ST FERGUS SUBSTATION

Flood Risk Assessment

Prepared for: **Scottish & Southern Electricity Networks**

SLR Ref: 428.00660.00058
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BASIS OF REPORT

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1.0 Introduction

1.1 Context

SLR Consulting Ltd (SLR) was appointed by Scottish & Southern Electricity Networks (SSE) to prepare a Flood Risk Assessment (FRA) in support of a planning application for a substation on land to the west of the A90, adjacent to St Fergus Gas Terminal, near St Fergus, Aberdeenshire.

This present report addresses the flood risks associated with the planned development on the site, which will comprise a substation and an associated additional steel transmission tower.

It is noted that drainage aspects of the proposals are not reviewed in this present report.

1.2 Policy and Guidance

This assessment has been completed in accordance with relevant guidance issued by Aberdeenshire Council (ABC), the Scottish Government, and the Scottish Environment Protection Agency (SEPA). It takes cognisance of *Scottish Planning Policy* (SSP)[1], the *National Planning Framework for Scotland 3* (NPF3)[2] and the *Flood Risk Management (Scotland) Act 2009*.

The assessment also references and takes due consideration (where appropriate) of the following principal guidance and policy documents:

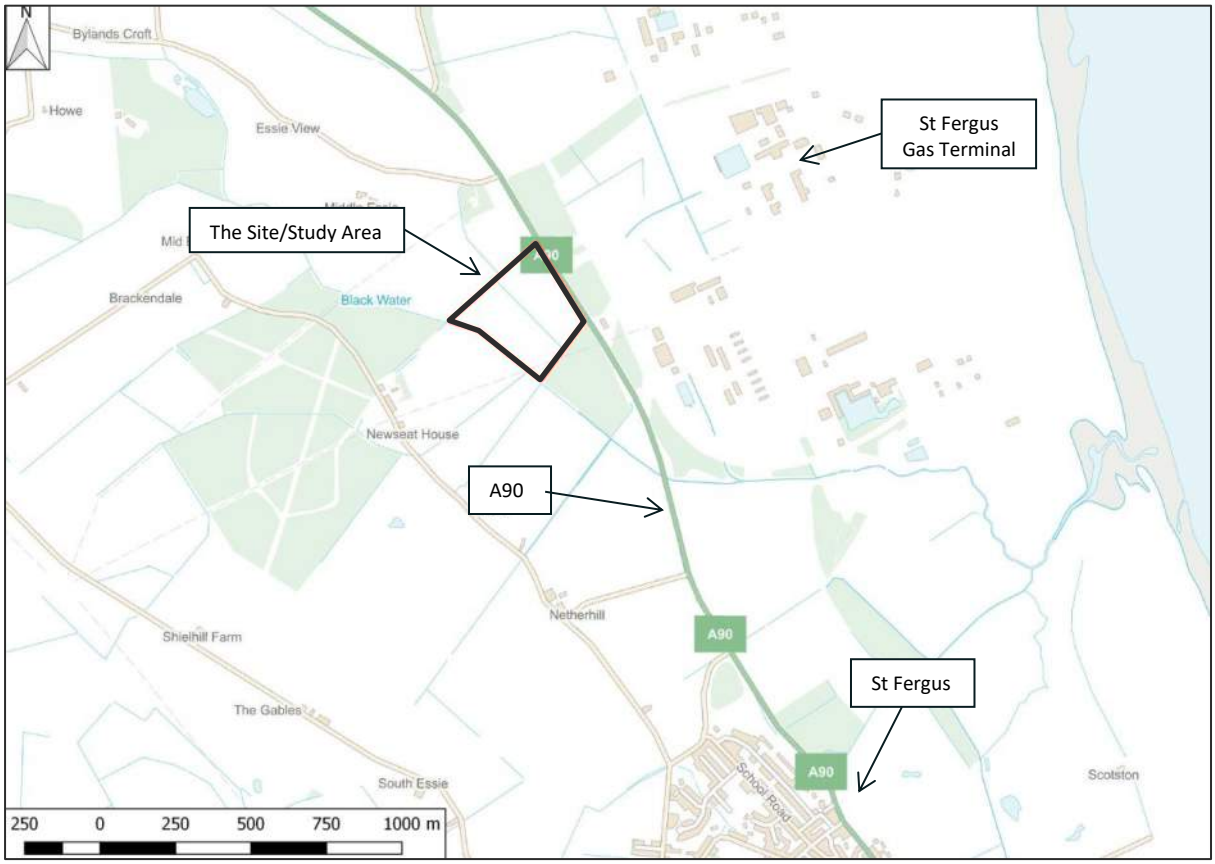
- British Standards Institution (2011) Assessing and Managing Flood Risk in Development – Code of Practice, Report BS-8533:2011, October 2011;
- CIRIA (2004) Development and Flood Risk – Guidance for the Construction Industry, Report C624; and
- SEPA (2015) Technical Flood Risk Guidance for Stakeholders (Reference: SS-NFR-P-002) June 2015.

1.3 Site Location

The Site is located approximately 2km to the north west of the village of St Fergus at National Grid Reference (NGR) NK 08853, and is shown in Figure 1-1 below. The Site is surrounded by pasture land and is bound to the east by the A90, opposite St Fergus Gas Terminal. A small watercourse, Black Water, runs through the Site, to the south west of the proposed substation. This watercourse flows in a south-easterly direction towards the coast. There is a small pond located within the Site to the south west of the proposed substation.

[1]The Scottish Government (2014) Scottish Planning Policy, June 2014
[2] The Scottish Government (2014) National Planning Framework 3, June 2014

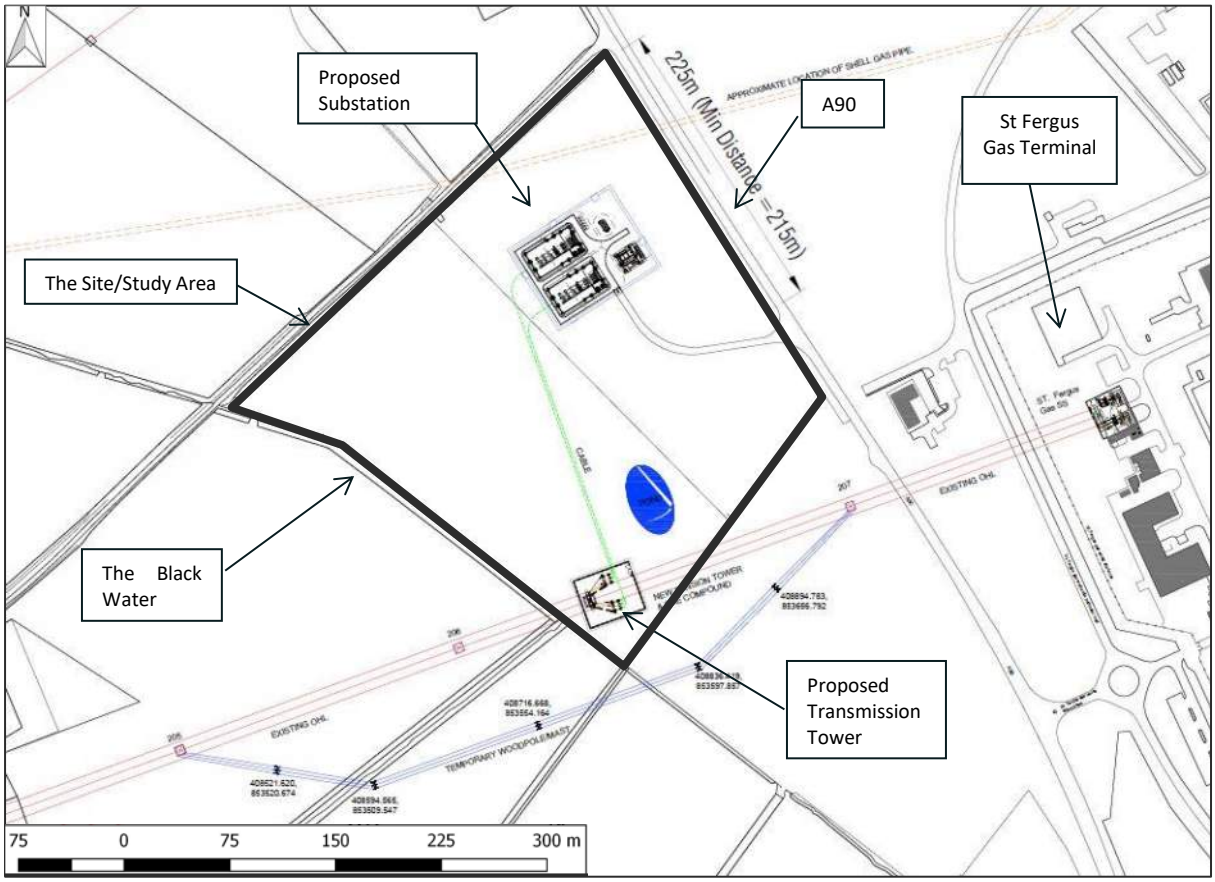
Figure 1-1 : Site Location



1.4 Proposed Development

The proposed development is shown below in Figure 1-2, which is an extract of the full plan provided in Appendix A. It consists of a substation in the northern part of the Site, construction of a steel transmission tower, and associated cabling. During construction, it is planned that a series of temporary timber transmission poles will be used to carry the aerial HV cables across the Black Water floodplain until the new steel tower is in place.

Figure 1-2: Proposed Development



1.5 Existing Site and Topography

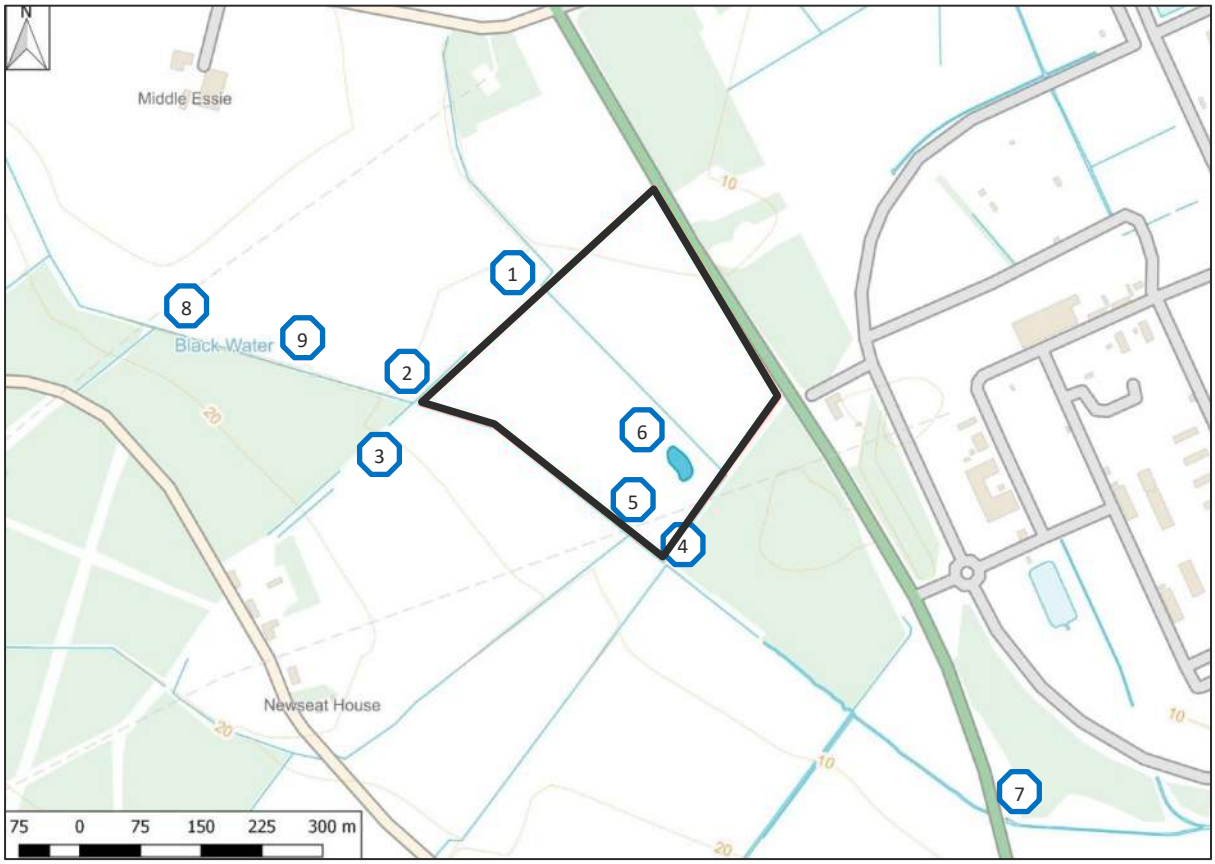
1.5.1 Local Topography

A walkover of the Site and surrounding area was conducted by a SLR hydrologist (Technical Director) on the 7th February 2019.

A topographic survey of the Site and adjacent land was undertaken by UTEC in February 2019, and is included in Appendix A.

In the following site description, reference is made to the included photographs taken during the site visit. For reference, the location of these photographs is shown in Figure 1-3 below.

Figure 1-3: Photograph Locations



In general terms the development Site itself comprises a flat plateau adjacent to the A90, with a sharp transition slope down to the floodplain some midway across the Site (see photographs at Locations 1, 3 and 6 below).

Location 1: From farm track panning left SE to SW

A farm track cuts across the fields from the A90 SW towards farm steadings, and crosses the Black Water at a rectangular reinforced concrete culvert (see photograph at Location 2 below).

Location 2: Farm track culvert

Location 3: From farm track panning NE to E

At the southern extremity of the Site, the Black Water floodplain becomes constrained by higher ground on the left bank, as shown in the photograph at Location 4 below. The photograph at Location 5 shows the typical vegetation and land cover at the Black Water along the length past the Site.

Location 4: Location of narrowing of floodplain – higher ground on LHS

Location 5: View across Black Water - existing transmission line on RHS

Location 6: View of pond on site

The Black Water proceeds downstream with dense vegetation on the left bank and with agricultural fields on the right bank, until it meets the A90. The watercourse is carried across the line of the A90 in a twin barrel corrugated steel culvert, as shown in photographs at Location 7 below.

Location 7: A90 Culvert – Looking downstream

Location 8: A90 Culvert – Looking upstream at culvert outlet

Location 9: A90 Culvert – culvert inlet

Upstream of the farm track culvert and the Site, the watercourse has a linear form, with fields on the left bank and pine tree plantation to the right hand side, as shown in photographs at Locations 8 and 9 below.

Location 10: Looking downstream along Black Water

Location 11: Looking downstream along Black Water

1.5.2 Geological Setting

A review of the British Geological Survey (BGS) Onshore Geoindex[3] data (1:50,000 scale Bedrock Geology, Superficial Deposits, Linear Features, Artificial Ground and Borehole Records) highlights the following.

The Site is located on Semipelite, Pelite and Psammite bedrock – the Crinan Subgroup and Tayvallich Subgroup. Overlaying the bedrock is a layer of tills, the Hatton Till Formation, consisting of Diamicton, Clay, Sand and Gravel.

1.6 Flood Risk Terminology

Probabilistic flood risks are typically expressed by the probability of the occurrence of a flood event (maximum flood height or other such indicator) of stated magnitude or greater in any one year – termed the Annual Exceedance Probability (AEP). This may be expressed as a percentage (such as 1%, 0.5%, etc.) or by the equivalent chance of occurrence (1 in 100, 1 in 200, etc.).

Where flood events have a Climate Change factor included, the flood event is denoted in this report by "+CC". For example, the 1 in 200 AEP flood event with Climate Change included is denoted "1 in 200+CC".

[3] BGS Onshore Geoindex available online at http://mapapps2.bgs.ac.uk/geoindex/home.html last accessed 02/04/2019

2.0 Flood risk review – sources of information

2.1 National Floodplain Mapping and Risk Assessment

Strategic level information regarding the current flood risk at the Site has been obtained from SEPA via the online Indicative Flood Extent Map[4] and National Flood Risk Assessment Portal[5].

2.2 Mapping and Terrain Data

Aerial imagery, OS elevation data (1:50,000 scale), the Site inspection and the local topographic survey referred to above have been used to assess the context of the application site and its immediate surroundings.

2.3 Planning Considerations

The relevant sections of Scottish Planning Policy (SPP), the Aberdeenshire Local Development Plan, and associated ABC planning guidance have been reviewed to inform this assessment.

2.4 Flood History and Records

There is no evidence from an internet search of reports of flooding along the length of Black Water near St Fergus.

[4] Scottish Environment Protection Agency (2016) Online Interactive Flood Extent Map Tool, available at: http://map.sepa.org.uk/floodmap/map.htm (last accessed 01/08/2018).

[5] Scottish Environment Protection Agency (2016) Online National Flood Risk Assessment Portal, available at: http://map.sepa.org.uk/nfra/map.htm (last accessed 01/08/2018).

3.0 Planning and Consultation

3.1 Scottish Planning Policy

The policy principles of Scottish Planning Policy (SPP) relating to **Managing Flood Risk and Drainage** state that the planning system should promote:

- *"a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change;*
- *flood avoidance: by safeguarding flood storage and conveying capacity, and locating development away from functional flood plains and medium to high risk areas;*
- *flood reduction: assessing flood risk and, where appropriate, undertaking natural and structural flood management measures, including flood protection, restoring natural features and characteristics, enhancing flood storage capacity, avoiding the construction of new culverts and opening existing culverts where possible; and*
- *avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface*"

and;

"To achieve this the planning system should prevent development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere."

SPP presents a risk framework for planning decision making relating to flood risk. A summary of this risk framework is replicated in Table 3-1.

Table 3-1
SPP Flood Risk Framework

SPP Flood Risk Framework
Little or No Risk *– annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years):* • *No constraints due to watercourse, tidal or coastal flooding.*
Low to Medium Risk *– annual probability of coastal or watercourse flooding is between 0.1% - 0.5% (1:1000 – 1:200 years):* • *Suitable for most development. A flood risk assessment may be required at the upper end of the probability range (i.e. close to 0.5%), and for essential infrastructure and the most vulnerable uses. Water resistant materials and construction may be required.* • *Generally not suitable for civil infrastructure. Where civil infrastructure must be located in these areas or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events.*

SPP Flood Risk Framework

Medium to High Risk *– annual probability of coastal or watercourse flooding is greater than 0.5% (1:200 years):*
• *May be suitable for:*
  ○ *residential, institutional, commercial and industrial development within built-up areas provided flood protection measures to the appropriate standard already exist and are maintained, are under construction, or are a planned measure in a current flood risk management plan;*
  ○ *essential infrastructure within built-up areas, designed and constructed to remain operational during floods and not impede water flow;*
  ○ *some recreational, sport, amenity and nature conservation uses, provided appropriate evacuation procedures are in place; and*
  ○ *job-related accommodation, e.g. for caretakers or operational staff.*
• *Generally not suitable for:*
  ○ *civil infrastructure and the most vulnerable uses;*
  ○ *additional development in undeveloped and sparsely developed areas, unless a location is essential for operational reasons, e.g. for navigation and water-based recreation, agriculture, transport or utilities infrastructure (which should be designed and constructed to be operational during floods and not impede water flow), and an alternative, lower risk location is not available; and*
  ○ *new caravan and camping sites.*
• *Where built development is permitted, measures to protect against or manage flood risk will be required and any loss of flood storage capacity mitigated to achieve a neutral or better outcome.*
• *Water-resistant materials and construction should be used where appropriate. Elevated buildings on structures such as stilts are unlikely to be acceptable.*

Surface Water Flooding • *Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years).* • *Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the Site, taking account of rain falling on the Site and run-off from adjacent areas.*

3.2 Structure and Local Plans

The **Aberdeenshire Local Development Plan** sets out broad guidance to inform local planning. Policy C4 "Flooding" indicates the following:

- Flood risk assessment will be required for development in the medium to high category of flood risk of 0.5%-10% annual probability (1 in 200 years to 1 in 10 years)
- Assessment should include an allowance for climate change and freeboard
- Development should avoid areas of medium to high risk, functional flood plain or other areas where the risks are otherwise assessed as heightened or unacceptable except where:
  - It is a development to effect flooding or erosion
  - It is consistent with the flood storage function of a flood plain
  - It would otherwise be unaffected by flooding (such as a play area or car park)
  - It is essential infrastructure

  - The location is essential for operational reasons for example for water based navigation, agriculture, transport or utilities infrastructure, and an alternative lower risk location is not available

- If development is to be permitted on land assessed as at a medium to high risk of flooding it should be designed to be flood resilient and use construction methods to assist in the evacuation of people and minimise damage
- The development must not result in increased severity of flood risk elsewhere through altering flood storage capacity or the pattern and flow of flood waters
- Maintenance buffer strips must also be provided for any water body
- In such areas land raising and/or excavations will only be permitted if it is for a flood alleviation measure, it is linked to the provision and maintenance of direct or indirect compensatory flood water storage to replace the lost capacity of the functional floodplain, and it will not create any inaccessible islands of development during flood events or result in the need for flood prevention measures elsewhere.

3.3 Consultation

3.3.1 Aberdeenshire Council

ABC were contacted in early April 2019. They did not report there having been any flood reports for the Black Water in this area.

3.3.2 BEAR Scotland

BEAR Scotland were also contacted in early April. They reported that the only recorded drainage incident in this area of the A90 was related to surface drainage only, and was not related to the Black Water culvert.

4.0 Flood Risk Screening

A screening review has been completed as below to identify whether there are any potential sources of flooding at the Site which warrant detailed assessment and /or mitigation.

A summary of the potential sources of flooding and a review of the potential risk posed by each source to the Site is presented in Table 4-1.

Table 4-1 : Flood Risk Screening

Source of Flood Risk	Description	Flood Risk Assessment
Coastal/Tidal	• The Site is located approximately 2km from the coast and is elevated to levels of 7.0m aOD. • With reference to Flood Maps[4] published by SEPA, the site is deemed not to be at risk of coastal flooding. • Flooding from this source is therefore considered negligible, and not considered further.	**Negligible Risk**
River	• The site is adjacent to Black Water. • With reference to Flood Maps[4] published by SEPA, the Site is shown to partially lie within an area of High risk of fluvial flooding (10% AEP, 1 in 10 chance). • Whilst the substation itself may remain flood-free in an extreme event, the new tower location and the works areas around this may be at High flood risk. • Therefore, fluvial flood risk is potentially significant and is considered further.	**Potential Risk to be considered further**
Surface Water (i.e. direct rainfall)	• With reference to Flood Maps[4] published by SEPA, the majority of the Site lies within an area of Low risk of surface water flooding (up to 0.1% AEP, 1 in 1000 chance). • The mapping indicates that a very localised area to the north east of the Site lies within an area shown to have a High likelihood of surface water flooding (10% AEP, 1 in 10 chance), but these areas are not indicative of a risk of overland flow towards the Site, but simply ponding into undulations in ground levels. • There are no external flow paths identified from upstream or surrounding the Site, and the Site is relatively flat and bound by the A90 to the east. • Flooding from this source is therefore considered negligible, and is not considered further.	**Negligible Risk**
Flow Paths	• As noted above, the Flood Maps[4] published by SEPA does not indicate that the Site is at risk from overland flow. • The Site has limited catchment areas around it that could cause any surface water flow towards the Site. • The Site falls away to the west, and as noted above, any runoff from the east side is re-directed by the A90.	**Negligible Risk**

Source of Flood Risk	Description	Flood Risk Assessment
	• Flooding from this source is therefore considered negligible, and is not considered further.	
Groundwater	• With reference to the Groundwater Flood Maps[4] published by SEPA, the site does not lie within an area likely to be at risk of groundwater flooding. • The topography of the Site and close proximity to the watercourse indicate that there is a low risk of groundwater to rise above ground level at the proposed development such as to present a flood risk. • Flooding from this source is therefore considered negligible and is not considered further.	**Negligible Risk**
Sewers and Artificial Drainage Systems, and Water Supply	• The site is currently undeveloped, and it is therefore unlikely for there to be any drainage system present. • The site is surrounded by pasture land and woodland and therefore is unlikely to have a significant public sewer that could impact the site. • Flooding from this source is therefore considered negligible and is not considered further.	**Negligible Risk**
Infrastructure Failure (i.e. reservoirs, canals, culvert blockage, etc.)	• The Site is not reliant on any flood defences as presented in the SEPA Flood Defences Map (information provided from the Scottish Flood Defence Asset Database (SFDAD)). • There are no reservoirs, canals or other artificial sources of potential flood risk near to or likely to affect the site. • Flooding from this source is therefore considered negligible and is not considered further.	**Negligible Risk**

5.0 Flood Risk Assessment

As noted in Table 4-1 above, the source of flooding that is to be considered further is the risk of flooding from fluvial sources.

5.1 Design Flood Levels

5.1.1 Design Flood Event

Guidance on the application of the SPP framework is found in SEPA's "Flood Risk and Land Use Vulnerability Guidance"[6]. Using terminology from this document, development that includes "civil infrastructure" is considered to represent a "Most Vulnerable Use", for which SEPA advise that the design event would be the 1 in 1000 AEP event. This guidance does not specify that substations fall into this category. However, SSE design standards do specify that substations should be designed to remain flood-free in a 1 :1000 AEP event.

The associated transmission tower would be considered in the SEPA vulnerability guidance to represent "Essential Infrastructure", as it requires to be sited in the floodplain for operational reasons.

The latest SEPA guidance on climate change allowances recommends that regional uplift values be considered based on CEH guidance[7] (that in turn is based on UKCP09 data). For the NE of Scotland, this advice indicates that for Medium and High emissions scenarios, and for a 50th %ile confidence level, the uplift should be at least 14% to 17%. However, SEPA also recommends that a minimum of 20% should be adopted across Scotland. Therefore, a design flood event of 1 in 1000 + 20% CC has been adopted.

5.1.2 SEPA Flood Modelling

SEPA's online Flood Maps provide indications of the likely flood patterns for a range of AEP. Whilst noting the limitations of this mapping, it can provide a guide to the likely scale of flooding in an area.

Given the limitations of the SEPA flood modelling and mapping, the mapping shown indicates that the 1 in 1000 AEP flood level at the site may be between 0.3 – 1m depth.

This flood mapping resource provides indications of the potential for flood risk at a local or "community" level and is intended to support community decisions. It is not considered by SEPA as suitable to assess flood risk at a site specific level.

5.1.3 Localised Hydraulic Modelling and Flood Level Prediction

In order to obtain a more refined estimate of flood levels at the Site, a numerical hydraulic model was established and used to determine the flood routing characteristics at the proposed St Fergus Substation.

Hydrology

It is understood that there is no publicly available flow gauging on the Black Water upstream of the Site.

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[6] SEPA - Flood Risk and Land Use Vulnerability Guidance, Ver 3, Feb. 2018

[7] CEH - An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change - Work Package 1 Report, 2011

In the absence of stream gauging, both ReFH[8] and FEH Pooling Group[9] methods have been used to develop the inflow in a 1 in 1000 + 20% CC event on the Black Water.

The key details of the rainfall and runoff parameters used in the ReFH method are given in Appendix B.

Details of the application and outcomes of the Pooling Group Method are presented in Appendix C.

It should be noted that a set of initial hydraulic model runs were carried out using a range of durations of rainfall event, in order to ensure that the critical event was captured for flood level response of Black Water. A range of events from 2.5 hours through to 24.5 hours were tested, and it was found that the 6.5 hour rainfall was critical for flood level. Longer and shorter durations resulted in lower flood levels.

The outcomes of the hydrological analyses, in terms of peak flowrates, are as follows:-

- ReFH Method: 1 in 1000 Peak Flowrate = 13.98 m^3/s;
- ReFH Method: 1 in 1000 + 20% Climate Change Peak Flowrate = 16.78 m^3/s;
- Target Pooling Group Method: 1 in 1000 Peak Flowrate = 12.07 m^3/s;
- Target Pooling Group Method: 1 in 1000 + 20% Climate Change Peak Flowrate = 14.48 m^3/s;

The ReFH method was chosen to be used in this model, as it presents a slightly more conservative estimate than the Target Pooling Group method, and is appropriate for smaller catchment, as in this case (catchment area is approximately 7.69km^2).

The input hydrograph using the ReFH flowrate (1 in 1000 + 20% CC) is shown in Appendix B.

Hydraulic Model

A one-dimensional HEC-RAS model was established for the Black Water upstream and downstream of the Site.

The input hydrology was the ReFH hydrograph, and the downstream boundary condition was set as Normal Depth (based on assumed stream bed gradient).

The model included two structures, representing the two culverts in the study reach (farm track culvert upstream of the Site, and the A90 culvert downstream of the Site).

In the base modelling, reflecting observations on site, one of the barrels of the A90 culvert was set as blocked to a depth of 700mm by silt; the other is full diameter. In a blockage scenario (see below), the clean barrel is also set as blocked to 700mm depth.

Modelling Results

Appendix D shows the outcomes of the hydraulic modelling. The key outcomes of the modelling for a 1:1000 + CC event are:

- Peak Inflow = 16.78 m^3/s
- Peak Outflow = 16.53 m^3/s
- Maximum Ponded Level adjacent to the Site – varies from 7.57m aOD to 7.70m aOD (adopt 7.70m aOD)

[8] Revitalised Flood Hydrograph Model 2.2 (ReFH), as defined in "The Revitalised Flood Hydrograph Model REFH2.2 Technical Guidance", CEH 2016

[9] As described in Volume 3 of the Flood Estimation Handbook (CEH, 1999) and implemented via WINFAP-FEH 3 software.

Sensitivity Analysis

Since the inflows have been estimated, and the resulting flood levels cannot be verified against actual flood events, some sensitivity analyses were carried out to gauge the uncertainty and sensitivity of the resulting flood level given above to these input parameters. The outcomes were as follows:

- Varying slope at downstream boundary (+/- 20%): No change
- Varying Manning's n value (+/- 20%): +/- 50mm
- Varying the blockage (siltation, etc.) of the downstream culvert +/- 10mm

Discussion

The hydraulic modelling indicates that (based on a conservative flow assessment) the maximum peak water level adjacent to the site would be at approximately 7.70m aOD. This level would extend towards the south west of the Site, and extend slightly over the north east part of the Site.

Figure 5-1 : Flood Extents

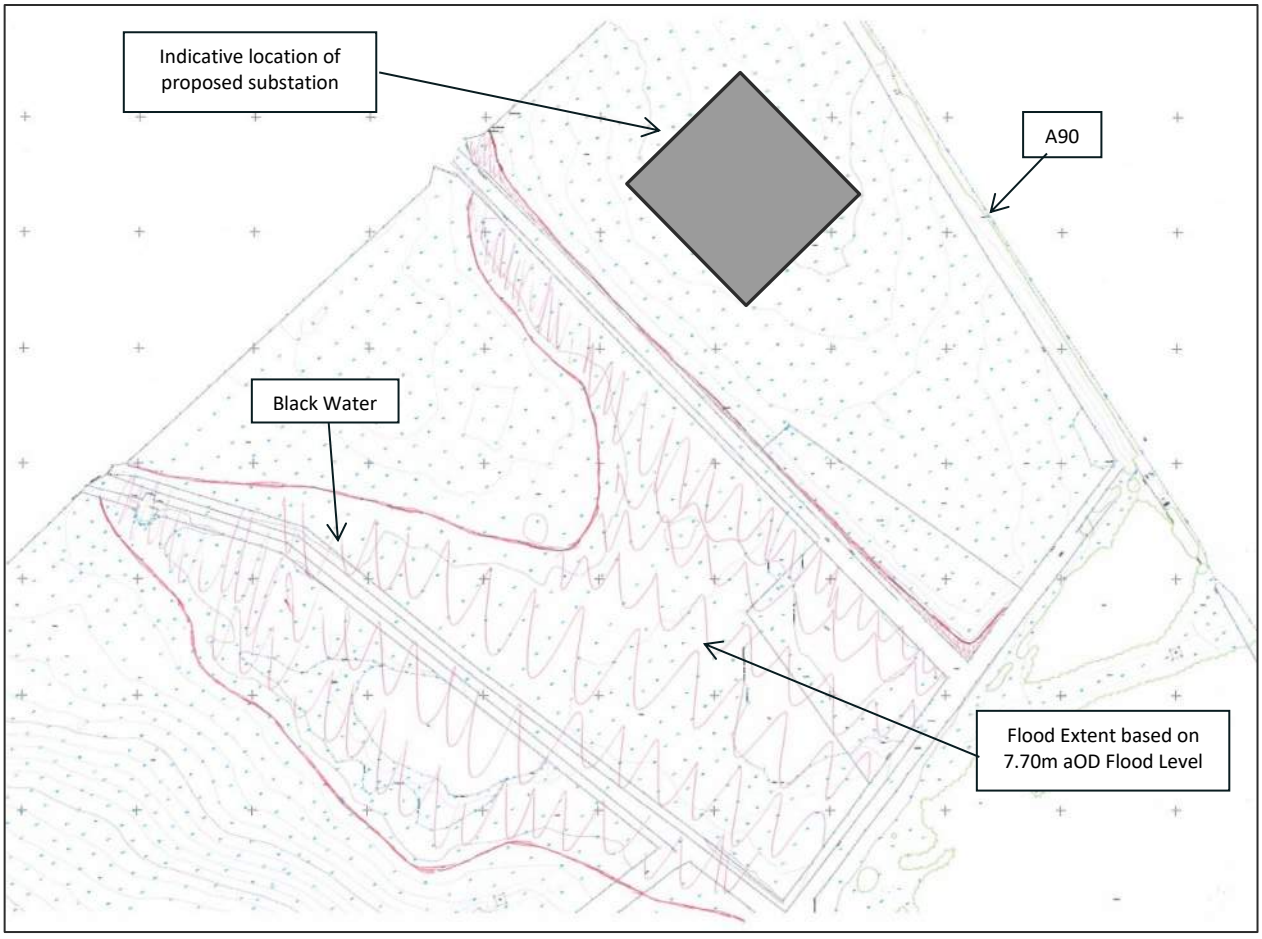


Figure 5-1 shows that in the 1 in 1000 +20% CC flood event, the flood extents would cover the majority of the south west part of the Site, including the location of the proposed transmission tower. Since the land in the north east part of the Site is at higher elevations, the flooding only extends slightly onto this part of the Site. The flood extent is not predicted to inundate the area in which the proposed substation is located.

5.1.4 Freeboard Provisions in the Development

A freeboard should be applied to the adopted design flood level to arrive at suitable design floor levels.

Freeboard allows for both uncertainty in the hydrology and hydraulic modelling that is used to derive flood levels, and other physical processes not allowed for in the design flood estimation, such as minor wave or wind effects, super-elevation of water surfaces, and settlement of defence structures[10].

SEPA advises a minimum freeboard of 500mm to 600mm for fluvial flood risk and raised flood defence situations, where wave, surge, defence settlement and other such effects may be present.

Guidance such as *Improving the flood performance of new buildings – Flood resilient construction*[11] referenced by the Building Standards for Scotland suggest that freeboard related to uncertainties alone should be around 300mm.

In this instance, a freeboard of 600mm is recommended. The design platform level should therefore be a minimum of 8.3m aOD.

5.2 Access and Egress

In a large flood event such as the 1 in 1000 + 20%CC, as shown in the area to the north east of the Site is not predicted to be inundated by flood water. Therefore, in an emergency access and egress can be taken via the main A90 road that bounds the east of the site.

5.3 Alignment with Flood Policy

The south west part of the Site, where the proposed transmission tower is to be located, is shown to be in a zone of Medium to High Flood Risk according to SPP criteria; the north east part of the Site, where the proposed substation is located, is shown to be within a zone of Low to Medium Flood Risk. The proposed development is therefore considered to be in accordance with SPP and Aberdeenshire Council policy and SEPA guidance regarding appropriate land uses.

[10] Environment Agency, Fluvial Freeboard Guidance Note, Report W187, C624, 2000.

[11] Environment Agency, Improving the flood performance of new buildings – Flood resilient construction, 2007.

6.0 Conclusions

SLR Consulting Ltd (SLR) was appointed by SSE to prepare a Flood Risk Assessment (FRA) in support of a planning application for a substation at St Fergus , Aberdeenshire.

In accordance with relevant local and national guidance, all potential sources of flooding to the Site have been considered.

The flood risk screening carried out in this review concludes that there is a Negligible risk of flooding from sources such as coastal, surface water, groundwater or infrastructure failure, but that fluvial flood risk required further consideration.

For the type of development proposed on this Site, the target or design flood risk level would be 1:1000 (0.1%) AEP, with an allowance made for future climate change effects.

The Site is adjacent to Black Water, and SEPA flood mapping indicated that part of the Site may be at some flood risk in the 1 in 10 AEP or larger flood events.

This present flood study included detailed consideration of the response of Black Water to the passage of a 1 in 1000 + 20% CC flood event through the Site. Two forms of analysis of estimated flood flows have been carried out, and the most conservative method, ReFH, has been used to estimate potential flood levels.

A one-dimensional hydraulic model of the river system was established. This was used to model the 1 in 1000 + 20% CC storm event.

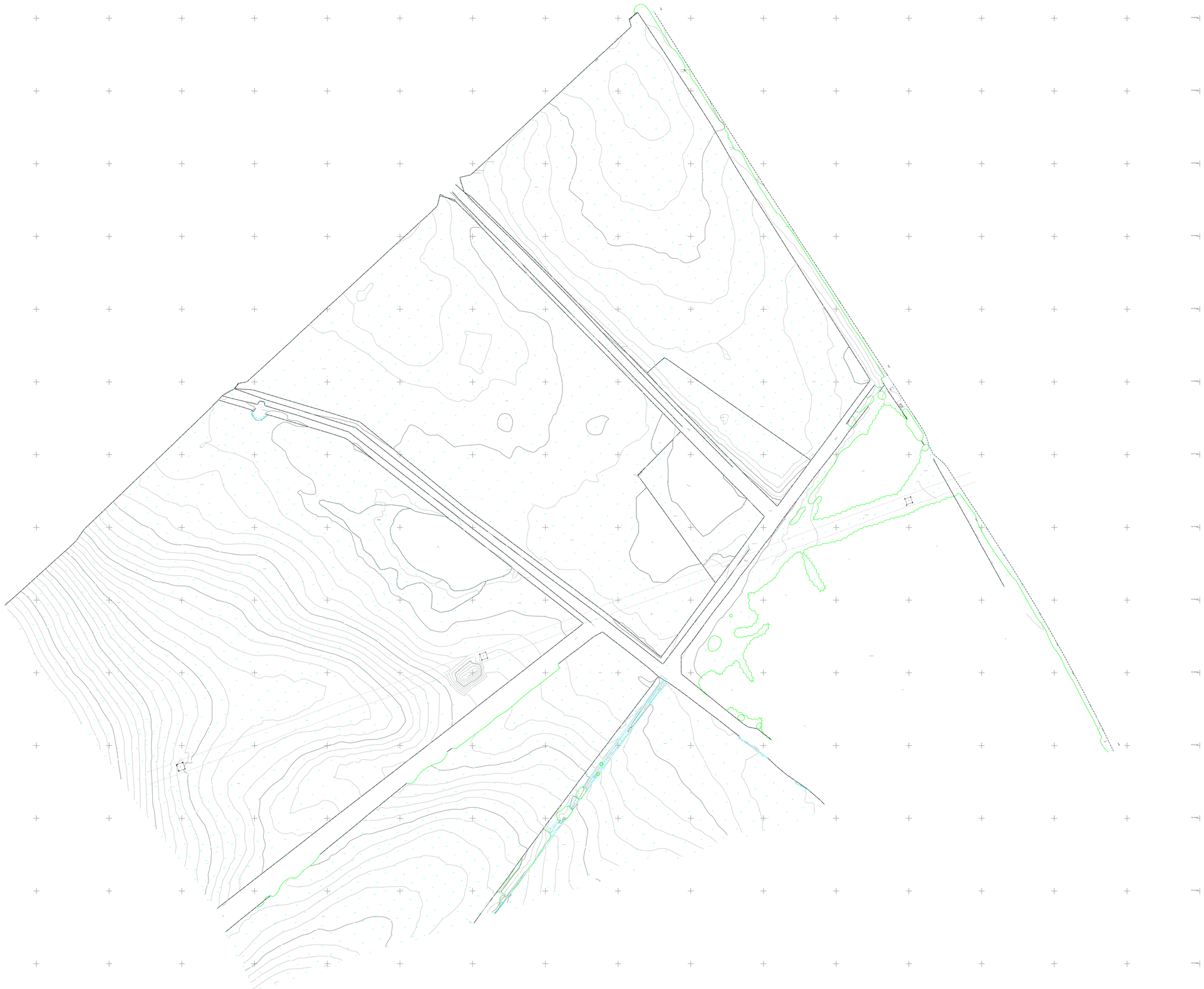
The modelling was also subject to sensitivity analysis by considering a range of roughness values, a range of downstream tailwater slopes, and a blockage scenario.

The maximum flood level in the Black Water floodplain adjacent to the Site is estimated to be 7.70m aOD, and with a suggested freeboard of 600mm, a design platform level is 8.3m aOD is recommended.

There is adequate provision for emergency ingress/egress to the Site directly from the A90.

APPENDIX A

Site Plans and Topographic Survey



AP	Anchor Point		Bottom of Bank
BH	Borehole		Building
BO	Bollard		Building (Open)
BT	Telecoms		Bush
COL	Column		Change of Surface
CTV	Cable TV		Crash Barrier
DP	Down Pipe		Drainage
EL	Eaves Level		Drop Kerb
EP	Electric Pylon		Fence
ER	Earthing Rod		Foliage
FH	Fire Hydrant		Gate
FL	Floor Level		Hedge
G	Gully		Kerbline
GA	Gas Valve		Overhead Elec.
IC	Inspection Cover		Overhead Line
IL	Invert Level		Overhead Tele.
JB	Junction Box		Pipe
KO	Kerb Outlet		Railway Line
LP	Lamp Post		Road Centreline
MH	Manhole		Road Edge
MK	Marker Post		Rock Outcrop
PO	Post		Sapling
RE	Rodding Eye	+10.00	Spot Height
RL	Ridge Level		Steps
RP	Reflector Post		Street Furniture
RS	Road Sign		Top of Bank
SC	Water Stop Cock		Tree
SL	Soffit Level		Utility Cover
TBM	Temp. Benchmark		Verge
TFE	Top of Feature		Wall
TFL	Top of Fence Lev.		Waterline
TFOL	Top of Foliage Lev.		
TL	Threshold Level		

Control Stations

Notes:

1. All dimensions are in metres unless otherwise stated.
2. All survey co-ordinates are related to OS National Grid (OSTN15)
3. All survey levels are related to OS Datum - Geoid model: OSGM15.
4. For further details with regards to the above information please contact UTEC StarNet.

Rev	Amendments	Date	Dwn	Chk

Drawn by: PD	Scale: NTS	Original Size A0
Checked by: JM	Date: 15/02/2019	Drg File Name: ST-SSE0082_01

Scottish & Southern Electricity Networks

St Fergus Gas Replacement
Topographic Survey 2D

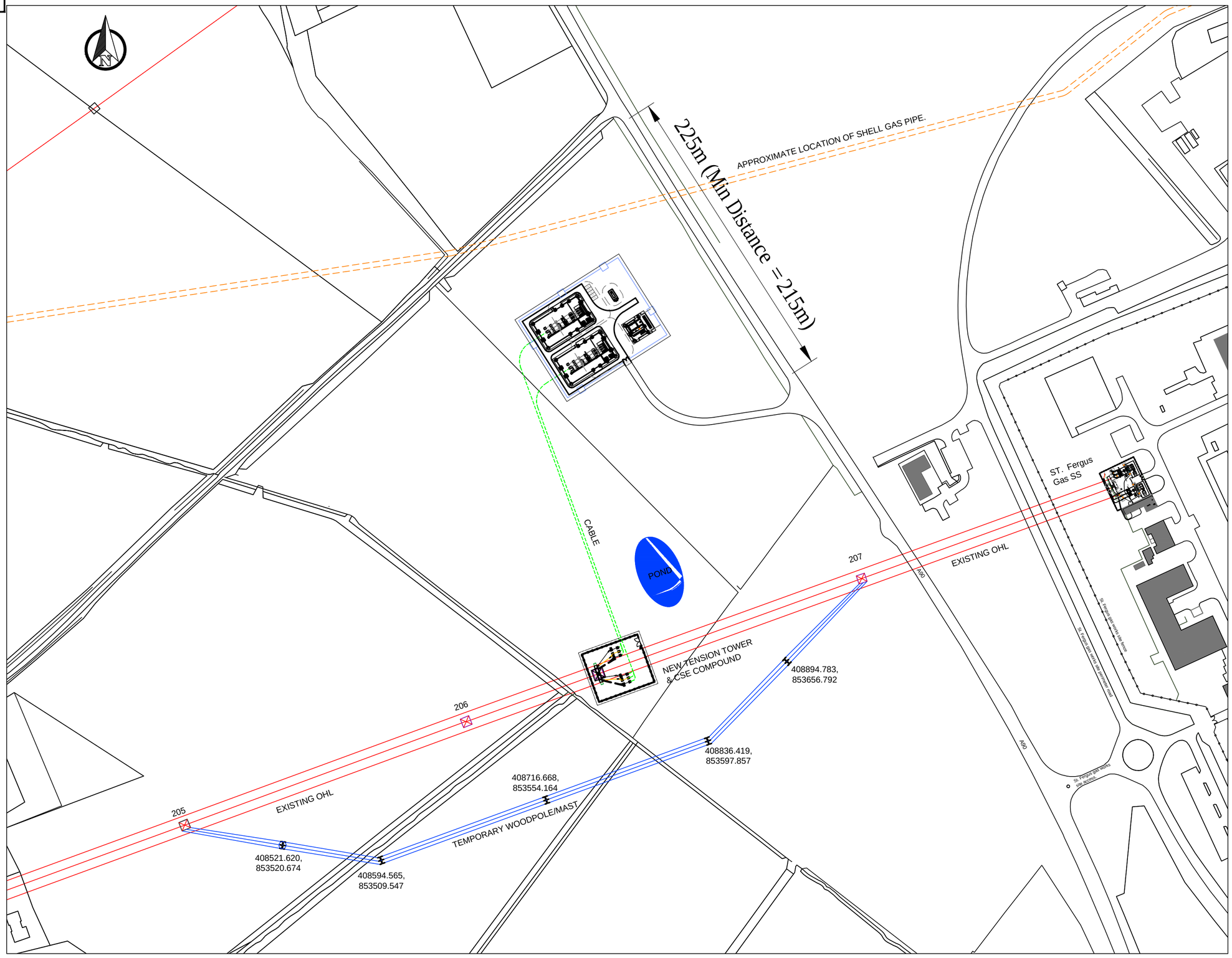
February 2019 - Sheet 0 of 13

UTEC

Unit 2B, Alba Business Pavilions,
Alba Business Park, Livingston, EH54 7BG
Tel: 01506 447 460

DRAWING No.	REV.
ST-SSE0082_01_00	-

A2



SITE LAYOUT

SCALE 1:2000

SCALE AT 1:2000

0m 50m 100m 150m 200m

LIST OF ALL RELEVANT DRAWINGS OR DOCUMENTS THAT DIRECTLY RELATE TO THE CURRENT REVISION OF THE DRAWING

DOCUMENT REFERENCE:

LEGEND:-

- EXISTING OHL
- DIVERTED OHL
- CABLE
- SHELL GAS PIPE (APPROXIMATE POSITION)

SITE LOCATION

PROPOSED SUBSTATION SITE

PRELIMINARY DESIGN ONLY NOT TO BE USED FOR CONSTRUCTION

DRAFT

Rev:	Drawn:	Approved:	Description:
03A	CM		FOR INTERNAL COMMENT ONLY. ACCESS TRACK REMOVED.
	Checked:	Date: 12.09.19	
Rev:	Drawn: PF	Approved: DR	Description: ISSUED FOR INFORMATION
02	Checked: JD	Date: 24.04.19	

Scottish & Southern Electricity Networks

SSE Inveralmond House, 200 Dunkeld Road
Perth, PH1 3AQ, UK www.sse.com

Project:
ST. FERGUS GAS TRANSFORMER REPLACEMENT

Project Number: LT000197 | Location: ST. FERGUS

Title:
PROPOSED SITE LAYOUT

Drawing Status: For Information	Drawn: PF
Scale: 1:2000 @ A2	Checked: JD
Date: 21.03.2018	Approved: DR

Drawing Number: LT197_AAAA_0802_0001 | Sheet No: 00 | Revision No: 03A

Date Plotted: 12.09.2019

File Name: LT197_AAAA_0802_0001_00_03A_DRAFT St.Fergus Gas TX Replacment_Proposed Site Layout.dwg

APPENDIX B

ReFH Method Hydrology Information

ReFH Hydrologic Parameters

VERSION	"FEH CD-ROM"	Version	3	exported at	#####	GMT	Thu	#####
CATCHMENT	GB	4E+05	9E+05	NK 09200 53300				
CENTROID	GB	4E+05	9E+05	NK 06889 53713				
AREA	7.6925							
ALTBAR	35							
ASPBAR	61							
ASPVAR	0.5							
BFIHOST	0.309							
DPLBAR	3.25							
DPSBAR	25							
FARL	0.998							
FPEXT	0.1684							
FPDBAR	0.982							
FPLOC	1.022							
LDP	6.39							
PROPWET	0.4							
RMED-1H	7.8							
RMED-1D	31.4							
RMED-2D	41.6							
SAAR	754							
SAAR4170	802							
SPRHOST	43.56							
URBCONC1990	-999999							
URBEXT1990	0.0002							
URBLOC1990	-999999							
URBCONC2000	-999999							
URBEXT2000	0.0002							
URBLOC2000	-999999							
C	-0.00943							
D1	0.4425							
D2	0.3726							
D3	0.24261							
E	0.22472							
F	2.19807							
C(1 km)	-0.01							
D1(1 km)	0.453							
D2(1 km)	0.358							
D3(1 km)	0.241							
E(1 km)	0.227							
F(1 km)	2.193							

APPENDIX C

Pooling Group Analysis Information

UK Design Flood Estimation

Generated on 05 April 2019 10:54:23 by kriches
Printed from the ReFH Flood Modelling software package, version 2.2.6589.25305

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 6B4D-806B

Site name: St Fergus

Easting: 409200

Northing: 853300

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 7.69

Using plot scale calculations: No

Site description: None

Model run: 1000 year

Summary of results

Rainfall - FEH 2013 (mm):	86.24	Total runoff (ML):	338.11
Total Rainfall (mm):	59.53	Total flow (ML):	592.77
Peak Rainfall (mm):	11.61	Peak flow (m^3/s):	13.98

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	06:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.72	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	147.67	No
Cmax (mm)	240.33	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	3.85	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.45	No
BL (hr)	29.92	No
BR	0.75	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0 [0]	Yes
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	1.059	0.000	0.653	0.000	0.453	0.453
00:30:00	1.641	0.000	1.021	0.015	0.446	0.461
01:00:00	2.532	0.000	1.597	0.070	0.439	0.509
01:30:00	3.889	0.000	2.505	0.186	0.433	0.619
02:00:00	5.930	0.000	3.942	0.398	0.430	0.828
02:30:00	8.912	0.000	6.200	0.762	0.430	1.191
03:00:00	11.608	0.000	8.570	1.363	0.436	1.799
03:30:00	8.912	0.000	6.961	2.311	0.452	2.762
04:00:00	5.930	0.000	4.815	3.621	0.481	4.102
04:30:00	3.889	0.000	3.237	5.168	0.528	5.696
05:00:00	2.532	0.000	2.141	6.834	0.594	7.428
05:30:00	1.641	0.000	1.402	8.514	0.680	9.194
06:00:00	1.059	0.000	0.911	10.102	0.785	10.887
06:30:00	0.000	0.000	0.000	11.469	0.906	12.375
07:00:00	0.000	0.000	0.000	12.429	1.040	13.469
07:30:00	0.000	0.000	0.000	12.800	1.180	13.980
08:00:00	0.000	0.000	0.000	12.633	1.319	13.953
08:30:00	0.000	0.000	0.000	12.086	1.452	13.538
09:00:00	0.000	0.000	0.000	11.290	1.573	12.864
09:30:00	0.000	0.000	0.000	10.344	1.682	12.027
10:00:00	0.000	0.000	0.000	9.324	1.777	11.101
10:30:00	0.000	0.000	0.000	8.295	1.857	10.152
11:00:00	0.000	0.000	0.000	7.349	1.924	9.273
11:30:00	0.000	0.000	0.000	6.525	1.979	8.504
12:00:00	0.000	0.000	0.000	5.804	2.023	7.827
12:30:00	0.000	0.000	0.000	5.155	2.057	7.212
13:00:00	0.000	0.000	0.000	4.553	2.084	6.637
13:30:00	0.000	0.000	0.000	3.984	2.103	6.086
14:00:00	0.000	0.000	0.000	3.435	2.114	5.549
14:30:00	0.000	0.000	0.000	2.905	2.118	5.024
15:00:00	0.000	0.000	0.000	2.388	2.116	4.504
15:30:00	0.000	0.000	0.000	1.889	2.108	3.997
16:00:00	0.000	0.000	0.000	1.419	2.094	3.513
16:30:00	0.000	0.000	0.000	0.995	2.074	3.069
17:00:00	0.000	0.000	0.000	0.642	2.050	2.692

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
17:30:00	0.000	0.000	0.000	0.385	2.022	2.408
18:00:00	0.000	0.000	0.000	0.217	1.992	2.209
18:30:00	0.000	0.000	0.000	0.112	1.962	2.073
19:00:00	0.000	0.000	0.000	0.050	1.930	1.980
19:30:00	0.000	0.000	0.000	0.017	1.898	1.915
20:00:00	0.000	0.000	0.000	0.003	1.867	1.870
20:30:00	0.000	0.000	0.000	0.000	1.836	1.836
21:00:00	0.000	0.000	0.000	0.000	1.806	1.806
21:30:00	0.000	0.000	0.000	0.000	1.776	1.776
22:00:00	0.000	0.000	0.000	0.000	1.746	1.746
22:30:00	0.000	0.000	0.000	0.000	1.717	1.717
23:00:00	0.000	0.000	0.000	0.000	1.689	1.689
23:30:00	0.000	0.000	0.000	0.000	1.661	1.661
24:00:00	0.000	0.000	0.000	0.000	1.634	1.634
24:30:00	0.000	0.000	0.000	0.000	1.606	1.606
25:00:00	0.000	0.000	0.000	0.000	1.580	1.580
25:30:00	0.000	0.000	0.000	0.000	1.554	1.554
26:00:00	0.000	0.000	0.000	0.000	1.528	1.528
26:30:00	0.000	0.000	0.000	0.000	1.503	1.503
27:00:00	0.000	0.000	0.000	0.000	1.478	1.478
27:30:00	0.000	0.000	0.000	0.000	1.453	1.453
28:00:00	0.000	0.000	0.000	0.000	1.429	1.429
28:30:00	0.000	0.000	0.000	0.000	1.405	1.405
29:00:00	0.000	0.000	0.000	0.000	1.382	1.382
29:30:00	0.000	0.000	0.000	0.000	1.359	1.359
30:00:00	0.000	0.000	0.000	0.000	1.337	1.337
30:30:00	0.000	0.000	0.000	0.000	1.315	1.315
31:00:00	0.000	0.000	0.000	0.000	1.293	1.293
31:30:00	0.000	0.000	0.000	0.000	1.271	1.271
32:00:00	0.000	0.000	0.000	0.000	1.250	1.250
32:30:00	0.000	0.000	0.000	0.000	1.230	1.230
33:00:00	0.000	0.000	0.000	0.000	1.209	1.209
33:30:00	0.000	0.000	0.000	0.000	1.189	1.189
34:00:00	0.000	0.000	0.000	0.000	1.169	1.169
34:30:00	0.000	0.000	0.000	0.000	1.150	1.150
35:00:00	0.000	0.000	0.000	0.000	1.131	1.131

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:30:00	0.000	0.000	0.000	0.000	1.112	1.112
36:00:00	0.000	0.000	0.000	0.000	1.094	1.094
36:30:00	0.000	0.000	0.000	0.000	1.076	1.076
37:00:00	0.000	0.000	0.000	0.000	1.058	1.058
37:30:00	0.000	0.000	0.000	0.000	1.040	1.040
38:00:00	0.000	0.000	0.000	0.000	1.023	1.023
38:30:00	0.000	0.000	0.000	0.000	1.006	1.006
39:00:00	0.000	0.000	0.000	0.000	0.990	0.990
39:30:00	0.000	0.000	0.000	0.000	0.973	0.973
40:00:00	0.000	0.000	0.000	0.000	0.957	0.957
40:30:00	0.000	0.000	0.000	0.000	0.941	0.941
41:00:00	0.000	0.000	0.000	0.000	0.926	0.926
41:30:00	0.000	0.000	0.000	0.000	0.910	0.910
42:00:00	0.000	0.000	0.000	0.000	0.895	0.895
42:30:00	0.000	0.000	0.000	0.000	0.880	0.880
43:00:00	0.000	0.000	0.000	0.000	0.866	0.866
43:30:00	0.000	0.000	0.000	0.000	0.851	0.851
44:00:00	0.000	0.000	0.000	0.000	0.837	0.837
44:30:00	0.000	0.000	0.000	0.000	0.823	0.823
45:00:00	0.000	0.000	0.000	0.000	0.810	0.810
45:30:00	0.000	0.000	0.000	0.000	0.796	0.796
46:00:00	0.000	0.000	0.000	0.000	0.783	0.783
46:30:00	0.000	0.000	0.000	0.000	0.770	0.770
47:00:00	0.000	0.000	0.000	0.000	0.757	0.757
47:30:00	0.000	0.000	0.000	0.000	0.745	0.745
48:00:00	0.000	0.000	0.000	0.000	0.732	0.732
48:30:00	0.000	0.000	0.000	0.000	0.720	0.720
49:00:00	0.000	0.000	0.000	0.000	0.708	0.708
49:30:00	0.000	0.000	0.000	0.000	0.697	0.697
50:00:00	0.000	0.000	0.000	0.000	0.685	0.685
50:30:00	0.000	0.000	0.000	0.000	0.674	0.674
51:00:00	0.000	0.000	0.000	0.000	0.663	0.663
51:30:00	0.000	0.000	0.000	0.000	0.652	0.652
52:00:00	0.000	0.000	0.000	0.000	0.641	0.641
52:30:00	0.000	0.000	0.000	0.000	0.630	0.630
53:00:00	0.000	0.000	0.000	0.000	0.620	0.620

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
53:30:00	0.000	0.000	0.000	0.000	0.610	0.610
54:00:00	0.000	0.000	0.000	0.000	0.599	0.599
54:30:00	0.000	0.000	0.000	0.000	0.589	0.589
55:00:00	0.000	0.000	0.000	0.000	0.580	0.580
55:30:00	0.000	0.000	0.000	0.000	0.570	0.570
56:00:00	0.000	0.000	0.000	0.000	0.561	0.561
56:30:00	0.000	0.000	0.000	0.000	0.551	0.551
57:00:00	0.000	0.000	0.000	0.000	0.542	0.542
57:30:00	0.000	0.000	0.000	0.000	0.533	0.533
58:00:00	0.000	0.000	0.000	0.000	0.524	0.524
58:30:00	0.000	0.000	0.000	0.000	0.516	0.516
59:00:00	0.000	0.000	0.000	0.000	0.507	0.507
59:30:00	0.000	0.000	0.000	0.000	0.499	0.499
60:00:00	0.000	0.000	0.000	0.000	0.491	0.491
60:30:00	0.000	0.000	0.000	0.000	0.482	0.482
61:00:00	0.000	0.000	0.000	0.000	0.474	0.474
61:30:00	0.000	0.000	0.000	0.000	0.467	0.467
62:00:00	0.000	0.000	0.000	0.000	0.459	0.459

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
Area (km²)	7.69	No
ALTBAR	35	No
ASPBAR	61	No
ASPVAR	0.5	No
BFIHOST	0.31	No
DPLBAR (km)	3.25	No
DPSBAR (mkm-¹)	25	No
FARL	1	No
LDP	6.39	No
PROPWET (mm)	0.4	No
RMED1H	7.8	No
RMED1D	31.4	No
RMED2D	41.6	No
SAAR (mm)	754	No
SAAR4170 (mm)	802	No
SPRHOST	43.56	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
Urban Area (km²)	0 [0]	**Yes**
DDF parameter C	-0.01	No
DDF parameter D1	0.44	No
DDF parameter D2	0.37	No
DDF parameter D3	0.24	No
DDF parameter E	0.22	No
DDF parameter F	2.2	No
DDF parameter C (1km grid value)	-0.01	No
DDF parameter D1 (1km grid value)	0.45	No
DDF parameter D2 (1km grid value)	0.36	No
DDF parameter D3 (1km grid value)	0.24	No
DDF parameter E (1km grid value)	0.23	No
DDF parameter F (1km grid value)	2.19	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM

Pooling Group Analysis

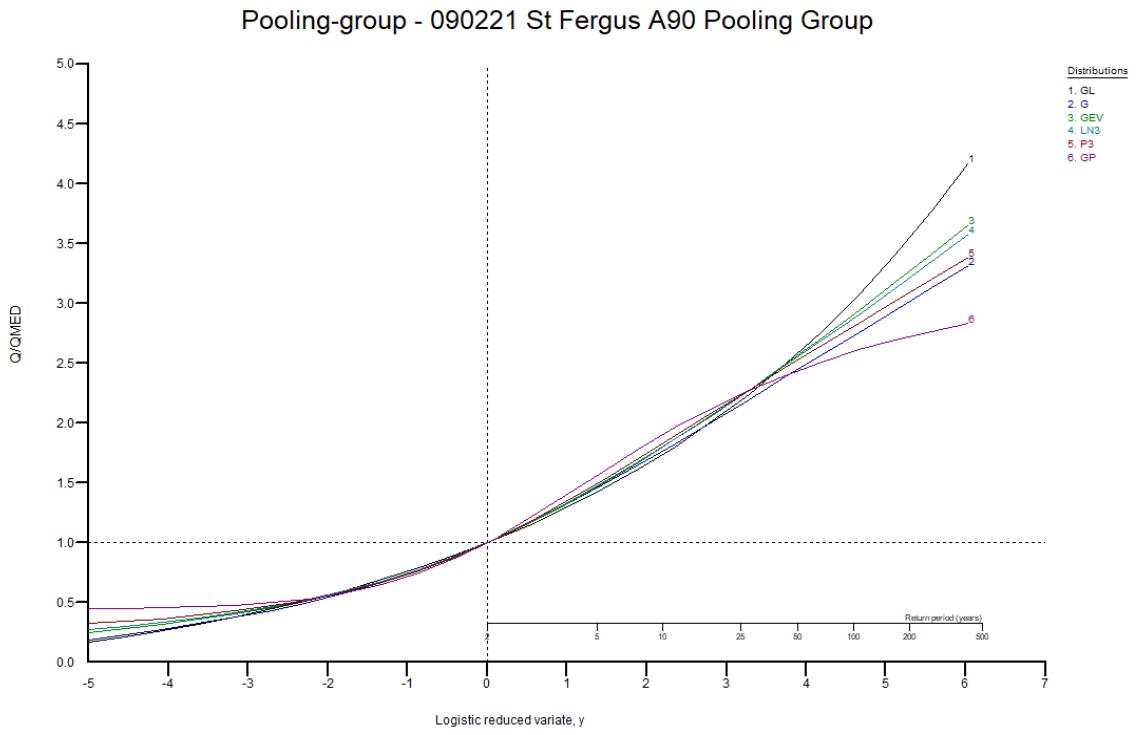
Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
27073 (Brompton Beck @ Snainton Ings)	0.778	36	0.816	0.203	0.06	0.674
27051 (Crimple @ Burn Bridge)	1.753	45	4.564	0.221	0.144	0.203
20002 (West Peffer Burn @ Luffness)	1.781	41	3.299	0.292	0.015	1.924
26802 (Gypsey Race @ Kirby Grindalythe)	1.843	18	0.108	0.316	0.217	0.207
25019 (Leven @ Easby)	1.921	39	5.677	0.34	0.377	0.636
203046 (Rathmore Burn @ Rathmore Bridge)	1.947	35	10.72	0.147	0.144	0.935
45816 (Haddeo @ Upton)	1.982	24	3.489	0.306	0.387	0.5
28033 (Dove @ Hollinsclough)	2.113	38	4.225	0.234	0.405	1.568
47022 (Tory Brook @ Newnham Park)	2.185	24	6.651	0.265	0.138	0.897
49006 (Camel @ Camelford)	2.226	11	11.154	0.124	-0.185	2.081
27010 (Hodge Beck @ Bransdale Weir)	2.233	41	9.42	0.224	0.293	0.902
44008 (South Winterbourne @ Winterbourne S	2.253	38	0.434	0.417	0.336	1.675
72014 (Conder @ Galgate)	2.265	49	16.283	0.22	0.111	0.176
25011 (Langdon Beck @ Langdon)	2.27	28	15.878	0.238	0.318	1.355
36010 (Bumpstead Brook @ Broad Green)	2.307	50	7.543	0.371	0.177	1.267
Total		517				
Weighted means		517		0.261	0.204	

Growth Curve Fitted Parameters				
Distribution	***Location***	***Scale***	***Shape***	***Bound***
GL	1.000	0.266	-0.204	-0.301
GEV	0.854	0.394	-0.053	-6.587
LN3	1.000	0.474	-0.423	-0.121

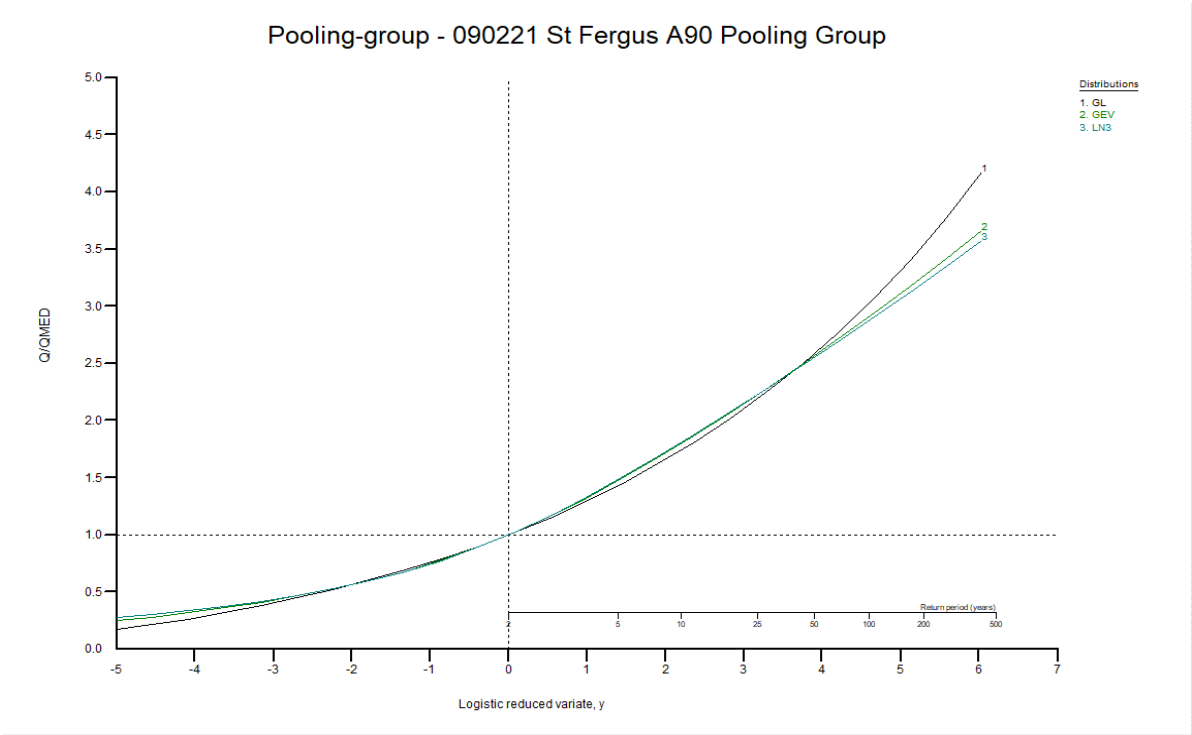
Growth Curves			
Return Period	***GL***	***GEV***	***LN3***
1 in 2	1.000	1.000	1.000
1 in 5	1.426	1.470	1.479
1 in 10	1.738	1.796	1.806
1 in 25	2.190	2.228	2.228
1 in 50	2.582	2.563	2.549
1 in 100	3.028	2.908	2.875
1 in 200	3.538	3.264	3.209
1 in 500	4.332	3.755	3.662
1 in 1000	5.039	4.142	4.017

Flood Frequency Curve			
Return Periods	*GL*	*GEV*	*LN3*
1 in 2	2.913	2.913	2.913
1 in 5	4.154	4.282	4.308
1 in 10	5.063	5.232	5.261
1 in 25	6.379	6.490	6.490
1 in 50	7.521	7.466	7.425
1 in 100	8.821	8.471	8.375
1 in 200	10.306	9.508	9.348
1 in 500	12.619	10.938	10.667
1 in 1000	14.679	12.066	11.702

All Pooling Group Growth Curve Distributions



Selected Pooling Group Growth Curve Distributions



WINFAP Multiple Donor QMED Adjustment

Station	Distance	URBEXT	QMED Obs	QMED Deurbanised	QMED CDs	Centriod X	Centriod Y	Area	SAAR	BFIHOST	FARL	Years of Data	QMED Suitability	Pooling Suitability	Weight
TARGET SITE		0				406889	853713	7.692	754	0.309	0.998				
10002 (Ugie @ Inverugie)	11.13	0.004	45.871	45.672	46.488	396185	850658	325.7	812	0.522	0.984	35	Yes	Yes	0.371
10001 (Ythan @ Ardlethen)	29.38	0.001	50.18	50.084	48.605	381355	839183	457.1	830	0.614	0.992	46	Yes	Yes	0.255
10003 (Ythan @ Ellon)	29.39	0.002	57.695	57.489	53.68	382301	837609	532.3	826	0.62	0.993	23	Yes	Yes	0.255
11004 (Urie @ Pitcaple)	51.16	0.003	21.42	21.348	32.027	362209	828798	195.4	870	0.562	0.996	18	Yes	Yes	0.165
9002 (Deveron @ Muiresk)	59.67	0.002	272.624	271.85	168.835	348676	840600	961.5	928	0.511	0.997	58	Yes	No	0.139
11001 (Don @ Parkhill)	60.95	0.004	136.246	135.481	150.678	357665	817763	1269	884	0.584	0.996	37	Yes	Yes	0.136

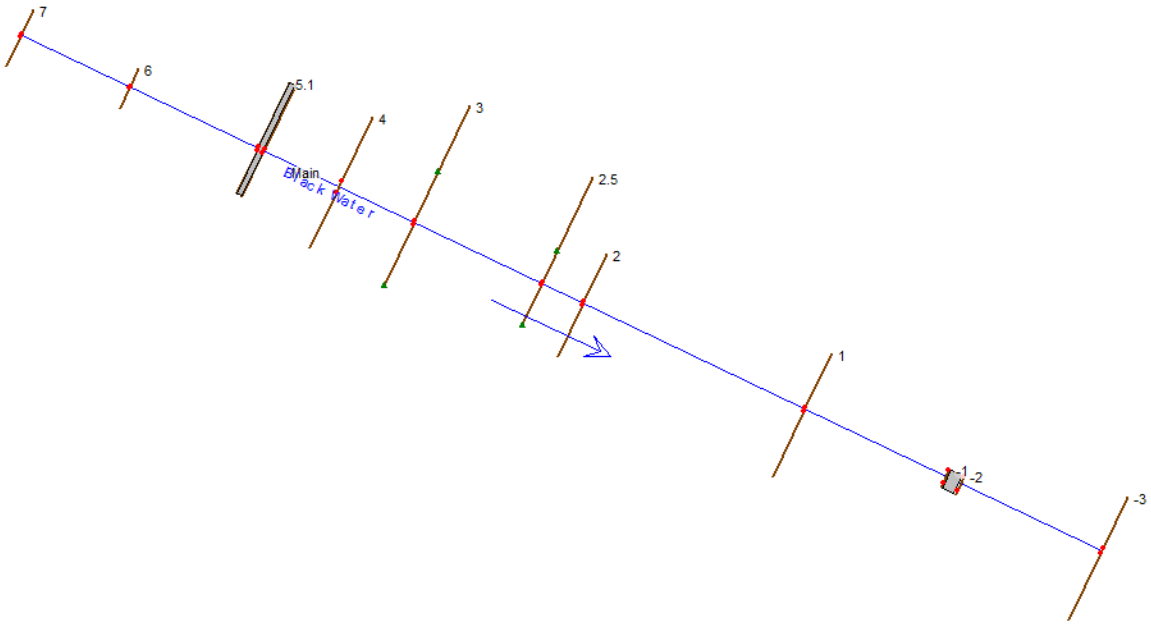
QMED from Catchment Descriptors	2.909
QMED from WINFAP Donor Adjustment	2.913

APPENDIX D

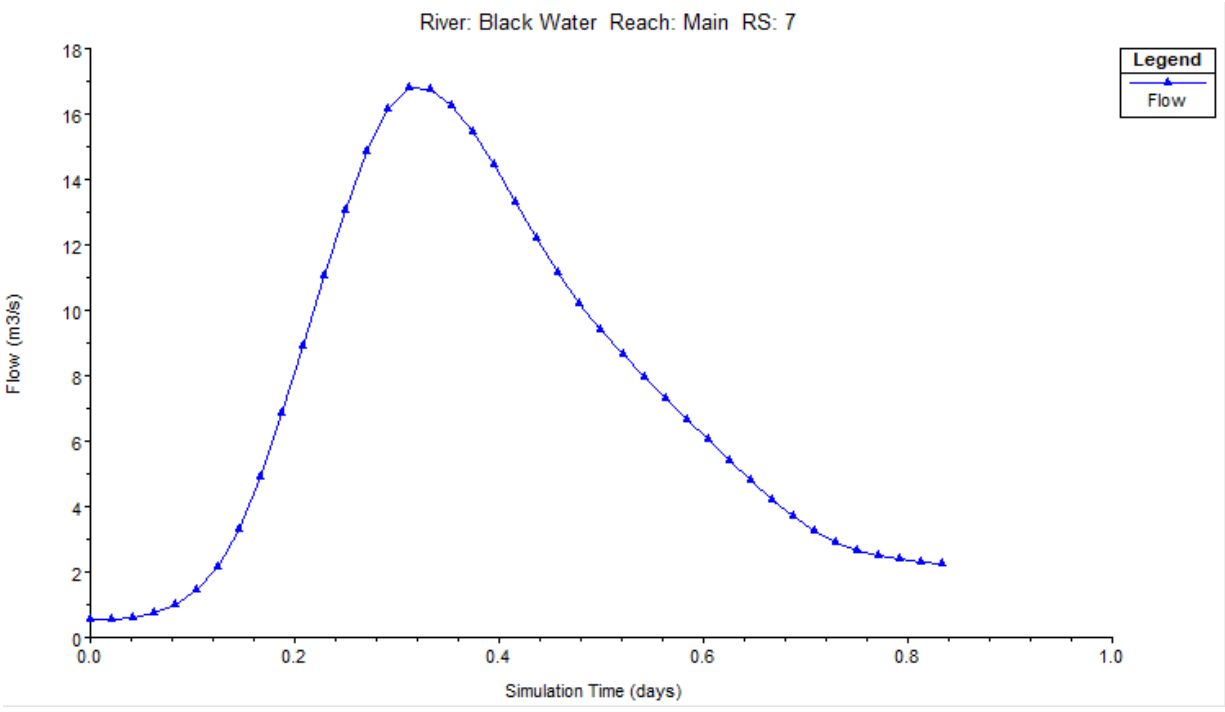
Hydraulic Modelling Results

HEC-RAS Model Outputs

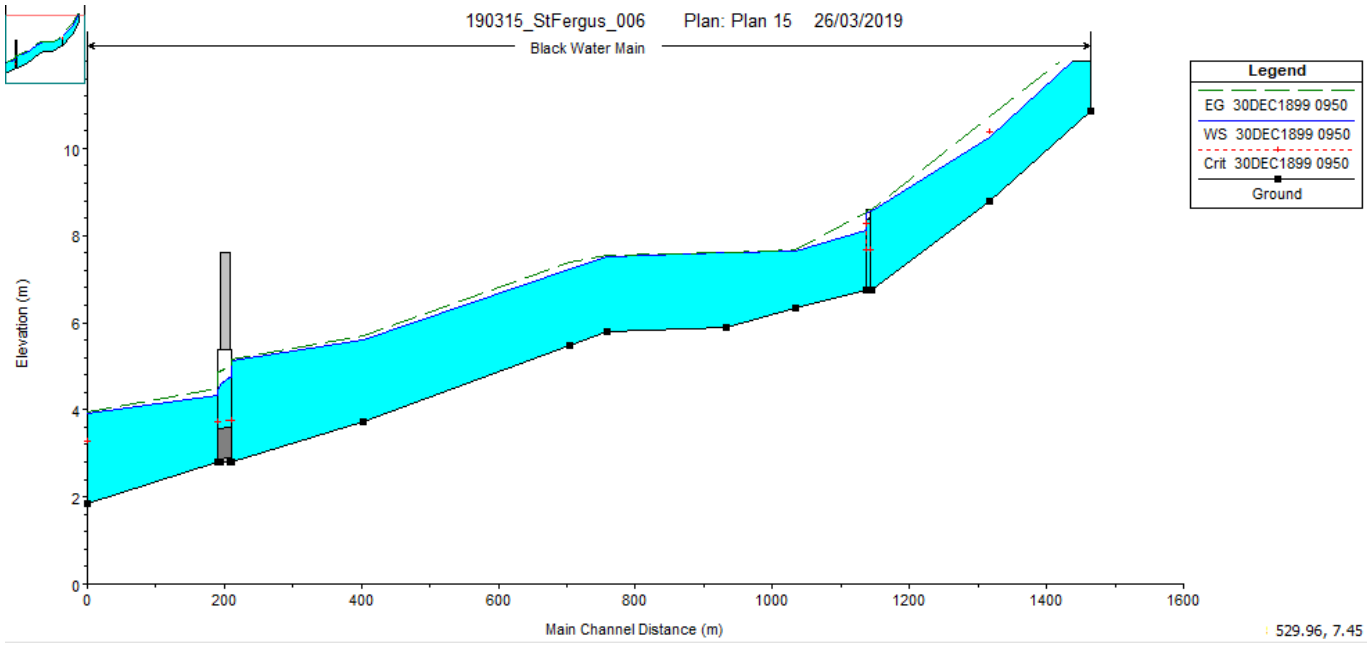
A. Model Geometric Arrangement (Diagrammatic)



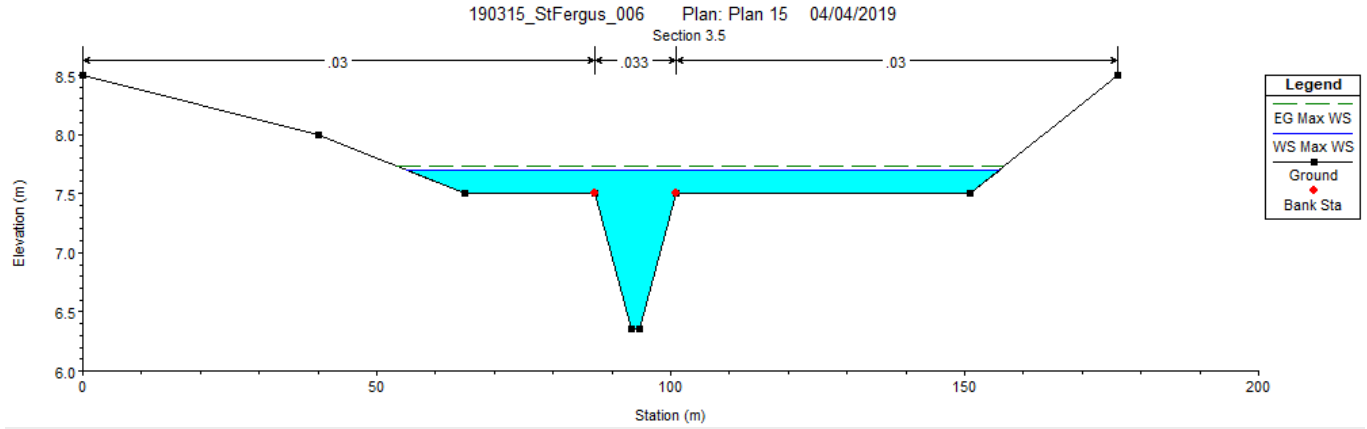
B. Inflow Hydrograph



C. Profile Plot



D. Cross section adjacent to Site



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