

MVV Environment Baldovie

**Energy from Waste Combined
Heat and Power Facility, Forties
Road, Dundee**

Flood Risk Assessment

FRA/01

Issue 2 | 13 December 2016

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 246472

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Executive summary

The Energy from Waste Combined Heat and Power (EfW CHP) facility proposed in Baldovie, Dundee, along Forties Road, will occupy a brownfield site that is currently used to store and process recovered highways and demolition material. The site is between the existing DERL facility and a vehicle scrap yard, north of the Dighty Water. The site is at risk of fluvial flooding, indicated by the SEPA flood maps.

There are other sources of flood risk, the most prevalent one is surface water – also identified by the SEPA flood maps - as the site is near the bottom of the hillside, where the ground levels out before the Dighty Burn. The drainage strategy (document submitted separately) addresses the runoff management, including the implementation of SUDS basins on the land opposite the proposed EfW CHP site. Due to lack of suitable space, the basins are placed on land occupied by functional floodplain. The volume displaced by the basins is to be provided elsewhere as compensatory storage.

The present site-specific flood risk assessment (FRA) was undertaken using a previous hydraulic model –first developed by a different consultant for the FRA of a new building in the Michelin site. Arup received that model and carried out a number of improvements, chiefly the replacement of the ground model representing the floodplain with LiDAR data provided by Dundee City Council, complemented by the topographical survey undertaken for this study. The hydrological inputs to the model are the same as those used by the consultant that undertook the original modeling work for the Michelin site assessment in 2014; after SEPA confirmed that the design flows were still applicable to the present study.

The modelling work confirms that the development site is partly within the functional floodplain (1 in 200yr event, 0.5% AEP). The proposed building footprint is to be raised to an elevation of 29.0mAOD, placing it outside the functional floodplain. The combined volume taken up by the proposed building and the SUDS basins is 2,060 m³, which is provided in a site on the right bank further upstream of the development site as compensatory storage.

1 Introduction and scope

Arup was commissioned by MVV Environment Baldovie (MVV) to carry out a flood risk assessment of the site for the proposed Energy from Waste Combined Heat and Power Facility at Forties Road, Dundee. The site lies near the Dighty Water on the south and a smaller watercourse called Fithie Burn further to the east. The SEPA flood maps¹ indicate that the site is at flood risk from river and surface water flooding. Thus, a detailed flood risk assessment was required.

This report summarises the work undertaken to ascertain the flood risk of the site, and the means of mitigating the identified flood risks.

2 Proposed development and site description

2.1 Proposed development

The proposed development is an industrial installation that incinerates residual waste to create steam and electricity through a turbine. The drawings in Appendix A show the proposed layout and longitudinal section. The proposed slab level for the installation is 29.0mAOD (note that the elevations on the cross section of the proposed facility in Appendix A are relative to the slab level). Some parts of the development like the waste pit are below this level (see Appendix A). The perimeter access road around the building rises from the same level at Forties Road (approx. 27.6mAOD) to the slab level, so vehicles can tip the waste directly into the pit. Thus, there will be parts of the internal road/access that will be between these elevations.

2.2 Site description

The study site lies between the Dighty Water and an existing waste management installation in the area called Baldovie, east Dundee. To the east is the Michelin tyre factory and to the west is a mixture of brownfield and urban park (Figure 1). NGR NO 44576 32863. The land falls north to south, forming the river valley from approx. 40mAOD at the north along Drumgeith Road to 27.8-28.5mAOD at the study site (Appendix A contains the topographical survey information). Below is a selection of photographs describing the site conditions.

The current use of the site is brownfield. An existing waste management plant is located immediately to the north of the study site and a vehicle scrap yard immediately to the south, further south is the channel of the Dighty Water. There are no flood alleviation measures in the vicinity. However, a flood storage area in the Michelin site has been recently completed.

¹ <http://map.sepa.org.uk/floodmap/map.htm>

A bridge under Baldovie Road is the only structure in the vicinity. Visual inspection suggests that its conditions is adequate. However, its height is fairly low and blockage is possible.

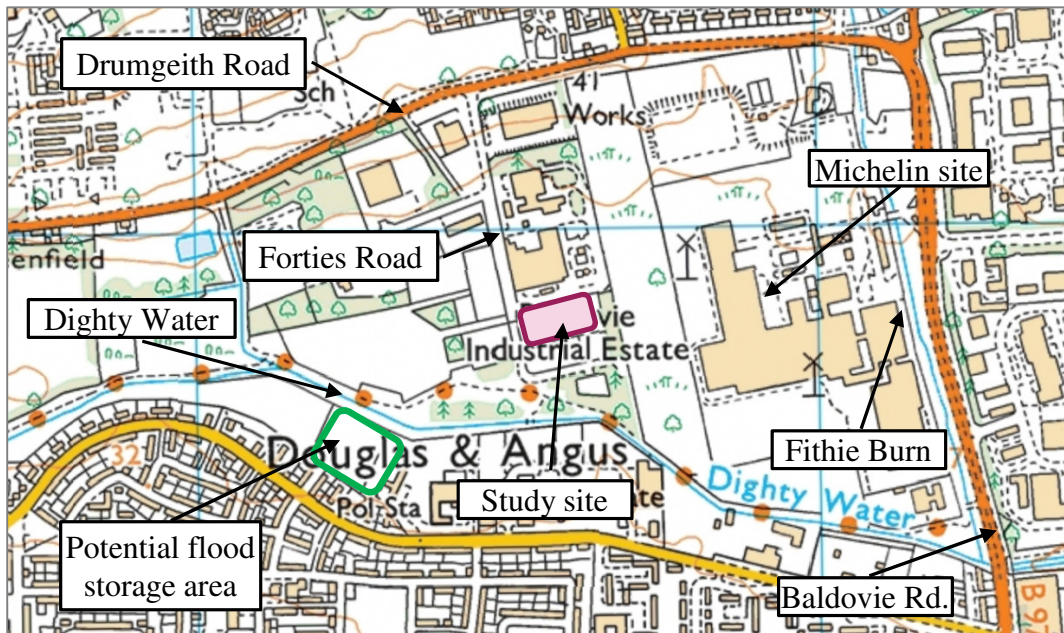


Figure 1. Location of study site. ©Bing Maps



View of the site (January 2016) from Forties Road



View of Forties Road from next to the site (note the fall of the ground)



Dighty Burn in the vicinity of the site



View of the floodplain from the right bank of Dighty Water looking north.



Upstream face of the bridge under Baldovie Road

View of the area selected for flood storage

2.2.1 Geology

The site bedrock geology is dominated by sandstone formations, whereas the superficial geology is made up of alluvium (Figure 2). Thus, the upper layers are permeable.

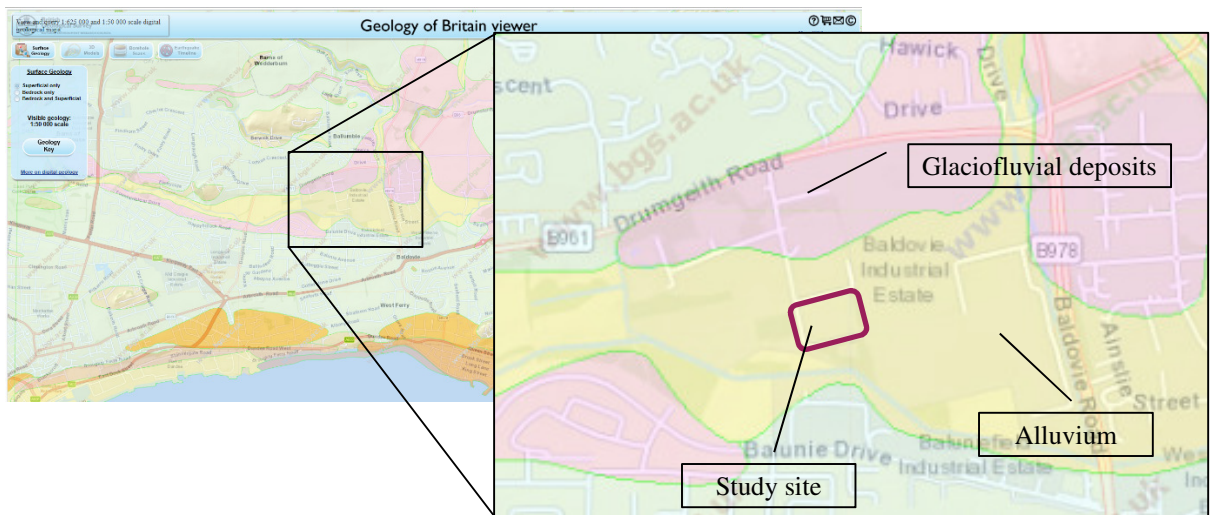


Figure 2. Superficial geology of the site and surrounding area. Source: BGS.

3 Flooding history

The British Hydrological Society Chronology of British Hydrological Events did not return any records of flooding along the Dighty Water. However, the Dighty Water is known to produce flooding. The Strategic Flood Risk Assessment (November 2014) for Dundee, Perth, Angus and North Fife contains a table of recent flood events. In recent years flooding occurred in Baldovie in September and December 2009 and October and December 2012. The site and surrounding areas also flooded in early January 2016, during the period when flooding and record water levels were recorded throughout Scotland. Photographic evidence of flooding was available for the 2016 event only (see Appendix C).

4 Approach and methodology

The present study follows the guidance provided by SEPA[1]. The current flood risk assessment is based on an initial screening of the potential flood risk posed by the different sources of flooding (see section 7).

Based on that preliminary assessment, fluvial flooding is the largest risk to the site and the analysis focused on it by undertaking detailed hydraulic modelling of the Dighty Water.

An existing hydrodynamic model, created by a different consultant in 2012-14 for a FRA of the adjacent Michelin site, immediately east of the present study site [2]. This model was updated by Arup with new topographical survey and LiDAR data for this study (see section 6.2 for more details). The model was also validated using photographic evidence and the oral description by Michelin and MVV staff of the flooding event in January 2016.

The preliminary assessment of the flood risk identified the need for flood compensatory storage. The sifting of an initial selection of possible sites resulted in the selection of an area south west of the study site, over the right bank of the Dighty Water (Figure 1).

Following Scottish planning legislation and SEPA guidance, the study focused on determining the functional floodplain, defined as the flood extent that results from the 1 in 200 year (0.5% AEP) flood event. The impact of climate change was also analysed, accounting for an increase of flows of 20% (following SEPA guidance).

The estimation of the functional floodplain defines the area that would be suited for development or if the development extends over the flood extent, the compensatory volume required to be provided elsewhere. The analysis of the configuration of the compensatory storage area in combination with the development proposals defined the final fluvial flood risk. The modelling work also ensured that flood risk was not increased elsewhere, as quantified by flood extent, water levels and pass forward flows.

The finished floor levels are defined, following SEPA guidance [1], as the water levels for the 1 in 200yr plus climate change event plus freeboard (to be agreed with Dundee City Council).

The assessment of the other sources of flood risk was undertaken based on the data availability. A number of recommendations for the development configurations are made as a consequence of the assessment.

5 Hydrological assessment

5.1 Design river flows

Atkins undertook a flood risk assessment for Michelin in 2012-14[2]. Their model included design flood hydrographs for the Dighty Water and Fithie Burn. The peak flows are below.

Table 1. Peak flows (m³/s) estimated by Atkins in 2012-14 and used for the present study.

Watercourse	1 in 200 yr (0.5% AEP)	1 in 200 yr plus climate change (+20%)
Dighty Water	35.8	46.2
Fithie Burn	18.1	21.7

Arup consulted SEPA on the need, or otherwise, for updating the 2014 hydrological assessment. SEPA confirmed that such update was not necessary and the design inflows developed by the previous consultant were still applicable (Appendix B). Thus, the present study also used the design inflows estimated by Atkins for the original modelling work.

5.2 January 2016 event flows

DCC requested the validation of the hydraulic model by representing the January 2016 flood event. The flow records at the nearby gauging station on the Dighty Water at Balmossie Mill, approx. 3km downstream of the study site, were used to obtain the model inflows (Figure 3). The flows recorded at the station were scaled, using the values of QMED estimated for the Dighty Water, Fithie Burn and at Balmossie GS. The ratio of QMED was used as scaling factors for the flows at Balmossie to generate the inflows for the hydraulic model. Further details of the procedure and results are in Appendix B.

Table 2. Scaling factors and resulting peak flows for the January 2016 event.

Sub-catchment	QMED ratio	Qp (m ³ /s)
Dighty Water	0.60	24.1
Fithie Burn	0.25	10

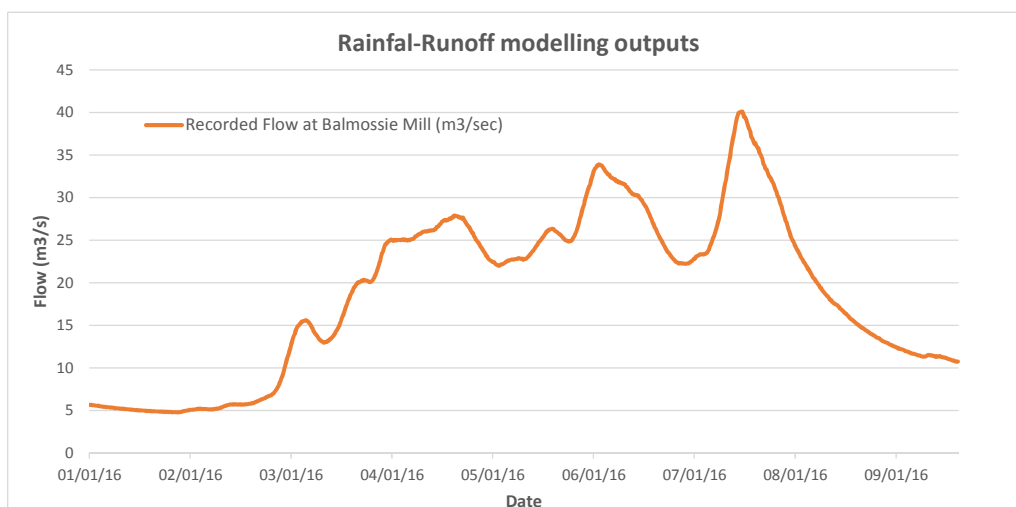


Figure 3. Recorded flows at Balmossie Mill in early January 2016.

6 Fluvial hydraulic modelling

6.1 Originating model

As previously stated, there was an existing hydrodynamic model of the Dighty Water and Fithie Burn developed by Atkins for their work on the Michelin site [2]. The model was an InfoWorks RS 1D-2D model, whereby the channel was represented in the 1D component using discrete cross sections and the floodplain to the north of the Dighty Water was modelled in the 2D domain. No floodplain to the south of the Dighty Water was included in the model. The sketch below is an extract from the Atkins 2014 FRA report showing the extent and schematisation of the original model.

The cross section data originated from a specific topographical survey, whereas NEXTMap data was used for the 2D domain ground levels (Appendix B in the Atkins 2014 report).

Arup reviewed this model and noted that the definition of the floodplain using NEXTMap data was inappropriate for the correct definition of the flow paths and water depths in the study area. Arup then sought complementary ground levels to update the model (see next section).

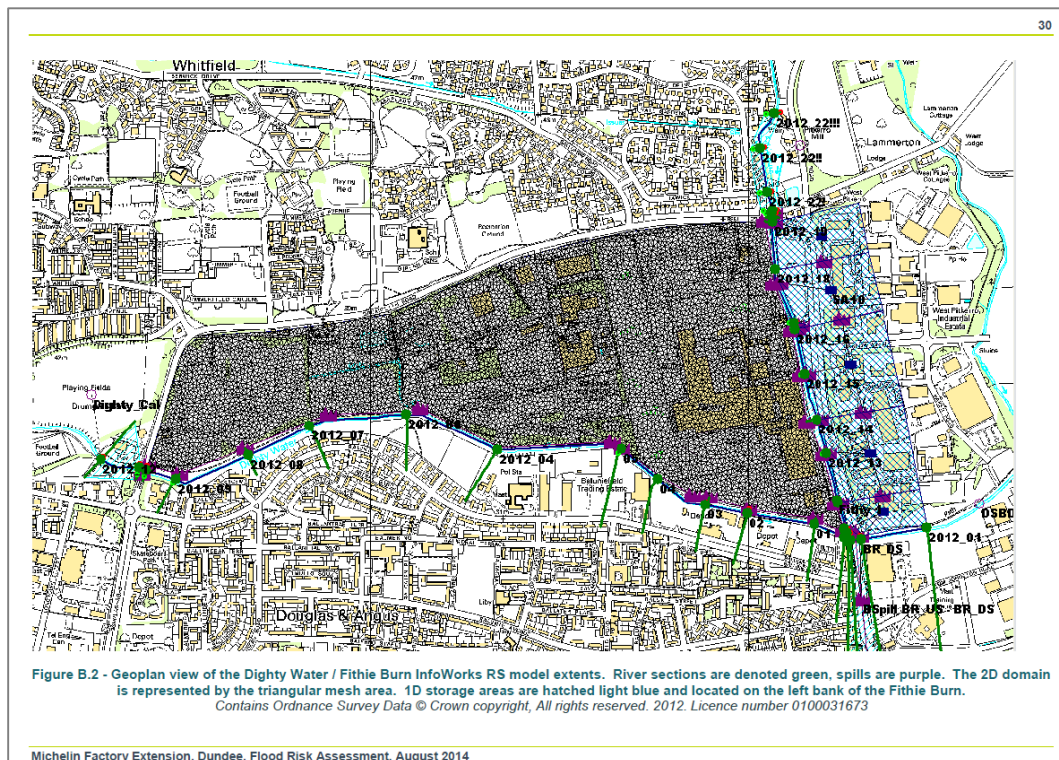


Figure 4. Schematisation of the original Atkins (2012-2014) hydraulic model.

6.2 Model updates

The original InfoWorks RS hydraulic model was converted/translated into InfoWorks ICM software, after resolving initial software incompatibilities (not all unites were imported correctly by IW ICM). The model outputs after translating the model were compared with the original model, concluding that the translation did not include any alteration to the model results.

The main updates to the hydraulic model correspond to:

- a. Replacement of the ground model of the 2D domain. The following sources of ground levels were incorporated into the model:
 - Topographical survey data of the study site and the area preselected for mitigation compensatory storage was available (see Appendix A).
 - LiDAR data newly released by Dundee City Council under the Open Government Licence², covering the entire extent of the hydraulic model and beyond.
 - The ground levels in the Michelin site proposed by the 2012-14 FRA, including the geometry of the flood compensatory storage area in the Michelin site to the east of the current study site. These were taken from the original hydraulic model.
- b. Amendment of some spill unit data points to better represent the bank profiles. Topographical survey and LiDAR data were used as sources of the elevation values.
- c. The addition of the area identified for compensatory storage into the hydraulic model also required the extension of the 2D domain and the update of the spill units connecting the area to the corresponding cross sections using topographical survey and LiDAR data elevations.

No other modification of the model was made, in particular, the design inflow, as mentioned above, remained the same as per the original Atkins FRA.

6.3 Final model

The final model used for the present FRA was then based on the original 2012-2014 InfoWorks RS model updated with new ground elevation data, significantly improving the reliability of the out of bank flows and water levels and overland flow routes.

Appendix C contains a sketch of the model schematisation and ground levels used.

² Scotland's LiDAR Phase 1 data is now available under an Open Government Licence. Scottish Government. (<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3>), and Phase 2 LiDAR is available under an Open Government Licence for non-commercial use (<http://www.nationalarchives.gov.uk/doc/non-commercial-government-licence/non-commercial-government-licence.htm>).

6.4 Model validation (Jan16 event)

In order to validate the model Dundee City Council (DCC) requested that the January 2016 flood event was modelled, demonstrating that the hydraulic model represents the flooding mechanism and overland flow routes satisfactorily. Only anecdotal reports of the flooding mechanisms, provided by Michelin staff and MVV, and the trash marks noted during the site visit by Arup in January were available. Thus, the model general representation of the event was ascertained.

Flow data from the gauging station Dighty Water at Balmossie Mill (NO476325), located approx. 3.4km d/s of the study site was used to set the model boundaries (see Appendix B). The baseline model was run with the estimated river flows for the period 1st-9th January 2016.

The model reasonably represents the flooding mechanism reported to Arup and the general flooded areas. River flows overtop the left bank to the SW of the study site, with overland flows initially contained south of the footpath. As overtopping increases waters reach the BMX track and quickly spread towards Forties Road, flooding the land between the study site and the BMX track. The flood storage area created in the Michelin site also floods. Note in particular the small flood route identified by the model at the entrance of the EfW site, off Forties Road, where sand bags were placed during the event to prevent water ingress (red circle in Figure 5). Appendix C contains details of the validation of the model using available photographic evidence.

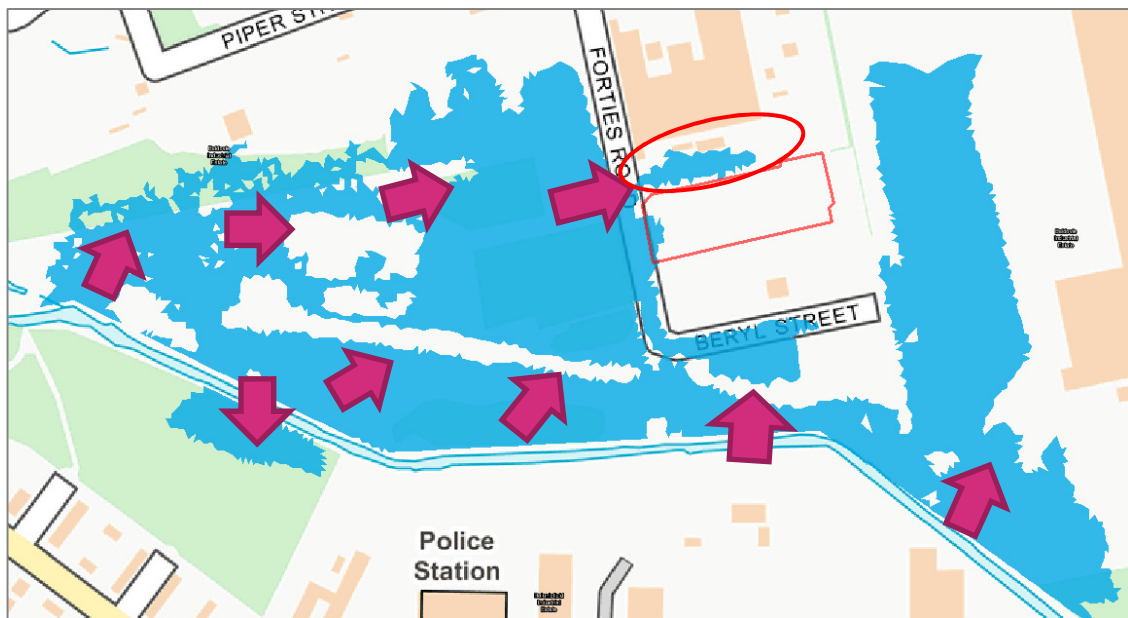


Figure 5. Modelled flood extent for the 7 January 2016 event. The arrows indicate the flow routes.

6.5 Sensitivity analyses

In accordance with SEPA guidance [1] the following sensitivity analyses were undertaken, using the predevelopment conditions model and the 200yr event as baseline. Table 3 shows water levels at a selection of key locations and Figure 10 shows the long profile along the river.

6.5.1 Higher flow

Flow inputs were increased by 20%, which is equivalent to the climate change scenario. Maximum water depths in the vicinity of the study site are in Figure 6.

6.5.2 Increased roughness

Roughness values throughout the entire models (1D units and 2D domain) were increased by 10%. The maximum flood depths are in Figure 7.

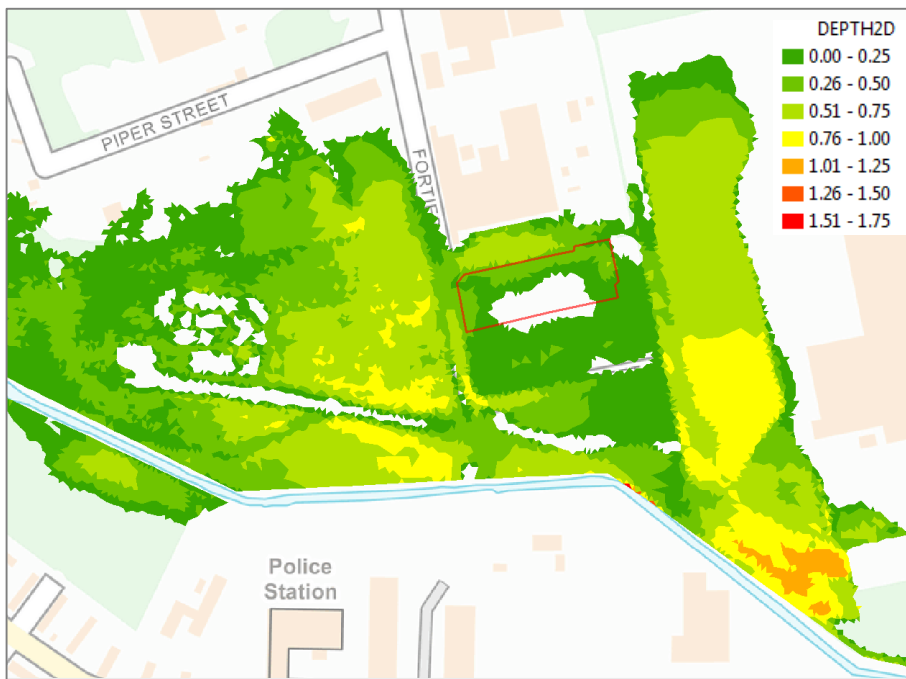


Figure 6. Maximum water depths (m) for the sensitivity analysis to increased flow.



Figure 7. Maximum water depths for the sensitivity analysis to increased roughness.

6.5.3 Structure blockage

The key structure in the Dighty Water is the bridge under the B978, immediately downstream of the confluence with Fithie Burn. The structure is made of three rectangular openings separated by concrete walls, acting as piers (Figure 8).



Figure 8. Upstream face of the B978 Bridge. Note the confluence of the Dighty Water and Fithie Burn immediately upstream.

SEPA Technical Guidance [1] does not specify a degree of blockage. We analysed a 1/3 blockage of the bridge. The total opening area of the bridge is 24.6m^2 ; 1/3 of it is 8.2m^2 . Since this value is nearly identical to the area of the leftmost opening (8.12m^2), the blockage was represented in the model by deleting this opening from the bridge unit. The resulting flood depths for the 1 in 200yr event with

bridge blockage are below. The flooded area is nearly identical to the 200yr+cc event, although flood depths are slightly larger.

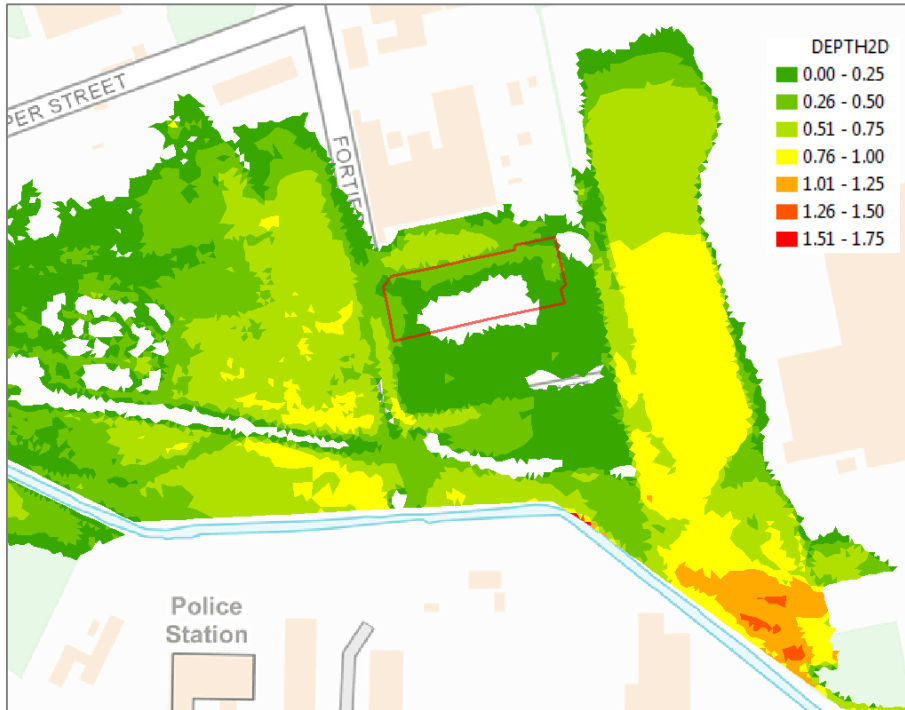


Figure 9. Maximum water depths for the sensitivity analysis to blocked structure.

6.5.4 Downstream boundary

The model downstream boundary is a normal-depth boundary, commonly used when the watercourse continues without restrictions and there are no effects of standing (lakes) or tidal waters. No bridges or other structures are in the river for over 800m and the confluence with the Murroes Burn happens over 500m downstream. Thus, no influences to the river conveyance were anticipated; so no sensitivity assessment was carried out.

6.5.5 Assessment of sensitivity of the model results.

The model results for the sensitivity runs show that water levels increase consistently along the Dighty Water (Table in Appendix C and Figure 10). The 33% blockage of the B978 Bridge showed a local rise of the water level upstream of the bridge to the same elevation as that of the climate change scenario. Higher river flows and partial blockage are therefore the most relevant uncertainties associated to the model results.

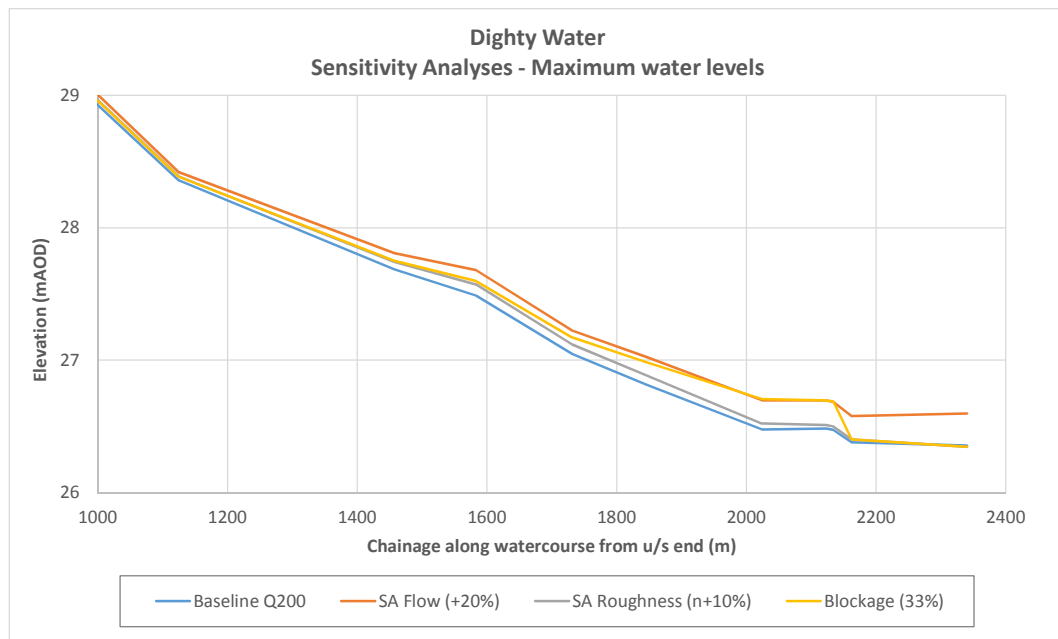


Figure 10. Long profile of maximum water levels for the sensitivity analysis runs.

6.6 Design events

6.6.1 Definition of functional floodplain

The flood extent (water levels and depths) over the study area for the 1 in 200 year event under existing conditions is in Figure 11. Values of water levels at key locations along the Dightly Water and the site are in Table 3. Water levels on the site are between 28mAOD and 28.25mAOD. Depths over the development site reach a maximum of 0.5m over the north edge. At Forties Road depths are higher (max = 0.75m). The proposed development footprint (red polygon in Figure 11) impinges over the functional floodplain. In order to reduce the risk of flooding, the building slab level is to be raised above flood waters (see section 6.6.2).



Figure 11. Maximum water levels (A) and depths (B) in the study area for the 1 in 200yr event under existing conditions. Development footprint is marked by the red polygon. The absence of flooded area to the west of the site in A) is due to the legend setting, which has a maximum of 28.5mAOD for clarity. Flooding occurs, as seen in B).

Table 3. Maximum water levels (mAOD) at key locations. All figures rounded to the nearest 0.01m. See Figure 12 for locations.

Name	Model unit	Location	Pre-development conditions				Post-development conditions	
			Baseline	Sensitivity analyses*				
			1 in 200yr	Increased Flow (+20 %)	Increased Roughness (+10%)	Structure blockage (33%)	1 in 200yr	1 in 200yr + CC
Balunie Drive	2012_07	River section	30.58	30.68	30.62	30.62	30.61	30.71
U/S of storage area	2012_06	River section	29.56	29.65	29.59	29.60	29.57	29.67
Storage area	n/a	Floodplain	n/a	n/a	n/a	n/a	28.87	29.079
Police station	2012_04	River section	28.34	28.40	28.37	28.37	28.34	28.42
Baluniefield Trading Estate	05	River section	27.66	27.76	27.71	27.72	27.67	27.79
B978 Bridge	BR_US!!	River section	26.48	26.69	26.51	26.69	26.49	26.71
Study site	n/a	Floodplain	28.17	28.24	28.20	28.20	n/a	n/a
Forties Road (entrance of site)	n/a	Floodplain	28.20	28.24	28.20	28.20	28.19	28.28

*Applied to the 1 in 200yr event under predevelopment conditions.

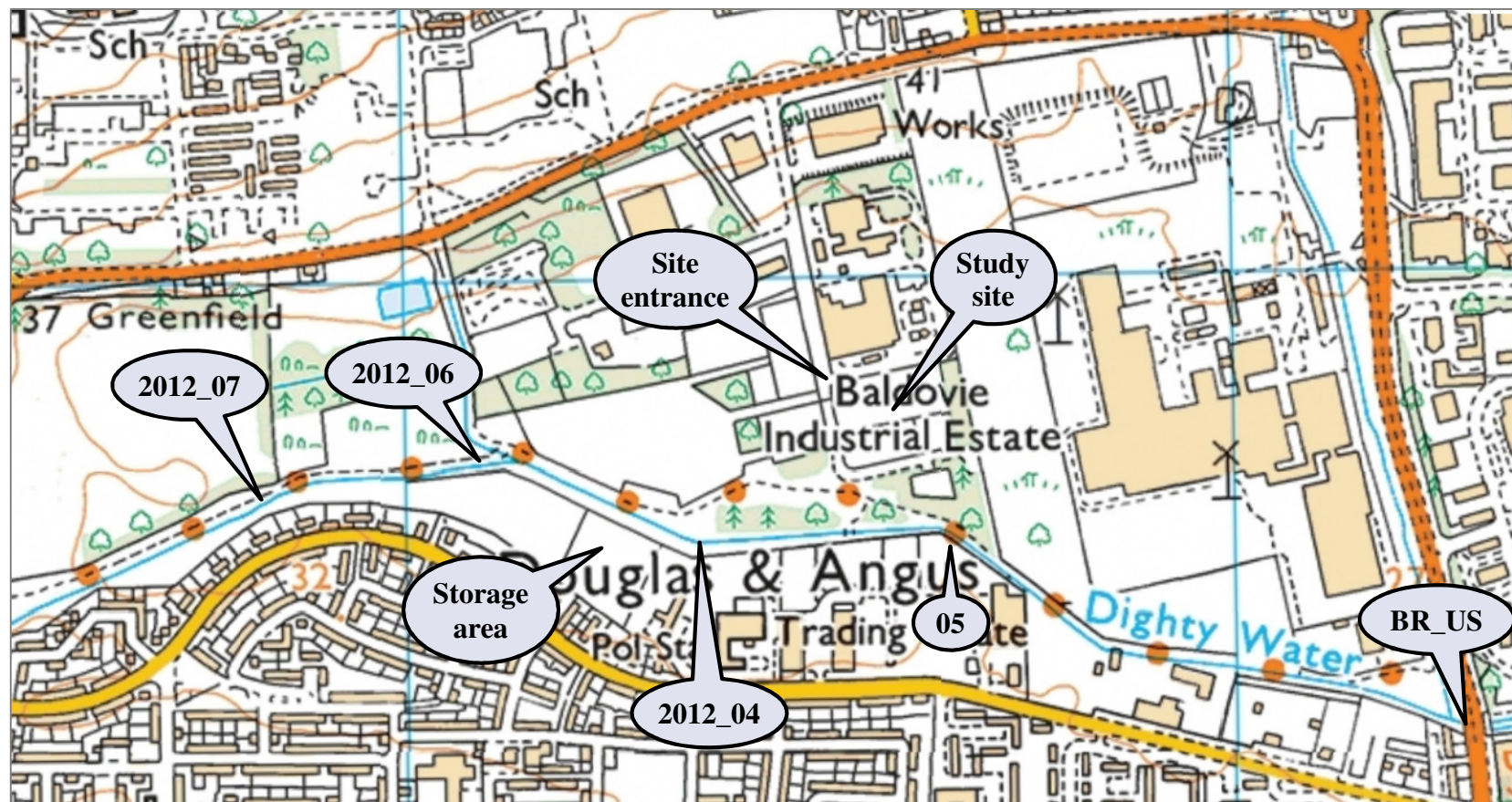


Figure 12. Key locations of model outputs.

6.6.2 Mitigation measures

Volume requirements

Land raising is the proposed measure to reduce the risk of flooding to the EfW facility. The proposed slab level –following SEPA’s recommendation [1]– will be set to an elevation equal to the maximum flood level for the 1 in 200 year event plus climate change plus a suitable freeboard (300-600mm). The volume of functional floodplain displaced by the proposals must be provided elsewhere as compensatory storage.

The estimated volume displaced by the development proposals during the 1 in 200 year event is 716 m³. Additional volume was to be provided due to the flood waters displaced by the proposed SUDS basins, which due to site space constraints are located adjacent to Forties Road³ (Figure 13) in an area flooded to 0.5-0.75m of depth (Figure 11B). Using a conservative approach, whereby the basin embankment outer edge was considered a vertical wall, the volume displaced is 1,344m³. Thus the total combined compensatory storage needs were 2,060m³.

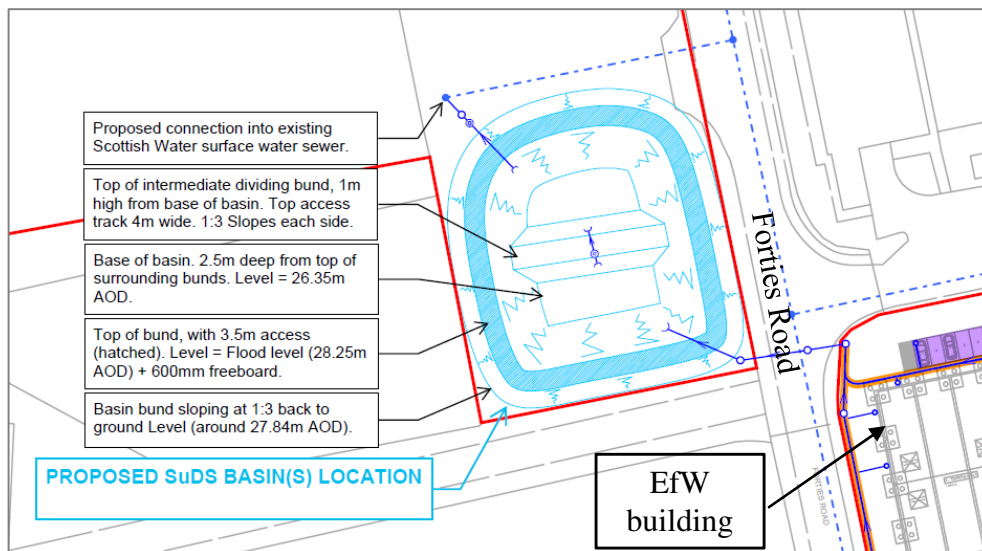


Figure 13. Sketch showing proposed SUDS basins opposite the EfW building across Forties Road.

Compensatory storage area properties

There is no suitable area in the vicinity of the development site where to implement compensatory storage. MVV agreed with DCC to use a plot on the right bank of the Dighty Water, further upstream from the development site (approx. NGR NO442327, see Figure 1) for the provision of compensatory storage.

³ Please note that the SUDS basins currently proposed and analysed are only intended to remain on the site west of Forties Road on a temporary basis. Once the current DERL facility is decommissioned and demolished, the SUDS basins will be relocated to the DERL site, subject to a specific reassessment and feasibility study.

A number of configurations were tested to demonstrate that provision of additional flood storage is viable in the area identified. All of the options aimed at passive filling and draining without pumping or gate operation, to eliminate malfunction and minimise maintenance. This conditioned the storage area characteristics.

The adopted compensatory storage consists of an excavated area of 8,860 m² (irregular polygon in plan) off the river banks, which takes overtopping flows naturally, and an open channel outlet connected to the natural ground at the S-E edge (Figure 14). The bed elevation of the storage area is at 28.6mAOD, just slightly above of the water level remaining in the natural ground on the N-E of the storage area at the end of the event, facilitating the automatic emptying. The outlet is 2m wide at its upstream end, tapering out to reduce flow velocities discharging into the natural ground. The invert is at the same elevation as the rest of the storage area, 28.6mAOD. The basin is bound by a low embankment (proposed top of embankment 29.3mAOD, 300mm freeboard above river bank level) on its east and north-east edges, made up of the excavation material.

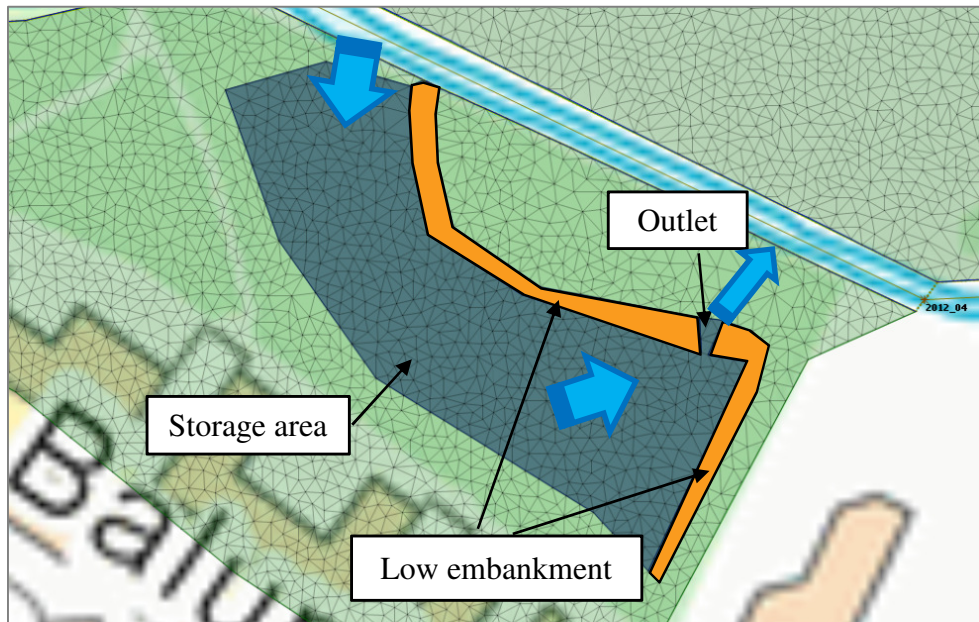


Figure 14. Sketch of the proposed flood compensatory storage area. The arrows represent the flow direction.

The preliminary ground excavation volume is 11,121 m³. The low embankment along the east and south-east edges of the storage area is approx. 230m long. An approximate embankment section with a top of embankment set at 29.3mAOD with side slopes of 1 in 3⁴ results in an approx. volume of 345m³. The remainder excavation material can be used to landscape the area or increase the size of the embankment. This will be defined at detailed design stage. Note that the storage area is constrained by the presence of properties to the south (Figure 15), so the storage area footprint had to go over higher ground. Increasing excavation

⁴ No geotechnical study for this structure is available yet, the values are only a preliminary estimation.

volumes. A further refinement of the storage can be carried out at detailed design stage. Here it is demonstrated that the required volume is achievable.

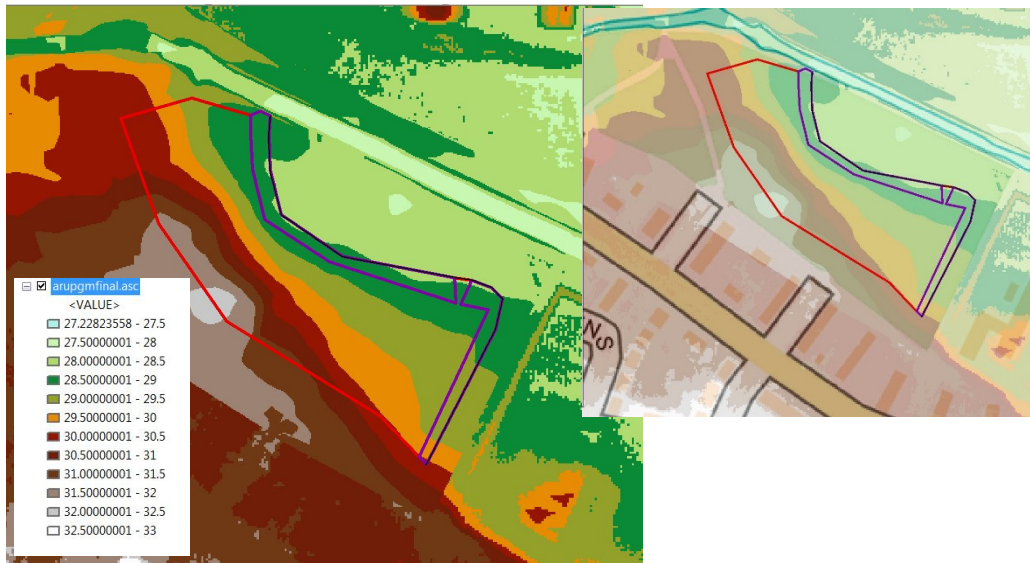


Figure 15. Existing ground elevations in the compensatory storage area. The smaller image shows the location of the properties south of the storage area on the OS map.

Volume provided

For the 1 in 200 year event the maximum volume stored are 2,525 m³, in excess of the already conservative volume needed. This excess volume should account for the vegetation/planting that is possible in the area. The maximum water depth is 0.285m (Figure 16), conditioned by the downstream water levels. This is an advantage as such shallow waters would minimise any risks to the public in flood events.

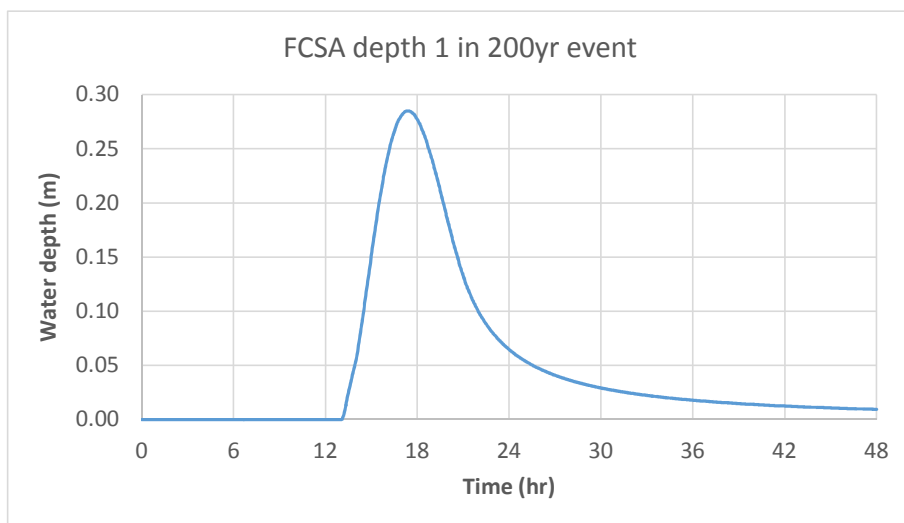


Figure 16. Time series of the water depth inside the flood compensatory storage area for the 1 in 200yr event post-development conditions, showing filling up and emptying.

The proposed storage area analysed is a vertical excavation (for simplicity in the representation in the hydraulic model). Detailed design should formalise the design of the excavation slopes based on geotechnical parameters. Please note that a minor reprofiling of the right bank near the north end of the storage area is required in order to ensure sufficient overtopping by river flows. The change is minimal, setting the elevation to 29.1mAOD, the current elevation is 29.22mAOD (see Figure 17).

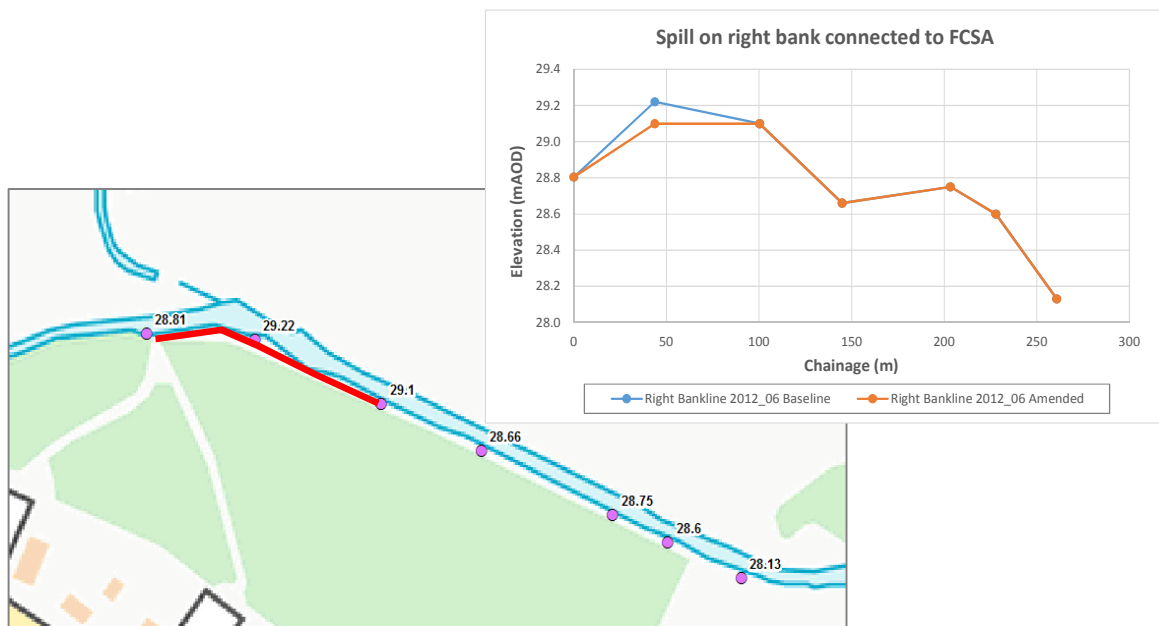


Figure 17. Proposed amendment of the spill profile connected to the u/s end of the flood compensatory storage area.

6.6.3 Post development conditions

After the incorporation of the proposed storage area, the model was run again for the 1 in 200yr event for the assessment of the impact of the development and the 1 in 200yr plus climate change event to inform the slab level. The flood maps for the 1 in 200yr event (pre and post development conditions) are in Appendix C. Figure 18 to Figure 20 show the model outputs over the study site. Maximum water levels at key locations are in Table 3.

The maximum depths for the 1 in 200yr event immediately to the north and west of the site are approx. 0.5-0.6m. However, maximum overland flow velocities are low (< 0.25m/s) in the site and its surroundings (Figure 20). Maximum water levels in the vicinity of the site (the site is above water levels and thus no data for the site is available) is 28.3mAOD. Following SEPA guidance [1], a suitable freeboard is 600mm. Thus, a finished floor level (slab level) of 29.0mAOD, as proposed will comply with the guidance.

The model results show that the development and proposed mitigation measures do not increase the river flows downstream of Baldovie Road⁵ (Table 4 and Figure 21), ensuring that flood risk is not increased elsewhere.

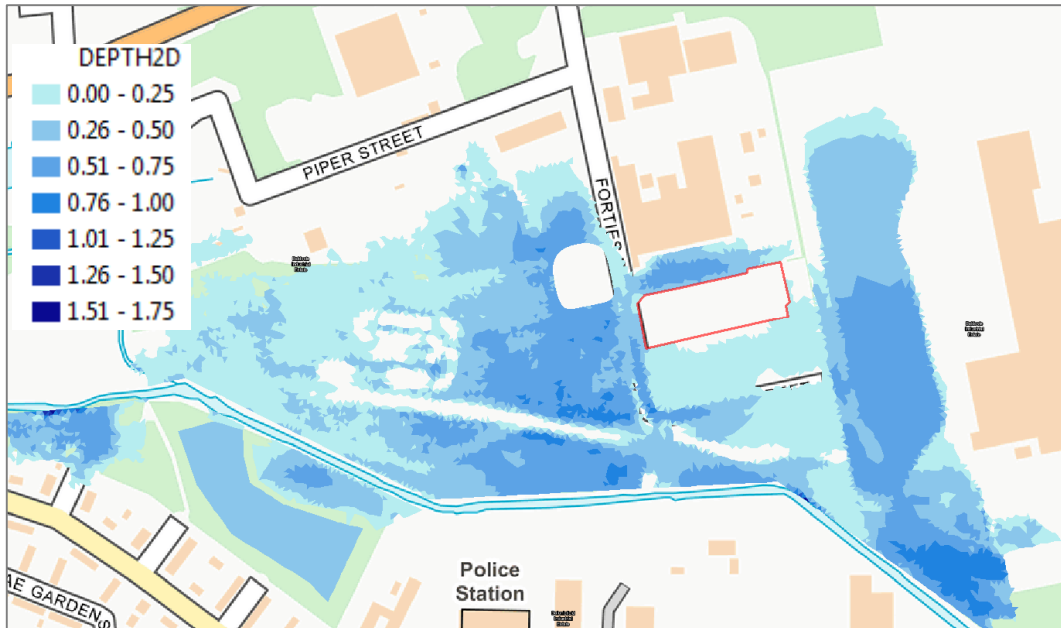


Figure 18. Maximum water depths for the 1 in 200yr event under post-development conditions. Note the gaps corresponding to the site and SUDS basins.



Figure 19. Maximum water levels (mAOD) for the 1 in 200yr event under post-development conditions. Note the gaps corresponding to the site and SUDS basins.

⁵ Peak flows are only 0.4% higher, considered immaterial.



Figure 20. Maximum velocities (m/s) for the 1 in 200yr event under post-development conditions. Note the gaps corresponding to the site and SUDS basins.

Table 4. Maximum river flows (m³/s) at key locations.

Location	Model unit	Pre-development conditions	Post-development conditions
		1 in 200yr	1 in 200yr
U/S end of model	2012_12	35.8	35.8
Balunie Drive	2012_07	36.5	36.6
U/S of storage area	2012_06	35.5	35.9
Police station	2012_04	22.5	22.7
Baluniefeld Trading Estate	05	30.4	30.6
B978 Bridge	BR_US!!	52.4	52.6
D/S end of model	2012_01	52.3	52.5

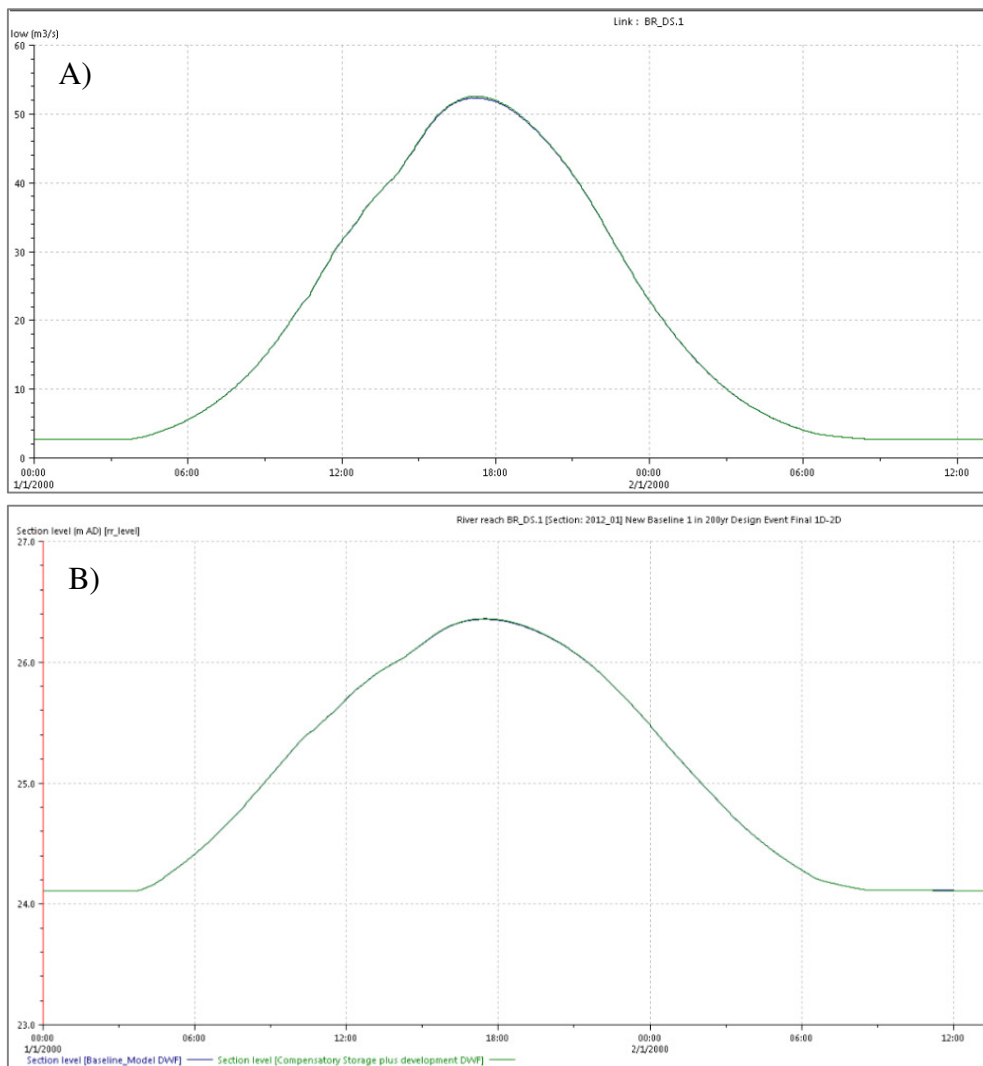


Figure 21. River flow (A) and water level (B) time series at the most d/s cross section in the hydraulic model for the 1 in 200yr event. Note the coincidence of pre (blue) and post development (green) values.

7 Flood risk assessment

Below is the assessment of the flood risk posed by the different types of flooding:

7.1 Coastal flood risk

The site is at approx. 1.8km away from the coastline of the Firth of Tay, with the SEPA flood maps showing that the site is not at risk of coastal flooding. The site is therefore considered not at risk of coastal flooding.

7.2 Fluvial flood risk

The flood risk from river flows is notable, with SEPA flood maps showing high likelihood of flooding of parts of the site (corresponding to a 10% AEP of 1 in 10yr event). The history of flooding related to the Dighty Water emphasises this risk. The extreme flood modelling carried out as part of this report also shows that the site and its vicinity are at risk of fluvial flooding.

The proposed development will be set at a finished floor level (slab level) above the 1 in 200yr plus climate change flood waters plus freeboard (29.0mAOD). However, the site access will inevitably have to tie in with the existing ground levels in the immediate surroundings. This will retain a degree of flood risk and vulnerability to the access and functioning of the proposed plant that must be accounted for.

Access and egress is conditioned by the tie in of the site internal roads to the levels at Forties Road –only access to the site- in order to allow the trucks to supply waste material. Thus, flood risk in the perimeter of the site and potential access limitations remain. However, based on the 1 in 200yr design hydrograph characteristics, approximately 7h pass from the time of first overtopping of the left bank of the Dighty Water at SW of the site to the time of maximum depths at the study site. Since the flow velocities are small and flooding occurs in other areas near the site before reaching the study site (e.g. Michelin flood storage area, BMX track and floodplain south of the footpath) there is sufficient warning to undertake evacuation or any other measure to safeguard life and property.

7.3 Pluvial flood risk

Pluvial flooding occurs when rainfall events overcome the capacity of the drainage network and water accumulates on low lying areas or runs overland. SEPA surface water flood map shows that the site is at or surrounded by areas at risk of flooding. However, since the site finished floor levels (except internal access road) will be raised above the 1 in 200 year plus climate change flood level plus freeboard, surface water flooding to the building and its elements is expected to be substantially minimised.

The drainage strategy for the site should incorporate sufficient capacity to accommodate minimum rainfall volumes and the post development site levels should avoid areas of ponding or unintended water accumulation.

Similarly to river flooding, tying access paths to existing ground levels may constitute a vulnerability to the development, affecting pedestrian and vehicular access and the normal operation of the plant.

7.4 Groundwater flood risk

Ground water flooding is defined by the British Geological Survey as: *the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are*

*exceeded*⁶. Groundwater itself can cause flooding but it also can prolong flooding by delaying natural drainage and percolation of water into the ground.

The borehole logs taken during the ground investigation stage were consulted. The position of the water table below ground at the boreholes indicated in Figure 22 on three different dates are in the table below and plotted in Figure 23.

The data shows that the water table during the monitoring period (end of summer and early autumn) is under 1m below ground around the SW corner of the site, in boreholes BHR03, with water levels rising above 1mbgl also at boreholes BHS09, BHM01 and BHR05. These values suggest that the ground is reasonably responsive to rainfall events and the water table can rise close to the ground surface.

The development proposals include a waste sink below ground level (Appendix A). The design of the building should ensure that no connectivity exists between the waste and ground water in order to avoid flooding and seepage of waste into the groundwater.

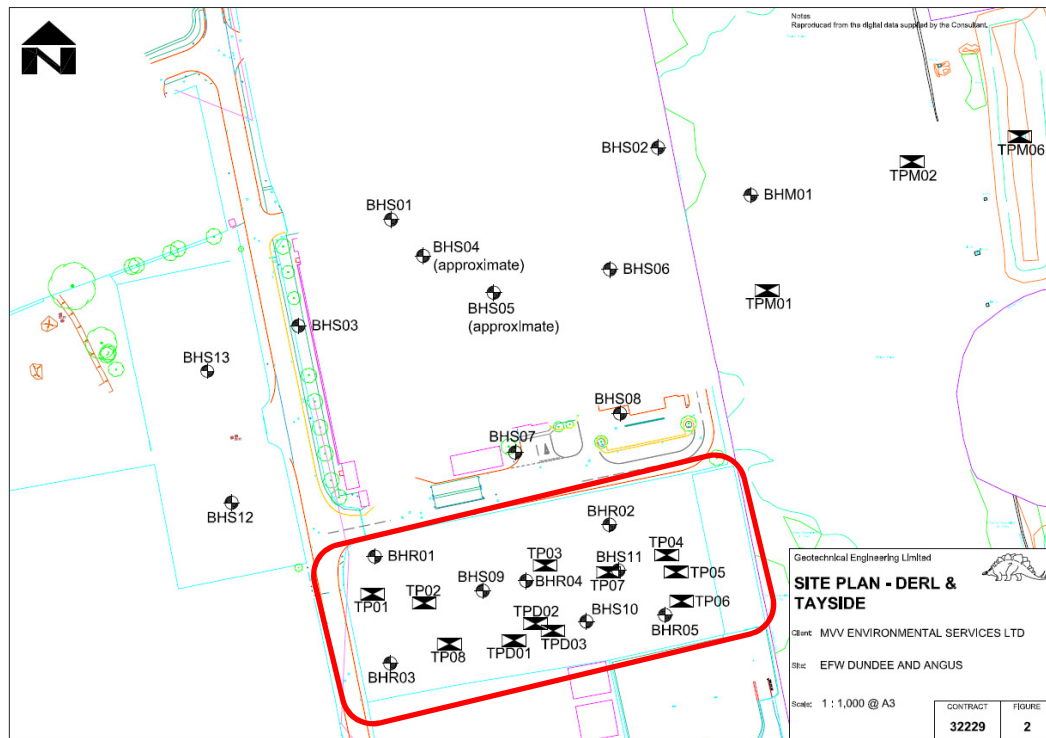


Figure 22. Location of boreholes on the study site. Site marked in red. Source: *Geotechnical Engineering Ltd. EFW Dundee and Angus. Factual report on ground investigation (preliminary issue). Prepared for MVV Environmental Services Ltd. Report Ref: 32229. 11th October 2016.*

⁶ http://www.bgs.ac.uk/research/groundwater/flooding/groundwater_flooding.html

Table 5. Groundwater records at the boreholes in the study site.

Borehole	Date	water depth (mbgl)	Borehole	Date	water depth (mbgl)
BHM01	28/09/2016	1.18	BHS05	29/09/2016	2.6
	05/10/2016	1.48		05/10/2016	2.64
	17/10/2016	0.88		18/10/2016	2.45
BHR01	26/09/2016	1.81	BHS09	26/09/2016	2.01
	04/10/2016	1.92		04/10/2016	2.02
	19/10/2016	1.73		19/10/2016	1.77
BHR02	27/09/2016	1.75	BHS10	26/09/2016	1.66
	04/10/2016	2.38		04/10/2016	1.74
	19/10/2016	1.63		19/10/2016	1.58
BHR03	26/09/2016	0.52	BHS11	27/09/2016	1.89
	04/10/2016	0.63		04/10/2016	2.29
	19/10/2016	0.21		19/10/2016	1.88
BHR05	27/09/2016	1.94	BHS12	27/09/2016	1.03
	04/10/2016	1.98		04/10/2016	1.14
	19/10/2016	0.87		18/10/2016	0.84

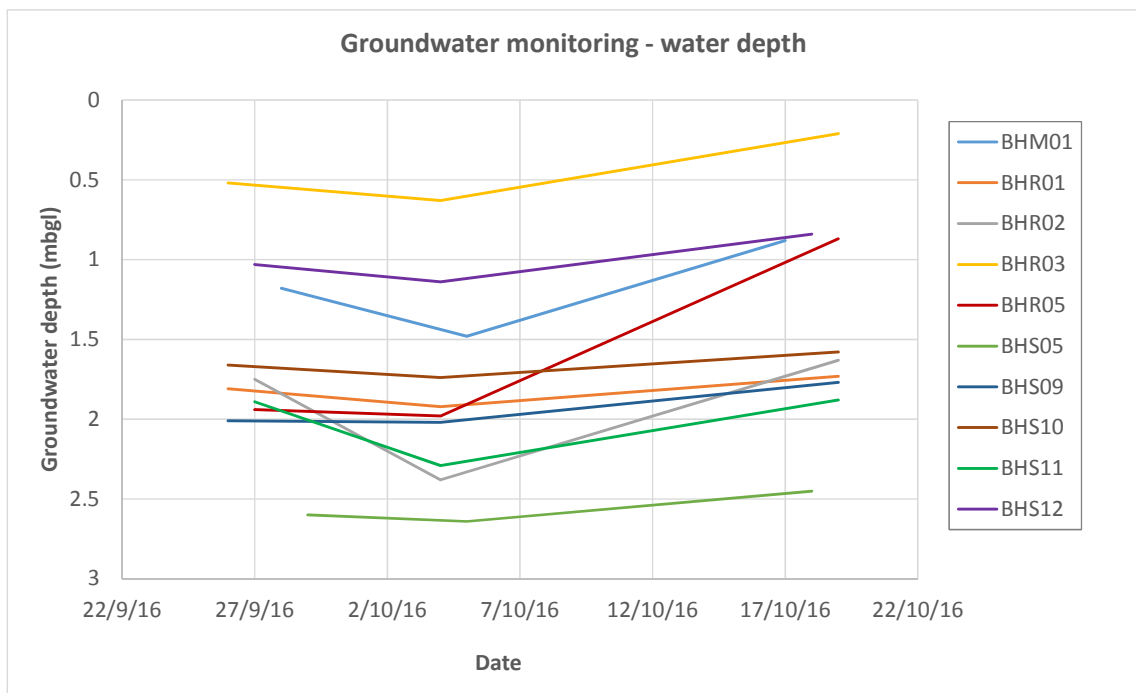


Figure 23. Groundwater monitoring data.

7.5 Infrastructure failure flood risk

The accidental failure of main infrastructure elements like reservoirs, canals, pressure mains, etc. may lead to flooding. No major water related infrastructure other than the general water supply mains and site drainage are present in the vicinity of the site (see drawing in Appendix A). The site levels and drainage network should be designed to account for this flood source, by elevating key

assets, ensuring water from accidental mains leakage or burst is drained away or implementing water barriers (permanent or temporary) at vulnerable locations (e.g. gates and entrances to buildings). Thus, the site is considered to be at low risk.

7.6 Drainage

Surface and foul drainage conduits run near the development site along Forties Road (Appendix A). Surcharge of these conduits may lead to localised flooding. Since the slab level will be set at a sufficiently high elevation, the development itself is considered to be at low risk. However, access and operation of the EfW may be compromised.

7.7 Impact on environment

The proposed development does not affect the course or characteristics of the watercourses in the area. However, the facility handles large amounts of waste and the development should avoid accidental spillage of such waste or runoff spreading contaminated water into the Dighty Water.

8 Summary and conclusions

The present flood risk assessment shows that fluvial flooding is the main source of flood risk to the site (Table 6). Due to the low-lying ground levels in the site, which is near the bottom of the Dighty Water valley, surface water flooding from heavy rainfall or other sources is also possible.

Historic flooding in the area, as recently as January 2016, supports the modelling outputs, which show the site and especially the areas to the south and west of the site being at high risk of flooding. Mitigation measures include setting the slab elevation above the flood water level corresponding to the 1 in 200 year plus climate change (20% flow increase) plus freeboard. This excludes the building from the functional floodplain and places the EfW facility at a reasonably safe elevation.

There are however elements of the development, such as the fuel bunker and a space in the machine house that are below ground. The development design should ensure that flood waters do not enter these spaces and especially do not result in polluted water spreading and reaching the watercourses. The incorporation of some form of perimeter protection is suggested.

Access to the site is conditioned by the need to tie in with existing ground levels at Forties Road, which is not modified by the development proposals. Thus, access and operation of the EfW facility may be limited during flooding episodes.

Table 6. Summary of flood risk from all sources.

Type of flooding	Existing risk	Mitigation measure	Residual risk
Coastal	Low	None	Low
Fluvial	High	Land raising (high slab level) and flood compensatory storage. Drainage network. Waterproofing of elements below ground and ensuring design prevents water ingress to silos or similar	Low to building, high to access
Pluvial	High		Medium
Drainage	Low		Low
Groundwater	Medium		Low
Infrastructure failure	Low		Low

The present flood risk assessment complies with current relevant planning legislation, in particular SPP and SEPA guidance in terms of the content of this report. The functional floodplain was defined, establishing the flood risk of the proposed development and the need for compensatory storage. The mitigations measures proposed provide sufficient compensatory flood volume and do not increase flood risk elsewhere.

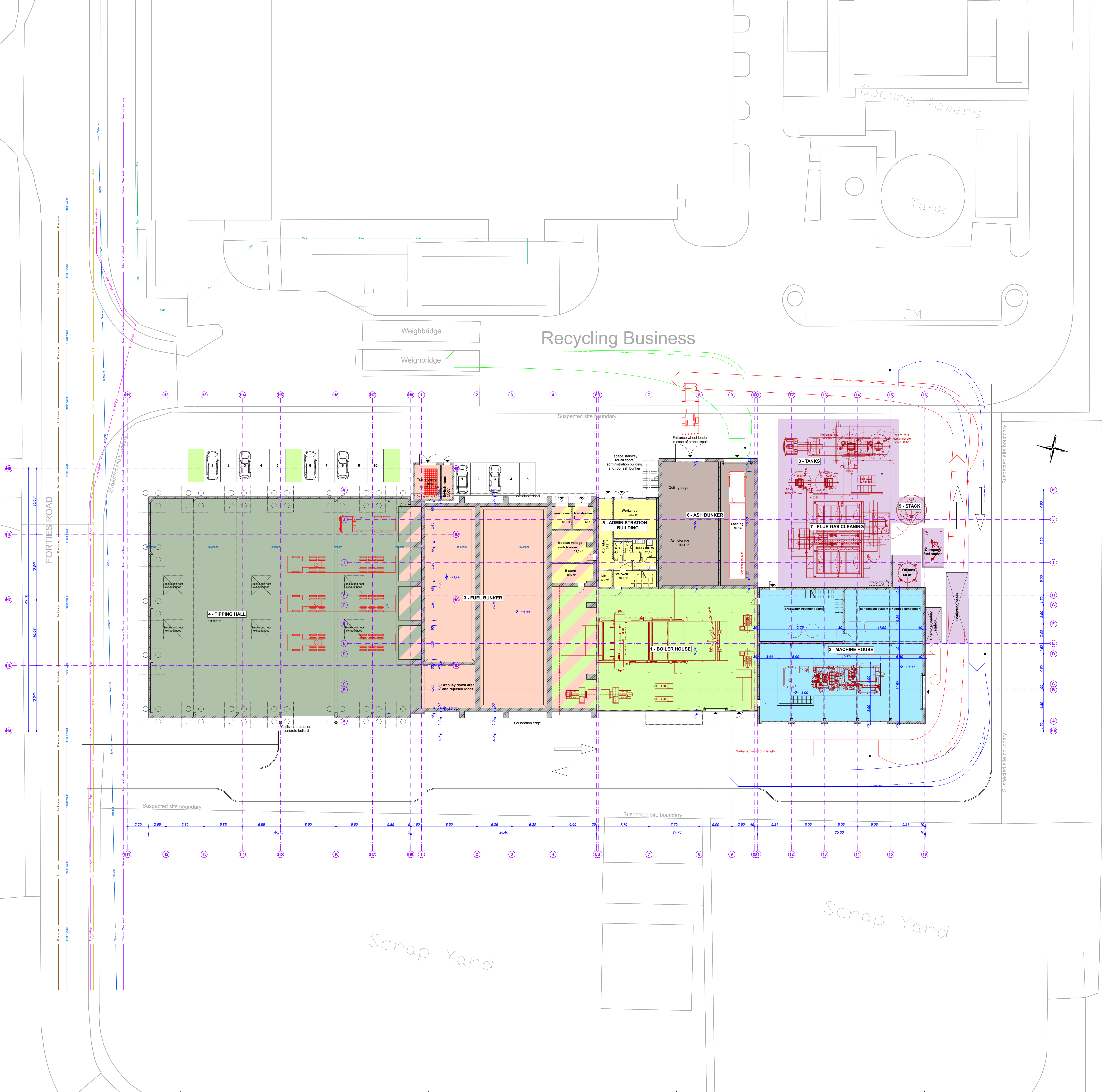
References

- [1] SEPA. Technical Flood Risk Guidance for Stakeholders. Version 9.1, June 2015.
- [2] Atkins. Michelin Tyre Plc. Flood Risk Assessment. Baldovie Road Site, Dundee. 12th August 2014 (15/01/15 update).

Appendix A

Site description, development
proposals and existing utilities

A1 Development proposals

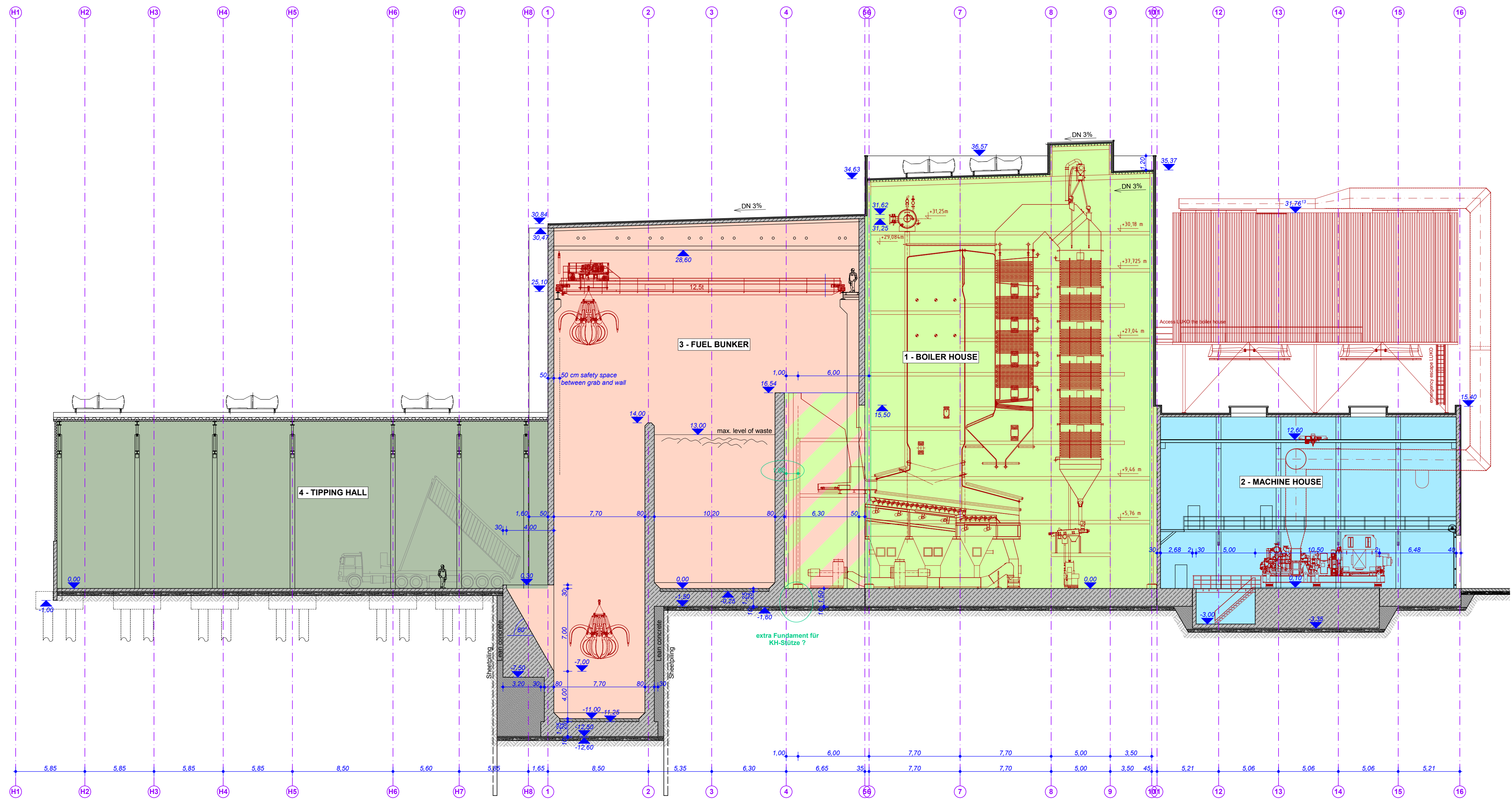


- Legend:**
- 1-BOILER HOUSE
 - 2-MACHINE HOUSE
 - 3-FUEL BUNKER
 - 4-TIPPING HALL
 - 5-ADMINISTRATION BUILDING
 - 6-ASH BUNKER
 - 7-FLUE GAS CLEANING
 - 8-TANKS
 - 9-STACK

- Fresh water
- Scottish water (Fresh)
- Low voltage
- 11 kV
- Telephony
- Gas
- Steam
- Scottish water (Fresh)
- 11 kV
- British Telephony
- Steam Gas LP

PRELIMINARY

5	VARUATION:	DATE:	PROCESSOR:
4			
3			
2			
1			
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CLIENT: Fa. Oschatz GmbH Westendhof 10-12 45143 Essen		OSCHATZ SIGNATURE OF CLIENT:	
CONTRACTOR: Projekt DUNDEE		PROJECT NUMBER OSCHATZ PU15-741	
PLANNING STAGE: building permit		PROJECT NUMBER INS 300-15	
DENOMINATION: AXIS PLAN		DATE: 24-09-2016	
		SCALE: M 1 : 200	
		PLAN NUMBER: 300-00-100	



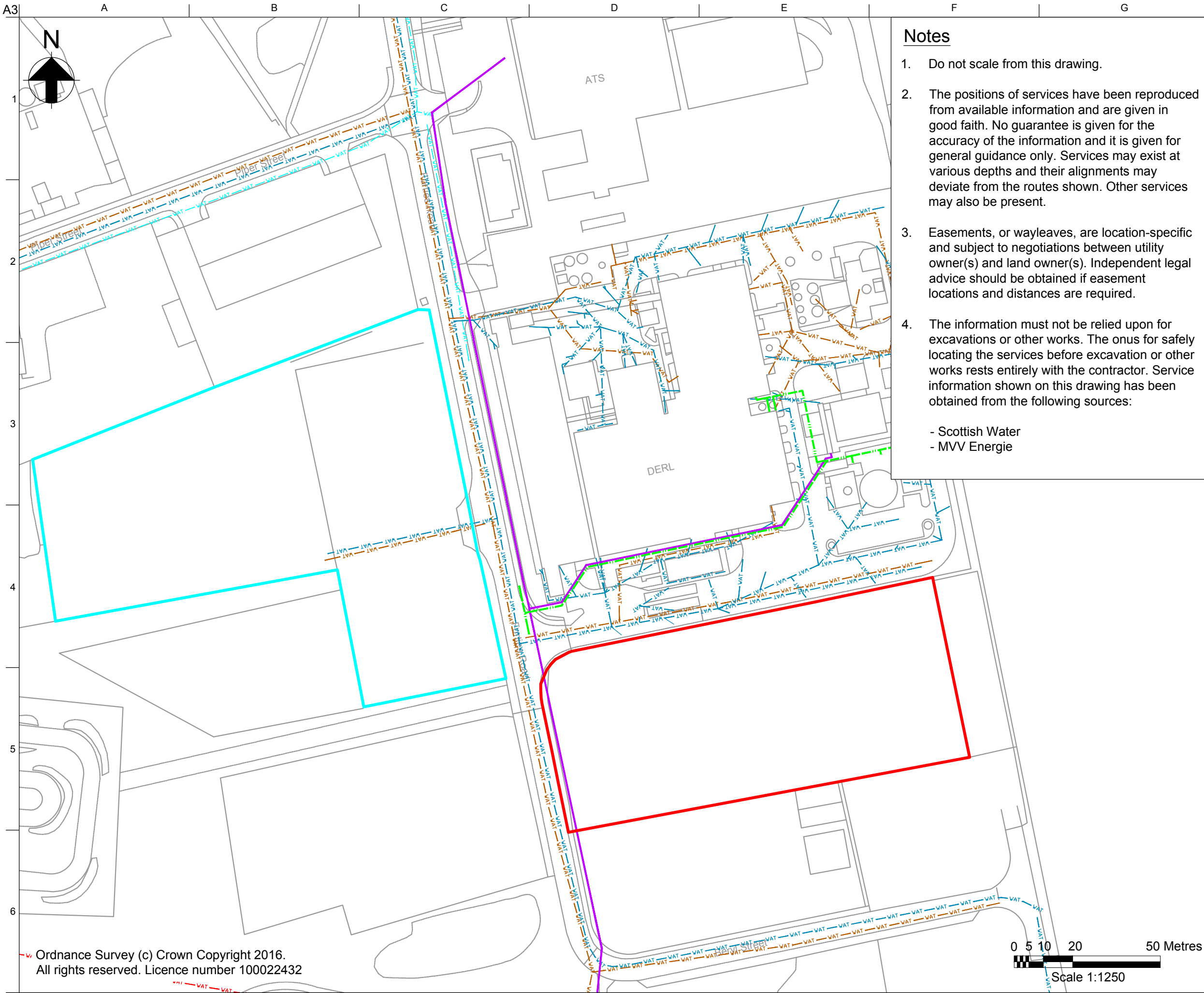
PRELIMINARY

Legend:

- 1 - BOILER HOUSE
- 2 - MACHINE HOUSE
- 3 - FUEL BUNKER
- 4 - TIPPING HALL
- 5 - ADMINISTRATION BUILDING
- 6 - ASH BUNKER
- 7 - FLUE GAS CLEANING
- 8 - TANKS
- 9 - STACK

VARIATION:		DATE:	PROCESSOR:
5			
4			
3			
2			
1			
INGENIEURBÜRO NEUBAU / SANIERUNG SCHNEIDER GmbH		KÖDITZGASSE 23 07318 SAALFELD TELEFON : 03671/33020 FAX : 03671/520416	SIGNATURE OF PLANNER:
CLIENT: Fa. Oschatz GmbH Westendhof 10-12 45143 Essen			SIGNATURE OF CLIENT:
CONTRACTOR: Projekt DUNDEE		PROJECT NUMBER OSCHATZ: PU15-741	PROJECT NUMBER INS: 300-15
PLANNING STAGE: building permit		DATE: 24-09-2016	MASSABOLITION: M 1 : 200
DENOMINATION: section A-A		PLAN NUMBER: 300-00-120	

A2 Existing water utilities in the study site



Notes

- 1. Do not scale from this drawing.
- 2. The positions of services have been reproduced from available information and are given in good faith. No guarantee is given for the accuracy of the information and it is given for general guidance only. Services may exist at various depths and their alignments may deviate from the routes shown. Other services may also be present.
- 3. Easements, or wayleaves, are location-specific and subject to negotiations between utility owner(s) and land owner(s). Independent legal advice should be obtained if easement locations and distances are required.
- 4. The information must not be relied upon for excavations or other works. The onus for safely locating the services before excavation or other works rests entirely with the contractor. Service information shown on this drawing has been obtained from the following sources:

- Scottish Water
- MVV Energie

Legend

- South Boundary
- West Boundary
- Scottish Water (Fresh)
- Scottish Water (Surface)
- Scottish Water (Foul)
- Scottish Water (Combined)
- DERL Abstraction Pipe
- DERL Water Supply (Other)

I2	07/06/16	DM	NM	GLD
Boundary, Notes & Legend Revised Following Client Comments.				
I1	25/05/16	DM	NM	GLD
Issued for Information				
Rev	Date	By	Chkd	Appd

ARUP

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West Lothian, EH30 9SE
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Client
MVV Environment Services Ltd

Project Title
MVV, Dundee

Drawing Title
South & West Boundary -
Water Utilities

Scale at A3 1:1250

Role
Consultancy

Suitability
For Information

Arup Job No
245510-00

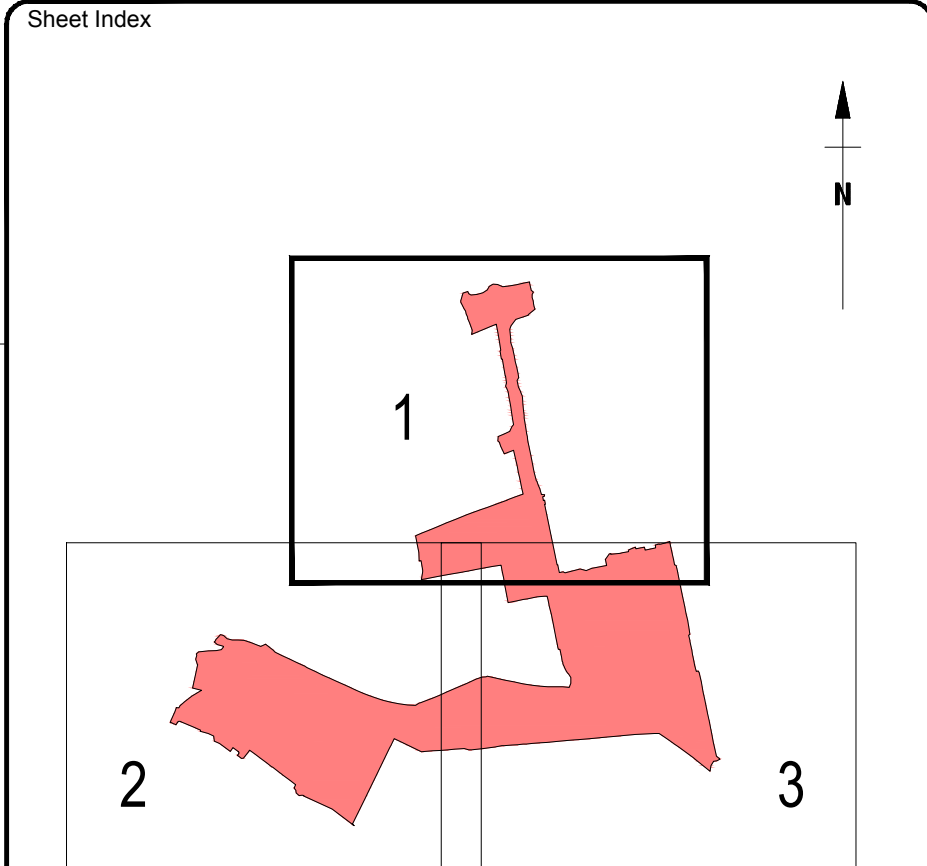
Name
SK-SW-003

Rev
I2

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0 5 10 20 50 Metres
Scale 1:1250

A3 Topographical survey of the site

[illegible][illegible]

MALCOLM HUGHES
LAND SURVEYORS
Chartered Land Surveyors

65 Cross Street, Sale, Manchester
M33 7HF, Tel: 0161 905 1265
www.malcolmhughes.co.uk
survey@mhls.co.uk



Client

ARUP

SCOTSTOUN HOUSE, SOUTH QUEENSFERRY

EDINBURGH, EH30 9SE

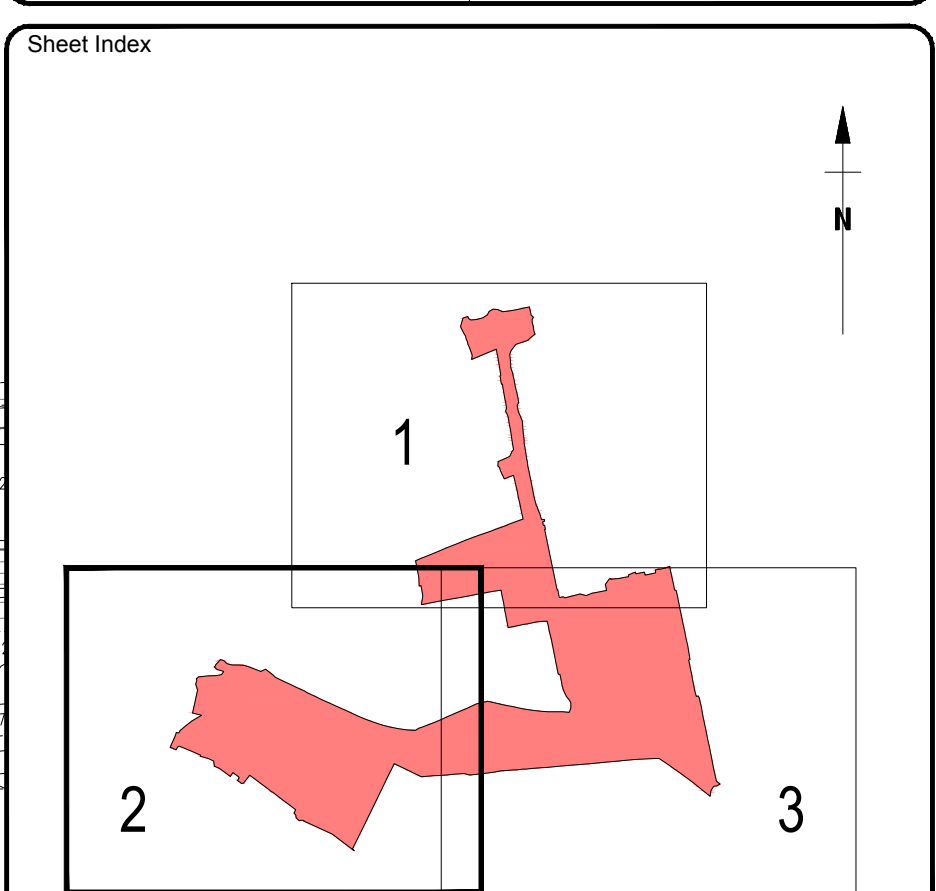
Project
 MVV
 DUNDEE

Drawing Title

TOPOGRAPHICAL SURVEY

Drawn By DJ	16/02/16	Survey Date February 2016
Checked by BM	16/02/16	Scale A0@1:500scale

Drawing No	17850/1	Revision
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EDINBURGH, EH30 9SE

Project

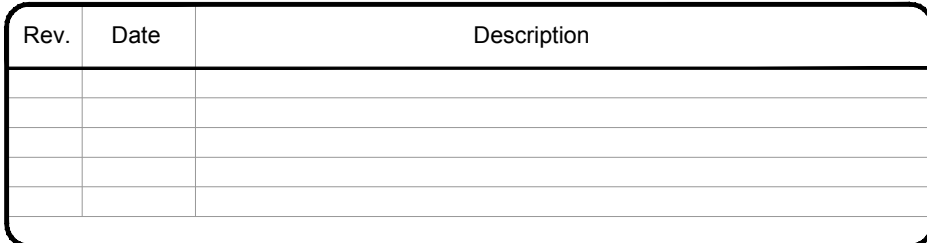
MVV
DUNDEE

Drawing Title

TOPOGRAPHICAL SURVEY

Drawn By DJ	16/02/16	Survey Date February 2016
Checked by BM	16/02/16	Scale A0@1:500scale
Drawing No 17850/2		Revision

Topographical Survey Legend	
BUILDINGS AND WALLS	GENERAL INFORMATION
Building  Building Footing  Run  Passage  Wall with Height  Retaining Wall 	Fence Post  Staircase Light  Data Notes  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel  Date Type Channel



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EDINBURGH, EH30 9SE

MVW

DUNDEE

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TOPOGRAPHICAL SURVEY

Survey Date: _____

18/02/16	Feb
Scale	100

16/02/16

17850/3

Appendix B

Hydrological assessment

B1 Design flows confirmation by SEPA

Miguel Piedra

From: MacConnachie, Malcolm <Malcolm.MacConnachie@SEPA.org.uk>
Sent: 21 March 2016 09:32
To: Miguel Piedra
Subject: RE: FRA in Dundee

Dear Miguel,

Sorry for the delay in responding to your email. We have been moving office which has taken us some time to deal with and we are now trying to get used to some new systems etc.

I have reviewed the hydrology and there seems little need to alter the design flows. The latest years annual maximum flows have left the Qmed for the Dighty Water gauging station at Balmossie relatively unchanged.

If you have any other queries please do not hesitate to contact me again.

Kind regards,

Malcolm

A.Malcolm MacConnachie

Senior Hydrologist

Scottish Environment Protection Agency

Strathern House

Broxden Business Park

Lamberkine Drive

Perth PH1 1RX

tel: 01738 627989

fax: 01738 630997

email: malcolm.macconnachie@sepa.org.uk

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From: Miguel Piedra [mailto:Miguel.Piedra@arup.com]
Sent: 16 March 2016 12:23
To: MacConnachie, Malcolm
Cc: Jessica Boath; Jane Saul
Subject: FW: FRA in Dundee

Dear Malcom,

Apologies for asking again. I am sure you are quite busy. But your feedback is key.

I refer to my previous email on 24/02/16 below. I would very much appreciate your opinion on whether the hydrological assessment undertaken for the Michelin factory extension needs updating or not, so we can inform our client, factor this in our work and ensure SEPA's approval in due course.

Many thanks

Miguel

Miguel M Piedra
Senior Engineer | Water
Civil Engineer MSc PhD CWEM MCIWEM

Arup
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United Kingdom
t +44 141 332 8534
f +44 141 332 3739
www.arup.com

From: Miguel Piedra
Sent: 24 February 2016 09:30
To: (Malcolm.MacConnachie@SEPA.org.uk)
Cc: 'sefloodriskrequest@sepa.org.uk'; 'Bruce Braithwaite'; Jane Saul; Gordon Diamond
Subject: FRA in Dundee

Dear Malcom,

I hope you are well.

Arup is carrying out a flood risk assessment for a site near the Dighty Burn in Dundee, next to the Michelin factory. Our client and Michelin are in good working relationships and I understand that Michelin has requested Atkins, who did the FRA for Michelin in 2014, to pass on to us the InfoWorks RS 1D-2D model that they created, which extends past our study site.

I am trying to ascertain the work involved in our FRA if we use the Atkins model, in particular the hydrological calculations. I understand from your colleague Andrew Jardine in the Arbroath office that you (or your team) may have reviewed the FRA and associated calculations.

Will you please provide advice on whether an update of the design peak flows will be required for our work? Dundee City Council has requested we validate the model with the December 2015 event but I am wondering whether a recalculation of the 200yr and 200yr+cc flows is necessary. I would have thought that being such a recent FRA it would not be necessary, but your advice will be most welcome, so our assessment is right first time. If you need detail on the methodology and data used by Atkins I can provide their 2014 report for your information, which Michelin has kindly provided to our client.

Many thanks for your help.

Best regards,

Miguel

Miguel M Piedra

Senior Engineer | Water

Civil Engineer MSc PhD CWEM MCIWEM

Arup

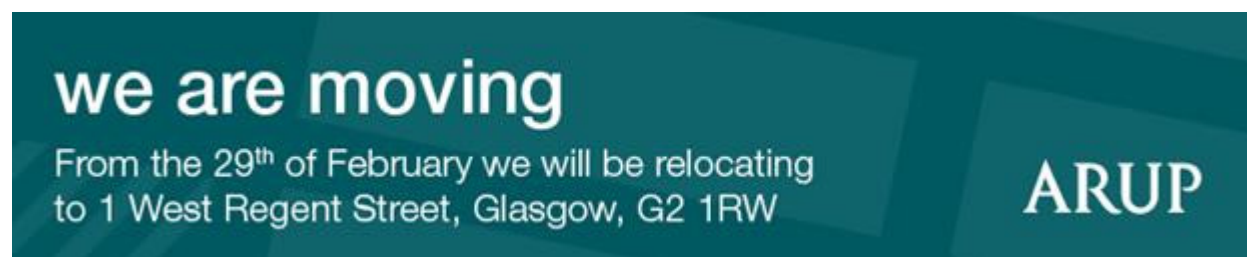
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B2 Atkins hydrological assessment

The hydrological assessment was carried out by Atkins in 2014. If the documentation on the calculations is required please contact Dundee City Council.

[http://idoxwam.dundeecity.gov.uk/idoxpa-web/files/0697346606D9A4426927D5B73ED7588F/pdf/15_00035_FULM-19 - FLOOD_RISK_ASSESSMENT-588672.pdf](http://idoxwam.dundeecity.gov.uk/idoxpa-web/files/0697346606D9A4426927D5B73ED7588F/pdf/15_00035_FULM-19_-_FLOOD_RISK_ASSESSMENT-588672.pdf)

B3 Estimation of January 2016 river flows and model validation

Job title	MVV Dundee FRA	Job number	Sheet number	Revision
		245510-00		2
Calc title	Hydrology note - Jan16 Observed event	Member/Location	F. Rhodes (Sheffield)	
		Drg. Ref.		
		Made by	FR	Date 02/11/16 Chd.

1 Scope

In order to verify the baseline hydraulic model developed for the study (Infoworks ICM), the observed flood event which affected Dighty Water in January 2016 was run through the baseline hydraulic model in an attempt to understand how well the model replicates known flooding at the subject site during this event.

This file note describes the exercise of deriving the hydrological inputs for the model, and the process of verifying the model using the results of the simulated observed event.

2 Site location and local water courses

The subject site is located to the north of Dighty Water, at grid reference 344900, 732700, within Baldovie Industrial Estate. The Dighty Water runs near the site in an approx. west-east direction. Fithie Burn enters Dighty Water from the north at the B978 Bridge. Further to the east, Murroes Burn also enters Dighty Water from the north approximately 0.5km downstream of the B978 Bridge. There are no further major tributaries entering Dighty Water before Balmossie Mill flow gauging station, 3km downstream of the subject site at NGR 374644, 732508. See Figure 1.

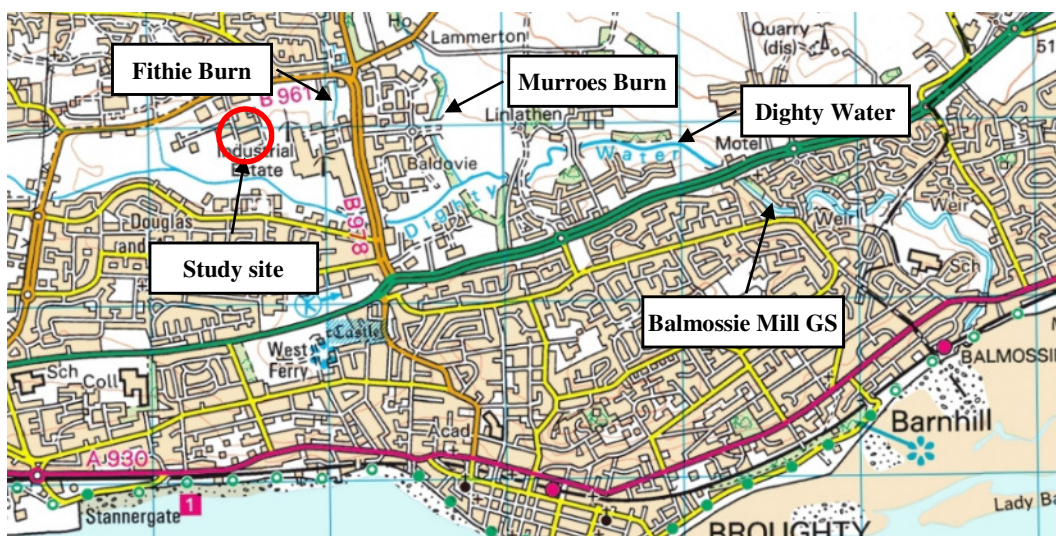


Figure 1: Location of study site shown (red circle) and local watercourses: Dighty Water, Fithie Burn and Murroes Burn.

Job title	MVV Dundee FRA	Job number	Sheet number	Revision
		245510-00		2
Calc title	Hydrology note - Jan16 Observed event	Member/Location	F. Rhodes (Sheffield)	
		Drg. Ref.		
		Made by	FR	Date 02/11/16 Chd.

3 January 2016 event

The end of 2015 and start of 2016 was a particularly wet period in the UK in general and Scotland in particular, with record water levels recorded in multiple gauging stations. Flooding occurred in the study area (north east of Dundee) in January 2016. The event followed a long period of rainfall between December 15th 2015 and January 7th 2016. The playing fields to the west of the study site were severely flooded. The study site and its vicinity flooded during the January 2016 event to a moderate extent.

Balmossie Mill flow gauging station is located on Dighty Water approximately 3km downstream of the subject site. The highest peak flow recorded at Balmossie Mill occurred on the 7th January at approximately 5.45pm, measuring 40.1 m³/sec. Previous to this there had been several smaller peaks occurring on the 2nd, 4th and 6th of January.

Photos of the site during and in the days immediately after the flood have been used to verify the baseline model (Section 6).

4 Approach and data sources

4.1 Methods

In order to validate the model, fluvial inflows representing the January 2016 event were obtained. Two methods were tested for creating the hydrological boundaries for this exercise:

1. Generation of event hydrographs using observed rainfall and a rainfall-runoff model. The observed rainfall and antecedent conditions for the event were obtained from SEPA and imported into FEH, FSR and ReFH rainfall runoff boundaries within the ISIS modelling package. Hydrographs from the different methods were produced for use as potential boundary conditions for the Infoworks model.
2. Scaling recorded flows at Balmossie Mill GS. The recorded flows for the January 2016 event at the Balmossie Mill were scaled based on values of QMED, estimated using catchment descriptors. The scaled event flows for Dighty Water and Fithie Burn formed the boundary conditions of the Infoworks model.

As described below, method 1 did not provide appropriate results, so method 2 (scaled recorded flows) was adopted.

Job title	MVV Dundee FRA	Job number	Sheet number	Revision
		245510-00		2
Calc title	Hydrology note - Jan16 Observed event	Member/Location	F. Rhodes (Sheffield)	
		Drg. Ref.		
		Made by	FR	Date 02/11/16 Chd.

4.2 Data requirements

Arup received the following information from SEPA:

1. Flow records: Time series of river flow for Dighty Water from 1 January 2015 to 15 January 2016 at Balmossie Mill gauge (station no. 14002). The location of the gauge is shown in Figure 1.
2. Rainfall data: Rainfall data was provided for the following rain gauges:
 - Baluniefield (station no. 374852) 1st January 2015 to 15th January 2016
 - Hatton (station no. 335640) 1st January 2015 to 15th January 2016
 - Letham Grange (station no. 338381) 1st January 2015 to 15th January 2016
 - Mylnefield (station no. 335651) 1st January 2015 to 15th January 2016

The locations of the rain gauges are given in Figure 2. The two rain gauges contributing to Dighty Water catchment are Baluniefield and Mylnefield.

No antecedent conditions were available in the format of MORECS data, however antecedent rainfall conditions for the 5 days prior to the maximum peak flow event allow pre-event rainfall to be calculated.

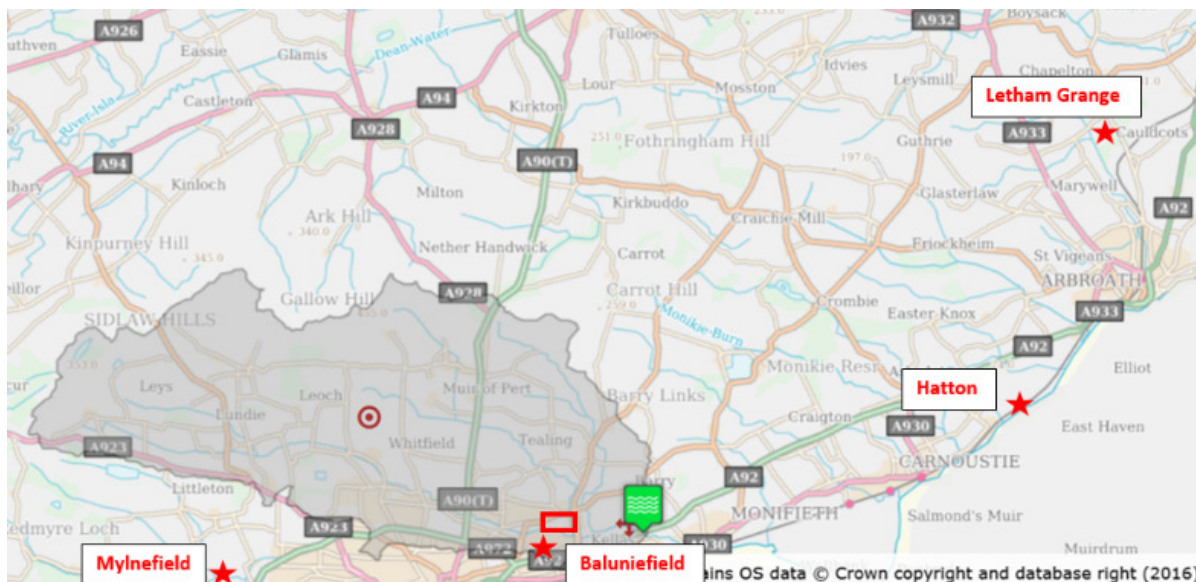


Figure 2: Location of rain gauges (stars) and Balmossie Mill GS (green marker). Dighty Water catchment is shown in grey. Approx. site location shown in red box.

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5 Calculations

5.1 Rainfall-Runoff method

The standard method for recreating an observed flood event is to enter the event rainfall and antecedent conditions into a rainfall runoff hydrological model and use it to derive a hydrograph to be used as the boundary condition for a hydraulic model representing the river and site at the time of the event.

This exercise was carried out using three types of rainfall-runoff models within the ISIS hydraulic modelling package for comparison: FEH, FSR and ReFH.

Rainfall from Baluniefield and Mylnefield rain gauges and flow from Balmossie Mill gauge from 15th December 2015 to 15th January 2016 were analysed. The main rainfall event contributing to the peak flow at Balmossie Mill on 7th January occurred between 1/1/16 and 7/1/16 (Figure 3). This was the period used in the hydrological modelling. Rainfall for the preceding 5 days (27th -31st December 2016) was also used to calculate antecedent conditions, in line with the FEH method. The exercise was carried out for the whole catchment up to Balmossie Mill, in order to calibrate the rainfall-runoff model parameters of the observed event at Balmossie Mill gauge.

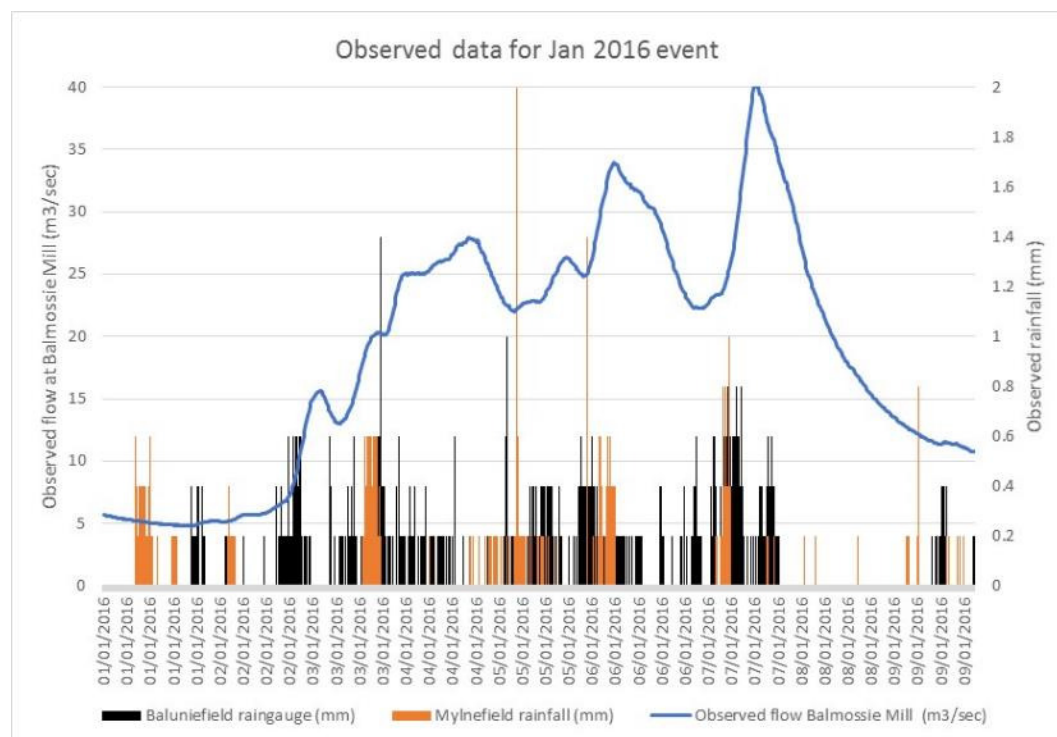


Figure 3: Observed event hydrograph from 1st January to 9th January 2016

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It is noted that rainfall data from Mylnefield rain gauge was not included in the rainfall-runoff models. The rainfall totals over the period 1-9 December 2016 were less than half of those at Baluniefield. Given the lack of runoff volume obtained by the hydrological models (see below), reducing the rainfall further would have accentuated this lack.

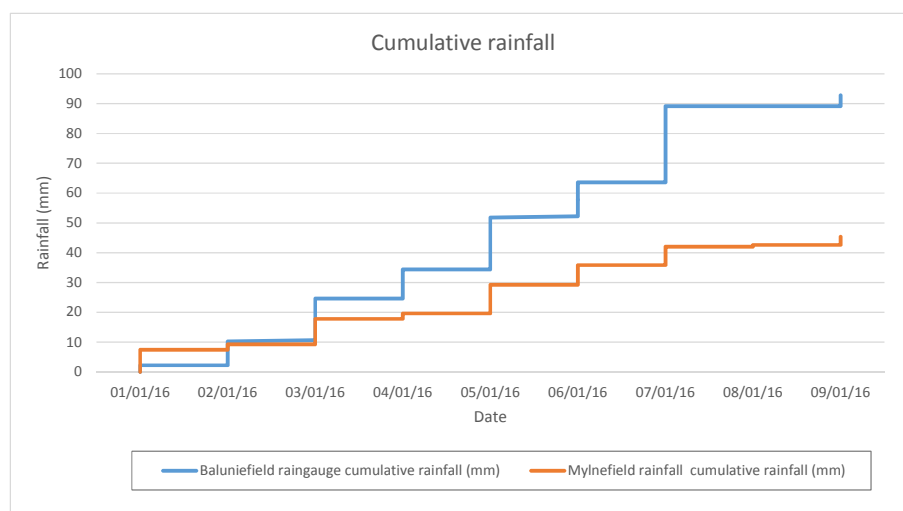


Figure 4. Cumulative rainfall at Baluniefield and Mylnefield rain gauges.

The following updates were made to the default model parameters within each hydrological unit:

- CWI – an observed value of CWI of 129.4 was used based on a 5-day antecedent rainfall value of 4.4mm (Eq. A.1, Volume 4, FEH), and an assumption of 0 for SMD (in the absence of data and in line with FEH recommendations). This value was used for the FEH and FSR models. ReFH uses different antecedent parameters which have not been amended from the default values.
- Time to peak was adjusted to match the largest peak event on 7/1/16 17.45 at Balmossie Mill. For FEH this was 6.25hr, for FSR 6.25hr and for ReFH 5.5hrs. This is based on the difference between the peak rainfall and the peak observed flow at Balmossie Mill for the main peak of the event on 7/1/16 17:45 hrs.
- Baseflow at the start of the event was set to 5.66m³/s to match the observed event (Figure 3).

Following the above amendments flows predicted by the hydrological models were still lower than those recorded at Balmossie Mill. An exercise to further investigate the rainfall values used in the hydrological models was undertaken in order to understand whether rainfall values recorded at Baluniefield are likely to be representative of rainfall values across the whole Dighty Water catchment area. Dighty Water has a reasonably large catchment and the Baluniefield rain gauge is located at downstream end of this catchment. Theoretically, as the catchment is reasonably large, it is likely that there would be some difference in rainfall totals between the upstream and downstream ends of the catchment, with higher rainfall anticipated at the upstream end. This could mean that Baluniefield raingauge may slightly underestimate rainfall totals contributing to the observed event. As there is no rain gauge in the upper catchment to make a direct comparison with Baluniefield rainfall totals, an estimate of the potential difference in rainfall totals between Baluniefield and wider Dighty Water catchment was made using a

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ratio of theoretical rainfall depths at the raingauge location to the whole catchment. Rainfall depths were calculated using rainfall catchment descriptors. These values are the 'Catchment Rain' parameters 'C, D1, D2, D3, E and F'; and 'GridRainD1, D2, D3, C, E and F' provided by the FEH web service. The Catchment Rain parameters describe the catchment rainfall averaged across the whole catchment selected, in this case up to the raingauge location*. The Grid Rain parameter is the rainfall averaged within the 1km grid square in which the FEH catchment outlet marker is placed (the downstream estimation point). In small catchments, the ratio of rainfall depths calculated from the grid square and the catchment parameters is likely to be similar. As the catchment size increases there may be more disparity, depending on the location of the rain gauge within the wider catchment.

* It is noted that as the Balmossie Mill flow gauge catchment descriptors had already been purchased from the FEH web service and are very close to the Baluniefield rain gauge (less than 3km away). These rainfall catchment descriptors were therefore used as a proxy location for Baluniefield rain gauge. For Dighty Water the rainfall adjustment ratio was calculated as follows:

1. Rainfall parameters were extracted from the FEH web service at the Balmossie Mill flow gauge location as a proxy for the Baluniefield rain gauge location.
2. Rainfall depths were calculated within a spreadsheet for a range of return period and durations using both the Grid Rain Parameters and the Catchment Rain parameters.
3. The ratio of rainfall depth calculated using 1km 'Grid Rain' parameters/ Rainfall depth calculated using 1km 'Catchment Rain' parameters was found for all return periods and durations.
4. This information was used to make a judgements as to a sensible average difference between rainfall totals between the upstream and downstream catchment of 1.06 (6%). Across all durations the ratio of 100yr rainfall calculated at the rain gauge over the whole catchment total ranged between 1.03 and 1.09.
5. An uplift of 6% was applied to the Baluniefield rainfall data within the ISIS hydrological boundaries to see what difference this made to total flows. This method is approximate to gain a feel for the importance of the rainfall contribution to the total modelled flow at Balmossie Mill.

The resulting rainfall runoff hydrographs are shown in Figure 4. Despite the amendments for local data and achievement of a reasonably good match on peak flow of the main event for the ReFH method, the volumetric element of the observed event has not been replicated very well for any method. The implication of this is that even if the ReFH hydrograph was used to simulate the observed event (having the best match on peak flow and volumetric shape), the overall volumetric underestimation across the whole event would be considerable. Whilst it is possible that further fine amendments could be made to the ReFH method to improve the correlation between the modelled hydrograph and the observed event, a pragmatic decision was made that these amendments would be unlikely to significantly change the result. Therefore, this this approach was discarded.

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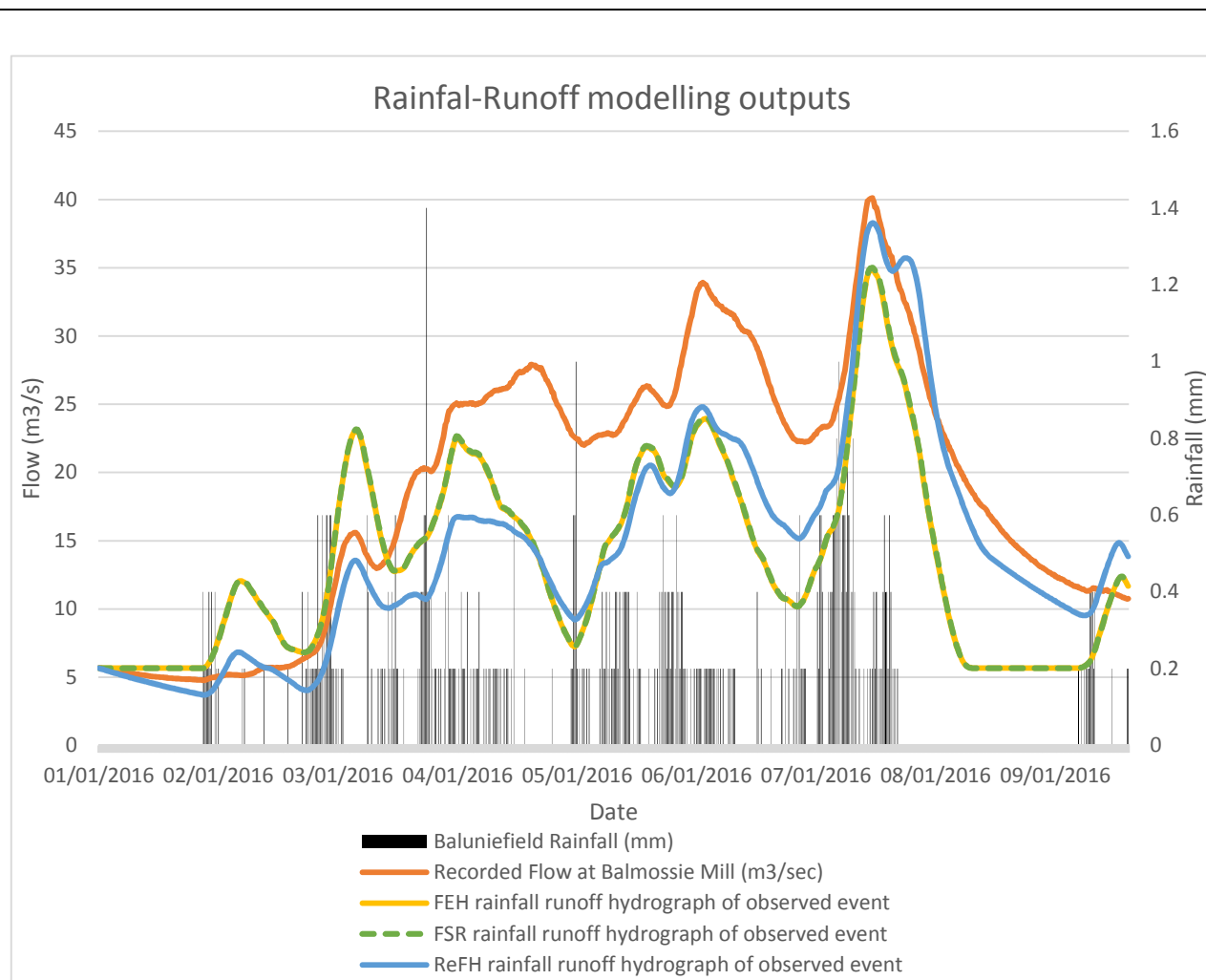


Figure 4: Simulated rainfall-runoff boundaries compared to observed event

5.2 Scaling recorded flows

In this method, the total recorded flow at Balmossie Mill (m³/sec) was split among the three sub-catchments present in the area using the ratios of QMED at each sub-catchment over QMED at Balmossie Mill. The estimation of QMED (2yr return period event) was based on ReFH2.

The method applied was as follows:

- 1) Three sub-catchments were set up within the ReFH2 software using catchment descriptors derived from the FEH web-service: Dighty Water (at the Fithie Burn confluence), Fithie Burn (at Dighty Water confluence) and Murroes Burn (at Dighty Water confluence)

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- 2) The critical duration at Balmossie Mill (with QMED as reference) was found using ReFH2 for the Balmossie Mill catchment (24.5hrs), and applied to each sub-catchment above as the design duration
- 3) QMED was then estimated at each sub-catchment and the proportion of the total QMED at Balmossie Mill was calculated.
- 4) These proportions were used to scale the recorded flow hydrograph at Balmossie Mill at the three sub-catchments
- 5) The resulting hydrographs for Dighty Water and Fithie Burn were used as inflows in the Infoworks model (Murroes Burn was not part of the model).

The method is based on a number of assumptions:

- the contribution of each watercourse during the January 2016 event is similar to the QMED scenario
- the ReFH2 method adequately describes QMED for all subcatchments
- the catchment area contributing flow to Dighty Water between the Murroes Burn confluence and the Balmossie gauge is not included within the proportions, however this is a very small area (3km², 2.4% of the total catchment area) and the impact will be negligible for the purpose of this exercise, as it is based on relative contributions.

It is considered that this method will give a reasonable approximation of the January 2106 flows along Dighty Water.

Table 1. Distribution of flows among the three sub-catchments for the January 2016 event.

Sub-catchment	Area (km ²)	QMED / QMED at Balmossie Mill
Dighty Water	72.0	0.60
Fithie Burn	30.8	0.25
Murroes Burn	20.7	0.15
Total to downstream of Murroes Burn confluence	123.7	
Total to Balmossie Mill gauge	126.7	

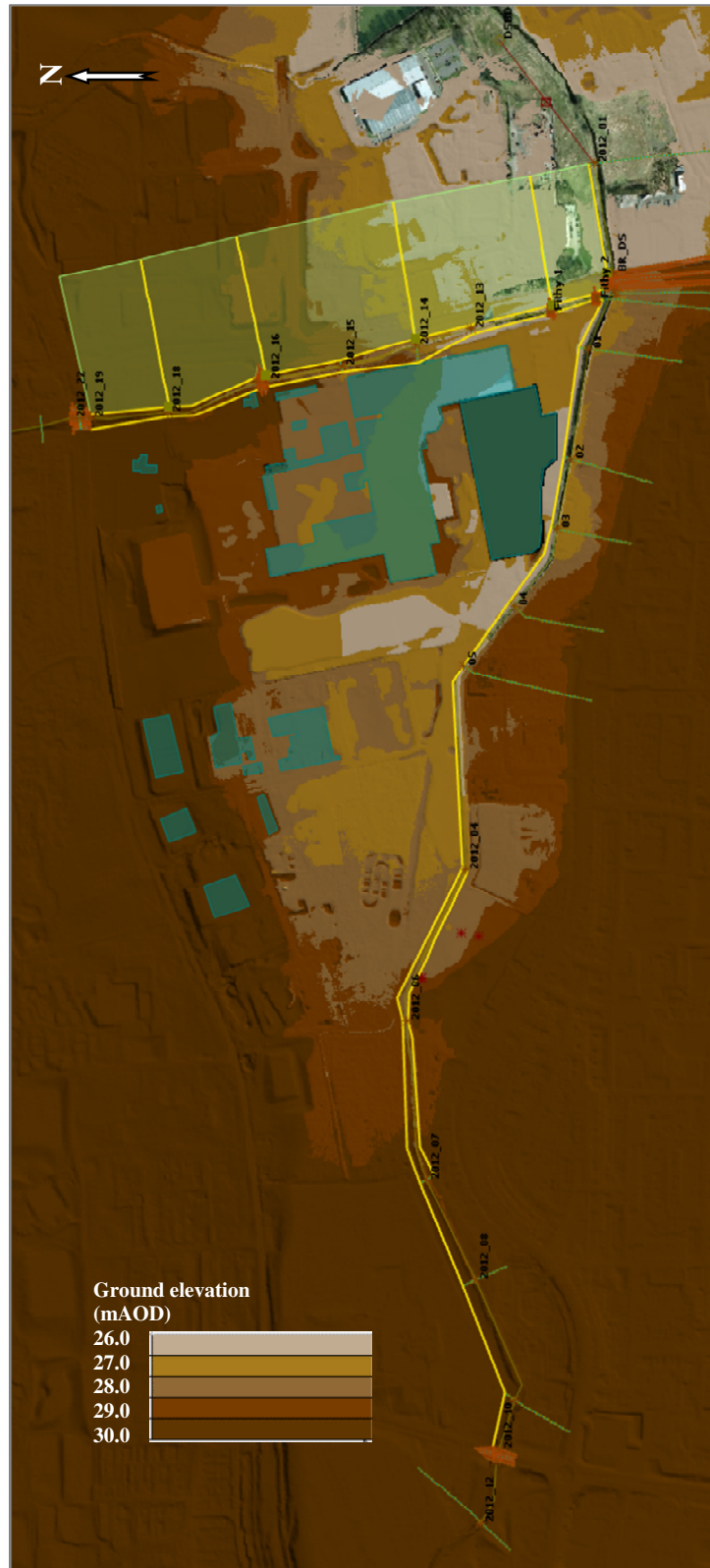
The proportions 60% Dighty Water and 25% Fithie Burn were applied to the Balmossie Mill observed flow record for the whole event and the scaled flows run through the Infoworks model.

The adopted method is the recorded flow scaling method due to the unsatisfactory replication of observed event using the rainfall-runoff method.

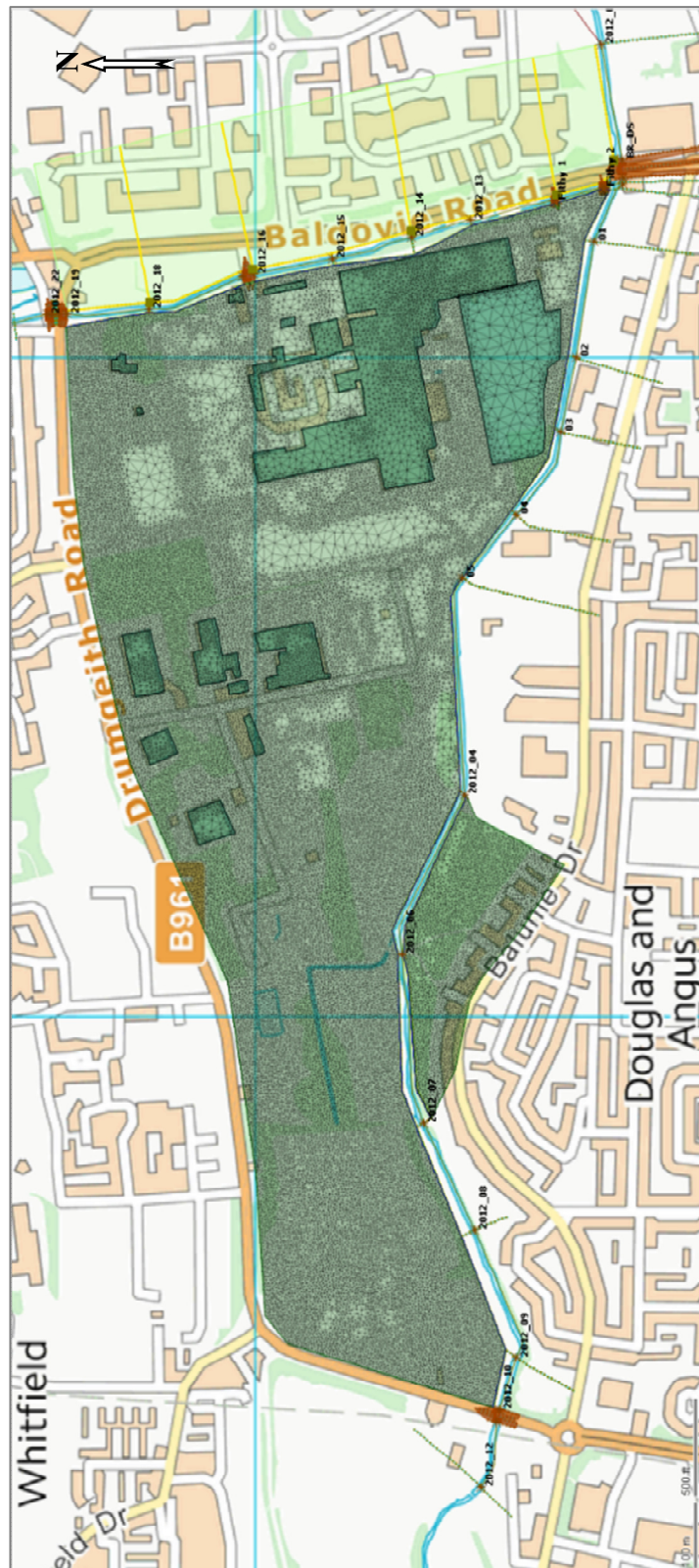
Appendix C

Hydraulic model details and outputs

C1 Combined ground model used for the modelling work



C2 Final model schematisation



Schematisation of the Arup hydraulic model

C3 Model validation

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1 Introduction

The present note provides photographic evidence collected from a range of sources in order to validate the outputs of the hydraulic model developed for the flood risk assessment of the proposed EfW facility at Forties Road, Dundee.

The estimation of the river flows was based on scaling the recorded flows at Balmossie Mill gauging station.

2 Sources of information

Various sources of information are available regarding the January 2016 flood extent on the site. This includes:

- Photographs taken on-site during the flood event on the site by Michelin staff⁽¹⁾
- Photographs taken in the days after the flood (19th December) by Arup staff showing wrack marks indicating flood extents and depths
- Information provided by Dundee City Council of the 2016 event including photographs and video of specific areas including Dundee Energy Recycling Limited (DERL) site on Forties Road; north of Balunie Drive (right bank of Dighty Water opposite site) and two locations around Drumgeith Park (upstream of site)(2).The dates vary between locations but all are between 5/1/16 and 8/1/16.
- Aerial photography shown on 'Yeken' website⁽³⁾. These images were published in February 2016 alongside images of flooding of Drumgeith Park dated 10th January 2016, it is therefore reasonable to assume this was the same event although the date of the photographs is not provided.

In addition Dundee council provided photos of flooding of the DERL site on Forties Road during previous events in October and December 2012, and flood extent maps showing that riverbank areas near the BMX track, and on Baldovie Road have flood event during one or more events dated between 1997 and 2013.

- (1) Personal correspondence from Louise Smart (Michelin) to Miguel Piedra (Arup), email dated 25th February 2016.
- (2) Personal correspondence from Andrew Reid (Dundee City Council) to Henry Snell (Arup), email dated 19th July 2016
- (3) <https://www.yeken.uk/aerial-photos-michelin-tyre-factory>

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3 Model results and flooding mechanism

The scaled observed event hydrographs were run through the Infoworks model. Only Dighty Water and Fithie Burn are included within the model. Figures 5a-h below show the modelled propagation of the observed event during key spill moments.

The results indicate that the onset of flooding occurred on the left bank of Dighty Water between the Baldovie Industrial Estate and the BMX track. Flooding continued to propagate here, spreading west past the southern extent of the industrial estate, and north onto the floodplain, bounded by slightly higher ground of the footpath. Some flow returned to Dighty Water (note arrows). Flood waters continue beyond the footpath to the south of the BMX track, with bank overtopping at the SW of the BMX track. Downstream flooding over the left bank becomes more extensive upstream of the river bend directly south of the site (Fig.5b-c). Flood waters continue to spread overland towards the BMX track, crossing it on their way to Forties Road, with increased overtopping of the left bank and flooding of the flood storage area in the Michelin site (Fig. 5c-d)

By the peak of the flood event the flood extent has increased to incorporate all of the left bank between upstream of the BMX track and downstream of the proposed building on the SE corner of the site, areas of the BMX track, land between the BMX track and the Forties Road; the access roads to the front of the DERL waste plant and the roads around the scrapyard, as well as the scrapyard itself. There is also an area on the right bank shown to flood, upstream of the BMX track, where the flood extent here is bounded by back gardens of homes on Balunie Drive. Flooding of the land immediately west of the study site is covered by flood waters, reaching partially into the entrance of DERL (Fig5g-h).



Figure 5a: Flow direction showing water leaving the channel at node 04, spreading towards the east, with some water going back into the river mid-way between 04 and 05.

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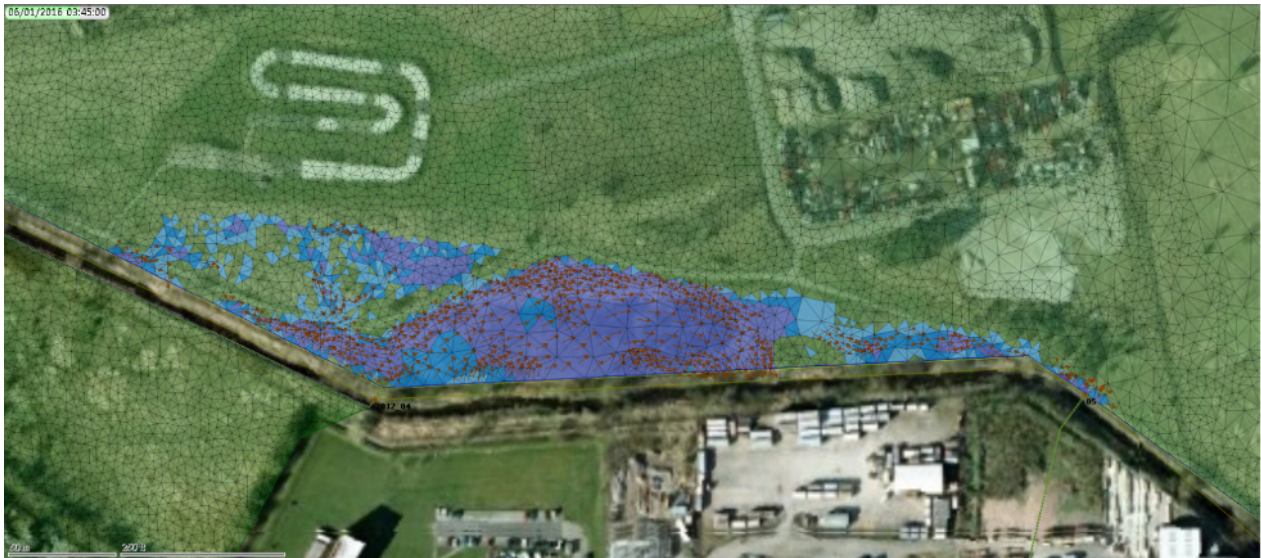


Figure 5b: Flow direction showing further upstream spill towards the BMX track



Figure 5c: Water travelling from node 2012_06 northwards and moving eastwards towards the back of the BMX track and spill downstream of node 05.

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Figure 5d: Water moving across the BMX track

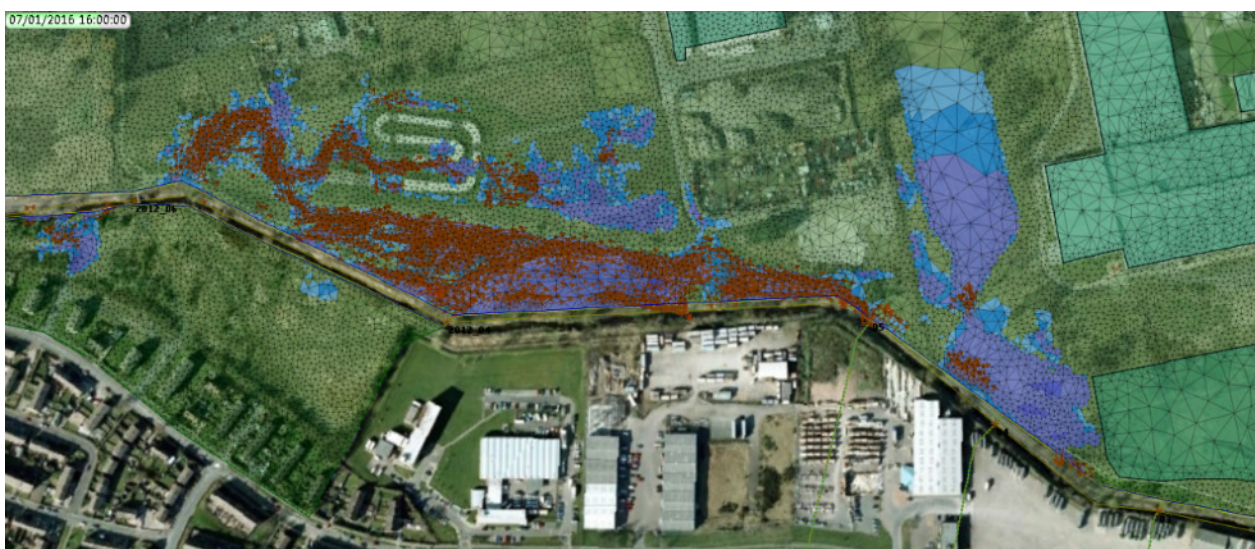


Figure 5e: Further flow towards BMX track eastwards towards Forties Road, and filling of existing compensatory storage. Spill on right bank upstream of 2012_06.

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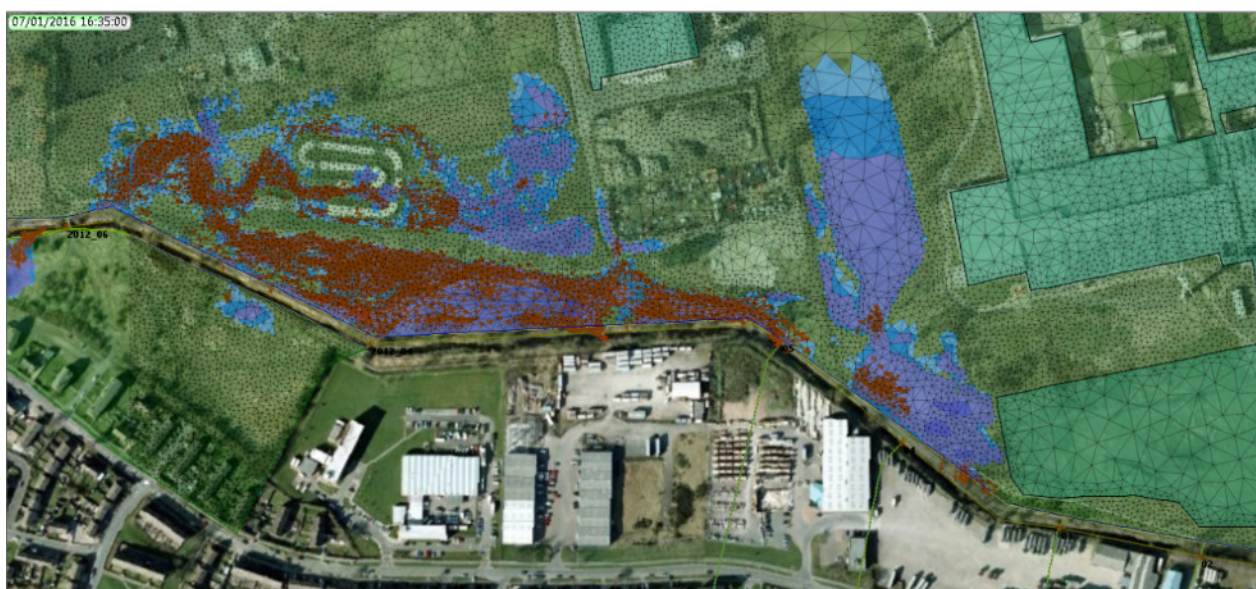


Figure 5f: Flow direction showing water spilling onto the Michelin site

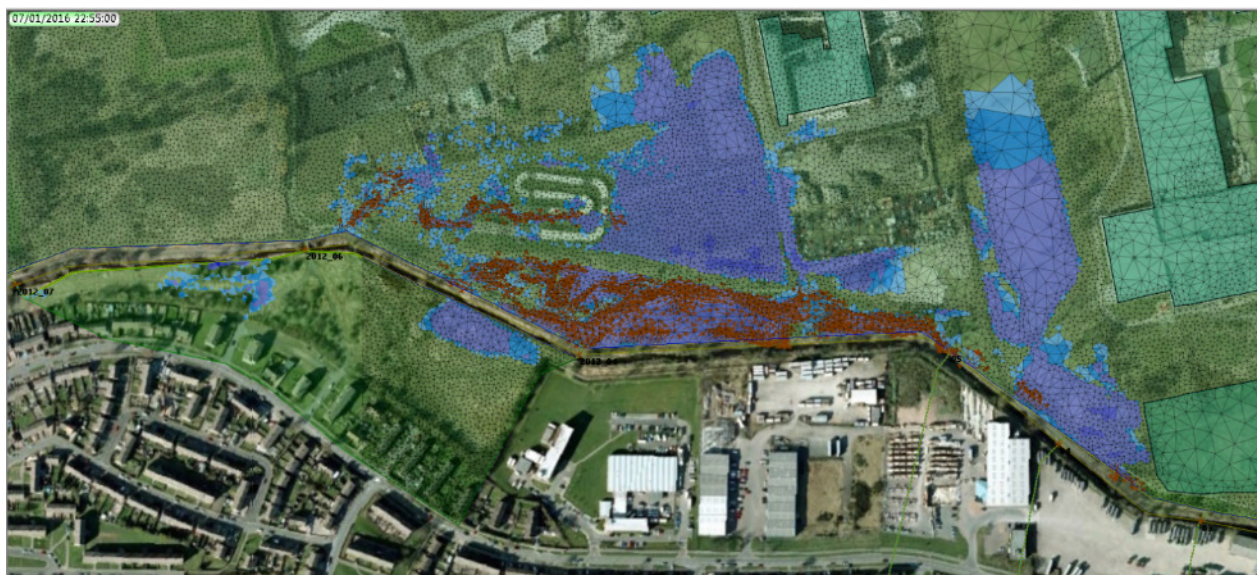


Figure 5g: Extent shortly before the peak extent was reached

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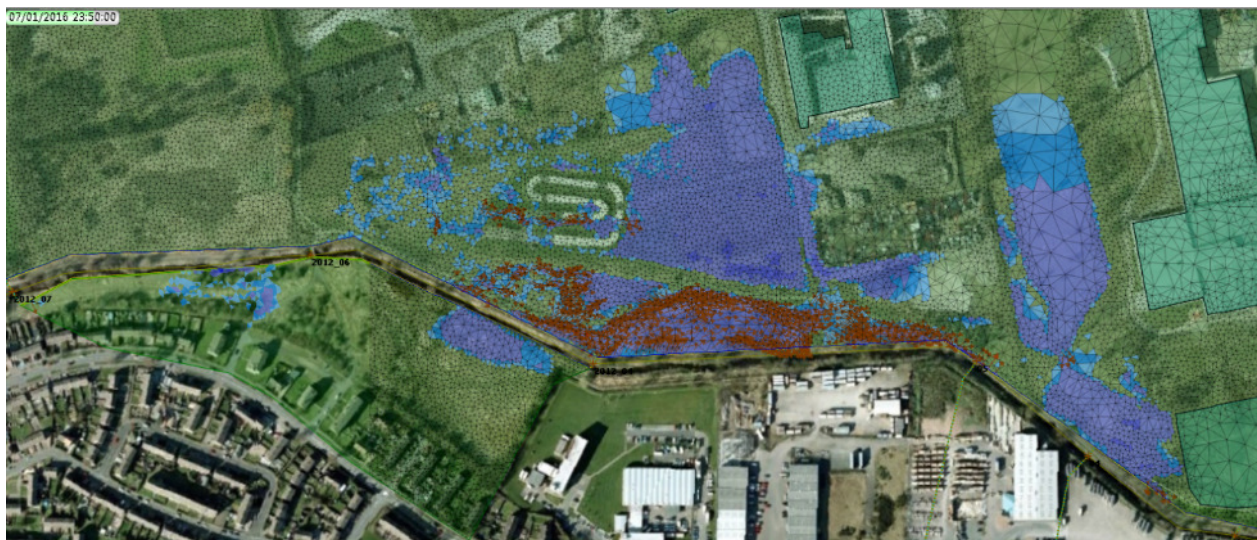


Figure 5h: Flood water deepens around the site and the scrap yard ponding in places

4 Verification of model outputs

The modelled maximum extent of the 2016 flood as described in Section 2.4.2 has been compared to information provided regarding this event as described in Section 2.4.1. Key areas have been cross-checked against photographs, and are described below. Figure 6 shows the locations of these comparisons.

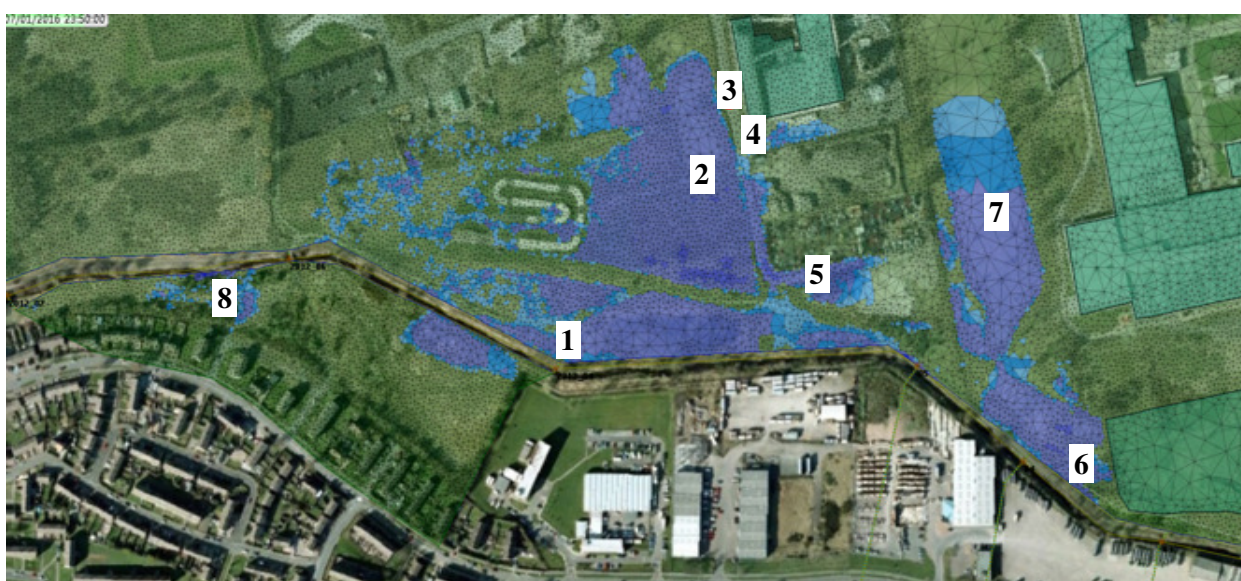


Figure 6: Map of key locations.

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Location 1: Initial spilling at node 2012_04 - the onset of flooding at this location (Figures 5a and 5b) agrees broadly with flood extents of previous events provided by DCC, which shows flooding in this area only (see circled area in Figure 7) during less severe flood events.

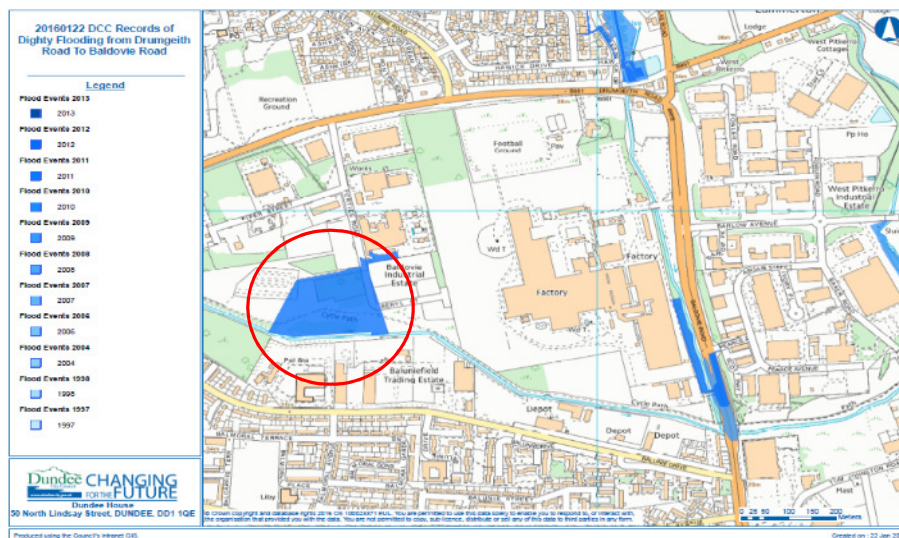


Figure 7: Previous flood extents in the vicinity of the study area (data provided by Dundee City Council)

Location 2: BMX track - whilst there are few photographs showing the overall extent of flooding at the BMX track, we know that there was some flooding of this area during the 2016 event, in particular along the access track from Forties Road, as shown in Figure 8a and b. This ties in with the modelled extents in Figure 5e-h.



Figure 8a: Flooding along BMX track access road off Forties Road on 6/1/15 (photo courtesy of DCC), approximate depth 0.2m. Location 2, Figure 6.

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Figure 8b: same location showing Forties Road (Arup, 19/1/16), floodwaters frozen

Location 3: Forties Road – modelling indicates flood water extended as far up Forties Road as the entrance to the DERL plant (Figure 5g-h). Grassland to the west was inundated a little farther north but not so far as buildings off Piper Street. This is supported by photographic evidence shortly before and after the maximum flood extent (Figures 9a-c).



Figure 9a: Forties Road flooding on 6/1/16, showing the entrance to the recycling centre on the left and the scrapyards to the left of the road in the distance. Forties road was inundated to approximately the recycling centre entrance (image courtesy of DCC). See location 3 on Figure 6.

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Figure 9b: Land to west of Forties Road showing inundation which does not extend as far as the buildings on Piper Road (shown on left of photo), 6/1/16 (image courtesy of DCC).



Figure 9c: Silt deposited in layby opposite recycling centre (19/1/16 – 12 days after flood, Arup)

Location 4: DERL plant entrance: Modelling indicates that this access road in from of the recycling building flooded, with water travelling eastwards past the front of the building and southward towards the scrapyard. During the event sandbags were used to prevent the worst of this flooding as shown in Figure 10. This ties in well with the modelled extent shown in Figures 5g-h. Figure 10 shows very shallow flow entering the site on 6/1/16. The sandbags prevented flooding extending further in this location.

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Figure 10: Entrance of the DERL plant showing sandbags (6/1/16), (photo courtesy of DCC). Location 4, Figure 6.

Location 5: Scrapyard – Modelling indicates flow entering the scrapyard from both the south as the river overtops at between 2012_04 and 05, and from flow entering from Forties road and from around the DERL plant to the north (Figures 5e-h). This is supported by Figures 11a and b which show the evidence of flooding in this location. The model predicts a flood depth of 0.15m – 0.4m at the peak of the flood extent on the road to the south of the scrapyard (Beryl Street).



Figure 11a: Flooding on Beryl Street to south of scrapyard showing scrapyard on left of photo (date unknown, image courtesy of Michelin). Location 6, Figure 6.

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Figure 11b: Silt deposited on Beryl Street (Arup, 19/1/16)

Location 6: Footpath near new building at SE of site. There are anecdotal reports of flooding up to manhole immediately adjacent to the building under construction. The approximate manhole location is marked by location 6 on Figure 6. Figure 12a and b show wrack marks on the fence indicative of a peak depth on the footpath of 0.3-0.4m. The model predicts a flood depth of approximately 0.2m at the peak of the flood extent on the path upstream of the building under construction. However this flooding does not extend beyond this point in the modelled observed event, even though wrack marks downstream on the footpath suggest the footpath continued to be flooded for some distance downstream, potentially to a depth of 0.3-0.4m.



Figure 12a: Left bank footpath showing silt. Anecdotal evidence suggests flooding extending into to the manhole located within the fenced area. Location 6, Figure 5. (Arup, 19/12/16).

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Figure 12b: Wrack marks would suggest a potential depth of 0.3-0.4m across the left bank footpath at location 6, Figure 6 (Arup, 19/1/16).

Location 7: Existing compensatory flood storage area. Aerial footage indicates this area was inundated, as shown in Figure 13. This ties in with the modelled peak flood extent (Figures 5e-h). The model predicts approximate flood depths of approximately 0.25m at the peak of the flood extent.



Figure 13: Aerial photo showing site, exiting compensatory flood storage area indicated

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Location 8: No information is available to verify this flood mechanism or extent.

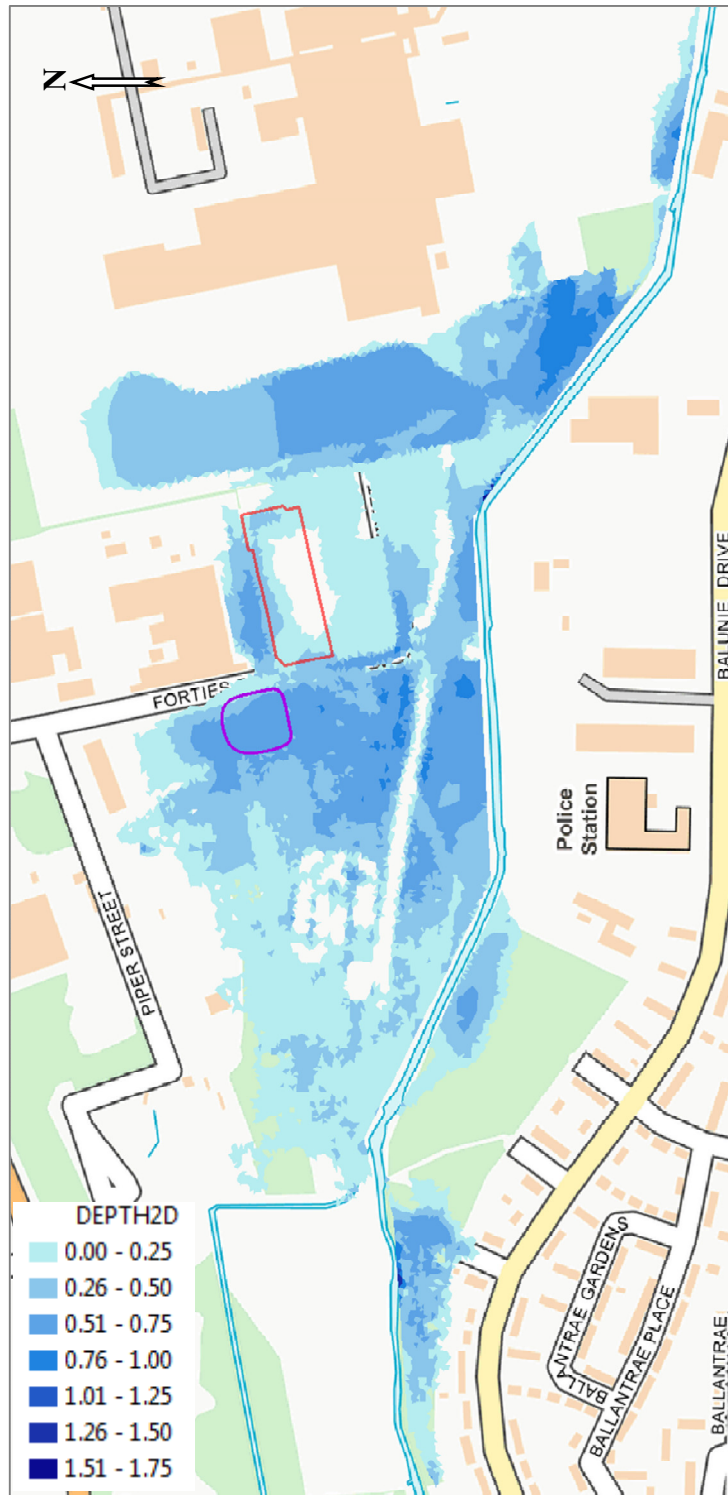
4.1.1 Conclusion

Figure 13 provides a good overview of the whole site which can be compared against Figure 5j, the modelled extent. Whilst the exact date of the photograph is not provided, and it appears flood extents have receded for the most part, the general extent of inundation, of at least impervious areas, can be seen.

Generally the model appears to replicate the observed event well in terms of extent and broad-scale depths. The model predicts a smaller flood extent along footpath south of the building shown under construction in Figure 12a, when wrack marks on photographs and anecdotal evidence suggest this area was also flooded. This area is not within the current scope of work, given the satisfactory match on the flood extent across the rest of the site, has not been considered further. The exact contribution of river flooding against surface water flooding cannot be known with any certainty. However a reasonably thorough verification has been possible and the model appears to be replicating flood extents on the site well.

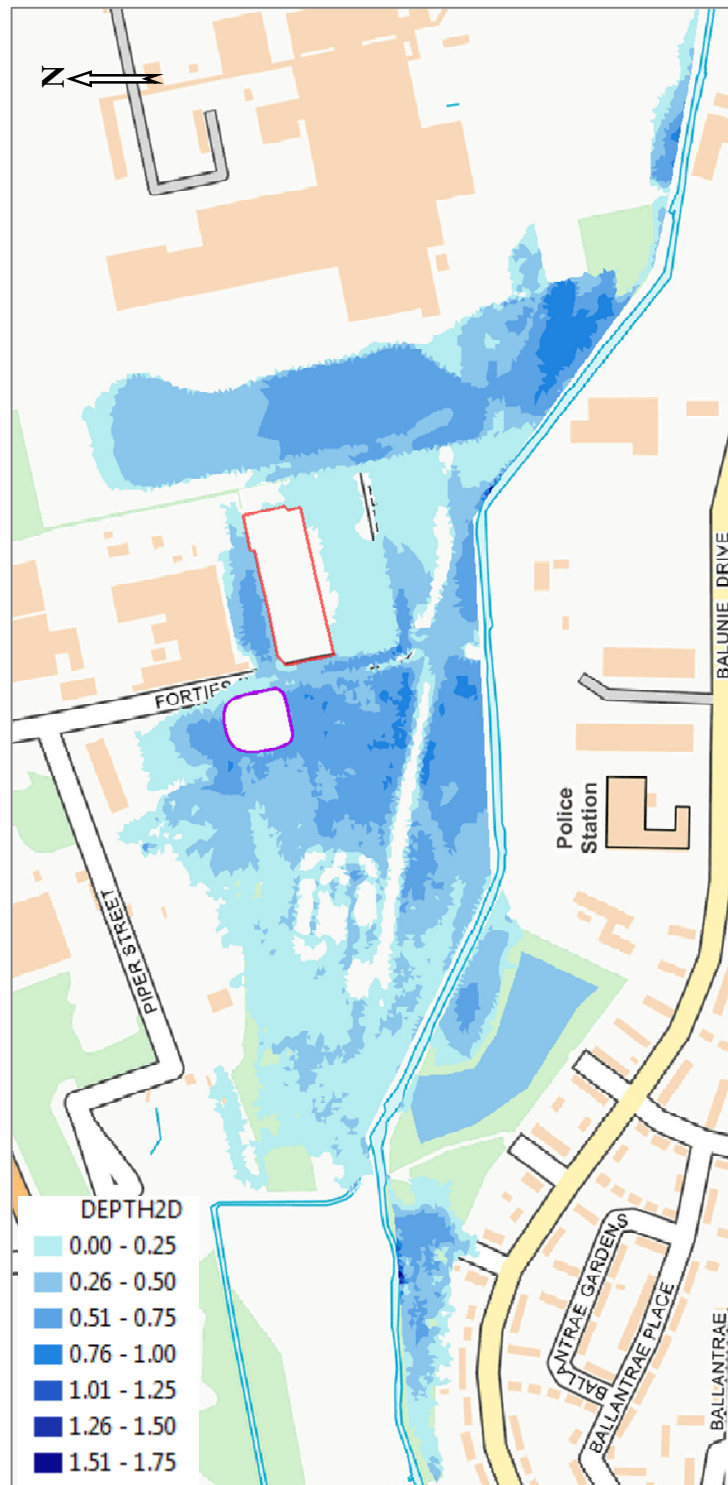
C4 Model outputs

Flood Map – 1 in 200yr Pre-development conditions



Maximum flood depths for the 1 in 200 year event under existing conditions. The site footprint (red) and SUDS basin outer perimeter (purple) are marked.

Flood Map – 1 in 200yr Post-development conditions



Maximum flood depths for the 1 in 200 year event under post-development conditions. The site footprint (red) and SUDS basin outer perimeter (purple) are marked.

Table of maximum water levels and flows

Maximum water levels (mAOD) along Dighty Water							
Node ID	Chainage (m)	Pre-development conditions				Post-development conditions	
		Q200	S.A. Flow (+20%)	S.A. Roughness (n+10%)	S.A Blockage (33%)	Q200	Q200+cc
2012_12	0	33.73	33.86	33.79	33.79	33.73	33.86
2012_11	105	33.13	33.28	33.21	33.21	33.13	33.28
2012_10	125	32.98	33.12	33.06	33.06	32.98	33.12
2012_09	208	32.48	32.62	32.55	32.55	32.48	32.62
2012_08	420	31.35	31.48	31.41	31.41	31.35	31.48
2012_07	599	30.61	30.71	30.66	30.66	30.63	30.74
2012_06	860	29.57	29.66	29.61	29.61	29.57	29.67
2012_04	1125	28.36	28.42	28.39	28.38	28.35	28.43
05	1457	27.69	27.81	27.74	27.75	27.68	27.81
04	1583	27.49	27.68	27.57	27.60	27.50	27.70
03	1731	27.05	27.23	27.12	27.17	27.06	27.24
02	1845	26.82	27.03	26.89	26.99	26.82	27.04
01	2024	26.48	26.70	26.52	26.71	26.48	26.71
BR_US!!	2123	26.48	26.70	26.51	26.70	26.49	26.71
BR_US	2134	26.47	26.69	26.50	26.69	26.48	26.70
BR_DS	2162	26.38	26.58	26.40	26.40	26.39	26.59
2012_01	2340	26.36	26.60	26.35	26.35	26.36	26.61

*Increase of water levels produced are below 0.01m, which are considered immaterial.

Maximum flows (m ³ /s) along Dighty Water							
Node ID	Chainage (m)	Pre-development conditions				Post-development conditions	
		Q200	S.A. Flow (+20%)	S.A. Roughness (n+10%)	S.A Blockage (33%)	Q200	Q200+cc
2012_12	0	35.8	43.0	35.8	35.8	35.8	43.0
2012_11	105	35.8	43.0	35.8	35.8	35.8	43.0
2012_10	125	35.8	43.0	35.8	35.8	35.8	43.0
2012_09	208	35.8	43.0	35.8	35.8	35.8	43.0
2012_08	420	35.9	43.1	36.0	35.9	36.0	43.2
2012_07	599	36.5	43.6	36.5	36.5	36.6	44.2
2012_06	860	35.5	42.5	35.5	35.4	35.9	43.1
2012_04	1125	22.5	23.2	20.8	20.8	22.7	23.1
05	1457	30.4	32.2	29.0	28.8	30.6	32.5
04	1583	27.0	29.3	25.2	25.2	27.3	30.0
03	1731	34.2	39.8	33.9	33.7	34.4	40.3
02	1845	33.8	38.9	33.3	33.2	34.0	39.6
01	2024	34.3	40.4	34.0	34.1	34.5	41.1
BR_US!!	2123	52.4	62.2	52.0	52.3	52.6	62.9
BR_US	2134	52.4	62.1	52.0	52.2	52.6	62.8
BR_DS	2162	52.4	62.0	52.0	52.1	52.6	62.7
2012_01*	2340	52.3	61.8	51.9	52.0	52.5	62.5

*Increase of flow noted is only 0.4%, considered immaterial for the purposes of the study.

Appendix D

SEPA FRA Checklist

D1 SEPA FRA checklist

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)

This document should be attached within the front cover of any flood risk assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal	
Site Name	Energy from Waste Combined Heat and Power Facility, Forties Road, Dundee
Grid Reference	Easting: 344576 Northing: 732863
Local Authority	Dundee City Council
Planning Reference number (if known)	16/00916
Nature of the development	Other If residential, state type:
Size of the development site	8 Ha
Identified Flood Risk	Source: Fluvial Source name: Dighty Water
Supporting Information	
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)	Yes
Has a historic flood search been undertaken?	Yes
Is a formal flood prevention scheme present?	No If known, state the standard of protection offered
Current / historical site use	brownfield
Hydrology	
Area of catchment	72 km ²
Qmed estimate	10.9 m ³ /s Method: Other
Estimate of 200 year design flood flow	36 m ³ /s
Estimation method(s) used *	Pooled analysis If other (please specify methodology used): Data transfer
	If Pooled analysis have group details been included Yes
Hydraulics	
Hydraulic modelling method	Linked 1D 2D Software used: Other
If other please specify	InfoWorks ICM (translated from InfoWorks RS)
Modelled reach length	2250 m
Any structures within the modelled length?	Bridges Specify, if combination
Brief summary of sensitivity tests, and range:	
variation on flow (%)	20 %
variation on channel roughness	10%
blockage of structure (range of % blocked)	33 %
boundary conditions:	Reference CIRIA culvert design guide R168, section 8.4
(1) type	Upstream Downstream
	Flow Select from List
(2) does it influence water levels at the site?	Specify if other Select from List
Has model been calibrated (gauge data / flood records)?	No
Is the hydraulic model available to SEPA?	Yes
Design flood levels	200 year 28.2 m AOD 200 year plus climate change 28.3 m AOD

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)

Coastal	
Estimate of 200 year design flood level	m AOD
Estimation method(s) used	Select from List If other (please specify methodology used):
Allowance for climate change (m)	m
Allowance for wave action etc (m)	m
Overall design flood level	m AOD
Development	
Is any of the site within the functional floodplain? (refer to SPP para 255)	Yes If yes, what is the net loss of storage 2060 m ³
Is the site brownfield or greenfield	Brownfield
Freeboard on design water level (m)	0.6 m
Is the development for essential civil infrastructure or vulnerable groups?	No If yes, has consideration been given to 1000 year design flood? Select from List
Is safe / dry access and egress available?	Vehicular Only Min access/egress level 27.6 m AOD
If there is no dry access, what return period is dry access available?	not assessed years
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event: 0.5-0.75 m Max Flood Velocity: 0.25 m/s
Design levels	Ground level 28 m AOD Min FFL: 29 m AOD
Mitigation	
Can development be designed to avoid all areas at risk of flooding?	No
Is mitigation proposed?	Yes
If yes, is compensatory storage necessary?	Yes
Demonstration of compensatory storage on a "like for like" basis?	Yes
Should water resistant materials and forms of construction be used?	Yes
Comments	
Any additional comments:	Design flows estimated by Atkins in 2014. SEPA confirmed that a revision of the calculations was not required for this FRA. Atkins inflows used. Installation at FFL, only access and internal roads below this level
Approved by:	Miguel M Piedra
Organisation:	Arup
Date:	09/12/2016

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accessed here:- [CLICK HERE](#)

* ReFH2 is now accepted by SEPA for flow estimates in Scotland. Any use of this method should be compared with other accepted methods.

Appendix E

Checking certificates

E1 Compliance certificate

APPENDIX 3

DUNDEE CITY COUNCIL CITY DEVELOPMENT DEPARTMENT

FLOOD RISK ASSESSMENT COMPLIANCE CERTIFICATE

I certify that all the reasonable skill, care and attention to be expected of a qualified and competent professional in this field has been exercised in carrying out the Flood Risk Assessments and preparing the Flood Risk Assessment Report for the below named development in accordance with the Reporting Requirements for Flood Risk Assessments issued by SEPA.

Name of Development:

*Energy from Waste Combined Heat & Power Facility
Forth Road, Dundee*

Name of Developer:

MVR Environment Services Ltd.

Planning Application No:

16/00916

Roads Construction Consent No:

Signed:



Name:

Miguel M. Pineda

Position Held:

Senior Engineer

Name and Address of Organisation:

ARUP 1 West Regent St.

Glasgow G2 1RW

Engineering Qualifications⁵:

CWEM MCWEM

Date:

5/Dec/16

⁵ Minimum Qualification - IEng from an appropriate Chartered Engineering Institution

E2 Independent check certificate

APPENDIX 4

DUNDEE CITY COUNCIL CITY DEVELOPMENT DEPARTMENT

FLOOD RISK ASSESSMENT – INDEPENDENT CHECK CERTIFICATE

I certify that all the reasonable skill, care and attention to be expected of a qualified and competent professional in this field has been exercised in checking the Flood Risk Assessments for the below named development with a view to ensuring that it has been accurately translated into the flood risk assessment report.

Name of Development: ENERGY FROM WASTE COMBINED HEAT & POWER

Name of Developer: MV ENVIRONMENT SERVICES LTD

Planning Application No: 16/00916

Roads Construction Consent No: N/A

Signed: 

Name⁶: DONALD J DALY

Position Held: ASSOCIATE

Name and Address of Organisation⁶: ARUP, CENTRAL SQUARE,
FORTH ST, NEWCASTLE NE7 3AL

Engineering Qualifications⁷: CENG, C.WEM, MICE MCIWEM

Date: 9.12.2016

⁶ Independent Checker can be someone from within the same organisation which prepared the Flood Risk Assessment but must be independent of the Team which prepared it

⁷ Minimum Qualification - IEng from an appropriate Chartered Engineering Institution