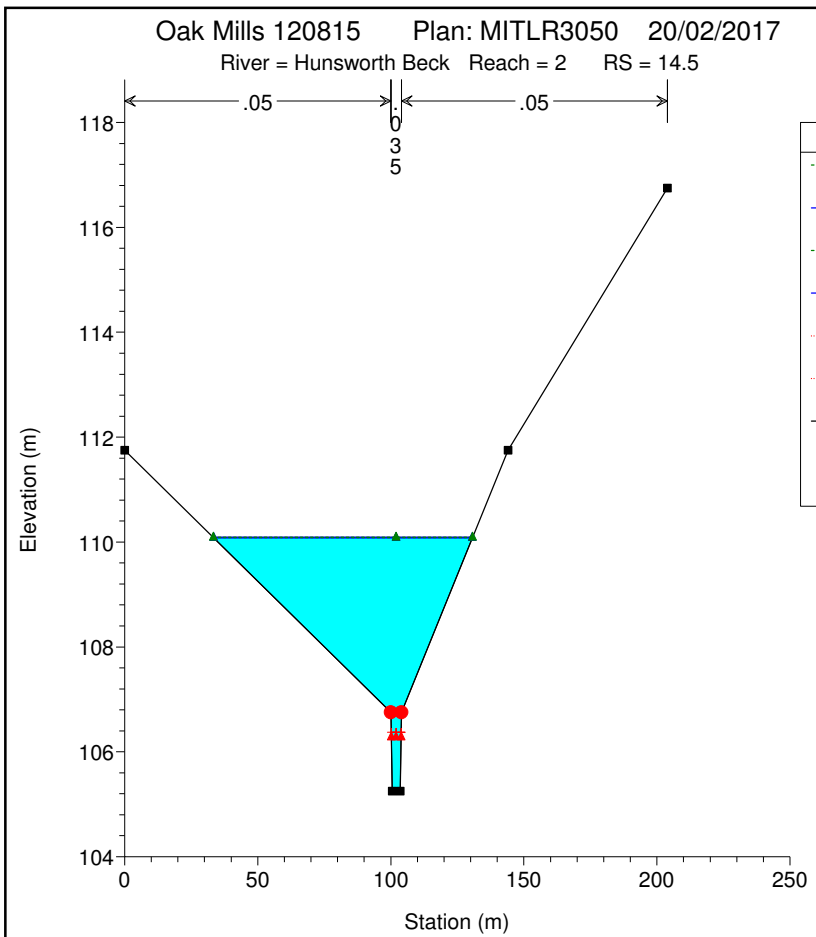
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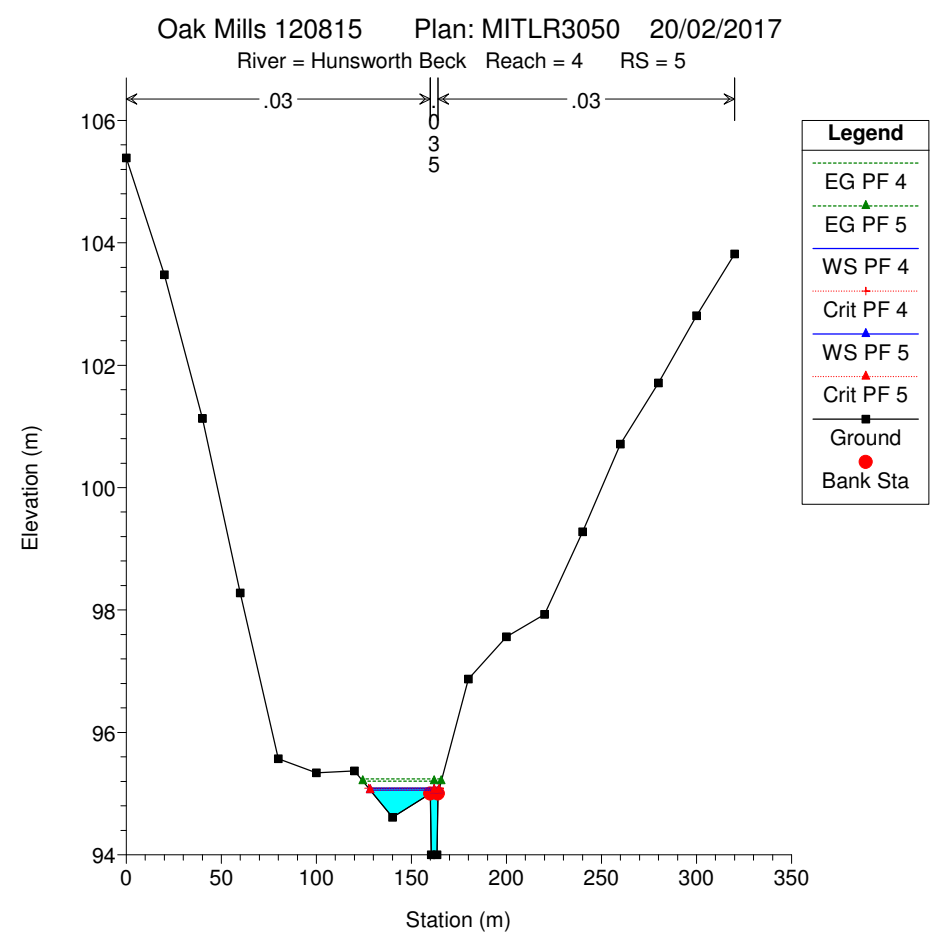
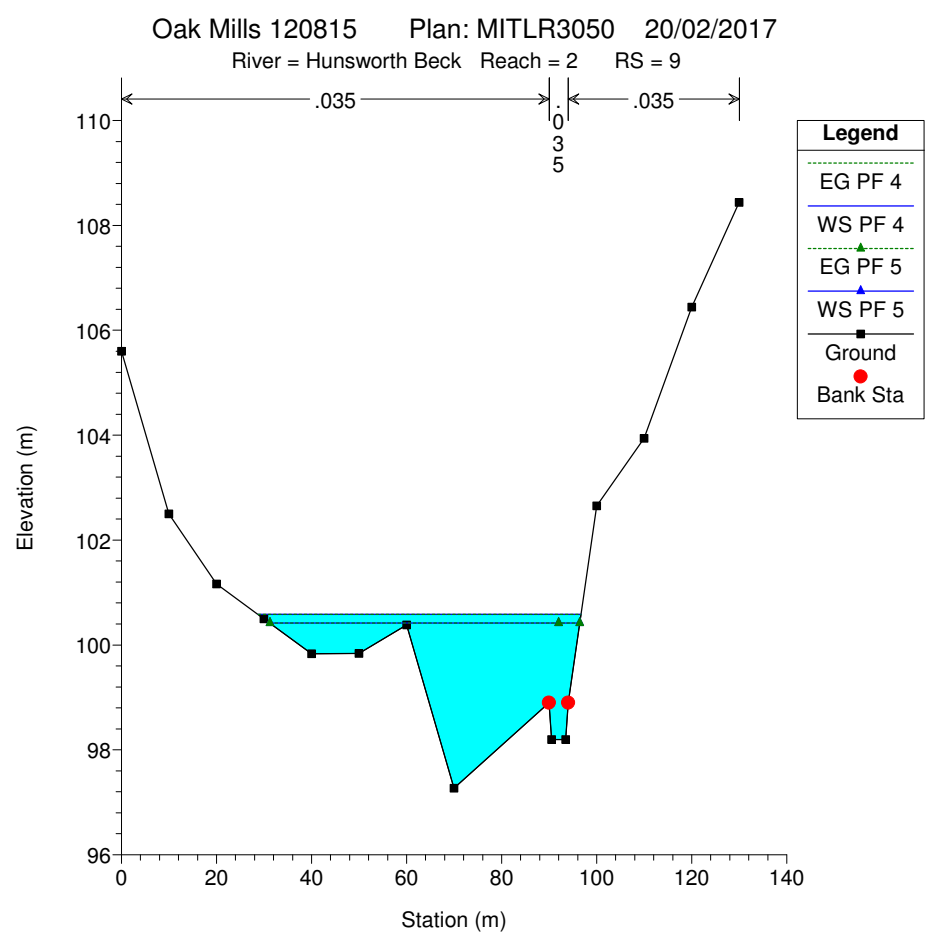
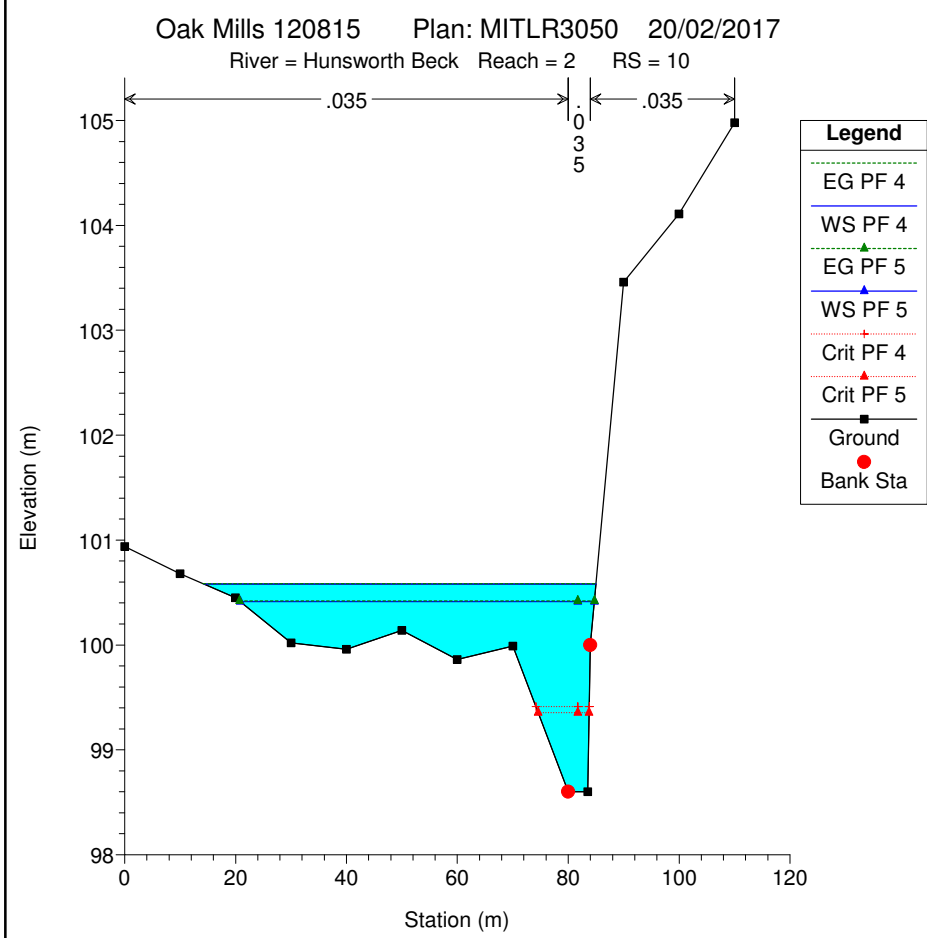
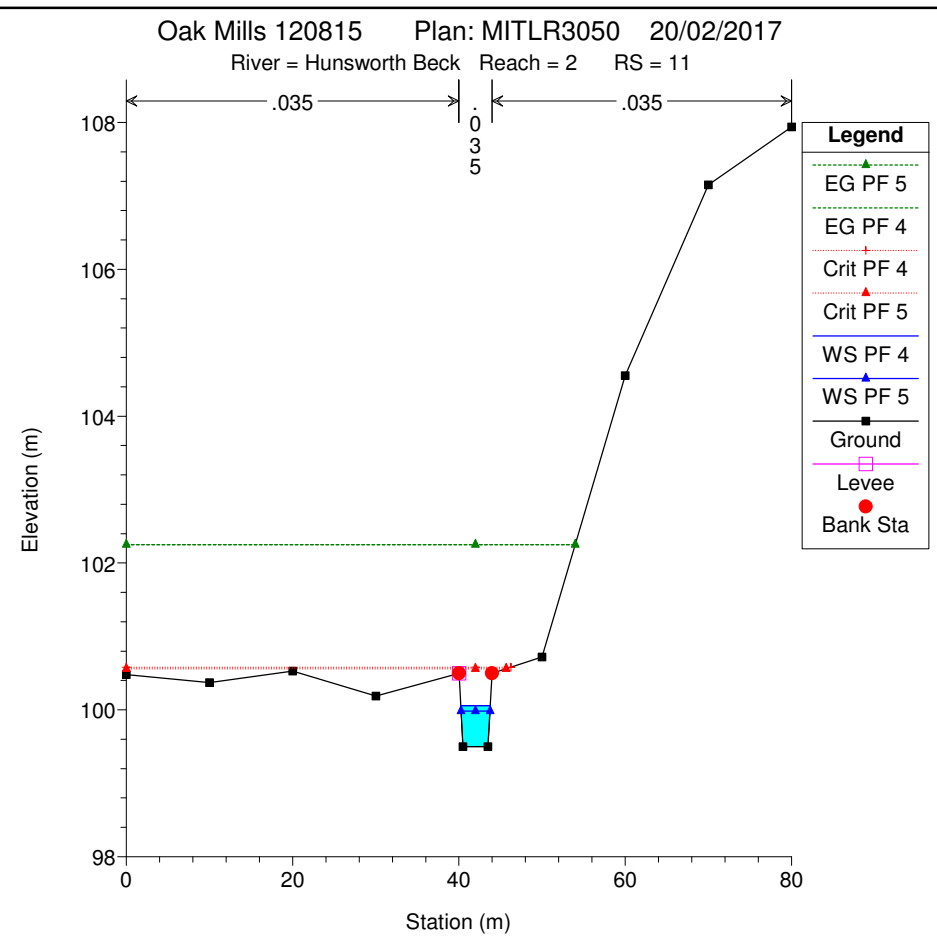
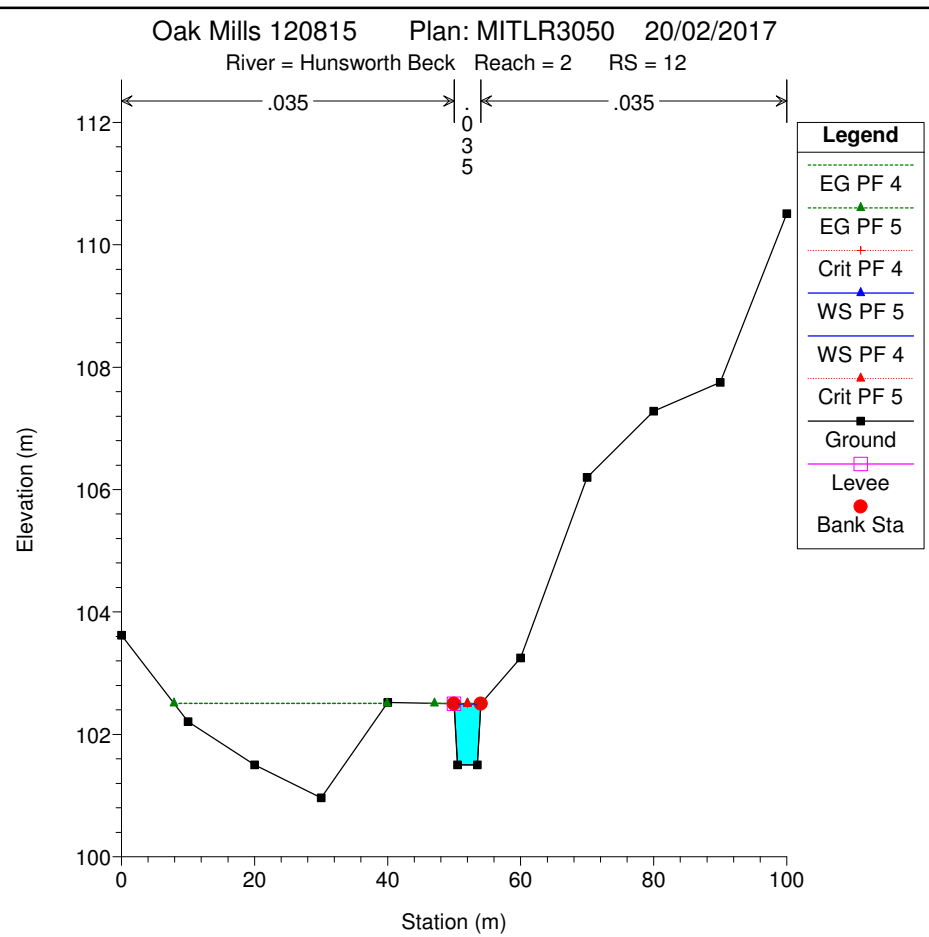
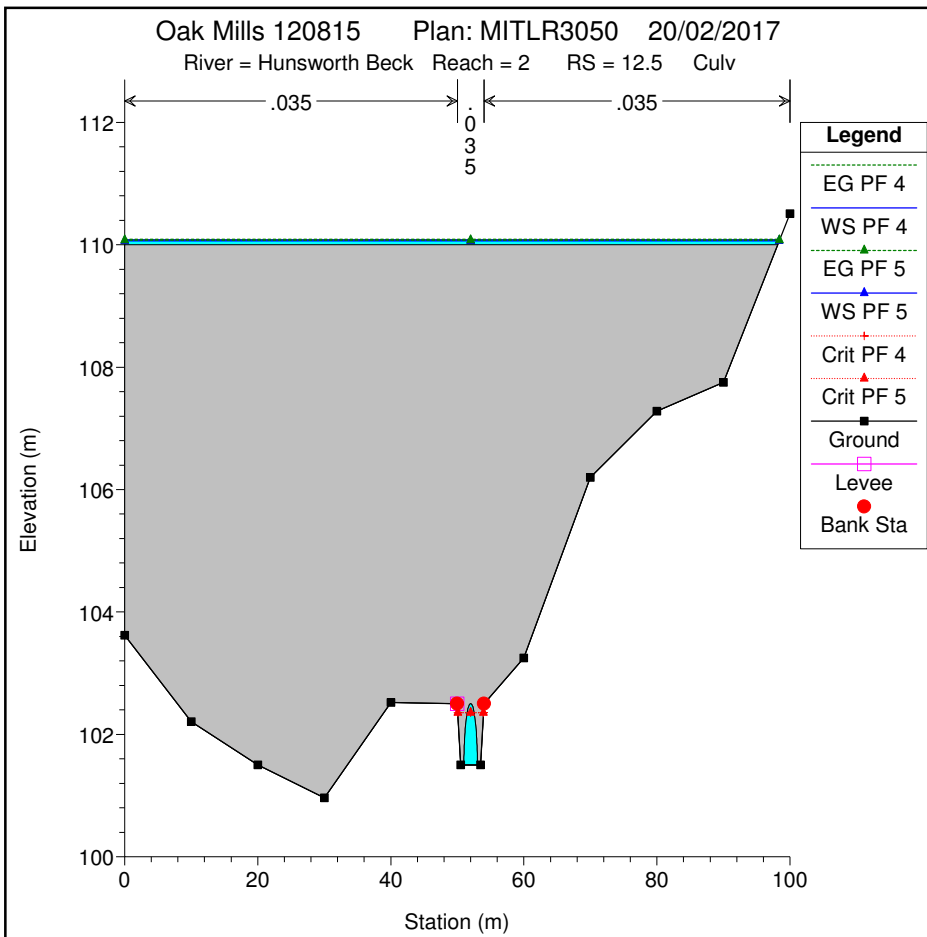
River	Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Hunsworth Beck	3	7.02	PF 5	15.77	96.31	97.59	97.28	97.72	0.004602	1.62	10.70	15.71	0.52
Hunsworth Beck	3	7	PF 4	18.20	96.05	97.08	97.08	97.18	0.008033	1.80	14.57	55.77	0.60
Hunsworth Beck	3	7	PF 5	15.77	96.05	97.08	97.08	97.15	0.006037	1.56	14.57	55.77	0.52
Hunsworth Beck	3	6	PF 4	18.20	95.00	95.73	95.79	95.93	0.021473	2.74	10.96	65.00	1.08
Hunsworth Beck	3	6	PF 5	15.77	95.00	95.69	95.77	95.98	0.030422	3.16	8.34	56.81	1.28
Hunsworth Beck	4	5	PF 4	19.71	94.00	95.09	95.09	95.24	0.008708	2.18	12.64	37.41	0.71
Hunsworth Beck	4	5	PF 5	17.08	94.00	95.06	95.06	95.20	0.008617	2.11	11.41	36.25	0.70
Hunsworth Beck	4	4	PF 4	19.71	93.00	93.46	93.49	93.68	0.017638	1.95	9.60	28.77	0.95
Hunsworth Beck	4	4	PF 5	17.08	93.00	93.43	93.45	93.63	0.018202	1.91	8.68	28.35	0.96
Hunsworth Beck	4	3	PF 4	19.71	91.00	92.92	92.49	92.94	0.000680	0.92	32.53	59.16	0.22
Hunsworth Beck	4	3	PF 5	17.08	91.00	92.86	92.44	92.88	0.000664	0.89	29.22	55.70	0.22
Hunsworth Beck	4	2	PF 4	19.71	91.00	92.50	92.50	92.70	0.006086	2.31	12.26	30.83	0.63
Hunsworth Beck	4	2	PF 5	17.08	91.00	92.45	92.45	92.64	0.006074	2.24	10.70	28.00	0.62
Hunsworth Beck	4	1	PF 4	19.71	89.00	90.38	90.55	90.88	0.014409	3.34	7.23	15.48	0.95
Hunsworth Beck	4	1	PF 5	17.08	89.00	90.31	90.48	90.80	0.014876	3.26	6.16	13.25	0.96
High Royds Beck	1	7	PF 4	6.18	119.25	119.50	120.19	126.13	1.292742	11.41	0.54	2.33	7.56
High Royds Beck	1	7	PF 5	5.36	119.25	119.50	120.08	124.48	0.970994	9.89	0.54	2.33	6.55
High Royds Beck	1	6	PF 4	6.18	107.25	108.51	108.15	108.65	0.004011	1.68	4.06	5.55	0.50
High Royds Beck	1	6	PF 5	5.36	107.25	108.44	108.07	108.56	0.003875	1.58	3.68	5.20	0.49
High Royds Beck	1	5	PF 4	6.18	105.43	106.15	106.15	106.30	0.009383	2.02	4.30	14.69	0.79
High Royds Beck	1	5	PF 5	5.36	105.43	106.11	106.11	106.26	0.009445	1.95	3.80	13.63	0.79
High Royds Beck	1	4	PF 4	6.18	103.15	104.32	104.40	104.59	0.013918	2.52	3.25	10.20	0.82
High Royds Beck	1	4	PF 5	5.36	103.15	104.28	104.35	104.54	0.013972	2.44	2.81	9.03	0.82
High Royds Beck	1	3	PF 4	6.18	100.00	100.60	100.44	100.61	0.002107	0.84	14.35	51.26	0.36
High Royds Beck	1	3	PF 5	5.36	100.00	100.48	100.43	100.52	0.007809	1.37	8.33	48.87	0.67
High Royds Beck	1	2.5		Culvert									
High Royds Beck	1	2	PF 4	6.18	99.78	100.58		100.59	0.000657	0.57	22.95	59.56	0.21
High Royds Beck	1	2	PF 5	5.36	99.78	100.42		100.43	0.001888	0.82	14.03	48.94	0.34
High Royds Beck	1	1	PF 4	6.18	99.45	100.58		100.58	0.000145	0.35	40.44	70.31	0.11
High Royds Beck	1	1	PF 5	5.36	99.45	100.41		100.42	0.000297	0.45	28.82	67.06	0.15
Cockleshaw Beck	1	3	PF 4	1.52	114.50	114.80	115.06	115.80	0.197359	4.42	0.34	1.29	2.73
Cockleshaw Beck	1	3	PF 5	1.31	114.50	114.80	115.01	115.55	0.148238	3.83	0.34	1.29	2.37
Cockleshaw Beck	1	2	PF 4	1.52	104.50	105.06	105.06	105.29	0.026225	2.14	0.71	1.53	1.01
Cockleshaw Beck	1	2	PF 5	1.31	104.50	105.01	105.01	105.23	0.026279	2.06	0.64	1.49	1.01
Cockleshaw Beck	1	1	PF 4	1.52	94.50	94.85	95.06	95.55	0.118546	3.69	0.41	1.33	2.13
Cockleshaw Beck	1	1	PF 5	1.31	94.50	94.82	95.01	95.46	0.119074	3.55	0.37	1.31	2.13

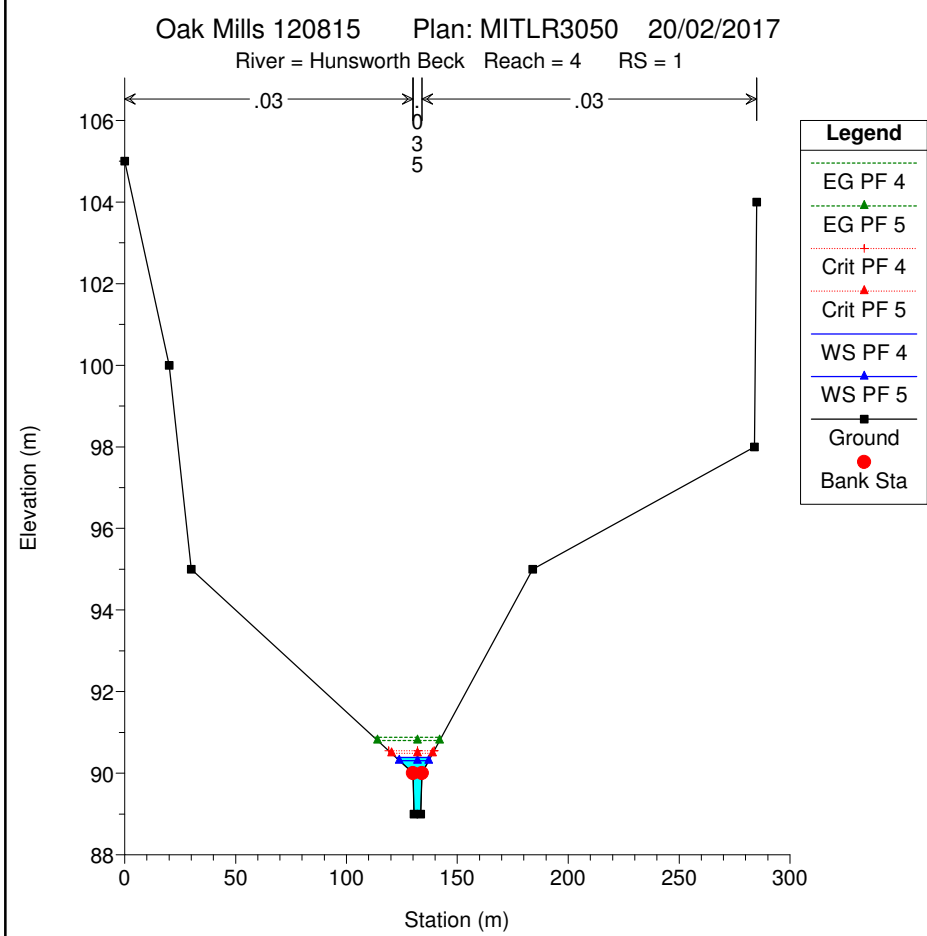
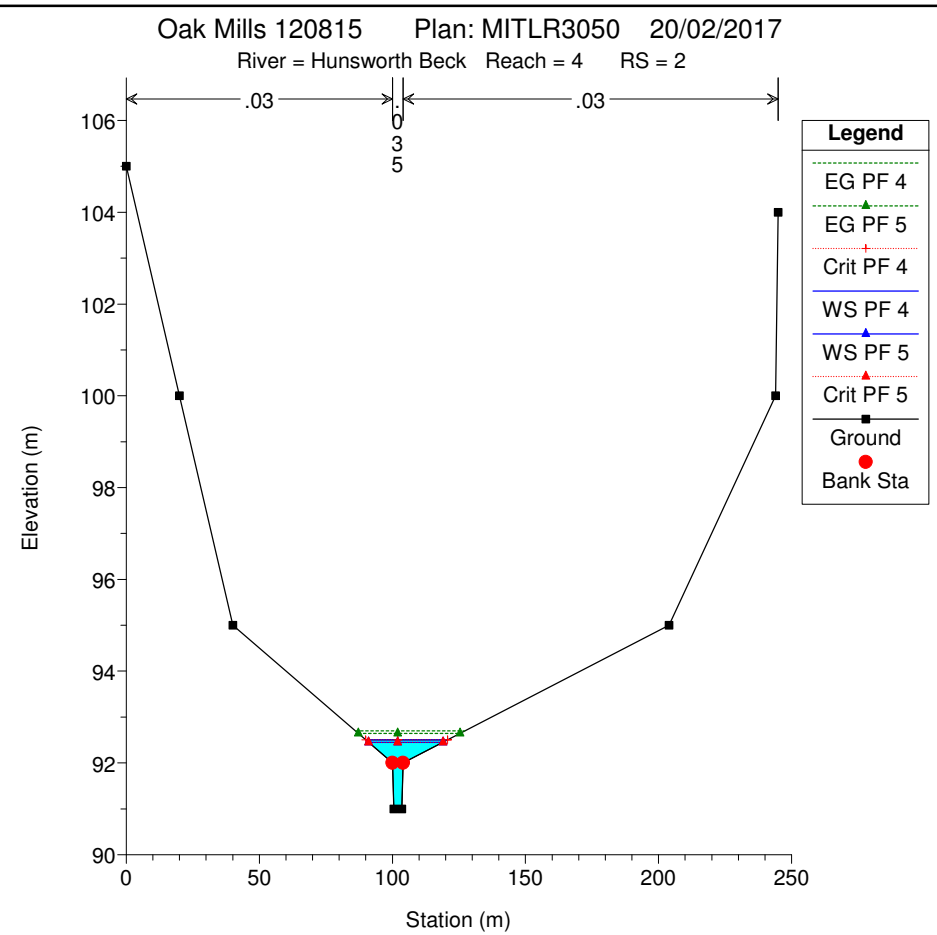
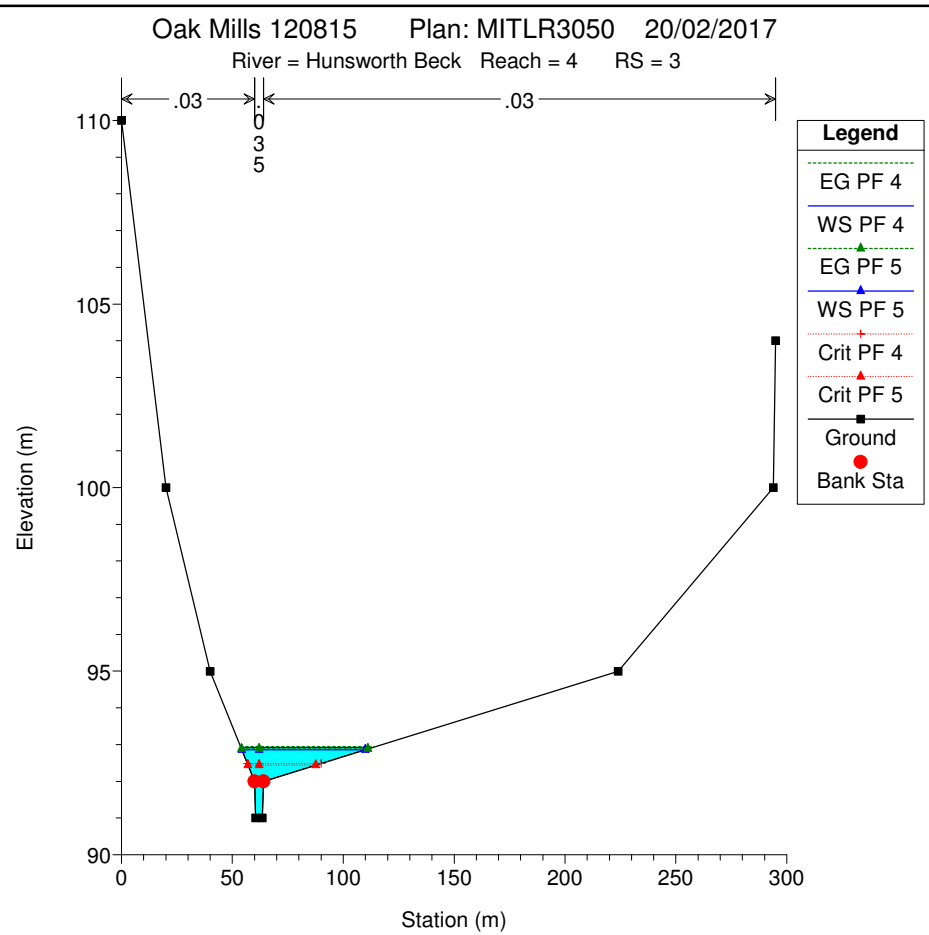
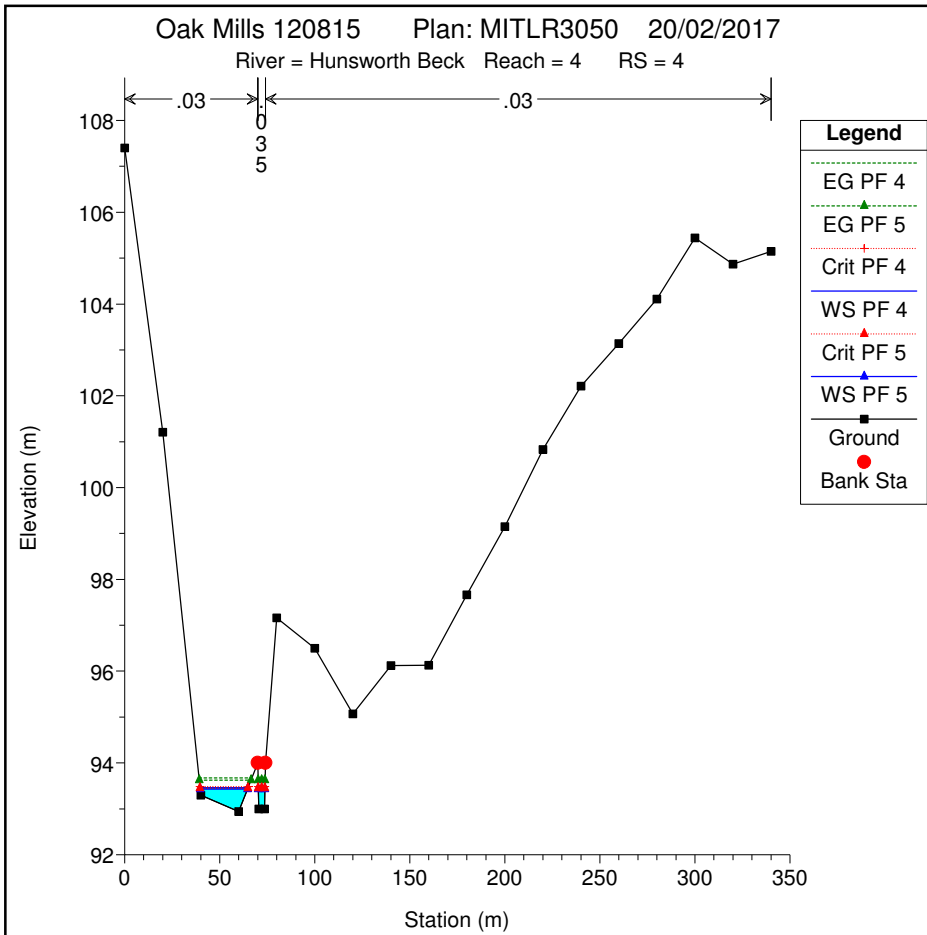






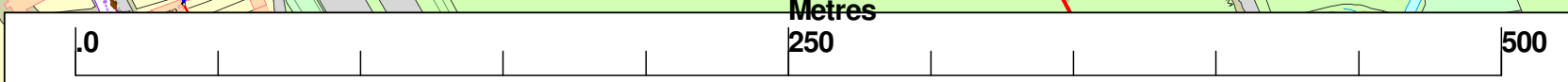
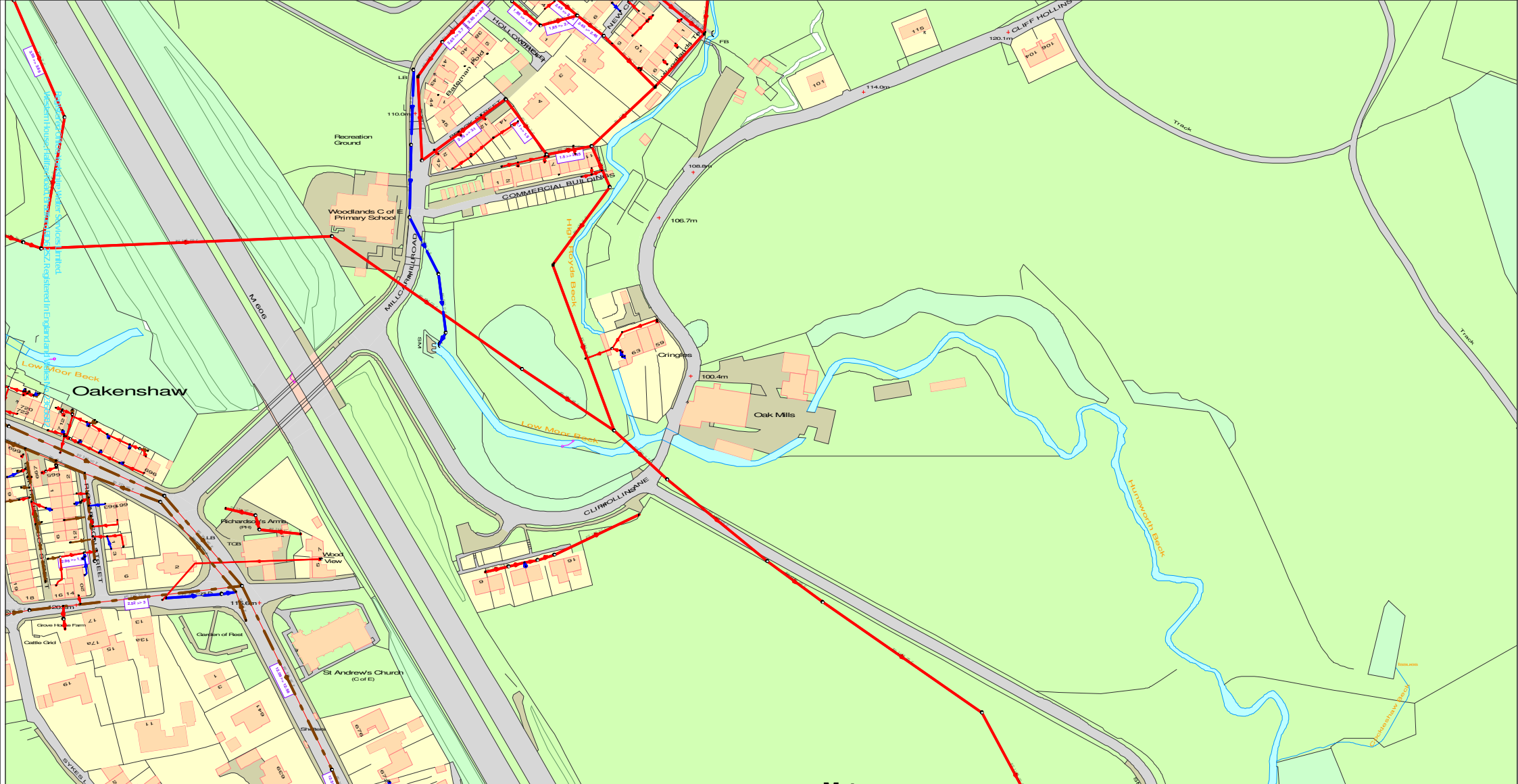







# Appendix AC

Yorkshire Water sewer map



**Safemove**  
A part of Yorkshire Water

417283 : 427622	Map Name : SE1727NW	Title	Partial Key	This plan is furnished as a general guide only and no warranty as to its correctness is given or implied. This plan must not be relied upon in the event of excavations or other works made in the vicinity of public sewers. No house or property connections are shown.
 Yorkshire Water PO Box 500, Halifax Road, Bradford BD6 2LZ Contact Name : Search Advisor H BROOK Contact Tel : 75 4487		Notes  (Ord) COPYRIGHT STATEMENTS: Reproduced by permission of Ordnance Survey on behalf of HMSO © Crown copyright and database 2014. All rights reserved Ordnance Survey Licence number 100022432	Foul Sewer = F Combined Sewer = C Surface Water Sewer = SW Trade Sewer = TD Partially Separate = PS  Date Req : 13/12/2016, 10:00:02 Source : Sewer Network Enquiry	Date Gen : 13/12/2016, 10:00:06