Framework:	Mapping & Modelling Framework
Supplier:	Jeremy Benn Associates Ltd
Company Number:	03246693
Geographical Area:	
Project Name:	Marton West Beck Flood Warning and Forecasting
Project Number:	[redacted]
Contract Type:	Professional Service Contract
Option:	Option C
Contract Number:	project_37307
Stage:	All_Work_Types

Revision	Status		Originator		Reviewer		Date
1	Draft		[redacted]		[redacted]		27/09/2022
2	Superseeded		[redacted]		[redacted]		29/09/2022
3	Final		[redacted]		[redacted]		10/10/2022

PROFESSIONAL SERVICE CONTRACT under the Mapping and Modelling Framework
CONTRACT DATA

Project Name Marton West Beck Flood Warning and Forecasting

Project Number [redacted]

This contract is made on 06/12/2022
between the *Client* and the *Consultant*

- This Contract is made pursuant to the Framework Agreement (the "Agreement") dated 16th day of May 2019 between the *Client* and the *Consultant* in relation to the NGSA Mapping and Modelling Support Framework. The entire Agreement and the following schedules are incorporated into this Contract by reference

- Schedules 1 to 22 inclusive

- The following documents are incorporated into this contract by reference
  Marton West Beck word scope v3

Part One - Data provided by the *Client*

Statements given in all Contracts

1 General

The *conditions of contract* are the core clauses and the clauses for the following main Option, the Option for resolving and avoiding disputes and secondary Options of the NEC4 Professional Service Contract June 2017.

Main Option: Option C

Option for resolving and avoiding disputes: W2

Secondary Options

X2: Changes in the law

X9: Transfer of rights

X10: Information modelling

X11: Termination by the *Client*

X18: Limitation of Liability

Y(UK)2: The Housing Grants, Construction and Regeneration Act 1996

Y(UK)3: The Contracts (Rights of Third Parties) Act 1999

Z: *Additional conditions of contract*

The *service* is As built modelling of the Marton West Beck flood alleviation scheme followed by an assessment of existing flood warning service / flood forecasting capability. Which are to be improved including the development of new flood warning areas for properties protected by the scheme.

The *Client* is Environment Agency

Address for communications
Tyneside House
Newcastle upon Tyne
NE4 7AR

Address for electronic communications [redacted]

The *Service Manager* is [redacted]

Address for communications [redacted]

Address for electronic communications [redacted]

The Scope is in
Marton West Beck word scope v3

The *language of the contract* is English

The *law of the contract* is
the law of England and Wales, subject to the jurisdiction of the courts of England and Wales

The period for reply is 2 weeks

The *period for retention* is
6 years following Completion or earlier termination

The following matters will be included in the Early Warning Register

Early warning meetings are to be held at intervals no longer than 2 weeks

2 The *Consultant's* main responsibilities

The *key dates* and *conditions* to be met are

conditions to be met	*key date*
'none set'	'none set'
'none set'	'none set'
'none set'	'none set'

The *Consultant* prepares forecasts of the total Defined Cost plus Fee and *expenses* at intervals no longer than 4 weeks

3 Time

The *starting date* is 08 December 2022

The *Client* provides access to the following persons, places and things

access	*access* date

The *Consultant* submits revised programmes at intervals no longer than 4 weeks

The *completion date* for the whole of the *service* is 07 July 2023

The period after the Contract Date within which the *Consultant* is to submit a first programme for acceptance is 4 weeks

4 Quality management

The period after the Contract Date within which the *Consultant* is to submit a quality policy statement and quality plan is 4 weeks

The period between Completion of the whole of the *service* and the *defects date* is 26 weeks

5 Payment

The *currency of the contract* is the £ sterling

The *assessment interval* is Monthly

The *expenses* stated by the *Client* are as stated in Schedule 9

The *interest rate* is 2.00% per annum (not less than 2) above the Base rate of the Bank of England

The locations for which the *Consultant* provides a charge for the cost of support people and office overhead are All UK Offices

The *Consultant's share percentages* and the *share ranges* are

share range	*Consultant's share percentage*

less than			80	%		0 %
from	80	%	to		120 %	50 %
greater than			120	%		100 %

6 Compensation events

These are additional compensation events

1. 'not used'
2. 'not used'
3. 'not used'
4. 'not used'
5. 'not used'

8 Liabilities and insurance

These are additional *Client's* liabilities

1. 'not used'
2. 'not used'
3. 'not used'

The minimum amount of cover and the periods for which the *Consultant* maintains insurance are

EVENT	MINIMUM AMOUNT OF	PERIOD FOLLOWING COMPLETION OF THE WHOLE OF THE *SERVICE* OR TERMINATION
The *Consultant's* failure to use the skill and care normally used by professionals providing services similar to the *service*	[redacted] Million in respect of each claim, without limit to the number of claims	[redacted]
Loss of or damage to property and liability for bodily injury to or death of a person (not an employee of the *Consultant)* from or in connection with the *Consultant* Providing the Service	[redacted] Million in respect of each claim, without limit to the number of claims	[redacted]
Death of or bodily injury to the employees of the *Consultant* arising out of and in the course of their employment in connection with the contract	Which ever is the greater of [redacted] or the amount required by law in respect of each claim, without limit to the number of claims	For the period required by law
The *Consultant's* total liability to the *Client* for all matters arising under or in connection with the contract, other than the excluded matters limited to		£[redacted]

Resolving and avoiding disputes

The *tribunal* is	Litigation in the courts
The *Adjudicator* is	'to be confirmed'
Address for communications	'to be confirmed'
Address for electronic communications	*'to be confirmed'*
The *Adjudicator nominating body* is	The Institution of Civil Engineers

Z Clauses

Z1 Disputes

Delete existing clause W2.1

Z2 Prevention

The text of clause 18 Prevention is deleted.
Delete the text of clause 60.1(12) and replaced by:
The *service* is are affected by any of the following events
• War, civil war, rebellion, revolution, insurrection, military or usurped power;
• Strikes, riots and civil commotion not confined to the employees of the *Consultant* and sub consultants,
• Ionising radiation or radioactive contamination from nuclear fuel or nuclear waste resulting from the combustion of nuclear fuel,
• Radioactive, toxic, explosive or other hazardous properties of an explosive nuclear device,
• Natural disaster,
• Fire and explosion,
• Impact by aircraft or other aerial device or thing dropped from them.

Z3 Disallowed Costs

Add the following in second bullet of 11.2 (18) add:
(including compensation events with the sub contractor, i.e. payment for work that should not have been undertaken).
Add the following additional bullets after 'and the cost of ' :
• Mistakes or delays caused by the *Consultant's* failure to follow standards in Scopes/quality plans.
• Reorganisation of the *Consultant's* project team.
• Additional costs or delays incurred due to *Consultant's* failure to comply with published and known guidance or document formats.
• Exceeding the Scope without prior instruction that leads to abortive cost
• Re-working of documents due to inadequate QA prior to submission, i.e. grammatical, factual arithmetical or design errors.
• Production or preparation of self-promotional material.
• Excessive charges for project management time on a commission for secondments or full time appointments (greater than 5% of commission value)
• Any hours exceeding 8 per day unless with prior written agreement of the *Service Manager*
• Any hours for travel beyond the location of the nearest consultant office to the project unless previously agreed with the *Service Manager*
• Attendance of additional individuals to meetings/ workshops etc who have not been previously invited by the *Service Manager*
• Costs associated with the attendance at additional meetings after programmed completion, if delay is due to *Consultant* performance.
• Costs associated with rectifications that are due to *Consultant* error or omission.
• Costs associated with the identification of opportunities to improve our processes and procedures for project delivery through the *Consultant's* involvement
• Was incurred due to a breach of safety requirements, or due additional work to comply with safety requirements
• Was incurred as a result of the *Client* issuing a Yellow or Red Card to prepare a Performance Improvement Plan
• Was incurred as a resulting of rectifying a non-compliance with the Framework Agreement and/or any call off contracts following an audit

Z4 Share on termination

Delete existing clause 93.3 and 93.4 and replace with:
92.3 In the event of termination in respect of a contract relating to services there is no *Consultant's* share'

Z6 The Schedule of Cost Components

The Schedule of Cost Components are as detailed in the Framework Schedule 9.

Z24 Requirement for Invoice

Add the following sentence to the end of clause 51.1:
The Party to which payment is due submits an invoice to the other Party for the amount to be paid within one week of the *Service Manager's* approval of a fee note.
Delete existing clause 51.2 and replace with:
51.2 Each certified payment is made within one week after the paying Party receives an invoice from the other Party and
If a certified payment is late, interest is paid on the late payment. Interest is assessed from the date by which the late payment should have been made until the date when the late payment is made, and is included in the first assessment after the late payment is made

Secondary Options

OPTION X2: Changes in the law

The *law of the project* is the law of England and Wales, subject to the jurisdiction of the courts of England and Wales

OPTION X10: Information modelling

The period after the Contract Date within which the *Consultant* is to submit a first Information Execution Plan for acceptance is 2 weeks

OPTION X18: Limitation of Liability

The *Consultant's* liability to the *Client* for indirect or consequential loss is limited to

[redacted]

The *Consultant's* liability to the *Client* for Defects that are not found until after the *defects date* is limited to

[redacted]

The *end of liability date is* 6 Years after the Completion of the whole of the *service*

Y(UK2): The Housing Grants, Construction and Regeneration Act 1996

The period for payment is 14 days after the date on which payment becomes due

Y(UK3): The Contracts (Rights of Third Parties Act) 1999

term	*beneficiary*
any	none

Part Two - Data provided by the *Consultant*

Completion of the data in full, according to the Options chosen, is essential to create a complete contract.

1 General

The *Consultant* is

Name: Jeremy Benn Associates Ltd

Address for communications:
1 Broughton Park Old Lane North
Broughton
Skipton
North Yorkshire
BD23 3FD

Email address: [redacted]

The subcontract *fee percentage* is: Option C [redacted]

The *key persons* are

Name (1) [redacted]
Job [redacted]
Responsibilities [redacted]
Qualifications [redacted]
Experience [redacted]

The *key persons* are

Name (2) [redacted]
Job [redacted]
Responsibilities [redacted]
Qualifications [redacted]
Experience [redacted]

The *key persons* are

Name (3) [redacted]
Job [redacted]
Responsibilities [redacted]
Qualifications [redacted]
Experience [redacted]

The *key persons* are

Name (4)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (5)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (6)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (7)
Job
Responsibilities
Qualifications
Experience

The following matters will be included in the Early Warning Register

3 Time

If a programme is to be identified in the Contract Data.

The programme identified in the Contract Data is

Q22-1831-MWB_Programme.pdf

5 Payment

The *activity schedule* is
Q22-1831-MWB_JBA-Activity_Schedule.pdf

The tendered total of the Prices is
£26,948.00

Resolving and avoiding disputes

The *Senior Representatives* of the *Consultant* are

Name (1) [redacted]
Address for communications
[redacted]

Address for electronic communications
[redacted]

Name (2) [redacted]
Address for communications
[redacted]

Address for electronic communications
[redacted]

X10: Information Modelling

The information execution plan identified in the Contract Data is
-

Contract Execution

Client **execution**

Signed Underhand by [**PRINT NAME**] for and on behalf of the Environment Agency

[redacted]

Consultant **execution**

Signed Underhand by [**PRINT NAME**] for and on behalf of Jeremy Benn Associates Ltd

[redacted]

[redacted]

Environment Agency
NEC4 professional service contract (PSC)
Scope

Project / contract Information

Project name	Marton West Beck Flood Warning and Forecasting
Project 1B1S reference	[redacted]
Contract reference	[redacted]
Date	10/10/22
Version number	3.0
Author	[redacted]

Revision history

Revision date	Summary of changes	Version number
10/08/2022	Initial Draft	1.0
31/8/2022	As built model added	2.0
03/10/2022	DgC Review	2.0
10/10/2022	Final	3.0

This scope should be read in conjunction with the version of the Minimum Technical Requirements current at the Contract Date. In the event of conflict, this scope shall prevail. The service is to be compliant with the version of the Minimum Technical Requirements.

Document	Document Title	Version No	Issue Date
LIT 18686	NEC4 Minimum Technical Requirements for Modelling	6.0	22/03/2022
LIT17616	2021-8_25_PSC_Middlesbrough Flood warning and Forecasting_V14_Including_asbuilt (Included in appendix)	5.0	01/12/2021

Details of the *service*

Details of the *service* are:

1. Objective

Following the completion of a flood alleviation scheme in 2020, there is now a need to update the as-built modelling and undertake further flood warning and forecasting studies. Reviews of the existing flood alert and warning areas (121FWF090 and 121FWF091) are to be made against the updated model and it will also be necessary to produce new flood warning areas for the properties now better protected by the scheme.

The existing Probability Distributed Model (PDM) (Middlesbrough Albert Park PDM 2014) rainfall runoff model shall also be improved and updated in line within minimum technical requirements for modelling document v6.0.

This Scope is supplemented with further technical details specified in the document 2021-8_25_PSC_Middlesbrough Flood warning and Forecasting_V13. These improvements will allow the Client to provide effective and updated flood resilience, warning, and alerts to the area.

Tasks include: data review, site visit, flood warning and forecasting method statements, as built modelling, survey specification and commissioning if needed, provision of GIS outputs and an assessment of the existing flood warning and forecasting provision and recommendations for improvement.

The results from this modelling will help to improve our understanding of flood risk, flood mapping and warning for key communities along Marton West. The *Consultant* should seek clarity with the *Service Manager* should there be any uncertainty around elements that are to be completed.

2. Outcome Specification

The *Consultant* shall undertake and complete the tasks as set out below further supporting information is included in the Appendix 1 in the document titled 2021-8_25_PSC_Middlebrough Flood warning and Forecasting_V14_Including_asbuilt

1. The *Consultant* will undertake a review of the existing Flood Warning (121FWF090 and 121FWF091) and Flood Alert (121WAF930) areas against the updated model output and advise of whether modifications are required. Commentary and recommendations from this review shall be included in the Flood Warning and Forecasting Method Statement.
2. The *Consultant* shall provide a clear method statement on required activities necessary to update flood warning and alert areas. In line with Environment Agency hydrology and modelling guidance for acceptance by the *Service Manager*. Please refer to the NEC4 Minimum Technical Requirements for Modelling_v6.0.xls for details.
3. The *Consultant* will undertake the required activities to derive the updated flood warning and new flood warning alongside updating the PDM model in line with Environment Agency hydrology and modelling guidance for acceptance by the *Service Manager*. Please refer to the NEC4 Minimum Technical Requirements for Modelling_v6.0.xls for details.
4. The *Consultant* will update the existing modelling using the as built survey as gathered by the EA

3. Constraints on how the *Consultant* provides the *service*

1. The *Consultant* shall only carry out work directly associated to Provide the Service as set out in the outcome specification above.

2. The *Consultant* is to report monthly on task they plan to do and tasks they have undertaken and time to be charged for that month as detailed in the *Client's* NEC4 Professional Services Contract.

3. The *Consultant* shall maintain close contact with the *Service Manager* in order that their actions reflect the *Client's* objectives.

4. The *Consultant* shall notify the *Service Manager* of any proposed changes from the Scope, and if there is any detrimental change to any of the following aspects of the contract, time, cost, and quality. The *Consultant* shall:

    I. cease all work, howsoever arising, associated with the task

    II. await the *Service Manager's* written instruction on how to proceed

5. Data held by the *Client* that is relevant to the project will be collected by the *Service Manager* and provided directly to the *Consultant*.

4. Standards to be achieved

4.1 Health and Safety

Health and Safety is the number one priority of the *Client*. The *Consultant* will promote and adopt safe working methods and shall strive to work in a safe manner.

5. Requirements of the programme

1. The *Consultant* shall provide a detailed programme in a format (pdf) agreed with the *Service Manager*. The programme must show critical path activities, gateway, risk buffers and activities requiring *Client* input, for example review periods. The programme shall comply with the requirement of Clause 31.

2. A baseline programme shall be provided for the project start up meeting and this will be updated monthly, with actual and forecast progress against the baseline. The programme shall cover all the activities to be undertaken by the *Consultant* to deliver the study. Include all major project and modelling milestones. Milestones include, but are not limited to:

    A. Startup meeting

    B. Data review

    C. Survey specification & Procurement if required

    D. Flood Warning and Forecasting Methodology

E. Update As Built Modelling

F. Design Runs

G. Flood Warning & Forecasting

H. Reporting

3. It is acknowledged that the *period for reply* identified in the contract is two weeks, however, please allow for 15 working days for the *Client* to review items F – H outlined above. Provision of 2 weeks' notice of submission for review is required.

6. Services and other things provided by the *Client*

1. All the data listed as being supplied to the *Consultant* as part of this study remains the Intellectual Property of the *Client.*

2. The *Client* is responsible for the accuracy & sufficiency of existing data owned by the *Client*. The *Client* will only cover the costs of sourcing new data if existing data is proven to be incomplete or to contain mistakes or errors.

3. The *Consultant* is responsible for any new data requirements. The *Consultant* is to scope, procure and manage the acquisition of any new surveys.

4. The data custodian for project deliverables from this commission will be the *Client*'s area Partnerships and Strategic Overview (PSO) team.

5. Licenses for LiDAR Data, Ordnance Survey mapping, model survey, hydrometric and historical data will be provided to the *Consultant* upon award of this commission.

6. All model and survey information will be provided to the *Consultant* according to *Client* data security policy. Once the commission is completed, the original data sent to the *Consultant* which is classed as commercially sensitive, is returned following the *Client* data security policy.

7. Timesheets as normally utilised by the *Consultant* shall be submitted with applications for payment unless otherwise agreed with the *Service Manager*. Electronic submissions would be acceptable.

8. Payment is subject to the procedure agreed in or under the framework.

9. The quality management system complies with the requirements of ISO9001 and ISO14001.

10. The *Consultant* shall use the specifications and guidance included in LIT 13528 Minimum Technical Requirements.

7. Appendix 1

2021-8_25_PSC_Middlesbrough Flood warning and Forecasting_V14_Including_asbuilt

Appendix 1

Project Details

Environment Agency NEC4 Professional Service Contract (PSC) Modelling Technical Scope
Project / contract Information

Project name	Marton West Beck Flood Warning and Forecasting
Expected completion date	07/07/2023
Version number	15
Environment Agency Area	North East
Area lead	[redacted]
Modelling technical	[redacted]
Contact for additional information n	[redacted]

This scope should be read in conjunction with LIT 56326 Fluvial Modelling Standards current at the Contract Date. In the event of conflict, this Scope shall prevail. The service is compliant with the minimum technical requirements set out in LIT 56326 Fluvial Modelling Standards and LIT 18686 NEC4 Minimum Technical Requirements for Modelling current at the Contract Date.

Project Overview

Following the completion of the Marton West Beck flood alleviation scheme in 2020 485 properties are now better protected to 1.33% AEP over the next 50 years. The aim of this project is to update the model to reflect the as built surveys, update flood maps (with and without defences), flood warning thresholds / all relevant updates for the flood warning system.

8: Fluvial -Update Existing Hydraulic Model(s)

The *Consultant* shall update the defended and defences removed or no defences exist 2022 JBA ICM model which includes a portion of the Marton West Beck scheme and was based on the 2020 Mott MacDonald Bentley Model which in turn built on the 2018 Aecom Model. The following activities are required:

8.4 The model must be able to simulate flood events for:

Fluvial defences removed: 50%, 0.1%, 0.5%, 1%, 1.33%, 2%, 3.3%, 5%, 10%, 20%.

Fluvial defended: 50%, 20%, 10%, 5%, 3.3%, 2%, 1.33%, 1%, 0.5%, 0.1% AEPs.

Climate change scenarios are required as part of this project.

Please refer to Minimum Technical Requirements for Modelling for details of climate change requirements. Updating of the floodplain representation using latest LiDAR. The area requiring update is shown on the study area plan in project details

8.5 Updating of: flood walls and screening arrangement to reflect As-built Drawings

8.6 Updating of the floodplain ground terrain due to reprofiling for a development on: areas included in the as-built Topo survey.

8.10 The model will be updated with the most up to date topographic survey (EA as built survey) and remote sensing data available at the time.

10: Design Simulations & Results

All scenarios listed below must be delivered for defended scenarios:

Fluvial, tidal, coastal, and surface water hazard scenarios are modelled with the flood defence system scenario of defended, no failure by breaching.

Scenarios:

Fluvial defences removed: 50%, 0.1%, 0.5%, 1%, 1.33%, 2%, 3.3%, 5%, 10%, 20%.

Fluvial defended: 50%, 20%, 10%, 5%, 3.3%, 2%, 1.33%, 1%, 0.5%, 0.1% AEPs.

Climate change scenarios are required as part of this project. Please refer to Minimum Technical Requirements for Modelling for details of climate change requirements.

In addition, the *Consultant* shall:

10.1 Identify the design event probabilities for which the defence provides benefit – this shall include all events where retained water level is above local ground levels. The assessment shall include identification of receptors protected. The analysis must be sufficiently detailed to distinguish between individual communities and include strategic infrastructure (trunk road, railways, power sub-stations). Provide this commentary as part of the Model Report.

10.7 Produce a table of the number of residential, critical infrastructure and other non-residential properties within all defended and defences removed, or no defences exist and blockage %AEP outlines referring to the flood level at the nearest relevant river gauge(s) - if applicable.

11: Flood Warning Improvements

The *Consultant* shall deliver the following services in accordance with the guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document. The following services are anticipated following receipt of the improved flood outlines, but allowance shall be made by the *Consultant* for liaising with the Flood Resilience team for specific guidance on the process and at key points:

11.1 Review the existing Flood Alert Area(s) and / or Flood Warning Areas extent(s) in comparison with the updated modelled outputs and advise whether modifications are required to the extent(s). Review the first impacts (out of bank), first property to flood and trigger thresholds using the updated and accepted flood maps / levels. There are two flood warning areas (121FWF090 and 121FWF091) and one Flood Alert (121WAF930).

We would like a new flood warning area(s) to be developed for properties protected by the Marton West Beck FAS.

We require a review of the existing incident management thresholds, including Operations thresholds at Albert Park RLG.

11.1.1 Update the existing Flood Alert Areas and / or Flood Warning Areas extents based on the updated modelled outputs (defences removed / no defences exist 0.1% AEP plus historic flood extents, where appropriate) following the *Service Manager's* acceptance of recommended modifications from 11.1 and provide revised extents.

11.4 Deliver an Excel spreadsheet which includes %AEP, land use type, risk category assigned and number of commercial / residential properties for each FWFRA. Information on suggested FWAs shall include names of FWFRAs aggregated to make the FWA, highest AEP, total number of properties, breakdown of commercial and residential properties, vulnerable receptors (utilities, hospitals, care homes etc) and overall assigned risk category.

11.5 Produce flood extent shapefiles with associated level at Flood Warning gauge for each of 2 existing Flood Warning Areas. Outlines are required for each simulated (with defences) %AEP between onset of flooding and the Extreme Flood Outline. Submit the proposal for the *Service Manager's* acceptance whether onset of flooding is first property to flood, first impacts or overtopping of defences.

11.6 Produce flood hazard shapefiles with associated level at the Flood Warning gauge for each of 2 existing Flood Warning Areas. Outlines are required for each simulated (with defences) %AEP between onset of flooding and the Extreme Flood Outline. Submit the proposal for the *Service Manager's* acceptance whether onset of flooding is first property to flood, first impacts or overtopping of defences.

11.7 Review the data quality of the gauge sites in the study area and provide a detailed recommendation for the gauges to be used in level-level correlation for each FWA.

11.8 Produce level-level correlation between the onset of flooding location and Flood Warning Gauge Site for each Flood Warning Area. Determine the frequency at which the trigger level will be exceeded. Make recommendations for improvements, explaining the benefits.

11.9 Produce travel time between the onset of flooding location and Flood Warning Gauge Site based on model results and verify these results through comparison with the available hydrometric data.

Project Specific Requirements

11.12 Where new modelled outputs have been produced, split the Extreme Flood Outline (without defences 0.1% AEP) into Flood Alert Areas that can be provided with a Flood Warning Service. Ensure any existing or proposed FWA's are covered by the Flood Alert Area(s).

11.13 Split the Extreme Flood Outline (without defences 0.1% AEP) into FWFRA's based on probability of flooding, flooding mechanism, lead time, time to peak, land use type and number of properties.

Aggregate the FWFRA's into communities that can be provided with a Flood Warning Service (i.e., where there is sufficient telemetry / model data). FWA's should be of a size and band of risk level that individual triggers can be set (multiple FWA's with the same trigger level should be combined). Deliver in GIS ESRI format the FWFRA's and aggregated FWA's.

11.14 Split the Extreme Flood Outline (without defences 0.1% AEP) into FWFRA's based on probability of flooding, flooding mechanism, lead time, time to peak, land use type and number of properties. Aggregate the FWFRA's into communities that can be provided with a Flood Warning Service (i.e., where there is sufficient telemetry / model data). FWA's should be of a size and band of risk level that individual triggers can be set (multiple FWA's with the same trigger level should be combined). Deliver in GIS ESRI format the FWFRA's and aggregated FWA's.

11.15 Determine the average rate of rise from available hydrometric records at the Flood Warning Gauge Site. Recommend ACT CON and RES triggers using the most extreme rate of rise if a lead time of 2+ hours is viable.

11.16 We require confirmation of which gauge at Albert Park would be best suited for Flood Warning purposes: 1) Albert Park RLG or 2) Albert Park footbridge RLG.

11.17 Determine new flood warning triggers for the chosen RLG

14: Flood Forecasting - Model Development and Calibration

The *Consultant* shall undertake the following activities to provide a model(s) suitable for flood forecasting in accordance with the Real Time Model development guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document.

Models to be used for flood forecasting must comply with the model strategy and comprise of either PDM or FMP (ISIS) models. Real time model development, calibration and configuration shall be in accordance with the Real Time Model Development Guidance.

14.1.2 The *Consultant* shall improve and update 1 existing PDM rainfall runoff model in accordance with the Real Time Model development guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document. Model to be included: Middlesbrough Albert Park PDM (2014)

Considerations for the development and calibration of new/updated models:

The *Consultant* shall:

14.2.1 Confirm the approach to infilling of any missing data in data record.

14.2.2 Calibrate the new/updated model, in accordance with the Real Time Model development guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document, and in line with the approach to model calibration agreed with the Client as part of the inception stage study

14.2.3 Undertake independent model validation (as distinct from model calibration). (Desired - if sufficient data available)

14.2.4 Check the performance of the model during multi-peaked events. Demonstrate how formal and informal floodplain storage fills and empties in the model and whether this is representative.

14.2.5 Provide a comparison with the results of any existing non-real-time model (for up to and including a 1 in 1000 / 0.1% AEP flood event, using existing hydrology) at individual forecast points, with justification provided for any differences (considering hydrograph shape, as well as peak level/flow). The *Consultant* shall demonstrate that adjustments made to the model to improve stability and reduce run times have not significantly degraded its performance in key areas.

14.2.6 Where an existing model is being updated, performance of the existing model shall be shown versus that of the updated model; for each of the calibration outputs covered within 14.2.2.

14.2.7 Derive False Alarm Ratio (FAR) for the calibrated model (ran in simulation mode), in accordance with the Real Time Model development guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document.

14.2.8 Report and justify any points where the model differs significantly from available observed data and make recommendations for any remedial action required.

14.2.9 The *Consultant* shall allow for a telephone meeting to discuss draft calibration deliverables to help facilitate Environment Agency review.

14.2.10 Model calibration performance shall mirror that achieved when the model is subsequently ran by the *Client* within the forecasting system. The *Consultant* will investigate and justify any differences in calibration performance when the model is running on the forecasting system

14.5 We require forecasts for different levels of blockage on Albert Park screen: suggested 50%, 75% and 100% (or as recommended by the *Consultant*).

Available Data - Treat as Site Information

Available Data - Treat as Site Information
All datasets supplied for the project must be returned to the *Client* upon project completion. Datasets returned should adopt the appropriate security marking, be password protected/encrypted in accordance with the latest government guidelines. Data that will be made available to the *Consultant* include:

Existing Model Summary - Forecasting Hydraulic

Model name	Date	Length of modelled watercourse (km)	Hydraulic model type	Other Type	Description	Information only or to be updated
Ormesby Beck						Info only
Middle Beck 2001 model						Info only