The Millbrook Power (Gas Fired Power Station) Order

5.4 Flood Risk Assessment

Planning Act 2008
The Infrastructure Planning
(Applications: Prescribed Forms and Procedure) Regulations 2009

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Executive Summary

This FRA has been prepared by PBA on behalf of MPL and in accordance with the National Planning Policy Framework to support an application for a DCO relating to the construction of a proposed Power Generation Plant in Bedfordshire. The Project will comprise an OCGT peaking power generating station fuelled by natural gas, along with associated development including a new Gas Connection to bring in fuel to supply the plant and an Electrical Connection to export the power generated to the NETS.

This FRA has been prepared following consultation with the EA, the Bedfordshire and River Ivel Internal Drainage Board and the Lead Local Flood Authority (Central Bedfordshire Council). It sets out:

(i) the nature of the existing flood risk constraints associated with watercourses and water bodies within and in the vicinity of the Project Site,
(ii) the likely nature of the impact of the proposed Project from a flood risk perspective and details of proposed mitigation measures; and
(iii) the scope of technical work undertaken to enable a detailed appraisal of flood risk constraints to inform both development planning/design and the preparation of the FRA.

The Project Site is partly located within The Rookery, between Milton Keynes and Bedford, extending over an area of some 210ha and comprising two former clay pits (Rookery North and Rookery South) separated by an east-west spine of unexcavated clay.

In accordance with the provisions of the Environment Act 1995, The Rookery has been the subject of a ROMP, which allows the minerals Planning Authority to update the older mineral planning permissions by imposing modern operating, restoration and aftercare conditions. The landowner submitted an application for the determination of new conditions in June 2009 and this application set out details of a LLRS which seeks to restore the former clay workings to low-intensity agricultural use, with measures included to enhance biodiversity and landscape. The LLRS works comprise the re-profiling of the pit base, slope buttressing works, the implementation of a surface water drainage strategy and landscaping works. These works will be completed in all aspects material to the Project prior to the commencement of construction works for the Project and the LLRS therefore provides the ‘baseline’ for the purposes of assessing flood risk constraints, the impact of the proposals from a flood risk perspective and associated mitigation measures.

The Mill Brook watercourse flows in a northerly direction along the western flank of Rookery South Pit and a Tributary of the Mill Brook, draining a catchment to the south of Rookery South Pit, joins the Mill Brook in the vicinity of the south-west corner of Rookery South Pit. The FRA has considered the nature of flood risk associated with these watercourses and, through hydraulic modelling analysis, has shown that during the 1 in 100 year flood event, floodwater may discharge into Rookery South Pit from a localised area along the upper reach of the tributary of the Mill Brook. However, the LLRS works are such that the Power Generation Plant Site will comprise a slightly elevated platform compared to current levels. In addition, the LLRS surface water drainage strategy has been designed to cater for floodwater influx into the Pit from the Mill Brook Tributary. On this basis, and within the context of Tables 1 and 3 of the NPPF Planning Practice Guidance, the Power Generation Plant Site is categorised as Flood Zone 1 – Low Probability. This Flood Zone classification has been agreed with the EA.

The LLRS includes the implementation of a surface water drainage strategy, this strategy having been designed to cater for the entire area of Rookery South Pit, including the consented Covanta RRF project. This FRA has reviewed the Project within the context of the LLRS drainage strategy and demonstrates that the surface water drainage infrastructure brought forward as part of the LLRS offers adequate storage capacity to accommodate surface water run-off from the additional impermeable area associated with the Project. On this basis, the Project is ‘compatible’ with, and accommodated by, the LLRS drainage strategy, such that no further mitigation measures are required as part of the Project.

The assessment considers the potential impacts of climate change upon (i) flood risk associated with the Mill Brook and its Tributary and (ii) the surface water run-off regime. The potential implications of extreme flooding (1 in 1,000 year, or 0.1% probability event) and 'residual risk' issues relating to the operation/performance of the surface water drainage system are also addressed and the assessment concludes that flood risk considerations do not constitute a barrier to the granting of a DCO for the Project.

1 Introduction

1.1 Background and Development Proposals

1.1.1 Peter Brett Associates LLP (PBA) has been appointed by Millbrook Power Limited (MPL) (the Applicant) to prepare a Flood Risk Assessment (FRA) in support of an application for a Development Consent Order (DCO) relating to the construction of a Power Generation Plant in Bedfordshire. The Project would comprise an Open Cycle Gas Turbine (OCGT) peaking power generating station fuelled by natural gas, along with integral infrastructure such as a new Gas Connection to bring in fuel to supply the plant and an Electrical Connection to export the power generated to the National Grid Electricity Transmission System (NETS).

1.1.2 Government policy in respect of development and flood risk in areas in England is contained within the Department for Communities and Local Government National Planning Policy Framework (NPPF) published in March 2012 and the accompanying Planning Practice Guidance (PPG) published in March 2014. In addition, the Overarching National Policy Statement for Energy (NPS EN-1) requires that applications for energy projects of 1ha or greater in Flood Zone 1 and all energy projects in Flood Zone 2 and 3 are accompanied by a FRA.

1.1.3 The NPPF requires Local Planning Authorities (LPAs) to consult the Environment Agency (EA) on all applications for development in flood risk areas (except minor development), including those in areas with critical drainage problems and for any development on land exceeding 1 hectare outside flood risk areas (as set out in Section 15 of the Planning Practice Guidance). However, The Planning Inspectorate will make the final decision with regards to applications for Development Consent Orders.

1.1.4 This FRA has been prepared in accordance with the NPPF and associated Planning Practice Guidance and following consultation with the EA, Bedfordshire and River Ivel Internal Drainage Board and the Lead Local Flood Authority (Central Bedfordshire Council). The level of detail entered into in any appraisal of flood risk is dependent upon the scale and potential impact of the proposed development and EA Standing Advice (https://www.gov.uk/guidance/flood-risk-assessment-standing-advice) outlines the requirements based upon the scale/nature of development and its location within the floodplain.

1.1.5 The NPPF requires that any appraisal of flood risk be undertaken by competent people as early as possible in the planning process. PBA has many years of experience in, amongst other areas, the assessment of flood risk, hydrology, flood defence and river engineering.

1.2 Advisories and Exclusions

1.2.1 The revised Construction (Design and Management) Regulations 2015 (CDM Regulations) came into force in April 2015 to update certain duties on all parties involved in a construction project, including those promoting the development. One of the designer’s responsibilities is to ensure that the client organisation, in this instance MPL, is made aware of their duties under the CDM Regulations. Further information on the CDM Regulations is provided in the client guide, available at http://www.hse.gov.uk/pubns/indg411.pdf

1.2.2 It should be noted that the insurance market applies its own tests to properties in terms of determining premiums and the insurability of properties for flood risk. Those undertaking development in areas which may be at risk of flooding are advised to contact their insurers or the Association of British Insurers (ABI) to seek further guidance prior to commencing development.

1.2.3 The findings of this FRA are based on data available at the time of the study (August 2017) and relate to the current development proposals as outlined in **Section 2**. PBA does not warrant that the advice in this report will guarantee the availability of flood insurance either now or in the future.

2 Project Description

2.1 Overview

2.1.1 The Project constitutes a Nationally Significant Infrastructure Project (NSIP) pursuant to the Planning Act 2008 and therefore requires a DCO under that Act.

2.1.2 The Project would comprise:

- A new Power Generation Plant in the form of an OCGT peaking power generating station, fuelled by natural gas with a rated electrical output of up to 299 MW. This is the output of the generating station as a whole, measured at the terminals of the generating equipment. The Power Generation Plant comprises:
  - generating equipment including one Gas Turbine Generator with one exhaust gas flue stack and Balance of Plant (together referred to as the 'Generating Equipment'), which are located within the 'Generating Equipment Site';
  - a new purpose built access road from Green Lane to the Generating Equipment Site (the 'Access Road' or the 'Short Access Road');
  - a temporary construction compound required during construction only (the 'Laydown Area');
- a new underground gas pipeline connection, approximately 1.8 km in length (the 'Pipeline') to bring natural gas to the Generating Equipment from the National Transmission System (the 'Gas Connection'). The Gas Connection also incorporates an Above Ground Installation (AGI) at the point of connection to the National Transmission System; and
- a new electrical connection to export power from the Generating Equipment to the National Grid Electricity Transmission System (NETS) (the 'Electrical Connection'), comprising an underground double circuit Tee-in. This would require one new tower (which will replace an existing tower and be located in the existing Grendon – Sundon transmission route corridor, thereby resulting in no net additional towers). This option would require two SECs, one located on each side of the existing transmission line, and both circuits would then be connected via underground cables approximately 500 m in length to a new substation (the 'Substation'*).*

2.1.3 The Generating Equipment, Access Road and Laydown Area are together known as the 'Power Generation Plant' and are located within the 'Power Generation Plant Site'. The Power Generation Plant Site is approximately 12.5 ha in area.

2.1.4 The Power Generation Plant, Gas Connection, and Electrical Connection, together with all access requirements are referred to as the 'Project'. The land upon which the Project would be developed, or which would be required in order to facilitate the development of the Project, is referred to as the 'Project Site'. The Project Site is approximately 48 ha in area. The Project is described in more detail in Chapter 3.

2.1.5 A full glossary of defined terms is presented in the Project Glossary, Document Reference 4.1.

2.1.6 As a peaking plant, the facility would operate when there is a 'stress event', such as a surge in demand or a sudden outage, and would also operate at times when renewable energy sources, such as wind and solar farms, cannot generate sufficient electricity due to their intermittent operation. The Generating Equipment would operate for up to a maximum of 2,250 hours in any given year, provided that the 5 year rolling average does not exceed 1,500 hours.

3 Scope of report

3.1.1 This report summarises:

- The legislation, guidance and policy that should be taken into account when planning a development from a flood risk perspective;
- the nature of the existing flood risk constraints associated with watercourses and water bodies within and in the vicinity of the Project Site;
- the likely nature of the impact of the proposed Project from a flood risk perspective and details of proposed mitigation measures and;
- the scope of technical work undertaken to enable a detailed appraisal of flood risk constraints to inform both development planning/design and the preparation of this NPPF compliant FRA.

3.1.2 The report is structured as follows:

- Section 4 summarises the legislation, guidance and policy context in respect of development and flood risk.
- Section 5 provides a description of the Project Site and its general surroundings.
- Section 6 provides an overview of the planning background relating to the Project Site.
- Section 7 provides an overview of the consultation undertaken to support preparation of this FRA.
- Section 8 addresses flood risk from tidal sources, groundwater, surface water, impounded water bodies and watercourses and categorises the Project Site in accordance with the flood zones set out in the NPPF.
- Section 9 considers the potential impacts of the Project from a flood risk perspective.
- Section 10 addresses surface water management.
- Section 11 addresses the implications of climate change.
- Section 12 discusses the nature of residual risk and
- Section 13 concludes the report.

4 Legislation, Guidance and Policy Context

4.1 National Policy Statements

4.1.1 The principal planning policy for the determination of energy-related NSIPs is provided by the National Policy Statements issued by the Government's Department for Climate Change. The Overarching National Policy Statement for Energy (EN-1) identifies flood risk as a topic requiring consideration/assessment as part of energy-related projects and requires that:

- Where the Project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the Project on, water quality, water resources and physical characteristics of the water environment;
- An application should be accompanied by a FRA for energy projects of 1ha or greater in Flood Zone 1 and all energy projects in Flood Zones 2 and 3;
- Where a project may be affected by or may increase flood risk, pre-application discussions should be undertaken with the EA and other bodies;
- Any requirements for sequential testing are satisfied;
- Priority is given to the use of Sustainable Drainage Systems (SuDS).

4.1.2 National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2) outlines the factors influencing site selection for fossil fuel generating stations and also sets out additional policy on the potential impacts of energy infrastructure projects. This includes policy on water quality and resource impacts and is concerned principally with water demand/consumption and the impacts of abstraction and discharge of cooling water. NPS EN-2 does not set out additional policy in respect of flood risk.

4.1.3 National Policy Statement for Electricity Networks Infrastructure (EN-5) provides the primary basis for decisions taken by the Secretary of State on applications it receives for electricity networks infrastructure and sets out the factors influencing route selection and the impacts that may arise from such development. However, NPS EN-5 does not set out additional policy in respect of flood risk.

4.2 National Planning Policy Framework (March 2012)

4.2.1 The NPPF and the accompanying Planning Practice Guidance sets out the Government's national policy on development and flood risk and seeks to provide clarity on what is required at regional and local levels to ensure that flood risk is taken into account at all stages in the planning process, to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk. The NPPF outlines a risk based approach to the planning process and is underpinned by the Sequential Test, which is designed to ensure that areas at little or no risk of flooding are developed in preference to areas at higher risk.

Where, following application of the Sequential Test, it is not possible, or consistent with wider sustainability objectives, for the development to be located in zones with a lower probability of flooding, the Exception Test can be applied. Essentially, the two parts of the Test require proposed development to show that it will provide wider sustainability benefits to the community that outweigh flood risk and that it will be safe for its lifetime, without increasing flood risk elsewhere. The Test therefore provides a mechanism to allow necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

4.2.2 The NPPF requires that the spatial planning process should consider the possible impacts of climate change and contingency allowances are provided to enable impacts to be considered over the lifetime of the development.

4.3 The Flood Risk Regulations (2009)

4.3.1 The Flood Risk Regulations transpose the EC Floods Directive (Directive 2007/60/EC) into domestic law. The regulations require that preliminary flood risk assessments are prepared by the EA and Unitary/County Authorities (Lead Local Flood Authorities) and that areas at significant potential risk of flooding are identified. For these "significant risk" areas, hazard maps must be produced and flood risk management plans developed to reduce flood risk.

4.4 Flood and Water Management Act & Sustainable Drainage Systems: Written Statement – HCWS161

4.4.1 The Flood and Water Management Act (FWMA) received Royal Assent on 8th April 2010 and takes forward some of the proposals set out in three previous strategy documents published by the UK Government: Future Water, Making Space for Water and the UK Government's response to the Sir Michael Pitt Review of the summer 2007 floods. In doing so it gives the EA a strategic overview of flood risk and gives local authorities responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.

4.4.2 The Flood and Water Management Act (Schedule 3) proposed the establishment of SuDS Approval Bodies (the “SAB”) at County or Unitary local authority levels. The role of the SAB was envisaged as implementing the recommendations of the Pitt Review (2008) in promoting the use of SuDS within future development.

4.4.3 Following a period of consultation, the proposed role of the SAB has been amended, with the promotion of SuDS being incorporated into the planning process. This has been achieved by designating Lead Local Flood Authorities as statutory consultees with regards to ‘local’ sources of flood risk and surface water management. Ministerial Written Statement HCWS161 details this change in policy, which came into effect in April 2015.

4.4.4 The FWMA also amends Section 106 of the Water Industry Act (WIA) in respect of the right of connection to a public sewer. In the future, the automatic right of connection will be revoked and all new connections must be made via a Section 104 Agreement for foul sewers and following the consent of the SAB for surface water connections. As the role of the SAB has been removed following HCWS161, this amendment to Section 106 of the WIA is now subsumed into the planning process under the purview of the Lead Local Flood Authority.

4.5 Water Environment (Water Framework Directive) (England and Wales) Regulations 2017

4.5.1 These regulations transpose the EU Water Framework Directive (2000/60/EC) (WFD) into law in England and Wales. The WFD is a wide-ranging piece of European legislation that establishes a new legal framework for the protection, improvement and sustainable use of surface waters, coastal waters and groundwater across Europe in order to:

- Promote sustainable water use;
- Contribute to the mitigation of floods and droughts;
- Prevent deterioration and enhance status of aquatic ecosystems, including groundwater;
- Reduce pollution.

4.5.2 Water management has historically been co-ordinated according to administrative or political boundaries. The WFD promotes an approach based on management by river basin - the natural geographical and hydrological unit. River basin management plans include clear objectives in respect of water quality and pollution control and a detailed account of how objectives are to be met within a prescribed timeframe.

4.6 The Environmental Permitting (England and Wales) Regulations 2016

4.6.1 The Regulations as amended provide the regulatory framework under which discharges to controlled waters and other emissions to the environment are controlled.

4.6.2 The Regulations also transpose the requirements of the Groundwater Directive into law in England and Wales. They place a duty on the EA to protect groundwater by prohibiting groundwater activities other than those carried out under a permit or exemption. Groundwater activities include discharges of pollutants to groundwater (whether direct or indirect).

4.6.3 The Regulations therefore require that the direct or indirect discharge of pollutants to groundwater must be subject to prior authorisation and also allow notices to be served to control activities which may lead to discharges of pollutants to groundwater.

4.7 Non-statutory Technical Standards for Sustainable Drainage Systems

4.7.1 This document contains non-statutory technical standards for the design, maintenance and operation of sustainable drainage systems serving housing, non-residential or mixed use developments and was published by Defra in March 2015.

4.8 Water Resources Act 1991

4.8.1 The Water Resources Act 1991 (WRA) came into effect in 1991 and sets out the responsibilities of the EA in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The WRA regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwater. Discharge to controlled waters is only permitted with the consent of the EA. Similarly, a licence is required to abstract from controlled waters.

4.9 Land Drainage Act 1991

4.9.1 The Act consolidates various enactments relating to Internal Drainage Boards and the functions of these Boards and local authorities in relation to land drainage. Amongst other matters, the Act sets out provisions and powers in respect of the control of flow of watercourses and watercourse restoration/improvement works.

4.10 The Building Regulations 2010

4.10.1 The Building Regulations 2010, Requirement H3, stipulates that rainwater from roofs and paved areas is carried away from the surface to discharge to one of the following, listed in order of priority:

1. an adequate soakaway or some other adequate infiltration system, or where that is not reasonably practicable;
2. a watercourse, or where that is not practicable;
3. a sewer.

4.11 Interim Code of Practice for Sustainable Drainage Systems (2004)

4.11.1 This Code of Practice provides support for developers in promoting and implementing a sustainable approach to water management and in particular Sustainable Drainage Systems (SuDS), to ensure their long-term viability and to promote consistent use. The document sets out the key regulatory requirements that must be considered and adhered to before SuDS are installed and commissioned.

4.12 Sewers for Adoption 7th Edition

4.12.1 'Sewers for Adoption' is the standard in England and Wales for the design and construction of sewers to adoptable standards. It is a guide to assist developers in preparing their submission to a Sewerage Undertaker prior to entering an Adoption Agreement under Section 104 of the Water Industry Act 1991.

4.13 Flood Risk Assessments: climate change allowances

4.13.1 This guidance was published by the Environment Agency in February 2016 and should be used as the basis for preparing FRAs. The guidance sets out the climate change allowances for peak river flow, peak rainfall intensity, sea level rise, off-shore wind speeds and extreme wave height.

4.13.2 Allowances in respect of peak river flow vary according to River Basin District, flood zone and proposed land-use (and therefore the lifetime of the development). The Project Site lies within the Anglian River Basin District.

4.14 Surface Waters Plan - Plan for Strategic Management of Surface Waters and their Local Environment in the Forest of Marston Vale (Bedfordshire and River Ivel Internal Drainage Board and the Forest of Marston Vale, June 2002)

4.14.1 This document was prepared to promote a series of policies that will encourage an integrated and sustainable approach to the management of surface waters in the context of major development in the area, including:

- An integrated approach to flood risk management, surface water drainage and the water environment;
- Promote government guidance such as PPS25 (*since replaced by the NPPF*), providing a framework for site-specific FRAs to be produced in support of planning applications;
- Implementation of strategic solutions to surface water drainage and flood risk that are sustainable and offer opportunities for environmental and recreational gains.

4.14.2 It should be noted that Rookery Pit lies outside of the Bedfordshire and River Ivel Internal Drainage Board's area of jurisdiction. However, Mill Brook, which flows along the western side of the Pit, outfalls to Stewartby Lake located just to the west, which is a water body maintained by the Bedfordshire and River Ivel Internal Drainage Board.

4.15 Central Bedfordshire Council Local Flood Risk Management Strategy (February 2014)

4.15.1 Central Bedfordshire Council, in its role as Lead Local Flood Authority (as defined by the Flood and Water Management Act, 2010), has prepared a Local Flood Risk Management Strategy. The strategy addresses flood risk arising from surface water, groundwater and ordinary watercourses, sets out a number of objectives for managing flood risk and the actions and the measures identified to achieve these objectives. The majority of the items set out in the strategy Action Plan are county-wide and the strategy does not identify any specific issues/actions/objectives for the area in the immediate vicinity of the Project Site.

4.16 Preliminary Flood Risk Assessment

4.16.1 In accordance with the requirements of the Flood Risk Regulations (2009), Central Bedfordshire Council, Bedford Borough Council and Milton Keynes Council commissioned the Bedford Group of Drainage Boards to prepare a Preliminary FRA. This constitutes a high level screening exercise to identify significant flood risk areas associated with flooding from surface water, groundwater and ordinary watercourses. The assessment did not identify any significant flood risk areas and, being a high level, strategic study, it does not contain any information in respect of flood risk associated with the Mill Brook catchment.

4.17 Strategic Flood Risk Assessment (May 2017)

4.17.1 Central Bedfordshire Council commissioned JBA Consulting Limited to prepare a Level 1 Strategic Flood Risk Assessment to inform preparation of the Local Plan (to 2036). The assessment is based upon historic flood records, hydraulic modelling data and the EA's Flood Map for Planning. The assessment does not present any detailed/site-specific information in respect of flood risk associated with the Mill Brook catchment.

5 Site and Surroundings

5.1 Site Location and Description

5.1.1 The Project Site is partly located within 'The Rookery', which extends over an area of some 210ha and comprises two former clay pits (Rookery North and Rookery South) separated by an east-west spine of unexcavated clay.

5.1.2 The Rookery is located in the Marston Vale between Milton Keynes and Bedford, approximately 3km north of Ampthill, a local market town, and 7km south-west of Bedford.

5.1.3 The general location of the Project Site is shown in **Figure 1**, **Appendix A.**

5.1.4 The Generating Equipment, Laydown Area and parts of the Access Road, Gas Connection and Electrical Connection would be located within part of Rookery South Pit, which is approximately 95ha in area and bounded by steep clay banks that are varied in nature and substrate. The level of the pit base currently varies between approximately 10m and 15m below ground level and includes open water, reed beds, pools and bare inundated clay. The land that remains at the original ground level (approximately 42m AOD) around the periphery of Rookery South Pit is predominantly bare ground that has previously been cleared of vegetation and maintained in this state for approximately the last 30 years.

5.1.5 The Gas Connection and Electrical Connection would be located largely outside of Rookery South Pit, in a mostly undeveloped, agricultural landscape which comprises large arable fields, small areas of woodland, hedgerows and a number of drainage ditches.

5.1.6 Access to the Project Site is from the north near Stewartby, via the A421 Bedford Road and Green Lane. A junction on Green Lane leads to an access track which extends south, along the western fringe of Rookery North Pit and into Rookery South Pit.

5.2 Wider Setting

5.2.1 The former chimneys of the Stewartby Brickworks and the settlement of Stewartby itself lie to the north of The Rookery. Other nearby residential areas include: Houghton Conquest approximately 1.5km to the east of the Project Site; Marston Moretaine approximately 1.2km to the west and Millbrook approximately 400m to the south. These residential areas are shown on **Figure 1, Appendix A**.

5.2.2 To the west of the Project Site is the Marston Vale Millennium Country Park. Millbrook Proving Ground, a vehicle testing ground covering 285ha, is located to the south-west of Rookery South Pit.

5.2.3 Overhead power lines run west to east, to the south of Rookery South Pit, and a number of public footpaths are located in and around the Project Site, linking it to the wider Marston Vale.

5.2.4 The closest residential dwelling to the Power Generation Plant Site is South Pillinge Farm, located approximately 130m to the west of the western boundary of the Project Site. South Pillinge Farm is separated from the Project Site by a small deciduous woodland.

5.3 Watercourses and Water Bodies

5.3.1 The Mill Brook watercourse flows in a northerly direction along the western flank of Rookery South Pit. The Brook rises in the vicinity of Millbrook, approximately 1.5km to the south of Rookery South Pit, and drains a predominantly rural catchment of approximately 3.8km^2. It passes through a culvert beneath the Marston Vale Railway Line and ultimately outfalls to Stewartby Lake, a further 400m downstream.

5.3.2 A tributary watercourse draining a catchment of 0.9km^2 passes to the south of Rookery South Pit within the Project Site and joins the Mill Brook to the east of South Pillinge Farm (**Figure 1, Appendix A**).

5.4 Flood Defences

5.4.1 There are no flood defences within/adjacent to the Project Site.

5.5 Geology, Hydrogeology and Groundwater Vulnerability

5.5.1 The 1:10,000 scale geological maps of the area indicate the presence of some superficial deposits covering the solid geology within Marston Vale. The superficial deposits comprise Alluvium (up to 2m thick), Head Deposits (derived from solifluction processes which occurred during glacial and periglacial times and up to 2m thick) and glacial sand, gravel and till (shown sporadically overlying the solid geology in the southern areas of the Vale at Marston Gate, Brogborough and Lidlington).

5.5.2 In terms of solid geology, the geological map indicates that the majority of the Vale is underlain by the Oxford Clay Formation of the Jurassic Period which, regionally, is recorded at thicknesses of 70m. The Oxford Clay Formation is underlain sequentially by the Kellaways Formation and the Great Oolite Group.

5.5.3 The groundwater vulnerability map for the Project Site indicates that the Oxford Clay is considered to be unproductive strata. The Oxford Clay therefore behaves as an effective aquitard (i.e. it impedes groundwater movement) where left undisturbed. The Alluvial and Head Deposits are designated as Minor Aquifers with variable soil leaching potential.

5.5.4 DEFRA publish indicative Groundwater Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply (http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx). The zones define areas where a range of human activities may damage/pollute groundwater. The maps show three main zones (inner, outer and total catchment) and a fourth zone of special interest.

5.5.5 Examination of the mapping shows that the Project Site does not lie within any Source Protection Zone. The closest Source Protection Zone (Total Catchment – Zone 3) is located approximately 2km to the south of the Project Site.

6 Planning Background

6.1 Context

6.1.1 The Environment Act 1995 requires owners and operators of mineral sites to periodically update the planning conditions that regulate and control extraction operations. This review process is known as the Review of Old Minerals Permission (ROMP) and aims to allow the minerals Planning Authority to update the older mineral planning permissions by imposing modern operating, restoration and aftercare conditions.

6.1.2 O&H Properties Ltd (O&H), as landowner of Rookery Pit, submitted an application for the determination of new conditions in June 2009 (application number: BC/CM/2000/8). This ROMP review application set out details of a Low Level Restoration Scheme (LLRS), the scope of which is summarised below and set out in the Drawings presented in **Appendix B.**

6.2 The Low Level Restoration Scheme (LLRS)

6.2.1 The LLRS seeks to restore the former clay workings to low-intensity agricultural use, with measures included to enhance biodiversity and landscape. The LLRS works within Rookery South Pit comprise:

- the re-profiling of the base of the pit involving the extraction of soils and clays from the permitted extraction area on the southern side with re-grading of the base of the pit to an approximate level of 15mbgl;
- implementation of surface water drainage measures and construction of an attenuation pond and pumping station to facilitate a managed surface water drainage strategy;
- a landscape strategy to include planting on the boundary of Rookery South Pit and the margins of the attenuation pond;
- provision of buttresses to the southern, eastern and northern slopes to ensure the long-term stability of those slopes, and re-grading through excavation;
- provision of a series of permissive footpaths around the perimeter of Rookery North Pit and around the attenuation pond within Rookery South Pit;
- provision of an access ramp into Rookery South Pit from Rookery North Pit which connects to Green Lane, Stewartby via an existing track along the western side of Rookery North Pit. Note that the ramp and existing track are both of an agricultural standard; and
- provision of a further, smaller access track into and out of Rookery South Pit from the south side of the pit connecting with Station Lane, near Millbrook Station.

6.2.2 To facilitate the proposed LLRS works, extraction of clay from a currently un-worked area situated directly to the south of the existing extent of Rookery South Pit will be undertaken. This area covers approximately 25 ha and forms part of the existing minerals extraction consent boundary, but has not historically been subject to excavation works. Deposits won from this area will provide material for use in the restoration, re-profiling and buttressing work to Rookery South Pit together with the implementation of a landscape and ecology strategy, which will integrate with ecological mitigation works and strategic landscape planting in Rookery North Pit.

6.2.3 Once the LLRS works are completed, Rookery South Pit will be approximately 15m below the surrounding ground level in the vicinity of the Generating Equipment Site, Laydown Area and the Substation.

6.2.4 The LLRS works will be completed prior to the commencement of construction works for the Project, with the possible exception of buttressing and re-profiling to the eastern side of Rookery South Pit, which has no bearing on the Project as it lies outside the boundary of the Project Site.

6.2.5 The LLRS therefore provides the baseline for the purposes of assessing (i) the nature of flood risk constraints associated with watercourses and water bodies within and in the vicinity of the Project Site and (ii) the likely nature of the impact of the development proposals from a flood risk perspective and associated mitigation measures.

7 Stakeholder Consultation

7.1.1 In preparing this FRA, consultation has been undertaken with the EA, the Bedfordshire and River Ivel Internal Drainage Board (IDB) and the Lead Local Flood Authority (Central Bedfordshire Council).

7.1.2 The purpose of this consultation was to:

- identify the issues to be addressed;
- agree design criteria/principles; and
- agree the methodology for the technical assessment/analysis required to inform the FRA.

7.1.3 A joint FRA 'scoping' meeting was held with both the EA and IDB in December 2014, at which the scope of the FRA and associated methodology and design principles were agreed. A copy of the meeting notes summarising the scope of matters discussed and agreed is enclosed within **Appendix C.**

7.1.4 Following the project being placed 'on hold' in 2015 and the subsequent change in legislation in April 2015 (following which the Lead Local Flood Authority (LLFA) became a statutory consultee in the planning process in respect of surface water drainage), a further meeting was held with both the IDB and LLFA in July 2017 to (i) 're-cap' on matters, (ii) ensure that any 'new' information was identified and (iii) agree the scope of work required to finalise the FRA. A copy of the meeting notes summarising the scope of matters discussed and agreed is enclosed within **Appendix C**. The EA advised that it was not necessary for a representative to attend the July 2017 meeting on account of (i) the site falling outside Flood Zones 2 and 3 and (ii) matters relating to surface water drainage no longer being part of the Agency's remit.

8 Flood Risk Assessment

8.1 Tidal/Coastal

8.1.1 Flooding arising from tidal or coastal sources is not an issue at this inland location given the distance to the sea.

8.2 Groundwater

8.2.1 Information in respect of the geological and hydrogeological setting of the site is set out in the report titled '*Millbrook Power Project, Phase 1 Ground Condition Assessment (Contamination and Ground Stability), July 2017',* prepared by Peter Brett Associates LLP. According to this report the solid geology of the area generally consists of the following sequence of strata:

- the Peterborough Member of the Oxford Clay Formation;
- underlain by the Kellaways Formation (including the Kellaways Clay Member);
- underlain by the Cornbrash Formation (limestone) and the Blisworth Clay Formation and Blisworth Limestone Formation at depth.

8.2.2 More specifically, the report indicates that the geological sequence in the base of Rookery South Pit comprises made ground in the form of Callow Clay fill (superficial deposits and weathered Oxford Clay not suitable for brickmaking which was removed and cast back into the Pit), underlain by Oxford Clay.

8.2.3 The report also indicates that the clayey deposits of the Callow Clay Fill, Oxford Clay, Kellaways Clay and Blisworth Clay Formation can be considered as being aquicludes/aquitards (an impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater). According to the report, the Cornbrash Formation is classified as a Minor Aquifer, but has been shown to be characterised by low permeability, such that it is considered to be an aquitard. The Blisworth Limestone Formation is similarly characterised by low permeability.

8.2.4 The report indicates that groundwater elevations in the base of Rookery South Pit are around 28.7m AOD (approximately 0.3m bgl).

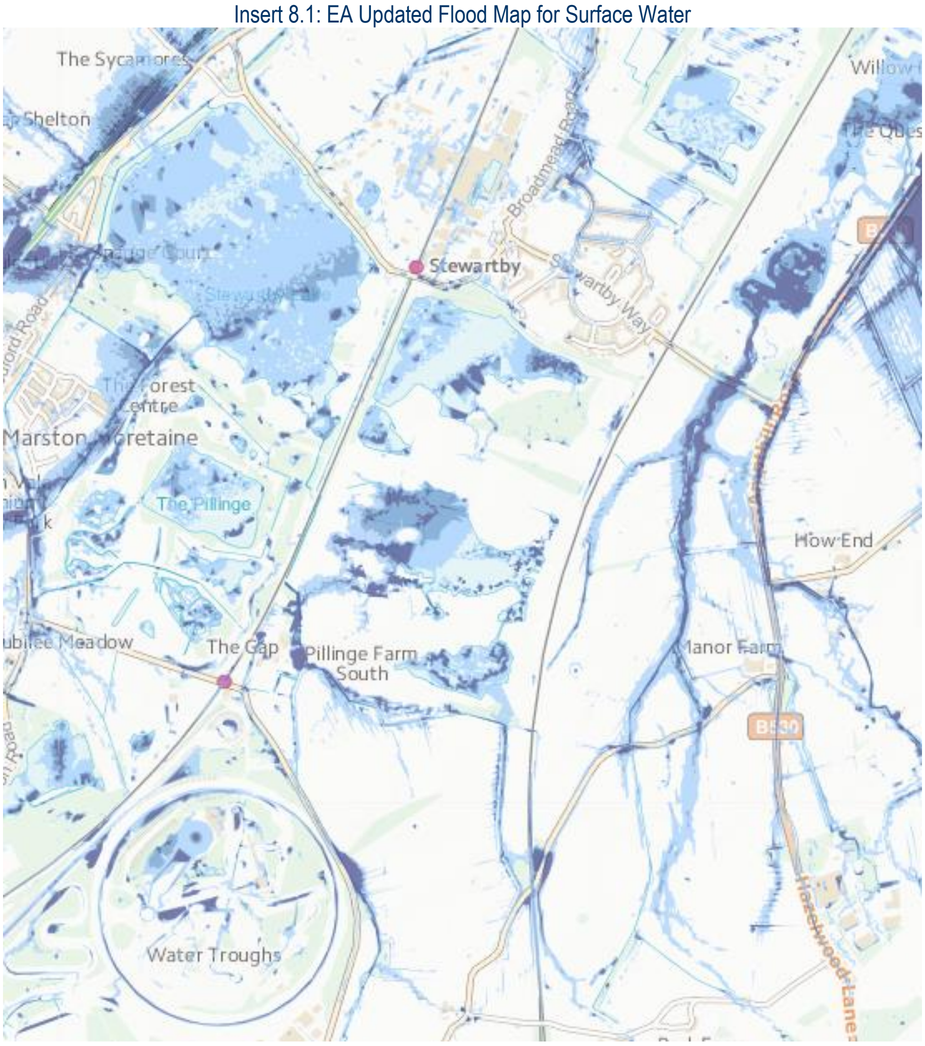
8.2.5 Enquiries conducted as part of this assessment and information collated as part of the aforementioned Ground Condition Assessment have not identified any evidence of elevated groundwater levels or records of groundwater flooding. Flooding arising from groundwater sources is not therefore considered to be an issue at this location.

8.3 Flood Risk from Surface Water Map

8.3.1 The site comprises a former clay pit that is being restored to low-intensity agricultural use. Surface water accumulating within the Pit is currently pumped to the Mill Brook, in accordance with the terms of an existing Consent to Discharge (EA reference PRCNF/14024) granted under Schedule 10 of the Water Resources Act 1991.

8.3.2 The 'Flood Risk from Surface Water Map' (https://flood-warning-information.service.gov.uk/long-term-flood-risk) shows areas that may potentially be susceptible to surface water flooding following an extreme rainfall event (Insert 8.1 below).

Insert 8.1: EA Updated Flood Map for Surface Water



8.3.3 It should be noted that this map is generated using a broad methodology applied at the national scale. The model utilises generalised information on infiltration, sewerage infrastructure, rainfall events and catchment topography to route rainfall over a ground surface model. As such, the analysis does not take account of site-scale factors/characteristics that may exert an influence upon surface water flood depths and extents. The map therefore only provides a guide regarding the areas that may be vulnerable to this source of flooding.

8.3.4 Moreover, this mapping is based upon the existing topography of the Pit base and is not therefore representative of the surface water drainage regime that will exist following implementation of the LLRS (as set out in Section 6 above).

8.3.5 As noted above, the LLRS provides the baseline for the purposes of assessing the nature of flood risk constraints. The LLRS works include the implementation of a surface water drainage strategy, comprising construction of a surface water balancing pond within the north-west corner of Rookery South Pit, the excavation of associated surface water interceptor channels within the base of the Pit and provision of a pumping station to enable surface water to be pumped to Rookery North Pit and the Mill Brook. The surface water drainage strategy has been designed to accommodate the Covanta RRF, along with other future development, including the Project. Proposals in respect of surface water management are set out in Section 10 of this report.

8.3.6 It is therefore concluded that surface water will be appropriately managed such that flood risk arising from surface water sources, both within and outside the Pit, is not considered to be an issue at this location.

8.4 Watercourses

8.4.1 The EA publishes floodplain maps on the internet (https://flood-map-for-planning.service.gov.uk)). These maps show the possible extent of fluvial flooding for the 1 in 100 year flood (that which would have a 1% probability of being exceeded each year) or the possible extent of tidal flooding to a 1 in 200 year event. Also shown is the possible extent of flooding arising from a 1 in 1,000 year event (0.1% probability).

8.4.2 In this instance, the EA's flood maps do not extend to include the Mill Brook and its Tributary on account of the small size of the contributing catchment area.

8.4.3 The nature of flood risk associated with the Mill Brook and its Tributary was originally assessed in 2008 ('the LLRS modelling study') as part of the ROMP review application and the findings reflected in the design of the LLRS. Flood risk was assessed by developing a HEC-RAS hydraulic model using a topographic survey of Rookery South Pit and the watercourse corridor and associated structures/crossings undertaken in 2003.

8.4.4 This analysis demonstrated that floodwater may discharge into the Pit during the 1 in 100 year flood event, the discharge occurring in a very localised area along the upper reach of the Mill Brook Tributary (Figure 2, Appendix D). The LLRS was subsequently designed to cater for this flooding mechanism – floodwater being allowed to discharge into the Pit on a 'managed' basis, such that it would be intercepted and routed to the surface water attenuation pond (the routing channels and attenuation pond being designed to accommodate both floodwater discharge from the Mill Brook Tributary and surface water run-off arising from within the Pit itself). This strategy was agreed with both the EA and the Bedfordshire and River Ivel IDB.

8.4.5 The LLRS modelling study was refined and updated in 2010 in support of proposals for development within the north-west area of Rookery South Pit (the Covanta RRF) and following further topographic survey of the Mill Brook corridor ('the Covanta modelling study').

8.4.6 Following consultation with the EA and IDB in July 2017, it was agreed that the 2010 Covanta modelling study provides the best available data in respect of flood risk associated with the Mill Brook such that it should be taken forward and used to inform the FRA prepared in support of the Project. However, it was noted that in the time that had elapsed since the 2010 study was concluded, the Flood Estimation Handbook (FEH) methodology and associated database (used to estimate flood flows for the purposes of hydraulic modelling) had been revised/updated. It was therefore agreed that the 2010 assessment of flood flows should be reviewed/validated before being used to inform the FRA prepared in support of the Project.

8.4.7 A summary of the revised and updated FEH analysis is set out in the Technical Note presented in **Appendix D**. This demonstrates that (i) flood flow estimates for the tributary are <u>lower</u> than those derived in 2010 and (ii) flood flow estimates for the Mill Brook are <u>higher</u> than those derived in 2010. Model sensitivity testing has therefore been undertaken to quantify the impact of the revised flow estimates upon peak water levels and floodwater discharge from the watercourses and into Rookery South Pit. Details of the modelling analysis are presented in the Technical Note enclosed in **Appendix D**. In summary, it was found that:

- The volume of floodwater discharge into the Pit from the Mill Brook Tributary during the 1 in 100 year plus climate change event amounts to c.5,000m3 (reduced from c.7,500m3 assessed in 2010). Floodwater discharge into the Pit does not occur along the main branch of the Mill Brook;

- The volume of floodwater discharge into the Pit from the Mill Brook tributary and the main branch of the Mill Brook during the 1 in 1,000 year event amounts to c.16,000m3 (reduced from c.21,000m3 in 2010).

8.4.8 In accordance with stakeholder requirements, consideration of the impacts of climate change is based upon the guidance titled ‘Flood risk assessments: climate change allowances’ published by the EA in 2016. In this instance, an allowance of +35% peak river flow has been used.

8.4.9 It should be noted that the volume of floodwater discharge into the Pit following a 1 in 100 year plus climate change event assessed as part of the LLRS modelling study in 2008 amounted to c.23,000m^3. The reduced volumes associated with both the 2010 and 2017 assessments are a result of revised catchment hydrology and improved model resolution.

8.5 Extent and Depth of Flooding

8.5.1 Hydraulic modelling has demonstrated that floodwater arising from the Mill Brook and its Tributary may discharge into Rookery South Pit during the 1 in 100 year, the 1 in 100 year plus climate change and the 1 in 1,000 year events.

8.5.2 However, as outlined in Section 6 above, the LLRS includes (i) re-profiling of the base of the pit to create an elevated platform and (ii) implementation of a surface water drainage strategy, comprising construction of a surface water balancing pond within the north-west corner of Rookery South Pit, the excavation of associated surface water interceptor channels within the base of the Pit and provision of a pumping station to enable surface water to be pumped to Rookery North Pit and the Mill Brook. The surface water drainage scheme has been designed to cater for floodwater influx into the Pit from the Mill Brook and its Tributary (the design and capacity of the surface water drainage scheme is discussed further in Section 10 of this report).

8.5.3 On this basis, and within the context of Tables 1 and 3 of the NPPF Planning Practice Guidance, the Power Generation Plant site is categorised as Flood Zone 1 – Low Probability. This Flood Zone classification has been agreed with the EA (ref correspondence included in **Appendix C**).

Table 1 Flood Zones

Zone 1 Low Probability	
Definition	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
Appropriate uses	All uses of land are appropriate in this zone
FRA requirements	For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA. This need only be brief unless the factors above or other local considerations require particular attention.
Policy aims	In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems.
Zone 2 Medium Probability	
Definition	This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
Appropriate uses	Essential infrastructure and the water-compatible, less vulnerable and more vulnerable uses, as set out in Table 2, are appropriate in this zone. The highly vulnerable uses are only appropriate in this zone if the Exception Test is passed.
FRA requirements	All development proposals in this zone should be accompanied by a FRA.
Policy aims	In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of sustainable drainage systems.

Zone 3a High Probability	
Definition	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Appropriate uses	The water-compatible and less vulnerable uses of land (Table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone. The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.
FRA requirements	All development proposals in this zone should be accompanied by a FRA.
Policy aims	In this zone, developers and local authorities should seek opportunities to: i. reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems; ii. relocate existing development to land in zones with a lower probability of flooding; and iii. create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.
Zone 3b The Functional Floodplain	
Definition	This zone comprises land where water *has* to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the EA. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.
Appropriate uses	Only the water-compatible uses and the essential infrastructure listed in Table 2 that has to be there should be permitted in this zone. It should be designed and constructed to: – remain operational and safe for users in times of flood; – result in no net loss of floodplain storage; – not impede water flows; and – not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test.
FRA requirements	All development proposals in this zone should be accompanied by a FRA.
Policy aims	In this zone, developers and local authorities should seek opportunities to: i. reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems; ii. relocate existing development to land with a lower probability of flooding.

8.5.4 The Power Generation Plant Site is located within the lowest probability flood zone and, as such, there is no requirement to apply the Sequential Test.

9 Impact of The Project

9.1 Fluvial

9.1.1 The Project will not give rise to any loss of floodplain storage or interrupt flood routing processes. On this basis, no mitigation measures are required.

9.2 Surface Water

9.2.1 Development will give rise to an increase in the impermeable area within Rookery South Pit.

9.2.2 Proposals in respect of surface water management are set out in Section 10 of this report.

10 Surface Water Management

10.1 LLRS Surface Water Drainage Strategy

10.1.1 As outlined in Section 6 above, a surface water drainage strategy will be implemented as part of the LLRS works. The LLRS works are taking place independently of the Project and will be completed in all aspects material to the Project prior to the commencement of construction works for the Project.

10.1.2 The principal components of the surface water drainage strategy are presented in **Drawing 3.1, Appendix B** and may be summarised as follows:

- the base of the pit will have been re-profiled such that surface water run-off sheds towards the north-west corner of the pit;
- construction of a surface water balancing pond within the north-west corner of Rookery South Pit;
- excavation of surface water interceptor channels within the base of the Pit to intercept surface water run-off and convey it to the attenuation pond;
- surface water run-off that collects within the Rookery South Pit attenuation pond will be pumped to Rookery North Pit as a strategic attenuation facility at a rate of 100l/s, and to the Mill Brook at a rate of 23l/s (in accordance with the existing Consent to Discharge, EA reference PRCNF/14024);
- the normal water level within Rookery North Pit will have been drawn down from 36m to 35m AOD to provide an additional storage volume, thereby allowing Rookery North to be used as a strategic attenuation facility in higher order rainfall events;
- a gravity return connection will allow surface water to be discharged from Rookery North back to the attenuation pond in Rookery South at a rate of no more than 23l/s.

Design Parameters

10.1.3 The design parameters adopted for the purposes of designing the LLRS surface water drainage strategy are as follows:

Impermeable Area

10.1.4 Given the nature of the pit and its surrounding clay catchment, it was assumed that the base of the pit, the side slopes of the pit and the small areas of land draining towards the pit are 100% impermeable. The total impermeable area assumed was approximately 105ha, the boundary of which is shown on **Drawing No. 3.1** contained within **Appendix B**.

Flood Estimation Handbook (FEH)

10.1.5 The sizing of the attenuation pond was undertaken using catchment specific rainfall parameters derived from the Flood Estimation Handbook (FEH).

Volumetric Run-off Coefficient

10.1.6 A volumetric run-off coefficient (Cv) of 0.85 was adopted in the sizing of the attenuation pond.

Climate Change

10.1.7 In accordance with the NPPF and associated Planning Practice Guidance, the attenuation pond was sized to allow for an increase of up to 30% in rainfall intensity due to the effects of climate change.

Sizing of the Attenuation Pond

10.1.8 The attenuation pond has been sized to accommodate rainfall events up to and including the 1 in 100 year event plus climate change (taken as an increase of 30% in rainfall intensity) with a 1 in 10 year plus climate change event following within one week of the 1 in 100 year rainfall event. The attenuation pond is a 'wet' pond containing a 0.5m normal water depth, a further 2m of storage depth (total depth of water when full of 2.5m), 1 in 3 side slopes and a 1.0m freeboard.

Mill Brook Floodwater Influx

10.1.9 In addition to catering for surface water run-off arising from within Rookery South Pit, the attenuation pond has been designed to accommodate floodwater influx from the Mill Brook and its Tributary associated with the 1 in 1000 year flood event.

Storage Volumes

10.1.10 In addition to assessing the quantum of surface water storage required to accommodate the 1 in 100 year plus climate change event, the design of the surface water drainage infrastructure brought forward as part of the LLRS was informed by consideration of 'residual risk' scenarios, including:

- Pumping station failure and;
- A 1 in 10 year plus climate change follow-on rainfall event occurring within one week of the 1 in 100 year plus climate change event.

10.1.11 Storage volumes for the various design scenarios, defined as part of the LLRS design process, are summarised in the table below:

Table 10.1 – Surface water storage volumes

Scenarios	Pump Rate	Storage Volume Required	Top Water Level (m AOD)
1 in 100 year rainfall event plus 30% climate change.	123l/s	101,391m^3	27.94
1 in 100 year rainfall event plus 30% climate change with pumping station failure (3 day duration).	0l/s	125,088m^3 assuming pumping station is off-line for up to 3 days	28.41
1 in 100 year rainfall event plus 30% climate change with a 1 in 10 year plus 30% climate change follow-on event.	123l/s	101,391m^3 (1 in 100 years plus climate change) + 91,614m^3 (1 in 10 year plus climate change) total = 193,005m^3	29.15

Scenarios	Pump Rate	Storage Volume Required	Top Water Level (m AOD)
1 in 100 year rainfall event plus 30% climate change with a 1 in 10 year plus 30% climate change follow-on event, plus 1 in 100 year plus climate change discharge from Mill Brook.	123l/s	101,391m^3 (1 in 100 years plus climate change) + 91,614m^3 (1 in 10 year plus climate change) +23,000m^3 (Mill Brook discharge) total = 216,005m^3	29.45

10.1.12 As set out in the table above, the Rookery South Pit attenuation pond has been sized to provide adequate storage to accommodate the 1 in 100 year plus climate change rainfall event, followed by the 1 in 10 year plus climate change rainfall event (i.e. total storage for surface water run-off amounts to 193,005m^3). Storage capacity also caters for floodwater influx from the Mill Brook associated with the 1 in 100 year plus climate change event (23,000m^3, as assessed in 2008), such that the total volume of storage within the pond (including freeboard) amounts to 216,005m^3.

10.2 Proposed Project Site Surface Water Drainage

Generating Equipment Site

10.2.1 Surface water run-off arising from internal roads and areas of hardstanding will be conveyed by a private, gravity surface water drainage network to the LLRS interceptor channels, ultimately outfalling to the LLRS surface water balancing pond. The private, gravity surface water drainage network will be designed in accordance with the requirements of the Building Regulations and BS EN 752.

10.2.2 Surface water run-off that may be mobilised as overland flows during extreme rainfall events will be conveyed by the internal roads to the LLRS drainage system. Site levels will therefore be designed accordingly.

Access Road

10.2.3 Surface water run-off from the access road extending from Green Lane will be conveyed via a gravity, highway drainage network and will outfall to the LLRS surface water balancing pond. Highway drainage will be designed in accordance with the requirements of the Design Manual for Roads and Bridges. Surface water run-off that may be mobilised as overland flows during extreme rainfall events will be conveyed within the highway cross-section.

Gas Connection

10.2.4 The connection comprises a buried pipeline, such that it will not give rise to an increase in impermeable area within the catchment of the Mill Brook and impact upon the surface water run-off regime.

10.2.5 The only permanent above ground structure associated with the gas connection is the Above Ground Installation (AGI) at the point of connection to the National Transmission System. It is currently envisaged that surface water run-off arising from areas of hardstanding associated with the AGI will be managed/controlled using a soakaway or other similar infiltration method. Infiltration testing will be undertaken as part of the detailed design process.

Electrical Connection

10.2.6 The Electrical Connection comprises an underground cable/circuit, such that it will not give rise to an increase in impermeable area within the catchment of the Mill Brook and impact upon the surface water run-off regime.

10.2.7 The Substation and SECs are the only permanent above ground structures associated with the Electrical Connection. Surface water run-off arising from the Substation will be conveyed to the LLRS interceptor channels, ultimately outfalling to the LLRS surface water balancing pond. It is currently envisaged that surface water run-off arising from areas of hardstanding associated with the SECs will be managed/controlled using a soakaway or other similar infiltration method. Infiltration testing will be undertaken as part of the detailed design process.

10.3 Review of The Project within the context of the LLRS Surface Water Drainage Strategy

10.3.1 As summarised above, the surface water drainage infrastructure brought forward as part of the LLRS has been designed to cater for all future development within Rookery South Pit, including the consented Covanta RRF project.

10.3.2 To establish whether the Project is 'compatible' with the LLRS drainage strategy (i.e. such that no further mitigation measures are required as part of the Project), the nature/extent of the contributing catchment area associated with the Project has been reviewed. This review has concluded that:

- The Generating Equipment, substation, temporary Laydown Area and southern part of the Access Road fall within the surface water drainage catchment defined for the purposes of designing the LLRS surface water drainage infrastructure (i.e. such that the LLRS drainage strategy caters for surface water run-off arising from these areas);
- The length of Access Road extending from Green Lane to the north-west corner of Rookery South Pit falls outside the surface water drainage catchment defined for the purposes of designing the LLRS surface water drainage infrastructure.

10.3.3 The additional impermeable area associated with the length of Access Road extending from Green Lane to the north-west corner of Rookery South Pit equates to approximately 17,200m^2 and it is proposed that surface water run-off from this area drains to the Rookery South Pit attenuation pond. This will therefore give rise to an increase in the area contributing to the pond. The impact of this additional contributing area draining to the pond has been assessed using the MicroDrainage design software and using design parameters previously established in respect of the LLRS.

10.3.4 Storage volumes for the various design scenarios, defined as part of the LLRS design process, and taking account of the additional impermeable area associated with the northern part of the Access Road, are summarised in the table below:

Table 10.2 – Surface water storage volumes

Scenarios	Pump Rate	Storage Volume Required	Top Water Level (m AOD)
1 in 100 year rainfall event plus 30% climate change	123l/s	103,184m^3	27.96

Scenarios	Pump Rate	Storage Volume Required	Top Water Level (m AOD)
1 in 100 year rainfall event plus 30% climate change with pumping station failure (3 day duration)	0l/s	127,100m^3 assuming pumping station is off-line for up to 3 days	28.43
1 in 100 year rainfall event plus 30% climate change with a 1 in 10 year plus 30% climate change follow-on event	123l/s	103,184m^3 (1 in 100 years plus climate change) + 95,099m^3 (1 in 10 year plus climate change) total = 198,283m^3	29.26
1 in 100 year rainfall event plus 30% climate change with a 1 in 10 year plus 30% climate change follow-on event, plus 1 in 100 year plus climate change discharge from Mill Brook.	123l/s	103,184m^3 (1 in 100 years plus climate change) +95,099m^3 (1 in 10 year plus climate change) +5,000m^3 (Mill Brook discharge) total = 203,283m^3	29.38

10.3.5 As set out in the table above, allowing for the additional impermeable area associated with the northern part of the Access Road, the storage volume required to cater for run-off associated with the 1 in 100 year plus climate change rainfall event, followed by the 1 in 10 year plus climate change rainfall event, increases from 193,005m^3 to 198,283m^3. Allowing for floodwater influx from the Mill Brook associated with the 1 in 100 year plus climate change event, the total volume of storage required reduces from 216,005m^3 (Table 10.1) to 203,283m^3. This reduction in the total volume of storage required is due to the reduced volume of floodwater influx from the Mill Brook.

10.3.6 The review set out above therefore demonstrates that the surface water attenuation pond brought forward as part of the LLRS offers adequate storage capacity to accommodate surface water run-off from the additional impermeable area associated with the length of Access Road extending from Green Lane to the north-west corner of Rookery South Pit. On this basis, the Project is ‘compatible’ with the LLRS drainage strategy, such that no further mitigation measures are required as part of The Project.

10.4 Extreme Flooding (0.1% Probability Event)

10.4.1 As set out in Section 8 above, the hydraulic modelling analysis has assessed flood risk associated with the 1 in 1,000 year event and this has shown that floodwater may discharge from the upper reach of the Mill Brook Tributary and also over the right (eastern) bank of the main branch of the Mill Brook immediately upstream of the culvert beneath the Bedford to Bletchley Railway.

10.4.2 As explained above, the LLRS surface water drainage scheme has been designed to cater for both surface water run-off and floodwater influx into the Pit from the Mill Brook and its Tributary. The table below summarises the storage requirements associated with the 1 in 1,000 year event.

Scenario	Pump Rate	Storage Volume Required	Top Water Level (m AOD)
1 in 1000 year rainfall event	123l/s	135,259m^3	28.39
1 in 1000 year rainfall event, plus 1 in 1000 year discharge from Mill Brook	123l/s	135,259m^3 (1 in 1000 years plus climate change) +16,000m^3 (Mill Brook discharge) total = 151,259m^3	28.67

10.4.3 As outlined above, the total volume of storage within the pond (including freeboard) exceeds 200,000m^3. The surface water attenuation pond therefore offers adequate storage capacity to accommodate both surface water run-off and floodwater influx into the Pit from the Mill Brook and its Tributary associated with the 1 in 1,000 year event.

10.5 Pollution Control

10.5.1 The Project includes the following potential sources of oil contamination:

- Oil-filled transformers;
- Lubrication systems for the Generating Equipment;
- Oil storage and;
- Areas of hardstanding for oil delivery vehicles.

10.5.2 All designated oil retaining areas will include secondary containment measures (bunds) designed to contain 110% of the volume of oil stored.

10.5.3 The surface water drainage system serving potentially contaminated oil retaining areas will pass surface water run-off through a Class 1 Full Retention Oil Separator (as set out in BS EN 858) prior to discharging surface water to the LLRS drainage system.

10.5.4 All private surface water drains will pass surface water run-off through an oil interceptor prior to outfalling to the LLRS surface water drainage system.

10.5.5 Surface water run-off arising from the access road will pass through an oil interceptor prior to outfalling to the LLRS surface water balancing pond. Highway drainage outfalls will include a penstock control to enable containment of contaminated run-off.

10.6 Maintenance

10.6.1 Private surface water drains will be operated and maintained by MPL. The LLRS surface water drainage infrastructure will be maintained by O&H Properties Limited.

11 Climate Change

11.1.1 In February 2016, the EA published guidance in respect of the climate change allowances that should be used as the basis for preparing FRAs (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances). The guidance sets out the climate change allowances for peak river flow, peak rainfall intensity, sea level rise, off-shore wind speeds and extreme wave height.

11.1.2 Allowances in respect of peak river flow vary according to River Basin District, flood zone and proposed land-use (and therefore the lifetime of the development). The Project site lies within the Anglian River Basin District.

11.1.3 PBA consulted both the Bedford Group of Drainage Boards and the Lead Local Flood Authority (Central Bedfordshire Council) regarding the interpretation and application of the 2016 guidance. In accordance with stakeholder requirements, an allowance of +35% peak river flow has been used. Although the analysis indicates that the volume of floodwater discharge into Rookery South Pit from the upper reach of the Mill Brook Tributary may increase as a result of climate change, it has been shown that the surface water conveyance and storage infrastructure within the Pit offers adequate capacity to accommodate such changes.

11.1.4 Given the anticipated design life of the Project, and based upon the recommended contingency allowances set out in the 2016 guidance, a 20% increase in peak rainfall intensity would typically be adopted for the purposes of designing a surface water drainage strategy to accommodate the effects of climate change. However, given the nature and location of the Project, a contingency allowance of 30% increase in peak rainfall intensity has been adopted in this instance (in accordance with the guidance in force at the time the LLRS was designed in 2008).

12 Residual Risk

12.1.1 Hydraulic modelling has demonstrated that floodwater arising from the Mill Brook and its Tributary may discharge into Rookery South Pit during the 1 in 100 year, the 1 in 100 year plus climate change and the 1 in 1,000 year events.

12.1.2 However, it has been shown that the surface water drainage infrastructure brought forward as part of the LLRS offers adequate capacity to cater for such conditions. It should also be noted that the locations at which floodwater may discharge from the watercourse and into the Pit are 'remote' from the Generating Equipment Site, and as such floodwater would not be expected to impact on sensitive power generation infrastructure.

12.1.3 The principal residual flood risk issue in this instance relates to the operation/performance of the surface water drainage system. As set out in Section 10, surface water run-off accumulating within the Rookery South attenuation pond is pumped to both Rookery North and the Mill Brook. Should the pumping station fail, water levels within the attenuation pond would be greater than those anticipated under 'normal' operating conditions. However, it has been shown (Table 10.2, Section 10 of this report) that the surface water drainage infrastructure brought forward as part of the LLRS offers adequate capacity to cater for a scenario where the pumping station is 'off-line' for up to three days, thus providing sufficient time for 'stand-by' arrangements to be brought into effect.

12.1.4 Notwithstanding the above, an incident management plan should be prepared so that visitors/operational staff are aware of the action to be taken in the event of floodwater/surface water affecting the Generating Equipment Site and associated highway access.

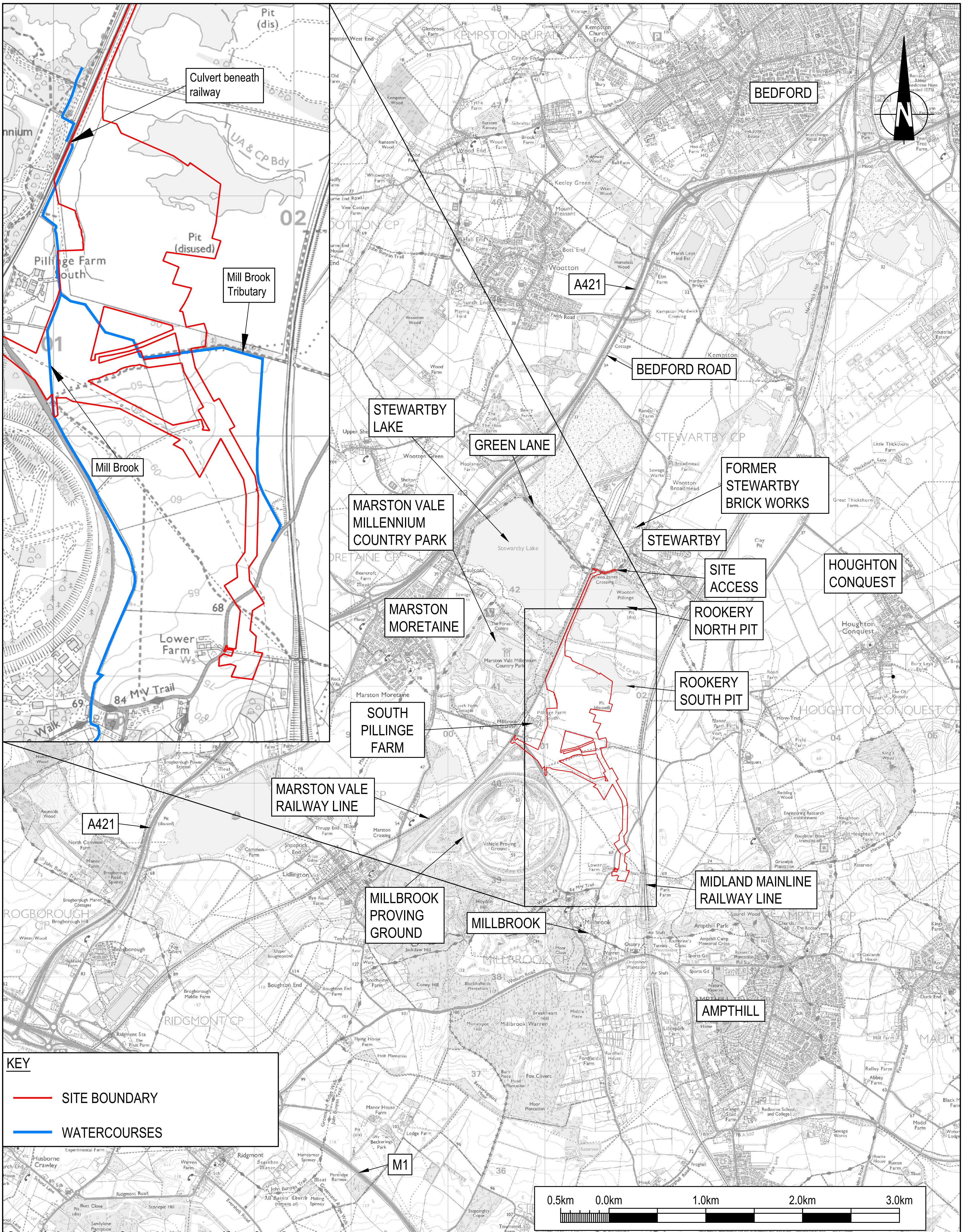
13 Concluding Remarks

13.1.1 National, Regional and Local planning policy requires that:

- Development is directed to sites at the lowest probability of flooding;
- Development accommodates the potential impacts of climate change;
- Development should not be permitted if it would be at unacceptable risk of flooding or create an unacceptable risk elsewhere;
- Where possible, development should contribute to reduced flood risk;
- New development should facilitate safe access and exit during flood conditions.

13.1.2 Within this context, the Project is considered to fully comply with National, Regional and Local planning policy in respect of development and flood risk. On this basis, it is concluded that flood risk considerations do not constitute a barrier to the granting of a DCO for the Project.

Appendix A Site Location Plan



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Client
Millbrook Power

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MILLBROOK POWER PROJECT

LOCATION PLAN

Mark	Revision	Drawn	Date	Chkd

Drawing Status
FLOOD RISK ASSESSMENT

Date of 1st Issue	03.02.15
A3 Scale	NTS
Drawn by	DB
Checked by	SH

Drawing Number
FIGURE 1
31116/3014/001

Revision
-

user name: david batash

File Location: j:\31116 rookery pit gas power station\cad\dwgs\hydro\31116_3014_001 - figure 1.dwg

Appendix B Low Level Restoration Scheme

KEY:

APPLICATION SITE BOUNDARY

ROOKERY SOUTH

MINOR CONTOUR (SHOWN IN 0.1m INTERVALS)

MAJOR CONTOUR (SHOWN IN 0.5m INTERVALS)

SURFACE WATER RISING MAIN

SURFACE WATER GRAVITY SEWER

PHASE 1 SOUTHERN PERMITTED EXTRACTION AREA

ROOKERY NORTH

APPROXIMATE WATER LEVEL 36m AOD TO EXISTING GROUND LEVEL

APPROXIMATE MAXIMUM TOP WATER LEVEL 35.6m AOD IN 1 IN 100 YEAR EVENT PLUS A 30% ALLOWANCE FOR CLIMATE CHANGE FOLLOWING REPROFILING OF ROOKERY NORTH

APPROXIMATE WATER LEVEL 35m AOD TO PROPOSED GROUND LEVEL

AREAS OF UNDERWATER GROUND TO BE REPROFILED TO 34.5m AOD TO PROVIDE ADDITIONAL MARGINAL AREAS. REFER TO DRAWING 14081/021/07

NOTES:

THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING NUMBER 14081/021/01

SURVEY DATA REFERENCED ON THIS DRAWING IS A COMBINATION OF TWO TOPOGRAPHICAL SURVEYS PREPARED BY ASSOCIATED SURVEYING CONSULTANTS (ASC) IN MAY 1997 AND SEPTEMBER 2003.

Mark	Revision	Drawn	Date	Chkd
C	MINOR TEXTUAL CHANGES	TA	03/06/09	CST
B	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
A	AMENDED GENERAL EARTHWORKS DESIGN	EJC	28/04/09	PJ

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status
PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
EXTENT OF PHASE 1 RESTORATION PLATFORM

Client

Date of 1st Issue: 03/03/09
Drawn by: EJC
A0 Scale: 1:2000
Checked by: PJ
Drawing Number: 3.2 14081/015/01
Revision: C

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KEY:

APPLICATION SITE BOUNDARY

ROOKERY SOUTH

MINOR CONTOUR (SHOWN IN 0.1m INTERVALS)

MAJOR CONTOUR (SHOWN IN 0.5m INTERVALS)

NOTES:

THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING NUMBERS 14081/021/01

SURVEY DATA REFERENCED ON THIS DRAWING IS A COMBINATION OF TWO TOPOGRAPHICAL SURVEYS PREPARED BY ASSOCIATED SURVEYING CONSULTANTS (ASC) IN MAY 1997 AND SEPTEMBER 2003.

Mark	Revision	Drawn	Date	Chkd
C	MINOR TEXTUAL CHANGES	EJC	03/06/09	CST
B	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
A	AMENDED GENERAL EARTHWORKS DESIGN	EJC	14/04/09	PJ

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UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status

PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
EXTENT OF PHASE 2 RESTORATION PLATFORM

Client

Date of 1st Issue 25/03/09	Drawn by EJC
A0 Scale 1:2000	Checked by PJ
Drawing Number 3.3 14081/015/02	Revision C

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KEY:

APPLICATION SITE BOUNDARY

ROOKERY SOUTH

MINOR CONTOUR (SHOWN IN 0.1m INTERVALS)

MAJOR CONTOUR (SHOWN IN 0.5m INTERVALS)

NOTES:

THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING NUMBERS 14081/021/01

SURVEY DATA REFERENCED ON THIS DRAWING IS A COMBINATION OF TWO TOPOGRAPHICAL SURVEYS PREPARED BY ASSOCIATED SURVEYING CONSULTANTS (ASC) IN MAY 1997 AND SEPTEMBER 2003.

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	03/06/09	CST
C	MINOR TEXTUAL CHANGES	TA	27/05/09	CST
B	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
A	AMENDED GENERAL EARTHWORKS DESIGN	EJC	14/04/09	PJ

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UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status

PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
EXTENT OF PHASES 3 AND 4
RESTORATION PLATFORM

Client

Date of 1st Issue: 03/03/09
Drawn by: EJC
A0 Scale: 1:2000
Checked by: PJ
Drawing Number: 3.4
14081/015/03
Revision: D

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KEY:

APPLICATION SITE BOUNDARY

HEADWALL STRUCTURE - ALL HEADWALLS TO BE BRICK BUILT OR TO HAVE BRICK CLADDING (HEADWALL SIZE INDICATIVE AT THIS SCALE)

ROOKERY SOUTH

DRAINAGE CATCHMENT = 1,053,724m²
CONTRIBUTING TO ATTENUATION POND IN ROOKERY SOUTH

MINOR CONTOUR (SHOWN IN 0.1m INTERVALS)

MAJOR CONTOUR (SHOWN IN 0.5m INTERVALS)

HIGH VOLTAGE OVERHEAD ELECTRICITY CABLE

SURFACE WATER RISING MAIN

SURFACE WATER GRAVITY SEWER

100 YEAR PLUS 30% CLIMATE CHANGE TOP WATER LEVEL

ROOKERY NORTH

APPROXIMATE WATER LEVEL 36m AOD TO EXISTING GROUND LEVEL

APPROXIMATE MAXIMUM TOP WATER LEVEL 35.6m AOD IN 1 IN 100 YEAR EVENT PLUS A 30% ALLOWANCE FOR CLIMATE CHANGE FOLLOWING REPROFILING OF ROOKERY NORTH

APPROXIMATE WATER LEVEL 35m AOD TO PROPOSED GROUND LEVEL

AREAS OF UNDERWATER GROUND TO BE REPROFILED TO 34.5m AOD TO PROVIDE ADDITIONAL MARGINAL AREAS. REFER TO DRAWING 14081/021/07

NOTES:

THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING NUMBERS 14081/021/02 - 07

SURVEY DATA REFERENCED ON THIS DRAWING IS A COMBINATION OF TWO TOPOGRAPHICAL SURVEYS PREPARED BY ASSOCIATED SURVEYING CONSULTANTS (ASC) AS DETAILED IN DRAWINGS ASC.97.182 AND ASC.03.393

Mark	Revision	Drawn	Date	Chkd
K	MINOR TEXTUAL CHANGES	EJC	03/06/09	PJ
J	MINOR TEXTUAL CHANGES	EJC	03/06/09	CST
I	MINOR ADDITIONS TO DRAWING NOTES	EJC	01/06/09	CST
H	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
G	REVISED ALIGNMENT OF NORTHERN ACCESS RAMP	EJC	05/08/09	PJ
F	ADDED NOISE BUND, AMENDED NORTHERN ACCESS AND INTERCEPTOR CHANNEL	EJC	29/04/09	PJ
E	MINOR AMENDMENTS TO BOUNDARY	TA	25/03/09	CST
D	MINOR TEXTURAL AMENDMENTS MADE	EJC	14/01/08	PJ
C	BASE CONTOURS ADDED	EJC	12/01/08	PJ
B	POND LOCATION CHANGED	EJC	09/01/09	PJ
A	ADDED MORE DETAIL TO DRAWING	TA	26/11/08	PJ

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Drawing Issue Status

PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
COMPLETED SCHEME

Client

Date of 1st Issue	Drawn by
21/11/08	TA
A0 Scale	Checked by
1:2000	PJ

Drawing Number 3.1 14081/021/01

Revision K

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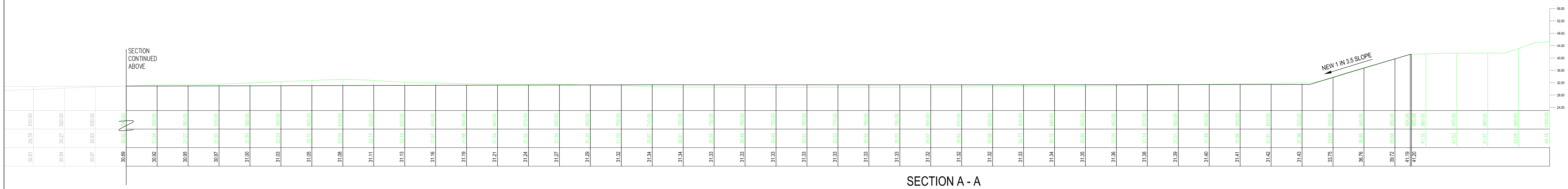
SECTION A - A
Horiz. 1:500 Vert. 1:500



SECTION A - A
Horiz. 1:500 Vert. 1:500

SECTION B - B
Horiz. 1:500 Vert. 1:500

SECTION B - B
Horiz. 1:500 Vert. 1:500

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
C	AMENDED NORTHERN ACCESS & INTERCEPTOR CHANNEL	EJC	06/05/09	PJ
B	SECTION UPDATED TO REFLECT POND AMENDMENTS	TA	21/01/09	PJ
A	REVISED GENERAL DESIGN	EJC	01/02/08	PJ

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Drawing Issue Status

PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
SITE CROSS SECTIONS - SHEET 1 OF 5

Client

Date of 1st Issue	Drawn by
21/11/08	TA
A0 Scale 1:500	Checked by PJ
Drawing Number 14081/021/02	Revision D

NOTE:
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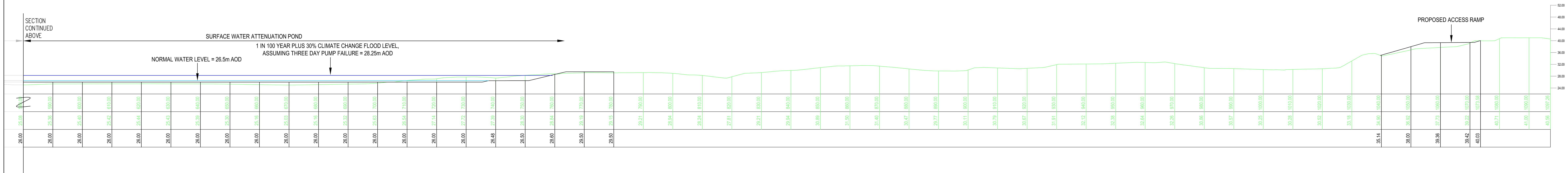
SECTION C - C

Horiz. 1:500 Vert. 1:500



SECTION C - C

Horiz. 1:500 Vert. 1:500

SECTION D - D

Horiz. 1:500 Vert. 1:500

SECTION D - D

Horiz. 1:500 Vert. 1:500

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
C	AMENDED NORTHERN ACCESS & INTERCEPTOR CHANNEL	EJC	06/05/09	PJ
B	SECTION UPDATED TO REFECT POND AMENDMENTS	TA	21/01/09	PJ
A	REVISED GENERAL DESIGN	EJC	01/12/08	PJ

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Drawing Issue Status
PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
SITE CROSS SECTIONS - SHEET 2 OF 5

Client

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS 14081/021/01, 02, 04, 05, 06

Date of 1st Issue: 21/11/08
Drawn by: TA
A0 Scale: 1:500
Checked by: PJ
Drawing Number: 14081/021/03
Revision: D

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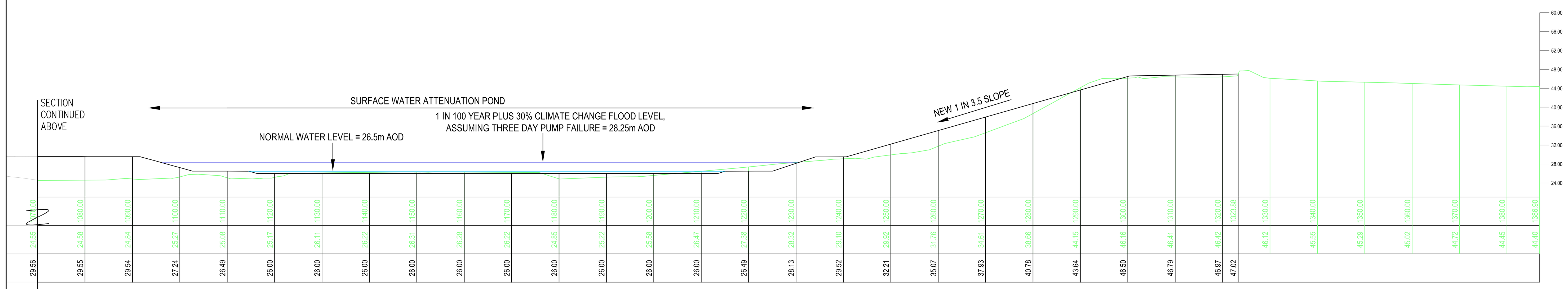
SECTION E - E
Horiz. 1:500 Vert. 1:500

SECTION E - E
Horiz. 1:500 Vert. 1:500

SECTION F - F
Horiz. 1:500 Vert. 1:500

SECTION F - F
Horiz. 1:500 Vert. 1:500



SECTION F - F
Horiz. 1:500 Vert. 1:500

NOTE:

THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS 14081/021/01, 02, 03, 05, 06

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
C	AMENDED NORTHERN ACCESS & INTERCEPTOR CHANNEL	EJC	06/05/09	PJ
B	SECTION UPDATED TO REFLECT POND AMENDMENTS	TA	21/01/09	PJ
A	REVISED GENERAL DESIGN	EJC	21/01/09	PJ

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
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Drawing Issue Status
PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
CROSS SECTIONS - SHEET 3 OF 5

Client

Date of 1st Issue	Drawn by
21/11/08	TA
A0 Scale 1:500	Checked by
Drawing Number 14081/021/04	Revision D

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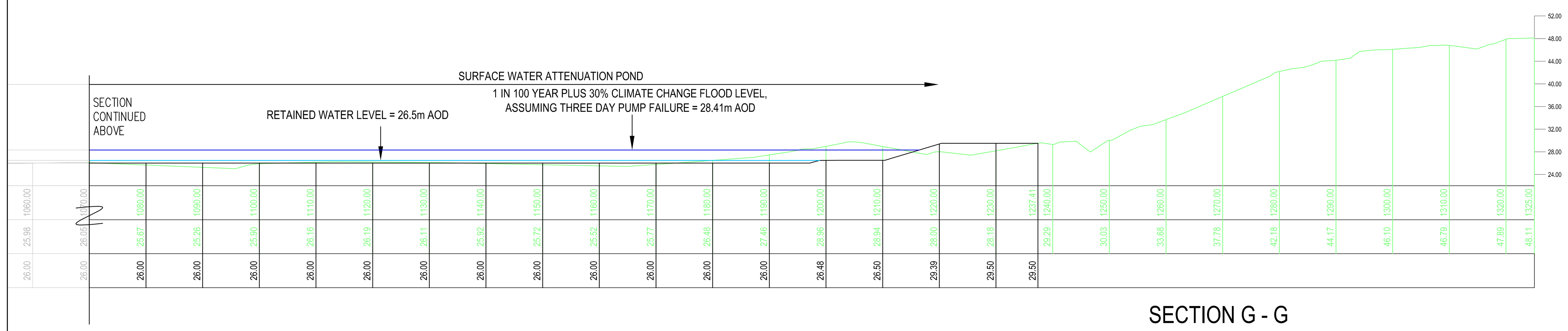
SECTION G - G
Horiz. 1:500 Vert. 1:500

SECTION G - G
Horiz. 1:500 Vert. 1:500



SECTION G - G
Horiz. 1:500 Vert. 1:500

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
C	AMENDED NORTHERN ACCESS & INTERCEPTOR CHANNEL	EJC	06/05/09	PJ
B	SECTION UPDATED TO REFLECT POND AMENDMENTS	TA	21/01/09	PJ
A	REVISED GENERAL DESIGN	EJC	01/12/08	PJ

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
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Drawing Issue Status
PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
SITE CROSS SECTIONS - SHEET 4 OF 5

Client

Date of 1st Issue	Drawn by
21/11/08	TA
A0 Scale: 1:500	Checked by: PJ
Drawing Number: 14081/021/05	Revision: D

NOTE:
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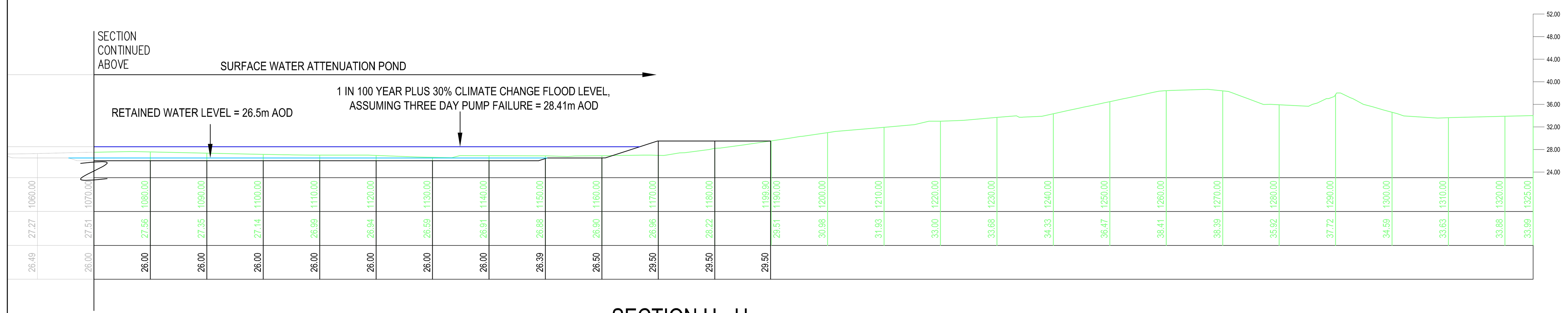
SECTION H - H
Horiz. 1:500 Vert. 1:500

SECTION H - H
Horiz. 1:500 Vert. 1:500



SECTION H - H
Horiz. 1:500 Vert. 1:500

Mark	Revision	Drawn	Date	Chkd
D	MINOR TEXTUAL CHANGES	TA	19/05/09	PJ
C	AMENDED NORTHERN ACCESS & INTERCEPTOR CHANNEL	EJC	06/05/09	PJ
B	SECTION UPDATED TO REFLECT POND AMENDMENTS	TA	21/01/09	PJ
A	REVISED GENERAL DESIGN	EJC	12/01/08	PJ

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
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Drawing Issue Status
PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
SITE CROSS SECTIONS - SHEET 5 OF 5

Client

Date of 1st Issue	Drawn by
21/11/08	TA
A0 Scale: 1:500	Checked by: PJ
Drawing Number: 14081/021/06	Revision: D

NOTE:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS 14081/021/01, 02, 03, 04, 05

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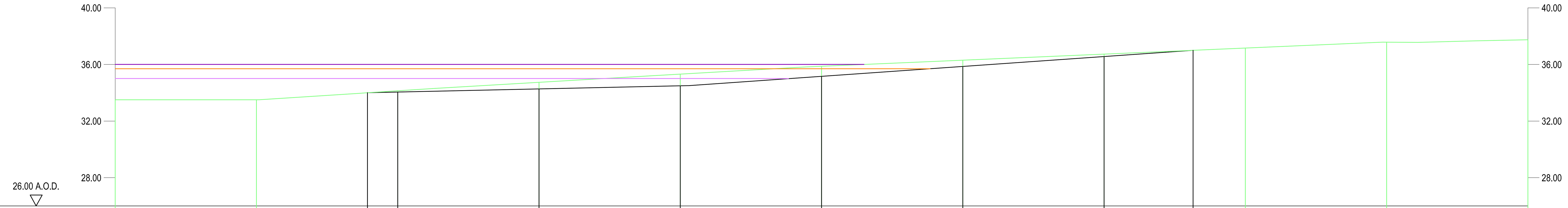
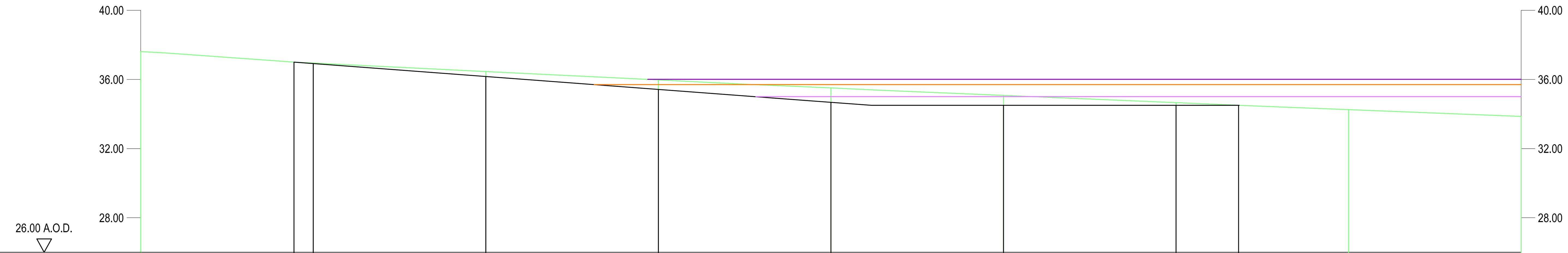


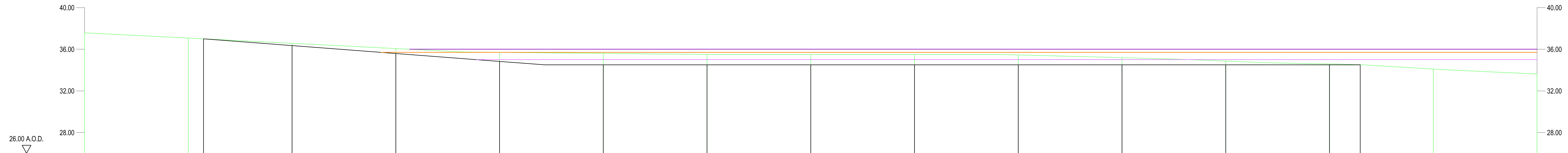
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00
EXISTING GROUND LEVEL	33.50	33.50	34.14	34.74	35.32	35.87	36.30	36.73	37.16	37.57	37.75
PROPOSED GROUND LEVEL	34.00	34.05	34.27	34.49	35.16	35.86	36.56	37.00			

SECTION I
HORIZ. 1:200 VERT. 1:200



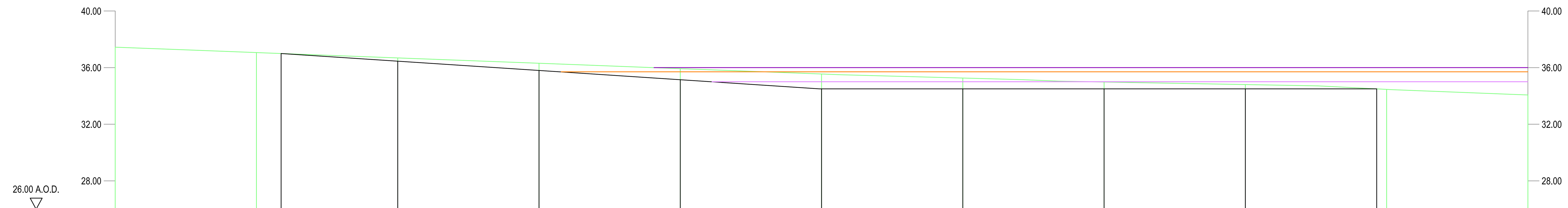
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00
EXISTING GROUND LEVEL	37.61	36.95	36.46	35.97	35.51	35.08	34.65	34.25	33.86
PROPOSED GROUND LEVEL	37.00	36.92	36.17	35.42	34.67	34.50	34.50	34.50	

SECTION J
HORIZ. 1:200 VERT. 1:200



CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00
EXISTING GROUND LEVEL	37.58	37.07	36.57	36.07	35.70	35.60	35.50	35.50	35.50	35.45	35.19	34.87	34.59	34.10	33.62
PROPOSED GROUND LEVEL	37.00	36.35	35.59	34.83	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50		

SECTION K
HORIZ. 1:200 VERT. 1:200



CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00
EXISTING GROUND LEVEL	37.44	37.07	36.69	36.31	35.93	35.55	35.26	34.98	34.80	34.46	34.07
PROPOSED GROUND LEVEL	36.46	36.46	35.80	35.15	34.50	34.50	34.50	34.50	34.50		

SECTION L
HORIZ. 1:200 VERT. 1:200

KEY:-

- APPROXIMATE WATER LEVEL 36m AOD TO EXISTING GROUND LEVEL
- APPROXIMATE TOP WATER LEVEL 35.6m AOD
- APPROXIMATE WATER LEVEL 35m AOD TO PROPOSED GROUND LEVEL

NOTE:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING 14081/21/01.

Mark	Revision	Drawn	Date	Chkd
A	MINOR TEXTUAL AMENDMENTS	TA	21/05/09	PJ

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status

PRELIMINARY

THE ROOKERY LOW LEVEL RESTORATION SCHEME
PROPOSED AREAS OF EDGE REPROFILING
WITHIN ROOKERY NORTH

Client

Date of 1st Issue: 01/12/08	Drawn by: TA
A1 Scale: 1:200	Checked by: PJ
Drawing Number: 14081/021/07	Revision: A

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Appendix C Stakeholder Consultation

From: Alys Bishop <Alys.Bishop@centralbedfordshire.gov.uk>
Sent: 01 August 2017 16:20
To: Stuart Harwood
Subject: RE: Millbrook Power - meeting notes
Attachments: RE: Millbrook Power Project, Rookery Pit, nr Stewartby Bedfordshire

Hi Stuart -

Yes, happy to confirm although timescales for the actions below would be appreciated (in particular action 2).

Regarding my action to contact the EA (actions 1 and 2 of the below) please see the attached response – as in the attached please contact angcentral.frb@environment-agency.gov.uk regarding WFD.

Please keep me updated as needed, if you need contacts for the multi-disciplinary meeting I would be happy to provide from CBC.

Best regards,
Alys

Alys Bishop MSc MCIWEM
Sustainable Drainage Engineer
Building Control and Flood Risk Management
Regeneration and Business Directorate

Central Bedfordshire Council GROUND EAST, Priory House, Monks Walk, Chicksands, Shefford, Bedfordshire, SG17 5TQ
Direct Dial: 0300 300 4215 | Internal: 74215 | Mobile: 07812678063 |
Email: alys.bishop@centralbedfordshire.gov.uk | Team email: floodrisk@centralbedfordshire.gov.uk

If you can't reach me on the above please leave a message with the Building Control Team on 0300 300 8635

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 01 August 2017 16:14
To: Alys Bishop
Subject: Millbrook Power - meeting notes
Importance: High

Alys,

Further to the e-mail below, we would be grateful if you would confirm that the attached notes constitute an accurate record of the meeting.

In addition, we would appreciate an update in respect of the following actions that sit with CBC:

1. EA consultation regarding scope of flood risk/drainage matters to be addressed (Item 2 of the attached);
2. Review and comment on FRA (Item 5 of the attached);
3. EA consultation to establish whether a WFD compliance assessment is required (Item 10 of the attached).

The project team urgently requires feedback in respect of Item 3 due to potential programme implications (noting that the DCO application is to be submitted in October).

Please feel free to call should you wish to discuss.

Thanks and regards,

Stuart Harwood
Associate
For and on behalf of Peter Brett Associates LLP - Northampton

t 01604 878313
m 07770-698159
e sharwood@peterbrett.com
w peterbrett.com

From: Stuart Harwood
Sent: 12 July 2017 15:50
To: 'Alys.Bishop@centralbedfordshire.gov.uk' <Alys.Bishop@centralbedfordshire.gov.uk>; Trevor Skelding <Trevor.Skelding@idbs.org.uk>
Subject: Millbrook Power - meeting notes
Importance: High

Alys/Trevor,

Please find attached a copy of the notes prepared following our meeting on 4th July 2017.

We would be grateful if you would confirm that the notes constitute an accurate record of the meeting. Alternatively, should you consider that the notes require amending, please record your amendments using track changes.

Please note the actions identified alongside Items 2, 5, and 10. Given potential programme implications, we are inevitably very keen to understand whether a WFD compliance assessment is required and would be grateful if you would clarify/confirm by no later than 21st July.

Please feel free to call should you have any queries.

Kind regards,

Stuart Harwood
Associate
For and on behalf of Peter Brett Associates LLP - Northampton

t 01604 878313
m 07770-698159
e sharwood@peterbrett.com
w peterbrett.com

Jade Taylor

From: Trevor Skelding <Trevor.Skelding@idbs.org.uk>
Sent: 18 July 2017 10:00
To: Stuart Harwood
Subject: RE: Millbrook Power - meeting notes

Stuart

The notes are accepted. Please note that a response to the Section 42 Consultation was sent on the 4th July 2017.

Regards

Trevor Skelding MSc IEng MICE
Principal Engineer

Bedford Group of Drainage Boards|Vale House|Broadmead Road|Stewartby|Bedfordshire|MK43 9ND

Tel: 01234 767995 | Fax: 01234 768582 | www.idbs.org.uk

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 12 July 2017 15:50
To: 'Alys.Bishop@centralbedfordshire.gov.uk' <Alys.Bishop@centralbedfordshire.gov.uk>; Trevor Skelding <Trevor.Skelding@idbs.org.uk>
Subject: Millbrook Power - meeting notes
Importance: High

Alys/Trevor,

Please find attached a copy of the notes prepared following our meeting on 4th July 2017.

We would be grateful if you would confirm that the notes constitute an accurate record of the meeting. Alternatively, should you consider that the notes require amending, please record your amendments using track changes.

Please note the actions identified alongside Items 2, 5, and 10. Given potential programme implications, we are inevitably very keen to understand whether a WFD compliance assessment is required and would be grateful if you would clarify/confirm by no later than 21st July.

Please feel free to call should you have any queries.

Kind regards,

Stuart Harwood
Associate
For and on behalf of Peter Brett Associates LLP - Northampton

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MINUTES

Meeting Title: Millbrook Power, Bedfordshire

Attendees: Alys Bishop (CBC), Trevor Skelding (Beds IDB), Stuart Harwood (PBA)

cc: Chris Leach (PBA), Nick Johnson (Millbrook Power Limited)

Date of Meeting: 4th July 2017

Job Number: 40335-3005

Item	Subject	Actions
1.	**Background/Introduction** SH provided an overview of the project and introduced the applicant based upon the information set out in the PEIR document (both CBC and the IDB having confirmed receipt as part of the S42 consultation). It was noted that a DCO application was to be made towards the end of 2017. Explained that the project had been placed 'on hold' in early 2015, at which point both the FRA and 'water' ES chapter had been prepared. The purpose of the meeting was therefore to: • 're-cap' on matters; • ensure that any 'new' information is identified and; • reach agreement regarding the issues to be addressed and the scope of any work that may be required to revise and update the 2014 FRA and ES chapter.	
2.	**Roles/Responsibilities** SH explained that PBA had re-consulted the Environment Agency (EA) and been advised that they had no comment to make in respect of flood risk and drainage and that they had deferred to the IDB and CBC as LLFA on such matters. TS confirmed that the IDB was principally interested in the surface water pumping regime from Rookery Pit (to the Mill Brook watercourse bordering the western boundary of the Pit) and ensuring that any pumping continued in accordance with the terms of the existing consent to discharge (which permits pumping at a rate of 23l/s). TS advised that, on the assumption that the pumping regime would be unchanged, the IDB would have no comment on the proposals. It was noted that the Mill Brook watercourse falls outside the IDB's District and would be classified as an Ordinary Watercourse, under the jurisdiction of the LLFA (CBC). AB acknowledged that CBC would 'lead' on flood risk/drainage matters, but noted that it's a 'legacy' project, such that she would need to consult the EA to ensure agreement/clarity regarding the scope of issues to address. It was also noted that any works (permanent or temporary) to the	 AB

	watercourses bordering Rookery Pit would require consent. Consent applications are dealt with by the IDB on behalf of Central Beds Council. TS queried whether Bedfordshire Borough Council (BBC) should be consulted (noting that the north-eastern corner of Rookery South Pit falls within BBC's area). AB commented that, as the application site and the vast majority of the Pit fell within CBC's area, CBC and the IDB would lead.	
3.	**Policy, Guidance and Evidence Base** AB advised that CBC's draft Local Plan, and the associated evidence base, had been published for public consultation. AB advised that the principal evidence base studies relevant to both the FRA and 'water' ES chapter are: • Level 1 Strategic Flood Risk Assessment (July 2017) • Water Cycle Study (July 2017) AB also highlighted (i) CBC's Local Flood Risk Management Strategy (February 2014), (ii) the Tri-Lead Local Authority Preliminary Flood Risk Assessment (June 2011), (iii) Central Bedfordshire Sustainable Drainage Supplementary Planning Document (adopted April 2014) and (iv) CBC's Advice Note 'Advice for the provision of surface water drainage systems for new developments (April 2015)'.	
4.	**Site and Project Description** SH provided a description of The Rookery (north and south - former clay pits) and an overview of the principal components of the project by reference to the information, figures, etc, included within the May 2017 Preliminary Environmental Information Report (provided on the Millbrook Power website: http://www.millbrookpower.co.uk/). It was noted that the generating plant will comprise only one generator unit (previously up to five), running for up to 2,250 hours per year. SH explained that the project constitutes a Nationally Significant Infrastructure Project pursuant to the 2008 Planning Act and therefore requires development consent under that Act. PBA has been appointed to prepare the Environmental Statement and associated Flood Risk Assessment in support of the application for a Development Consent Order (DCO).	
5.	**PEIR and Section 42 Consultation** TS acknowledged receipt of the PEIR, but confirmed that the IDB had yet to respond. TS to draft a response ASAP. AB acknowledged receipt of the PEIR (uploaded to CBC's file sharing/hosting site by SH on 2nd June) but had yet to review the document and would consult colleagues re: whether a response had been drafted. *Post-meeting note: AB advised via e-mail dated 4th July that CBC had responded to the consultation.*	 TS AB

	SH highlighted that the PEIR document incorporates a copy of the FRA as drafted prior to the project being placed on hold in March 2015 (the FRA comprising Appendix G of the PEIR). SH explained that it would be helpful to receive CBC's feedback/comment on the draft FRA prior to finalising the document for submission. AB agreed to review and comment on the document. AB to advise re: timeframe for completing the review. SH referred to the EA's response to the Section 42 consultation, the Agency having commented that the site is located in Flood Zone 1 (according to their Flood Map) and that the IDB and LLFA should be consulted for 'drainage advice'.	AB
6.	**Low Level Restoration Scheme** SH explained that The Rookery is the subject of a Low Level Restoration Scheme (LLRS) and that, once restored, Rookery South (the location of the Millbrook Power project), would be approximately 15m below the surrounding ground level. SH explained that the principal works associated with the LLRS comprise: • Re-profiling of the base of the pit to create a platform graded to fall to the north; • Implementation of a surface water drainage system, comprising a balancing pond, network of interceptor channels and pumping station; • Buttressing of the pit slopes; • Provision of access ramps; • Landscaping works/planting around the pit edge and balancing pond. It was noted and agreed that, as the LLRS is to be implemented/completed prior to any development within Rookery South Pit, the LLRS constitutes the 'baseline' for the purposes of the EIA and preparation of the FRA for the Millbrook Power project (this being consistent with the approach adopted for the Covanta project). AB queried provisions in respect of maintenance of the balancing pond, etc. SH advised that responsibility for maintenance sat with O&H Properties Ltd.	
7.	**Surface Water Management** SH explained that the LLRS drainage scheme comprises/operates as follows: • Surface water collecting in the balancing pond will be pumped to (i) Rookery North at a rate of 100l/s and (ii) the Mill Brook at a rate of 23l/s (as per the terms of the existing Consent to Discharge); • The water level in Rookery North will be drawn down by approximately 1m; • Water from Rookery North will return to the balancing pond in Rookery South via a gravity connection at a rate of no	

	more than 23l/s. • By using Rookery North as a strategic storm water storage facility, the balancing pond would return to its normal water level approximately 12 days after the 1 in 100 year plus climate change event. SH explained that, in respect of design parameters, the base and side-slopes of Rookery South Pit are assumed to be 100% impermeable and the sizing of the balancing pond has been undertaken using catchment-specific rainfall parameters derived from the Flood Estimation Handbook (FEH). The balancing pond has been sized to accommodate rainfall events up to and including the 1 in 100 year event including climate change and comprises a retained water depth of 0.5m. As the LLRS design has been prepared assuming the Pit to be 100% impermeable and the Millbrook Power project falls within the catchment of the Pit, it was agreed that the LLRS drainage strategy offers adequate capacity to accommodate surface water run-off from the Millbrook Power project, such that no additional mitigation would be required in respect of surface water run-off control. SH explained that design of the surface water drainage strategy caters for residual risk scenarios comprising (i) the 1 in 100 year plus climate change event and a period of pumping station failure (pumps off-line for 3 days) and (ii) a "follow-on" event - a 1 in 10 year plus climate change event occurring within 1 week of the 1 in 100 year plus climate change event. The pond has been sized to provide sufficient residual capacity above that required for the 1 in 100 year plus climate change event to accommodate both residual risk scenarios. On this basis, it was agreed that the design of the drainage strategy is robust.	
8.	**Flood Risk Associated with Mill Brook** SH explained that a HEC-RAS hydraulic model of the Mill Brook and its tributary (running along the southern fringe of Rookery South Pit) had been developed as part of PBA's previous work (to inform design of the LLRS (2008) and the FRA for the Covanta RRF scheme (2010)). The analysis had shown that floodwater may 'spill' into Rookery South Pit from a localised area of the tributary, albeit at a relatively low rate (peak spill rate of approx. $0.2m^3/s$). SH explained that, as per the LLRS proposals, floodwater will be allowed to spill into the Pit as per the "existing" situation, but will be "managed" by being intercepted and conveyed to the attenuation pond. SH confirmed that the surface water drainage channels and attenuation pond being brought forward as part of the LLRS had been designed to accommodate floodwater influx from the Mill Brook tributary. In addition, it was noted that the 'raised' platform created by the LLRS works will be such that the site of the Millbrook Power project will be elevated above water levels within the balancing pond and associated drainage channels, etc.	

	On this basis, it was agreed that the project site would be adequately safeguarded from flooding, such that no further mitigation works would be required as part of the project. SH explained that consideration of the 1,000 year event in 2010 had shown that floodwater may spill over the eastern bank of the Mill Brook immediately upstream of the culvert beneath the railway (in the vicinity of the north-west corner of the Covanta RRF site). Given the distance from the Millbrook Power site, coupled with the topography across the base of the Pit following implementation of the LLRS, it was agreed that mitigation measures would not need to be brought forward as part of the Millbrook Power project. (It was also noted that measures had been incorporated within the design of the Covanta RRF scheme to cater for this floodwater spill). The requirement to divert the lower reach of the Mill Brook tributary (as part of the LLRS) was noted and SH advised that the diverted reach had been designed to convey 100 year plus climate change flood flows ‘in bank’. TS and AB confirmed this is an adequate design standard. TS confirmed that the IDB would deal with any consent applications for watercourse works on behalf of CBC. SH highlighted the fact that the hydraulic modelling analysis dates to 2010. The EA has previously (2014) advised that the model provides the best available data in respect of flood risk associated with the Mill Brook, such that it should be taken forward and used to inform the FRA prepared in support of the Millbrook Power Project. It was noted that the assessment of catchment hydrology (flood flows) was revisited in 2014 to establish whether estimates were higher/lower than those derived in 2010. SH confirmed that the 2014 analysis resulted in lower flood flow estimates than derived in 2010 and, as agreed with the EA, the modelling analysis was not therefore updated. TS and AB advised that the hydrology assessment should be revisited. TS and AB agreed that, where the updated, 2017 analysis provides flow estimates that are less than or equal to the 2010 estimates, it would not be necessary to revisit the hydraulic modelling analysis (i.e. the 2010 modelling data/output could be taken forward and used to inform the FRA).	
9.	**Climate Change** It was noted that guidance regarding the allowances to be used for the purposes of preparing FRA’s had changed following the publication of EA guidance titled ‘Flood risk assessments: climate change allowances (February 2016)’. Whilst both TS and AB noted that the LLRS benefits from planning permission and acknowledged that the 2016 guidance would not need to be applied ‘retrospectively’, the FRA prepared for the Millbrook Power scheme should comply with the 2016 guidance. It was noted that the current guidance requires that a rainfall intensity allowance of between 10% and 20% is adopted (based upon a project design life of c.25 years). SH confirmed that the	

	LLRS surface water drainage strategy had been designed using a 30% increase in rainfall intensity and it was therefore agreed that the strategy was robust when reviewed within the context of the current climate change allowances guidance (i.e. such that the Millbrook Power Project would not need to bring forward additional mitigation for surface water run-off). In respect of peak river flow allowances, it was noted that the current guidance requires that an allowance of between 20% and 35% is adopted. SH confirmed that the modelling analysis undertaken in 2010 and the draft FRA prepared in 2014 assessed the implications of a 20% increase in flood flows within the Mill Brook and its tributary. TS and AB suggested that model sensitivity testing was undertaken to establish the impacts of a 35% increase in flood flows upon flood water influx to Rookery South Pit (i.e. whether the balancing pond offers adequate capacity to accommodate additional inflows).	
10.	**Water Framework Directive** AB queried whether a Water Framework Directive (WFD) compliance assessment was being prepared in support of the DCO application. SH explained that this had not been identified as a requirement following EIA scoping and stakeholder consultation completed previously (2014). AB noted that the Mill Brook watercourse outfalls to Stewartby Lake, a WFD designated water body, and will therefore consult the EA to establish whether a WFD compliance assessment is required in this instance and, if so, the scope required.	AB
11.	**AOB** AB suggested that a multi-disciplinary ‘follow-up’ meeting/workshop may be beneficial to ensure the various technical strands are ‘joined up’, there are no conflicting/competing requirements, etc.	

Stuart Harwood

From: Trevor Skelding <Trevor.Skelding@idbs.org.uk>
Sent: 14 January 2015 10:58
To: Stuart Harwood
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds

Stuart

I confirm that this record of the points discussed is correct in respect of the IDB.

Regards

Trevor Skelding MSc IEng MICE
Principal Engineer
The Bedford Group Of Drainage Boards
01234 767995

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 14 January 2015 10:29
To: Baldock, Hayley M; Trevor Skelding
Cc: Chris Leach
Subject: Millbrook Power, Rookery Pit, Stewartby, Beds
Importance: High

Hayley/Trevor,

Please find attached a copy of the notes prepared following our meeting in respect of the above on 12th December 2014.

We would be grateful if you would confirm that the attached constitutes an accurate record of the points discussed/agreed, etc. Should you consider that the notes require amending or wish to offer further comment regarding flood risk/water management matters, please feel free to call.

Hayley – you will note that the penultimate paragraph under Item 6 (flood risk associated with the Mill Brook) refers to the hydraulic modelling analysis undertaken in 2010 and the fact that this assessment, submitted in support of the FRA, would have been reviewed/audited by the EA. Consultation in respect of the Rookery South Resource Recovery Facility was dealt with under your reference   AC/2010/113063/02-L01   (IPC Application Reference EN01011) – we would be grateful if you would refer back to your records and confirm that the 2010 modelling analysis was indeed reviewed and deemed 'fit for purpose', etc.

Thanks and regards,

Stuart.

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
11 Prospect Court, Courteenhall Road, Blisworth, Northampton, NN7 3DG
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From: Stuart Harwood
Sent: 05 December 2014 11:01
To: 'Baldock, Hayley M'; Trevor Skelding
Subject: Millbrook Power, Rookery Pit, Stewartby, Beds
Importance: High

Hayley,

Thanks for the confirmation.

As discussed, PBA previously undertook a detailed assessment of the baseline environment from a flood risk perspective in 2010 in support of the Covanta energy from waste proposal. We subsequently prepared the FRA in support of the DCO application for the Covanta facility (located within the north-west area of Rookery South Pit). This included (i) hydraulic modelling to assess the nature of flood risk associated with the Mill Brook and its tributary and (ii) details of a surface water management strategy to serve development within the Pit. You will note that Rookery Pit is subject to an ongoing Low Level Restoration Scheme (LLRS). As these works are being implemented prior to construction of the Millbrook Power scheme, the LLRS therefore constitutes the 'baseline' for the purposes of EIA and preparation of the FRA (as per the Covanta scheme).

The Covanta scheme was to be located in the north-west of Rookery South Pit, whereas the Millbrook Power scheme is located in the south-west of the Pit, so the flood risk/water management issues are fundamentally the same. As far as we are aware, nothing has changed since 2010, so the 2010 technical assessment and associated design principles, parameters and flood risk mitigation works/strategy can be taken forward as the basis for the Millbrook scheme.

See link below to the FRA prepared in support of the Covanta scheme – this should set the scene and provide adequate background ahead of our meeting on 12th Dec.

http://infrastructure.planningportal.gov.uk/wp-content/ipc/uploads/projects/EN010011/2.%20Post-Submission/Application%20Documents/Reports/Flood%20Risk%20Assessment%20-%20Appendices.PDF

As below, the purpose of the meeting is to 're-cap' on matters, ensure that any 'new' information is identified and ensure that we are all 'on the same page' in respect of the issues to be addressed and the scope of technical assessment required in respect of flood risk and wider water management matters.

Happy to discuss should you have any queries or require additional info, etc, ahead of the meeting.

Thanks and regards,

Stuart.

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
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w www.peterbrett.com

From: Baldock, Hayley M [mailto:hayley.baldock@environment-agency.gov.uk]
Sent: 05 December 2014 09:47
To: Stuart Harwood; Trevor Skelding
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds

Hi Stuart/Trevor,

Thank you for amending the date for this. 10am would be great for me at the IDB's offices.

See you both then.

Kind regards

Hayley Baldock (nee Newcombe)
FCRM Officer, Partnerships and Strategic Overview Team
Cambridgeshire and Bedfordshire Area
☎ Phone: (Ext.) 01480 483960 (Int.) 7 50 3960
E-mail: hayley.baldock@environment-agency.gov.uk

Please note that I will not normally be in the office on Tuesday's

---

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 04 December 2014 17:27
To: Trevor Skelding
Cc: Baldock, Hayley M
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds

Thanks Trevor.

Hayley – see below – would be grateful if you could confirm attendance on the 12th Dec (am) at the IDB's offices in Stewartby and a time that suits (9.30/10.00 ?)

Thanks both.

Regards,

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
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From: Trevor Skelding [mailto:Trevor.Skelding@idbs.org.uk]
Sent: 04 December 2014 16:34
To: Stuart Harwood
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds

Stuart

Morning of the 12th is possible.

Regards

Trevor Skelding MSc IEng MICE
Principal Engineer
The Bedford Group Of Drainage Boards
01234 767995

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 04 December 2014 15:22
To: Trevor Skelding
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds
Importance: High

Trevor,

Hayley Baldock at the EA is available on 12th and 15th Dec – are you available for either of these dates ?

I think there would be some value in a 'joint' meeting (EA & IDB) if we can find mutually convenient dates. Alternatively we'll need to run with separate mtgs as we need to complete stakeholder consultation by the Xmas break.

Thanks,

Stuart.

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
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From: Trevor Skelding [mailto:Trevor.Skelding@idbs.org.uk]
Sent: 02 December 2014 16:08
To: Stuart Harwood
Subject: RE: Millbrook Power, Rookery Pit, Stewartby, Beds

Stuart

Monday 8th and Thursday 11th are available.

Regards

Trevor Skelding MSc IEng MICE
Principal Engineer
The Bedford Group Of Drainage Boards
01234 767995

From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 02 December 2014 16:03

To: hayley.baldock@environment-agency.co.uk
Cc: Trevor Skelding
Subject: Millbrook Power, Rookery Pit, Stewartby, Beds
Importance: High

Hayley,

Further to the e-mail below, I have spoken with Paul Henderson and understand that you now deal with flood risk matters associated with sites/proposals in the Bedford/Marston Vale area.

You will note from the e-mail below that we are seeking to convene a joint meeting with both the EA and the Bedford Group of Drainage Boards to discuss the scope of FRA required in respect of the Millbrook Power project. It would therefore be appreciated if you could confirm your availability to attend a meeting at the IDB's Stewartby office during the weeks commencing 8th and 15th of December. We understand that the Agency will levy a fee for pre-application advice and would be grateful if you could confirm fees for attendance at a meeting so that we may seek client approval in advance (we would anticipate a meeting of no more than 2hrs, plus your travel time).

Trevor – apologies, we will need to cancel the meeting scheduled for this Thursday 4th Dec. Could you confirm your availability for the weeks as above – thanks.

Should you have any queries or wish to discuss, please feel free to call.

Thanks and regards,

Stuart.

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
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From: Stuart Harwood [mailto:SHarwood@peterbrett.com]
Sent: 18 November 2014 10:06
To: Trevor Skelding; John Oldfield; Henderson, Paul (paul.henderson@environment-agency.gov.uk)
Subject: Millbrook Power, Rookery Pit, Stewartby, Beds

Gents,

PBA has been appointed to prepare the EIA in respect of the DCO application for the above. As part of this work we are also preparing the Flood Risk Assessment, which will comprise an appendix to the relevant ES chapter.

You may recall that PBA previously prepared the FRA in support of the DCO application for the Covanta Resource Recovery Facility (located within the north-west area of Rookery South Pit). This included (i) hydraulic modelling to assess the nature of flood risk associated with the Mill Brook and its tributary and (ii) details of a surface water management strategy to serve development within the Pit. You will note that Rookery Pit is subject to an ongoing Low Level Restoration Scheme (LLRS). As these works are being implemented prior to construction of the Millbrook

Power scheme, the LLRS therefore constitutes the 'baseline' for the purposes of EIA and preparation of the FRA (as per the Covanta scheme).

We are progressing the technical work in accordance with the scope, design principles and parameters previously agreed with both the EA and IDB in respect of the Covanta scheme. However, given the time that has elapsed since this work was undertaken (2010), it would seem appropriate to convene a joint meeting to 're-cap' on matters, ensure that any 'new' information is identified and ensure that we are all 'on the same page' in respect of the issues to be addressed and the scope of technical assessment required in respect of flood risk and wider water management matters. It would therefore be appreciated if you could confirm your availability to attend a meeting during the first two weeks of December (1^{st} – 12^{th}).

Trevor/John – would it be possible to hold the meeting at your offices in Stewartby ?

In terms of attendees, and in addition to yourselves, I would anticipate no more than x2 PBA staff and x1 representative from the client team.

Should you have any queries or wish to discuss, please feel free to call.

Thanks and regards,

Stuart.

Stuart Harwood
Associate

For and on behalf of Peter Brett Associates LLP
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MINUTES

Meeting Title:	Millbrook Power, Bedfordshire
Attendees:	Hayley Baldock (EA), Trevor Skelding (Beds IDB), Stuart Harwood (PBA)
cc:	Chris Leach (PBA), Nick Johnson (Millbrook Power Limited)
Date of Meeting:	12th December 2014
Job Number:	31116-3007

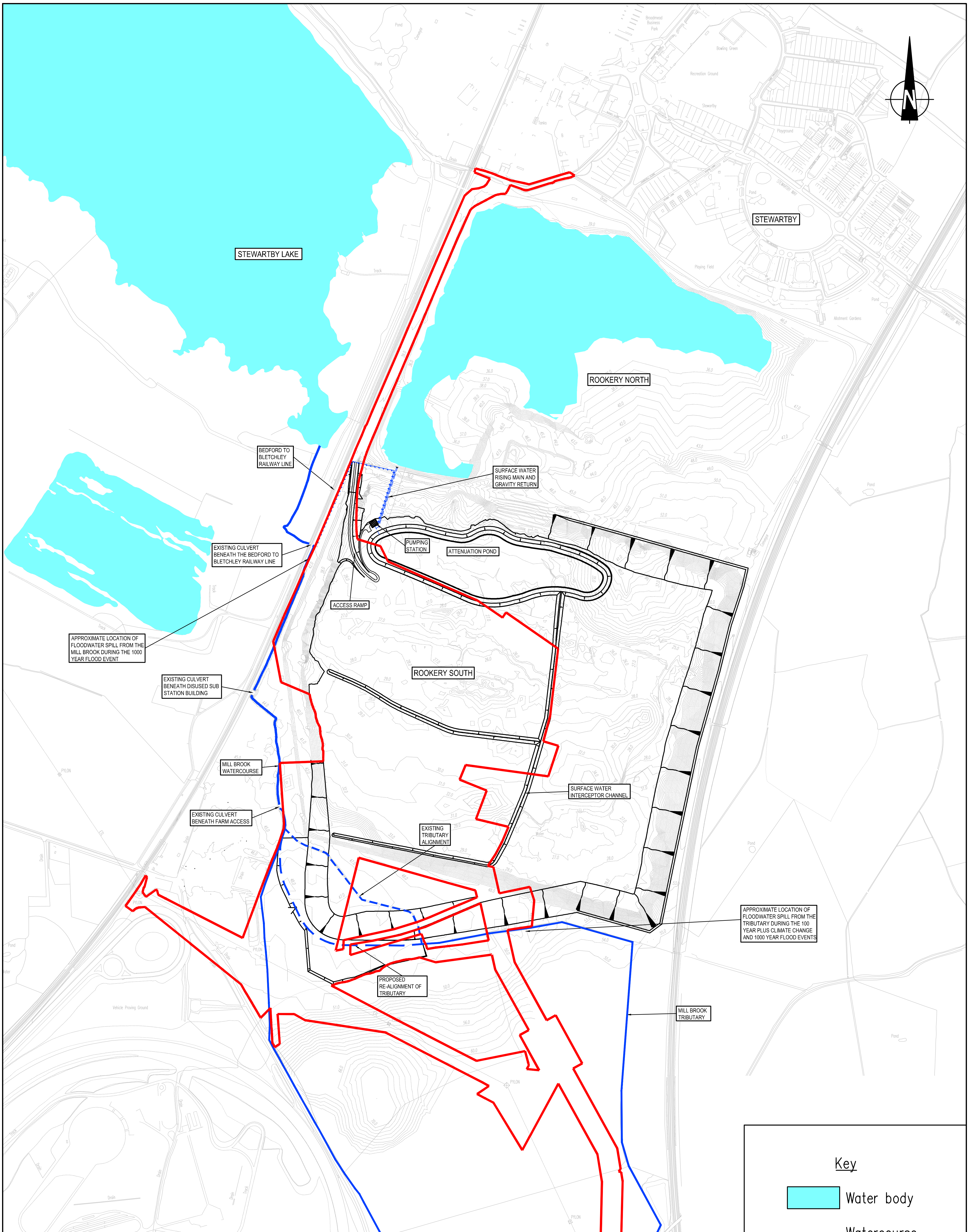
Item	Subject	Actions
1.	**Background/Introduction** SH explained that the purpose of the meeting was to: • provide the EA and IDB with an overview of the project; • set out and agree the design principles and parameters to be taken forward in respect of flood risk and surface water management; • agree the scope of the Flood Risk Assessment to support the DCO application.	
2.	**Roles/Responsibilities** HB and TS confirmed the scope/extent of both the EAs and IDBs remit in the area. TS confirmed that the IDB was principally interested in the nature of the surface water pumping regime from Rookery Pit (to the Mill Brook watercourse bordering the western boundary of the Pit) and ensuring that any pumping continued in accordance with the terms of the existing consent to discharge (which permits pumping at a rate of 23l/s). It was noted that Central Beds Council, as LLFA, has a remit that extends to include surface water (as set out in the Flood and Water Management Act). Given the current 'transitional' period regarding allocation of roles/responsibilities relating to flood risk management, HB confirmed that the EA would assess/review the FRA in its wider sense, considering flood risk associated with watercourses and surface water management. It was also noted that any works (permanent or temporary) to the watercourses bordering Rookery Pit would require consent. Consent applications are dealt with by the IDB on behalf of Central Beds Council.	
3.	**Site and Project Description** SH provided a description of The Rookery (north and south - former clay pits) and an overview of the principal components of the project by reference to the information, figures, etc, included within the Preliminary Environmental Information Report (provided on the Millbrook Power website: http://www.millbrookpower.co.uk/). The generating equipment (x5 turbines), 400kv sub-station,	

	electrical connection and gas connection were highlighted. SH explained that the project constitutes a Nationally Significant Infrastructure Project pursuant to the 2008 Planning Act and therefore requires development consent under that Act. PBA has been appointed to prepare the Environmental Statement and associated Flood Risk Assessment in support of the application for a Development Consent Order (DCO).	
4.	**Low Level Restoration Scheme** SH explained that The Rookery is the subject of a Low Level Restoration Scheme (LLRS) and that, once restored, Rookery South (the location of the Millbrook Power project), would be approximately 15m below the surrounding ground level. SH explained that the principal works associated with the LLRS comprise: • Re-profiling of the base of the pit to create a platform graded to fall to the north; • Implementation of a surface water drainage system, comprising a balancing pond, network of interceptor channels and pumping station; • Buttressing of the pit slopes; • Provision of access ramps; • Landscaping works/planting around the pit edge and balancing pond. It was noted and agreed that, as the LLRS is to be implemented/completed prior to any development within Rookery South Pit, the LLRS constitutes the 'baseline' for the purposes of the EIA and preparation of the FRA for the Millbrook Power project.	
5.	**Surface Water Management** SH explained that the LLRS drainage scheme comprises/operates as follows: • Surface water collecting in the balancing pond will be pumped to (i) Rookery North at a rate of 100l/s and (ii) the Mill Brook at a rate of 23l/s (as per the terms of the existing Consent to Discharge); • The water level in Rookery North will be drawn down by approximately 1m; • Water from Rookery North will return to the balancing pond in Rookery South via a gravity connection at a rate of no more than 23l/s. • By using Rookery North as a strategic stormwater storage facility, the balancing pond would return to its normal water level approximately 12 days after the 1 in 100 year plus climate change event. SH explained that, in respect of design parameters, the base and side-slopes of Rookery South are assumed to be 100% impermeable and the sizing of the balancing pond has been undertaken using catchment-specific rainfall parameters derived from the Flood Estimation Handbook (FEH).	

	The balancing pond has been sized to accommodate rainfall events up to and including the 1 in 100 year event including climate change and comprises a retained water depth of 0.5m. As the LLRS design has been prepared assuming the Pit to be 100% impermeable and the Millbrook Power project falls within the catchment of the Pit, it was agreed that the LLRS drainage strategy offers adequate capacity to accommodate surface water run-off from the Millbrook Power project, such that no additional mitigation would be required in respect of surface water run-off control. SH explained that design of the surface water strategy caters for residual risk scenarios comprising (i) the 1 in 100 year plus climate change event and a period of pumping station failure (pumps off-line for 3 days) and (ii) a "follow-on" event - a 1 in 10 year plus climate change event occurring within 1 week of the 1 in 100 year plus climate change event. The pond has been sized to provide sufficient residual capacity above that required for the 1 in 100 year plus climate change event to accommodate both residual risk scenarios. On this basis, it was agreed that the design of the drainage strategy is robust. In terms of details/commentary to be included within the FRA for the Millbrook Power project, HB agreed that a scope similar to that set out in the document prepared in support of the Covanta RRF scheme would be appropriate.	
6.	**Flood Risk Associated with Mill Brook** SH explained that a HEC-RAS hydraulic model of the Mill Brook and its tributary (running along the southern fringe of Rookery South Pit) had been developed as part of PBA's previous work (to inform design of the LLRS (2008) and the FRA for the Covanta RRF scheme (2010)). The analysis had shown that floodwater would 'spill' into Rookery South Pit from a localised area of the tributary, albeit at a relatively low rate (peak spill rate of approx. 0.2m^3/s). SH explained that, as per the LLRS proposals, floodwater will be allowed to spill into the pit as per the "existing" situation, but will be "managed" by being intercepted and conveyed to the attenuation pond. SH confirmed that the surface water drainage channels and attenuation pond being brought forward as part of the LLRS had been designed to accommodate floodwater influx from the Mill Brook tributary. In addition, it was noted that the 'raised' platform created by the LLRS works will be such that the site of the Millbrook Power project will be elevated above water levels within the balancing pond and associated drainage channels, etc. On this basis, it was agreed that the project site would be adequately safeguarded from flooding, such that no further mitigation works would be required as part of the project. In terms of the flood zone classification of the project site post implementation of the LLRS, it was noted that the 2010 assessment indicated that the raised platforms within Rookery South Pit would	

	be classified as Flood Zone 2. It was agreed that the Millbrook Power project site could most likely be classified as Flood Zone 1 (low probability of flooding) – the hydraulic model to be used to confirm. SH explained that consideration of the 1,000 year event in 2010 had shown that floodwater may spill over the eastern bank of the Mill Brook immediately upstream of the culvert beneath the railway (in the vicinity of the north-west corner of the Covanta RRF site). Given the distance from the Millbrook Power site, coupled with the topography across the base of the Pit following implementation of the LLRS, HB agreed that mitigation measures would not need to be brought forward as part of the Millbrook Power project. (It was also noted that measures had been incorporated within the design of the Covanta RRF scheme to cater for this floodwater spill). The requirement to divert the lower reach of the Mill Brook tributary was noted and SH advised that the diverted reach had been designed to convey 100 year plus climate change flood flows 'in bank'. TS and HB confirmed this is an adequate design standard. TS confirmed that the IDB would deal with any consent applications for watercourse works on behalf of CBC. SH highlighted the fact that the hydraulic modelling analysis dates to 2010 and that the FEH method has evolved/been updated in the interim. It was agreed that the 2010 hydrology/assessment of Mill Brook flood flows should be reviewed/validated. HB agreed that, where the updated, 2014 analysis provides flow estimates that are less than or equal to the 2010 estimates, it would not be necessary to revisit the hydraulic modelling analysis (i.e. the 2010 modelling data/output could be taken forward and used to inform the FRA). It was noted that the hydraulic model files had been submitted to the EA as part of the 2010 Covanta RRF FRA and HB advised that the EA would ordinarily review/audit such work to ensure it is 'fit for purpose', etc. HB agreed to check the EA's records. HB advised that consideration should be given to provisions for maintenance of the flood risk/surface water management infrastructure – outline details of the options available should be set out in the FRA (the detail to be brought forward at a later date as part of conditions, etc).	
7.	**Summary** It was agreed that little had changed in the time that has elapsed since PBA's previous (2008 and 2010) assessments, such that this work and associated design principles/parameters, etc, could be taken forward as the basis for the Millbrook Power project. It was also agreed that, as the LLRS scheme and associated flood risk/surface water management strategy is essentially 'fixed' (and caters for the site of the Millbrook Power project) no additional flood risk related mitigation works will need to be brought forward as part of the Millbrook Power project.	

Appendix D Hydraulic Modelling



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Client: Millbrook Power

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.
UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

MILLBROOK POWER PROJECT

WATERCOURSES AND DRAINAGE FEATURES CONTEXT PLAN

Mark	Revision	Drawn	Date	Chkd

Drawing Status: FLOOD RISK ASSESSMENT

Date of 1st Issue	03.02.15
A3 Scale	NTS
Drawn by	DB
Checked by	SH

Drawing Number: FIGURE 2
Revision: -

TECHNICAL NOTE

Job Name:	Millbrook Power Project
Job No:	31116
Note No:	31116/3014/TN01
Date:	27/01/2015
Prepared By:	Sarah Kirby
Reviewed By:	Stuart Harwood
Subject:	**Hydrological and Hydraulic Modelling**

Item	Subject
1.	**INTRODUCTION** Peter Brett Associates has been appointed by Millbrook Power Limited to prepare a Flood Risk Assessment (FRA) in support of an application for a Development Consent Order relating to the construction of a power generation plant. The proposed plant is located in The Rookery, comprising two former clay pits (Rookery North and South). The Mill Brook watercourse flows in a northerly direction along the western flank of Rookery South Pit and a tributary of the Brook, draining a catchment to the south of the Pit, joins the Mill Brook in the vicinity of the south-west corner of the Pit. Environment Agency floodplain maps do not extend to include the Mill Brook or its tributary on account of the small size of the contributing catchment areas. The nature of flood risk associated with the Mill Brook and its tributary was originally assessed in 2008 in support of a planning application relating to the Review of Old Mineral Permissions (ROMP), which set out details of a Low Level Restoration Scheme for the Rookery Pits. Flood risk was assessed by developing a HEC-RAS hydraulic model using topographic survey of Rookery South Pit and the watercourse corridor. This study was subsequently refined and updated in 2010 in support of proposals for development within the north-west area of Rookery South Pit and following further, more detailed survey of the watercourse corridor. Following consultation with the EA and Bedford Group of Drainage Boards in December 2014, it was agreed that the 2010 study provides the best available data in respect of flood risk associated with the Mill Brook and its tributary, such that it should be taken forward and used to inform the FRA prepared in support of the Millbrook Power Project. However, it was noted that in the time that has elapsed since the 2010 study was concluded, the Flood Estimation Handbook (FEH) methodology and associated database (used to estimate flood flows for the purposes of hydraulic modelling) has been revised/updated. It was therefore agreed that the 2010 assessment of flood flows should be reviewed/validated. The 2014 appraisal concluded that the 2014 flood flow estimates were lower than those derived in 2010, such that it was not necessary to revisit the 2010 hydraulic modelling analysis. The DCO submission is now to be made towards the end of this year and following re-consultation with both the IDB and LLFA (July 2017), they have requested that a further review of the hydrology is undertaken to establish whether 2017 flood flow estimates are higher/lower than those derived in 2010. This Technical Note sets out a summary of (i) the revised and updated FEH analysis and (ii) the scope of hydraulic modelling analysis undertaken as part of the 2010 and 2014 studies.

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2.	**HYDROLOGY**

A hydrological and hydraulic modelling assessment of the Mill Brook and its tributary was carried out in 2010. Flood flows were estimated using the ReFH methodology and the appraisal found that the contributing catchment extended to include an additional area outside the FEH catchment boundary. Both the catchment area and URBEXT descriptors were therefore amended accordingly.

Both the EA and IDB have been consulted and have confirmed that there have been no changes within the catchment that would impact upon the hydrological analysis. However, as noted above, the FEH methodology and associated database has been revised/updated in the time that has elapsed since the 2010 and 2014 studies Catchment hydrology has therefore been re-assessed to establish whether the flood flows estimated in 2010 may be taken forward and used to inform the FRA prepared in support of the Millbrook Power Project.

Flood estimation has been based upon the Flood Estimation Handbook Statistical (FEH) methodology and ReFH methodology.

Catchment Delineation & Modelling Approach

Flows have been estimated at the downstream extent of the reach of watercourse represented in the hydraulic model - at the culvert beneath the Bedford to Bletchley/Marston Vale railway line, as per the 2010 assessment (see **Figure 1**). The FEH catchment was derived at grid reference 501085, 241335 using the new FEH web service (https://fehweb.ceh.ac.uk/) . The total catchment area as defined by FEH is 3.49km^2 (red outline shown in **Figure 2**) and the tributary catchment is 1.49km^2 (green outline shown in **Figure 2**).

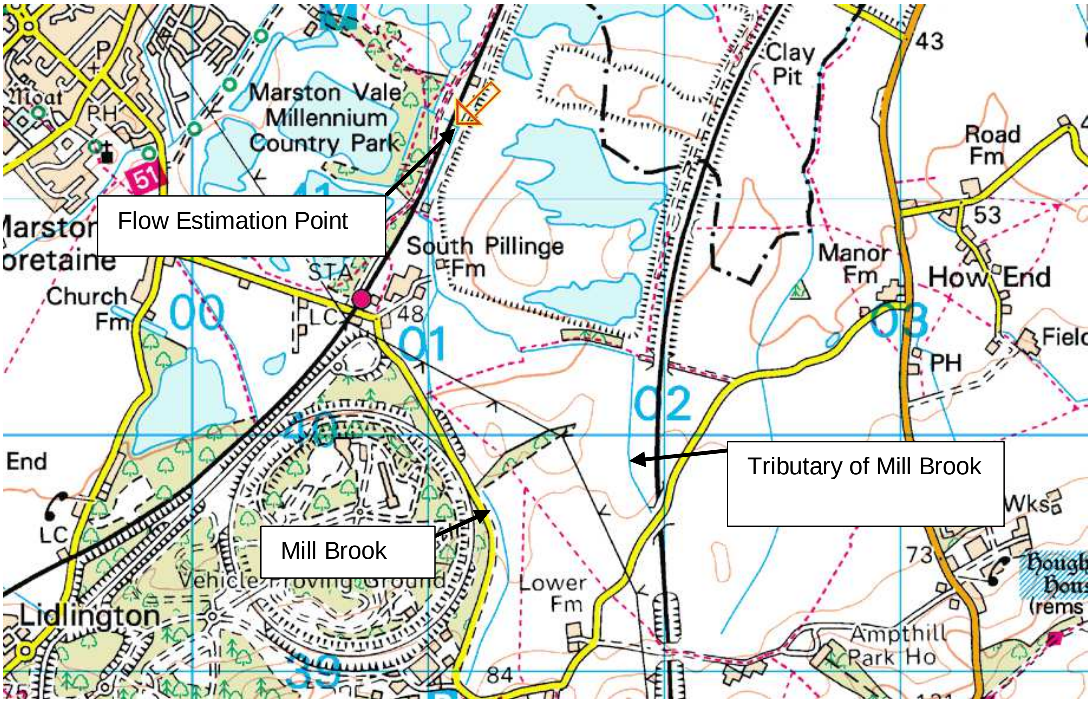

Figure 1 – Flow Estimation Point
Contains Ordnance Survey Data (Crown Copyright, 2015)

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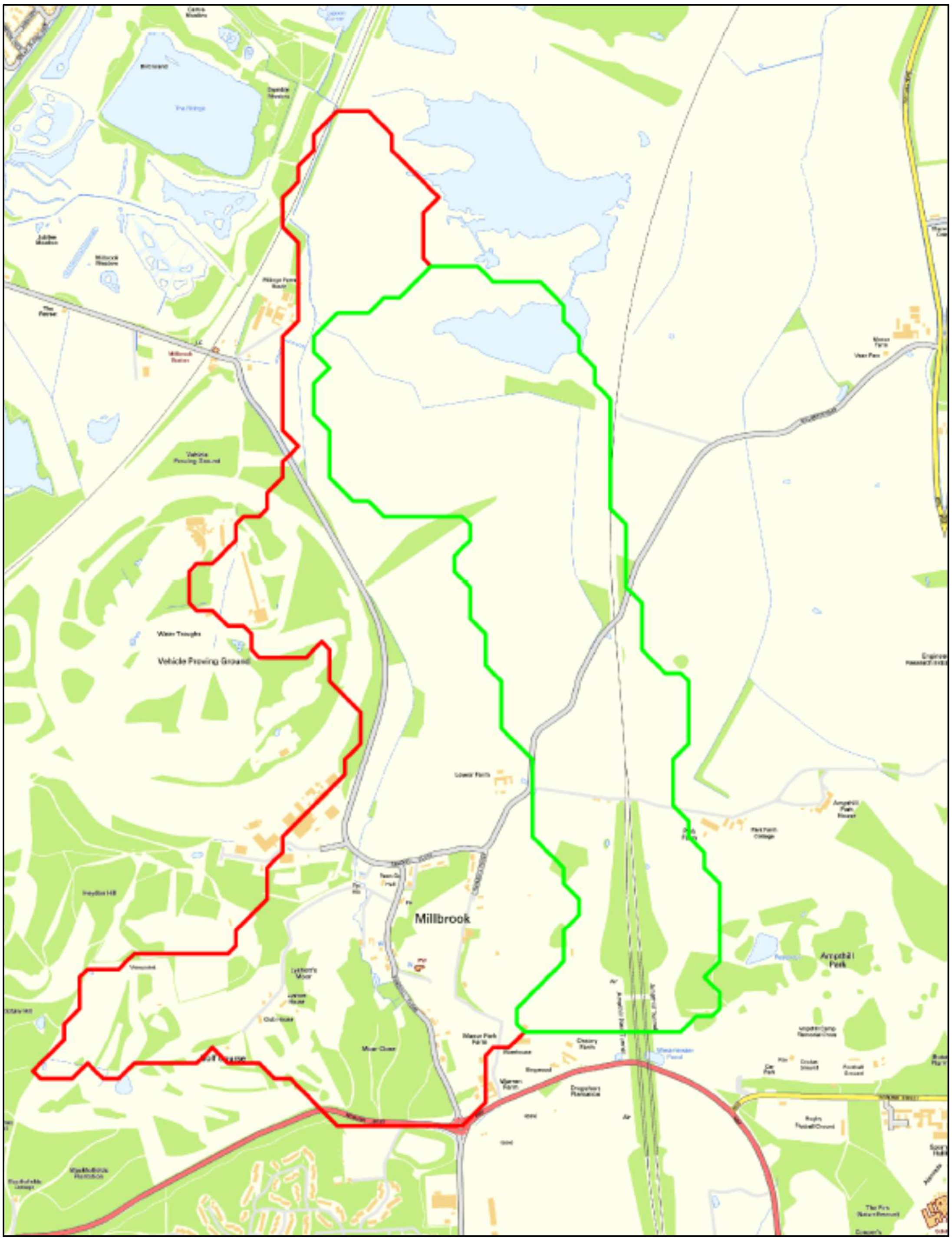
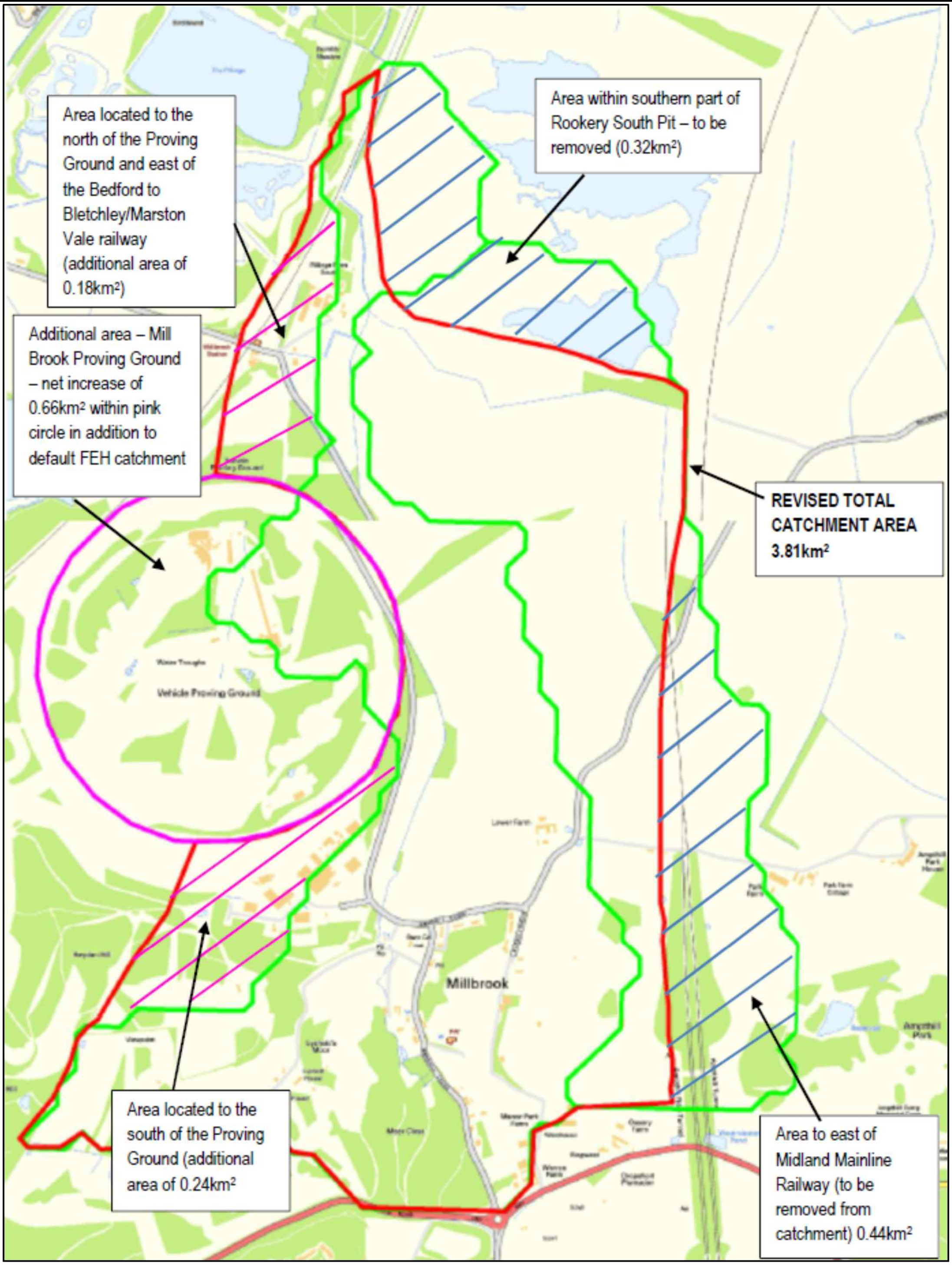


Figure 2 – FEH Web Service https://fehweb.ceh.ac.uk/ - Mill Brook catchment (red) and Mill Brook tributary sub-catchment (green)
Contains Ordnance Survey Data (Crown Copyright, 2017)

Item	Subject
	The FEH catchments were reviewed against 1:25,000 scale OS mapping, historical mapping and based upon site observations. This identified two areas that fall outside the FEH catchment boundary and which should therefore be removed from the catchment area (shown as blue hatched areas on **Figure 3**). These include: • Area to the east of the Midland Mainline railway (0.44km²) • Area within the southern part of Rookery South Pit (0.32km²) In addition, the FEH defined catchment does not include several areas which were found to fall within the contributing catchment of the Mill Brook (i.e. such that the catchment should be modified to include these areas): • Additional area associated with the Millbrook Vehicle Proving Ground (highlighted in pink in **Figure 3** and totalling an area of 0.85km². (Default FEH catchment included 0.19km² of the Millbrook Proving Ground , such that the 'net' addition is 0.66 km²). • Area located to the north of the Proving Ground and east of the Bedford to Bletchley/Marston Vale railway (highlighted in pink hatching and totalling an area of 0.18km²) • Area immediately to the south of the proving ground (highlighted in pink hatching and totalling an area of 0.24km²) **Figure 3** below shows the revised catchment area in bold red and also includes the proving ground highlighted in pink. The original default FEH catchments can be seen in the background (in green). The 2014 revised total catchment area of the Mill Brook is 3.81km² (revised FEH total catchment of 3.15km² plus the 0.66km² Proving Ground area) and the revised tributary catchment is 0.86km². The 2010 assessment used a catchment area of 4.49km² for the Mill Brook and 1.49km² for the tributary catchment. The 2014 amended catchment areas have been taken forward in this assessment.

Item	Subject
	 Figure 3 – Revised catchment areas Contains Ordnance Survey Data (Crown Copyright, 2017) The 2010 assessment included a detailed assessment of the urban/suburban areas within the FEH catchment and proving ground area. Ordnance Survey mapping was used to determine that approximately 2% of the proving ground area was urban and 2% was suburban (in accordance with FEH definitions). Of the FEH catchment, approximately 0.8% of the catchment was deemed to be urban and approximately 1% of the catchment was deemed to be suburban.

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	Using equation 6.2 from FEH Volume 5 ($URBEXT = URB_{EXT} + 0.5SUBURB_{EXT}$) the URBEXT value for the Proving Ground was estimated to be 0.03 and for the FEH catchment was 0.013.

There has been no change in the urban extent since the 2010 or 2014 assessment (as confirmed by a review of up to date aerial imagery and mapping) and therefore there was no need to update these URBEXT values.

In order to determine the updated URBEXT value for the updated total catchment at the downstream extent of the modelled reach, area weighting (as per the methodology outlined in Section 7.2.2 of FEH Volume 5) was used to combine the FEH catchment and Proving Ground URBEXT values based on the parameters shown in **Table 1** (using the revised catchment areas outlined above)

Catchment Area	Area (km^2)	URBEXT value	Fraction of Combined Catchment
FEH Catchment	3.15	0.013	0.83
Proving Ground	0.66	0.03	0.17

Table 1 Area Weighting Parameters

Using the methodology outlined in FEH Volume 5, the updated URBEXT value for the total catchment was estimated to be 0.0159.

The other catchment descriptors (apart from DPLBAR) are not area dependent and therefore the revised catchment area would not result in any significant changes to the FEH descriptors. The DPLBAR value based on the revised catchment area of 3.81km^2 would decrease slightly and therefore the original FEH value was used.

The key catchment descriptors are shown in **Table 2** (with revised AREA and URBEXT values). The SPRHOST and BFIHOST values indicate that the catchment is not permeable.

Catchment Descriptor	Downstream Extent – Mill Brook
AREA	**3.81**
BFIHOST	0.41
DPLBAR	2.51
DPSBAR	54.5
FARL	0.999
FPEXT	0.131
PROPWET	0.27
SAAR	594
SPRHOST	49.16
$URBEXT_{2000}$	**0.0159**

Table 2 FEH webservice Catchment Descriptors for Mill Brook (with amended AREA and URBEXT)

ReFH Flow Estimation

The ReFH method can be used to provide peak flows and also hydrographs. Parameters in the ReFH model are derived from catchment descriptors.

Since the 2014 ReFH assessment, ReFH2 software has been released that uses the updated FEH2013 DDF rainfall data and this has been used to generate hydrographs. Hydrographs were derived at the downstream extent of the reach of watercourse represented in the hydraulic model - at the culvert beneath the Bedford to Bletchley/Marston

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	Vale railway line, as per the 2010 assessment. Several storm durations have been considered for the 1% annual probability (1 in 100 year) event to identify the critical storm duration. For this analysis, the 7 hour storm is shown to produce the highest peak flow using a time-step of 1 hour. **Table 3** provides a summary of the peak flows estimated using the ReFH2 method. The hydrograph outputs from ReFH2 are included in **Appendix A**.

Return Period	Flow (m^3/s)
2	1.14
5	1.51
10	1.78
20	2.06
50	2.54
100	3.06
200	3.80
1000	5.84

Table 3 – ReFH2 Flows for downstream extent of Mill Brook

FEH Statistical Estimation

QMED Estimation

QMED was calculated using the updated QMED equation for rural catchments based on standard FEH relationships, as follows:

$$QMED = 8.3062 AREA^{0.8510} 0.1536^{\frac{1000}{SAAR}} FARL^{3.4451} 0.0460^{BFIHOST^2}$$

This yields QMED $_{cds\ ss\ rural}$ (the as rural QMED estimate for the total rural catchment based upon FEH catchment descriptors). The calculated QMED $_{cds\ ss\ rural}$ for the downstream extent of the Mill Brook is $0.66m^3/s$. The $URBEXT_{2000}$ value is below the threshold at which FEH recommends an urban adjustment is made ($URBEXT_{2000}$>0.03) and therefore no urban adjustment was applied to the QMED.

The FEH highlights that the validity of the QMED value estimated simply from catchment descriptors can be improved by using a data transfer procedure. EA Guidance on *Improvements to the Flood Estimation Handbook statistical method*, published in July 2008, identifies the need to find a single donor site to adjust the QMED estimate that is both hydrologically similar and geographically close. In this instance no suitable donor stations were found that are hydrologically similar and geographically close (within 30km) and therefore a donor adjustment was not made to the QMED estimate.

Derivation of Pooled Growth Curve

WINFAP-FEH Version 3 and HiFlows data version 5 were used in this hydrological analysis. WINFAP-FEH was used to identify hydrologically similar gauged sites, define a pooling group at the downstream extent of the reach and derive a flood frequency curve for the reach. The initial pooling group was defined with a target of 700 station years of data (on account of the likelihood that a number of catchment gauging station records may need to be removed during the pooling group review process). The default pooling group is shown in **Appendix A**.

The pooling group was created using HiFlow dataset 'Sites suitable for Pooling':

Item	Subject
	Derivation of Flood Frequency Curve The flood frequency curve provides estimates of design flood flows for a range of flood return periods and is derived by factoring up the estimate of QMED using the pooled growth curve fittings. In this instance, the default pooling group was used as a comparison to ReFH flows. In this instance the $URBEXT_{2000}$ value is less than 0.03 and therefore an urban adjustment was not applied to the flood frequency curve. The 1 in 1000 year flow was obtained from WINFAP by selecting further return periods before calculating the growth factors. The resulting flood frequency curve is presented below in **Table 4** along with the ReFH flow estimates.

Return Period (yrs)	FEH Statistical Flow Estimates - Default Pooling Group		ReFH Flow Estimates (m^3/s)
	Growth Curve Fittings	Flood Frequency Curve (m^3/s)	
2	1.00	0.66	1.14
5	1.40	0.92	1.51
10	1.69	1.11	1.78
20	2.01	1.32	2.06
50	2.50	1.64	2.54
100	2.93	1.92	3.06
200	3.42	2.25	3.80
1000	4.91	3.23	5.84

Table 4 – Default Flood Frequency Curve for downstream extent of Mill Brook

As the ReFH peak flows were greater than the default pooling group flows no further modifications to the pooling group were made and no further FEH Statistical assessment was completed. In accordance with the latest EA Flood Estimation Guidelines (2015) ReFH is generally preferred for smaller catchments as uncertainties exist in pooling via WINFAP for normal (i.e. non permeable, non-urban) small catchments.

3. **SUMMARY AND CONCLUSIONS**

The peak ReFH flows for the 2010 and 2017 assessments are shown in **Table 5**.

Return Period	2010 Flow (m^3/s)	2017 Flow (m^3/s)
100	3.3	3.06
100 + 20%	3.96	
100 + 35%		4.13
1000	5.9	5.84

Table 5 – Comparison of ReFH peak flows (2010 and 2017 assessments)

It can be seen that the flood flow estimates based upon the current (2017) methodology and parameters are lower than those derived in 2010 for the 100 year and very similar for the 1,000 year. The peak flow estimate for the 2017 1 in 100 year plus climate change scenario is higher than that adopted in 2010 (on account of the publication of new guidance requiring that a 35% up-lift is applied).

The flow estimates summarised in **Table 5** above relate to the total contributing catchment area taken at the culvert beneath the Bedford to Bletchley railway (i.e. comprising flows within the Mill Brook AND its tributary). For the purposes of the hydraulic modelling, inflows are derived by areal weighting of the 'lumped' flow estimates. A summary of the inflows derived by areal weighting for both the 2010 and 2017 assessments is presented in

Item	Subject
	Appendix A. The 2017 estimates of the tributary inflows are significantly lower than the 2010 estimates and the 2017 estimates of the Mill Brook inflows are higher than the 2010 estimates. This has arisen as a result of the adjustment of catchment areas discussed above, resulting in the tributary catchment now comprising a smaller proportion of the overall catchment (and the Mill Brook catchment therefore comprising a larger proportion of the overall catchment) than was the case in 2010. As a result, the areal weighting ratios have changed (in favour of the Mill Brook catchment). It is therefore concluded that further model sensitivity tests should be undertaken to quantify the impact of the revised flow estimates upon peak flood levels and floodwater discharge from the watercourses and into Rookery South Pit. A summary of the analysis undertaken is presented below.
4.	**HYDRAULIC MODELLING** The 2010 hydraulic assessment was undertaken using the HEC-RAS modelling software (Version 4.0.0) and using an 'unsteady' modelling approach on account of the fact that issues relating to floodwater storage and 'discharge/spill' from the watercourse system needed to be considered. The objective of the modelling was to derive a series of design flood levels and establish whether Rookery South Pit would be at risk of inundation as a result of flooding on the Mill Brook and its tributary during the 1 in 100 year and 1 in 100 year plus climate change flood events. **Schematisation** A model schematic plan is presented in **Appendix B** (Drawing No. 31116/3014/003) and shows model extents and the locations of cross-sections and hydraulic structures. The Mill Brook and its tributary both consist of a single channel which is represented as a series of river and structure cross-sections based upon topographic survey undertaken in 2009. The lower reach of the Mill Brook tributary is to be diverted as part of the LLRS. The diverted reach will consist of a trapezoidal channel profile with a base width of 2m, depth of 1.5m and top width of 6m. The diversion works will be implemented prior to construction of the Millbrook Power Project and details of the proposed channel configuration were therefore included in the HEC-RAS model. There are nine structures within the study area (as shown on **Drawing No. 31116/3014/003, Appendix B**). These structures are modelled as culverts, with the exception of Structure S2a, which is represented using a deck/roadway component within the model. Seven lateral structures (representing floodwater 'discharge/spill' from the watercourses) are included in the model (as shown on **Drawing No. 31116/3014/003, Appendix B**). The Mill Brook outfalls to Stewartby Lake approximately 400m downstream of the culvert beneath the Bedford to Bletchley/Marston Vale railway. The Bedfordshire and River Ivel Internal Drainage Board provided peak water level data for Stewartby Lake associated with historic flood events. However, the highest recorded water level within Stewartby Lake (35.71mAOD) does not extend to influence the modelled reach of watercourse. The downstream boundary of the hydraulic model is therefore based upon 'normal depth', calculated using the topographic survey.
5.	**RESULTS** The model provides a design series of flood levels for the 1 in 100 year and 1 in 100 year plus climate change events. The modelling analysis indicates that floodwater may discharge into Rookery South Pit during the 1 in 100 year event. This discharge occurs in a very localised area along the upper reach of the Mill Brook tributary at a peak rate of approximately 0.2m^3/s, giving rise to a volume of approximately 6,500m^3. Floodwater

Item	Subject
	discharge does not occur along the main branch of the Mill Brook – the minimum freeboard between the 100 year flood level and the discharge threshold being approximately 250-300mm along the reach immediately upstream of the culvert beneath the Bedford to Bletchley/Marston Vale railway. During the 1 in 100 year plus climate change flood event, the model indicates that discharge from the upper reach of the Mill Brook tributary increases marginally, resulting in a discharge volume of approximately 7,500m^3. Floodwater discharge does not occur along the main branch of the Mill Brook – the minimum freeboard between the 100 year plus climate change flood level and the discharge threshold being approximately 150-200mm along the reach immediately upstream of the Bedford to Bletchley/Marston Vale railway. A CD containing the model files is included in **Appendix B**.
6.	**SENSITIVITY ANALYSIS** Sensitivity analysis was undertaken to quantify the sensitivity of model results to (i) assumptions regarding model parameters and (ii) more extreme conditions than those considered above. The results associated with sensitivity testing for (i) Mannings ‘n’ plus 20% and (ii) partial blockage of the culvert beneath the Bedford to Bletchley/Marston Vale railway are summarised below. **Mannings ‘n’ +20%** Modelling analysis has shown that water levels may increase by up to approximately 100mm as a result of a 20% increase in Mannings ‘n’. This results in a marginal increase in the peak rate of floodwater discharge into Rookery South Pit from the upper reach of the Mill Brook tributary, such that the discharge volume increases by approximately 2,500m^3 for the 100 year event. **Structure Blockage** The culvert beneath the Bedford to Bletchley/Marston Vale railway constitutes a constriction to river flows. The potential impact of culvert blockage upon flood levels was simulated by blocking 50% of the opening area of the culvert. This test indicated that the water level immediately upstream of the culvert would increase by approximately 0.6m, thereby giving rise to floodwater ‘spill’ over the eastern bank of the Mill Brook. This increases the volume of floodwater discharge into Rookery South Pit by approximately 13,000m^3 when compared to the 100 year scenario without culvert blockage.
7.	**2017 REVIEW AND MODEL SENSITIVITY TESTING** As part of the 2014 review, catchment areas were revised/adjusted, resulting in the tributary sub-catchment comprising a smaller proportion of the overall catchment (and the Mill Brook sub-catchment therefore comprising a larger proportion of the overall catchment) than was the case in 2010. As a result, the areal weighting ratios applied to derive inflows changed, from approximately 70:30 (2010) to 80:20 (2017) in favour of the Mill Brook catchment. This, coupled with the fact that the 2017 lumped flow estimates for the total contributing catchment to the culvert beneath the railway are higher than those derived in 2014 (but marginally lower than those derived in 2010), means that (i) the 2017 estimates of the tributary inflows are lower than the 2010 estimates and (ii) the 2017 estimates of the Mill Brook inflows are higher than the 2010 estimates. Model sensitivity testing has therefore been completed (using the HEC-RAS modelling software Version 4.1.0) to quantify the impact of the revised flow estimates upon peak flood levels and floodwater discharge from the watercourses and into Rookery South Pit. This analysis has shown that the volume of floodwater discharge into the Pit during the 1 in 100 year plus climate change event is reduced from c.7,500m^3 to c. 5,000m^3. Similarly, floodwater discharge into the Pit during the 1 in 1,000 year event is reduced from c.21,000m^3 to c.16,000m^3. The reduction in discharge volumes occurs as a result of

Item	Subject
	reduced flows and therefore water levels within the tributary (resulting in a reduction in the duration of floodwater spill from the channel). Although flood flows within the Mill Brook are higher than the 2010 estimates, the right bank of the Brook is not readily overtopped, thereby constraining the magnitude/duration of floodwater discharge from the channel to Rookery South Pit.

DOCUMENT ISSUE RECORD

Technical Note No	Rev	Date	Prepared	Checked	Reviewed (Discipline Lead)	Approved (Project Director)
31116/3014/TN01	-	27.01.15	SK	SH	SH	PJ
31116/3014/TN01	A	12.08.17	SK	SH	SH	PJ

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Appendix A

Hydrological Assessment

Default Pooling Group Details

ReFH Hydrographs

Flow Summary

31116 MillBrook - Default PG 170803

Stations suitable for pooling

Station	Distance	Years of da	QMED AM	L-CV	L-SKEW	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.627	34	0.816	0.198	0.056	0.742
76011 (Coal Burn @ Coalburn)	1.786	38	1.84	0.165	0.331	1.601
27051 (Crimple @ Burn Bridge)	1.831	43	4.514	0.219	0.154	0.283
45816 (Haddeo @ Upton)	2.073	22	3.489	0.314	0.415	0.611
28033 (Dove @ Hollinsclough)	2.323	36	4.225	0.24	0.415	0.727
26802 (Gypsey Race @ Kirby Grindalythe)	2.334	16	0.112	0.274	0.274	0.312
25019 (Leven @ Easby)	2.38	37	4.989	0.342	0.39	0.866
20002 (West Peffer Burn @ Luffness)	2.659	41	3.299	0.292	0.015	1.494
49006 (Camel @ Camelford)	2.699	9	11.5	0.129	-0.252	2.724
47022 (Tory Brook @ Newnham Park)	2.717	22	7.227	0.262	0.093	0.718
25011 (Langdon Beck @ Langdon)	2.755	28	15.878	0.238	0.318	1.289
203046 (Rathmore Burn @ Rathmore Bridge)	2.784	33	10.77	0.136	0.104	0.761
27010 (Hodge Beck @ Bransdale Weir)	2.788	41	9.42	0.224	0.293	0.232
44008 (South Winterbourne @ Winterbourne Steeplet	2.854	36	0.434	0.418	0.344	1.949
25003 (Trout Beck @ Moor House)	2.885	42	15.142	0.172	0.293	0.698
36010 (Bumpstead Brook @ Broad Green)	2.93	48	7.545	0.37	0.178	1.619
71003 (Croasdale Beck @ Croasdale Flume)	2.931	37	10.9	0.212	0.323	0.456
206006 (Annalong @ Recorder)	2.999	48	15.33	0.189	0.052	1.888
22003 (Usway Burn @ Shillmoor)	3.02	13	16.17	0.282	0.311	1.373
72014 (Conder @ Galgate)	3.178	48	17.595	0.196	0.06	0.461
49003 (de Lank @ de Lank)	3.188	49	14.324	0.227	0.214	0.197
Total		721				
Weighted means				0.243	0.216	

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:10:19 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 2 year

Summary of results

Rainfall - FEH 2013 (mm):	25.67	Total runoff (ML):	26.70
Total Rainfall (mm):	16.50	Total flow (ML):	50.00
Peak Rainfall (mm):	5.57	Peak flow (m^3/s):	1.14

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	0.670	0.000	0.269	0.000	0.160	0.160
01:00:00	1.501	0.000	0.608	0.006	0.157	0.163
02:00:00	3.291	0.000	1.355	0.032	0.153	0.185
03:00:00	5.573	0.000	2.368	0.102	0.151	0.253
04:00:00	3.291	0.000	1.440	0.254	0.151	0.404
05:00:00	1.501	0.000	0.667	0.477	0.154	0.631
06:00:00	0.670	0.000	0.300	0.707	0.163	0.870
07:00:00	0.000	0.000	0.000	0.885	0.175	1.060
08:00:00	0.000	0.000	0.000	0.948	0.190	1.138
09:00:00	0.000	0.000	0.000	0.886	0.205	1.091
10:00:00	0.000	0.000	0.000	0.761	0.218	0.979
11:00:00	0.000	0.000	0.000	0.618	0.228	0.846
12:00:00	0.000	0.000	0.000	0.490	0.234	0.725
13:00:00	0.000	0.000	0.000	0.391	0.238	0.629
14:00:00	0.000	0.000	0.000	0.307	0.240	0.547
15:00:00	0.000	0.000	0.000	0.231	0.240	0.471
16:00:00	0.000	0.000	0.000	0.160	0.239	0.398
17:00:00	0.000	0.000	0.000	0.095	0.235	0.331
18:00:00	0.000	0.000	0.000	0.045	0.231	0.276
19:00:00	0.000	0.000	0.000	0.017	0.226	0.243
20:00:00	0.000	0.000	0.000	0.005	0.221	0.225
21:00:00	0.000	0.000	0.000	0.001	0.215	0.216
22:00:00	0.000	0.000	0.000	0.000	0.210	0.210
23:00:00	0.000	0.000	0.000	0.000	0.205	0.205
24:00:00	0.000	0.000	0.000	0.000	0.200	0.200
25:00:00	0.000	0.000	0.000	0.000	0.195	0.195
26:00:00	0.000	0.000	0.000	0.000	0.190	0.190
27:00:00	0.000	0.000	0.000	0.000	0.186	0.186
28:00:00	0.000	0.000	0.000	0.000	0.181	0.181
29:00:00	0.000	0.000	0.000	0.000	0.177	0.177
30:00:00	0.000	0.000	0.000	0.000	0.172	0.172
31:00:00	0.000	0.000	0.000	0.000	0.168	0.168
32:00:00	0.000	0.000	0.000	0.000	0.164	0.164

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:10:27 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details

Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 5 year

Summary of results

Rainfall - FEH 2013 (mm):	34.58	Total runoff (ML):	36.67
Total Rainfall (mm):	22.22	Total flow (ML):	68.86
Peak Rainfall (mm):	7.51	Peak flow (m^3/s):	1.51

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	0.903	0.000	0.363	0.000	0.160	0.160
01:00:00	2.021	0.000	0.821	0.008	0.157	0.165
02:00:00	4.432	0.000	1.842	0.044	0.153	0.197
03:00:00	7.506	0.000	3.251	0.138	0.151	0.290
04:00:00	4.432	0.000	1.997	0.345	0.152	0.497
05:00:00	2.021	0.000	0.930	0.650	0.159	0.809
06:00:00	0.903	0.000	0.419	0.966	0.171	1.138
07:00:00	0.000	0.000	0.000	1.213	0.190	1.403
08:00:00	0.000	0.000	0.000	1.302	0.212	1.514
09:00:00	0.000	0.000	0.000	1.219	0.234	1.453
10:00:00	0.000	0.000	0.000	1.048	0.253	1.300
11:00:00	0.000	0.000	0.000	0.851	0.267	1.118
12:00:00	0.000	0.000	0.000	0.676	0.277	0.953
13:00:00	0.000	0.000	0.000	0.539	0.284	0.822
14:00:00	0.000	0.000	0.000	0.423	0.287	0.711
15:00:00	0.000	0.000	0.000	0.319	0.289	0.607
16:00:00	0.000	0.000	0.000	0.221	0.287	0.508
17:00:00	0.000	0.000	0.000	0.132	0.284	0.416
18:00:00	0.000	0.000	0.000	0.062	0.279	0.342
19:00:00	0.000	0.000	0.000	0.023	0.273	0.297
20:00:00	0.000	0.000	0.000	0.006	0.267	0.273
21:00:00	0.000	0.000	0.000	0.001	0.260	0.261
22:00:00	0.000	0.000	0.000	0.000	0.254	0.254
23:00:00	0.000	0.000	0.000	0.000	0.248	0.248
24:00:00	0.000	0.000	0.000	0.000	0.242	0.242
25:00:00	0.000	0.000	0.000	0.000	0.236	0.236
26:00:00	0.000	0.000	0.000	0.000	0.230	0.230
27:00:00	0.000	0.000	0.000	0.000	0.224	0.224
28:00:00	0.000	0.000	0.000	0.000	0.219	0.219
29:00:00	0.000	0.000	0.000	0.000	0.213	0.213
30:00:00	0.000	0.000	0.000	0.000	0.208	0.208
31:00:00	0.000	0.000	0.000	0.000	0.203	0.203
32:00:00	0.000	0.000	0.000	0.000	0.198	0.198
33:00:00	0.000	0.000	0.000	0.000	0.193	0.193
34:00:00	0.000	0.000	0.000	0.000	0.188	0.188

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)
35:00:00	0.000	0.000	0.000	0.000	0.184	0.184
36:00:00	0.000	0.000	0.000	0.000	0.179	0.179
37:00:00	0.000	0.000	0.000	0.000	0.175	0.175
38:00:00	0.000	0.000	0.000	0.000	0.171	0.171
39:00:00	0.000	0.000	0.000	0.000	0.166	0.166
40:00:00	0.000	0.000	0.000	0.000	0.162	0.162

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:10:47 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 10 year

Summary of results

Rainfall - FEH 2013 (mm):	40.68	Total runoff (ML):	43.72
Total Rainfall (mm):	26.14	Total flow (ML):	81.67
Peak Rainfall (mm):	8.83	Peak flow (m^3/s):	1.78

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	1.063	0.000	0.427	0.000	0.160	0.160
01:00:00	2.378	0.000	0.969	0.010	0.157	0.166
02:00:00	5.214	0.000	2.182	0.051	0.153	0.205
03:00:00	8.832	0.000	3.876	0.163	0.152	0.315
04:00:00	5.214	0.000	2.396	0.408	0.154	0.562
05:00:00	2.378	0.000	1.119	0.771	0.162	0.933
06:00:00	1.063	0.000	0.505	1.149	0.178	1.326
07:00:00	0.000	0.000	0.000	1.444	0.200	1.644
08:00:00	0.000	0.000	0.000	1.552	0.227	1.779
09:00:00	0.000	0.000	0.000	1.455	0.254	1.709
10:00:00	0.000	0.000	0.000	1.251	0.277	1.528
11:00:00	0.000	0.000	0.000	1.017	0.295	1.312
12:00:00	0.000	0.000	0.000	0.807	0.308	1.115
13:00:00	0.000	0.000	0.000	0.644	0.316	0.960
14:00:00	0.000	0.000	0.000	0.506	0.321	0.827
15:00:00	0.000	0.000	0.000	0.381	0.323	0.704
16:00:00	0.000	0.000	0.000	0.264	0.322	0.586
17:00:00	0.000	0.000	0.000	0.158	0.319	0.477
18:00:00	0.000	0.000	0.000	0.075	0.313	0.388
19:00:00	0.000	0.000	0.000	0.028	0.307	0.335
20:00:00	0.000	0.000	0.000	0.008	0.300	0.307
21:00:00	0.000	0.000	0.000	0.001	0.292	0.293
22:00:00	0.000	0.000	0.000	0.000	0.285	0.285
23:00:00	0.000	0.000	0.000	0.000	0.278	0.278
24:00:00	0.000	0.000	0.000	0.000	0.271	0.271
25:00:00	0.000	0.000	0.000	0.000	0.265	0.265
26:00:00	0.000	0.000	0.000	0.000	0.258	0.258
27:00:00	0.000	0.000	0.000	0.000	0.252	0.252
28:00:00	0.000	0.000	0.000	0.000	0.246	0.246
29:00:00	0.000	0.000	0.000	0.000	0.240	0.240
30:00:00	0.000	0.000	0.000	0.000	0.234	0.234
31:00:00	0.000	0.000	0.000	0.000	0.228	0.228
32:00:00	0.000	0.000	0.000	0.000	0.222	0.222
33:00:00	0.000	0.000	0.000	0.000	0.217	0.217
34:00:00	0.000	0.000	0.000	0.000	0.211	0.211

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)
35:00:00	0.000	0.000	0.000	0.000	0.206	0.206
36:00:00	0.000	0.000	0.000	0.000	0.201	0.201
37:00:00	0.000	0.000	0.000	0.000	0.196	0.196
38:00:00	0.000	0.000	0.000	0.000	0.191	0.191
39:00:00	0.000	0.000	0.000	0.000	0.187	0.187
40:00:00	0.000	0.000	0.000	0.000	0.182	0.182
41:00:00	0.000	0.000	0.000	0.000	0.178	0.178
42:00:00	0.000	0.000	0.000	0.000	0.173	0.173
43:00:00	0.000	0.000	0.000	0.000	0.169	0.169
44:00:00	0.000	0.000	0.000	0.000	0.165	0.165

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:10:54 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 20 year

Summary of results

Rainfall - FEH 2013 (mm):	47.08	Total runoff (ML):	51.28
Total Rainfall (mm):	30.25	Total flow (ML):	96.14
Peak Rainfall (mm):	10.22	Peak flow (m^3/s):	2.06

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	1.229	0.000	0.495	0.000	0.160	0.160
01:00:00	2.752	0.000	1.124	0.011	0.157	0.168
02:00:00	6.034	0.000	2.541	0.060	0.153	0.213
03:00:00	10.219	0.000	4.547	0.190	0.152	0.342
04:00:00	6.034	0.000	2.828	0.475	0.155	0.630
05:00:00	2.752	0.000	1.325	0.900	0.165	1.065
06:00:00	1.229	0.000	0.599	1.343	0.184	1.527
07:00:00	0.000	0.000	0.000	1.691	0.211	1.902
08:00:00	0.000	0.000	0.000	1.820	0.243	2.064
09:00:00	0.000	0.000	0.000	1.709	0.275	1.984
10:00:00	0.000	0.000	0.000	1.471	0.303	1.774
11:00:00	0.000	0.000	0.000	1.196	0.325	1.520
12:00:00	0.000	0.000	0.000	0.949	0.340	1.289
13:00:00	0.000	0.000	0.000	0.757	0.351	1.107
14:00:00	0.000	0.000	0.000	0.595	0.357	0.952
15:00:00	0.000	0.000	0.000	0.448	0.359	0.808
16:00:00	0.000	0.000	0.000	0.311	0.359	0.670
17:00:00	0.000	0.000	0.000	0.187	0.356	0.542
18:00:00	0.000	0.000	0.000	0.088	0.350	0.438
19:00:00	0.000	0.000	0.000	0.033	0.343	0.376
20:00:00	0.000	0.000	0.000	0.009	0.335	0.344
21:00:00	0.000	0.000	0.000	0.001	0.327	0.328
22:00:00	0.000	0.000	0.000	0.000	0.319	0.319
23:00:00	0.000	0.000	0.000	0.000	0.311	0.311
24:00:00	0.000	0.000	0.000	0.000	0.303	0.303
25:00:00	0.000	0.000	0.000	0.000	0.296	0.296
26:00:00	0.000	0.000	0.000	0.000	0.288	0.288
27:00:00	0.000	0.000	0.000	0.000	0.281	0.281
28:00:00	0.000	0.000	0.000	0.000	0.274	0.274
29:00:00	0.000	0.000	0.000	0.000	0.268	0.268
30:00:00	0.000	0.000	0.000	0.000	0.261	0.261
31:00:00	0.000	0.000	0.000	0.000	0.255	0.255
32:00:00	0.000	0.000	0.000	0.000	0.248	0.248
33:00:00	0.000	0.000	0.000	0.000	0.242	0.242
34:00:00	0.000	0.000	0.000	0.000	0.236	0.236

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)
35:00:00	0.000	0.000	0.000	0.000	0.230	0.230
36:00:00	0.000	0.000	0.000	0.000	0.225	0.225
37:00:00	0.000	0.000	0.000	0.000	0.219	0.219
38:00:00	0.000	0.000	0.000	0.000	0.214	0.214
39:00:00	0.000	0.000	0.000	0.000	0.209	0.209
40:00:00	0.000	0.000	0.000	0.000	0.203	0.203
41:00:00	0.000	0.000	0.000	0.000	0.198	0.198
42:00:00	0.000	0.000	0.000	0.000	0.194	0.194
43:00:00	0.000	0.000	0.000	0.000	0.189	0.189
44:00:00	0.000	0.000	0.000	0.000	0.184	0.184
45:00:00	0.000	0.000	0.000	0.000	0.180	0.180
46:00:00	0.000	0.000	0.000	0.000	0.175	0.175
47:00:00	0.000	0.000	0.000	0.000	0.171	0.171
48:00:00	0.000	0.000	0.000	0.000	0.167	0.167
49:00:00	0.000	0.000	0.000	0.000	0.163	0.163

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:11:08 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km²): 3.81

Using plot scale calculations: No

Site description: None

Model run: 50 year

Summary of results

Rainfall - FEH 2013 (mm):	57.33	Total runoff (ML):	63.80
Total Rainfall (mm):	36.84	Total flow (ML):	119.31
Peak Rainfall (mm):	12.45	Peak flow (m^3/s):	2.54

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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 (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
00:00:00	1.497	0.000	0.603	0.000	0.160	0.160
01:00:00	3.351	0.000	1.374	0.014	0.157	0.170
02:00:00	7.348	0.000	3.127	0.073	0.154	0.226
03:00:00	12.445	0.000	5.657	0.232	0.153	0.385
04:00:00	7.348	0.000	3.553	0.584	0.157	0.741
05:00:00	3.351	0.000	1.673	1.111	0.171	1.281
06:00:00	1.497	0.000	0.758	1.663	0.195	1.858
07:00:00	0.000	0.000	0.000	2.099	0.229	2.329
08:00:00	0.000	0.000	0.000	2.265	0.270	2.535
09:00:00	0.000	0.000	0.000	2.130	0.311	2.441
10:00:00	0.000	0.000	0.000	1.835	0.346	2.181
11:00:00	0.000	0.000	0.000	1.493	0.374	1.867
12:00:00	0.000	0.000	0.000	1.185	0.394	1.579
13:00:00	0.000	0.000	0.000	0.945	0.408	1.352
14:00:00	0.000	0.000	0.000	0.743	0.416	1.159
15:00:00	0.000	0.000	0.000	0.560	0.420	0.981
16:00:00	0.000	0.000	0.000	0.390	0.420	0.810
17:00:00	0.000	0.000	0.000	0.234	0.417	0.651
18:00:00	0.000	0.000	0.000	0.111	0.411	0.522
19:00:00	0.000	0.000	0.000	0.042	0.402	0.444
20:00:00	0.000	0.000	0.000	0.011	0.393	0.404
21:00:00	0.000	0.000	0.000	0.001	0.383	0.385
22:00:00	0.000	0.000	0.000	0.000	0.374	0.374
23:00:00	0.000	0.000	0.000	0.000	0.365	0.365
24:00:00	0.000	0.000	0.000	0.000	0.356	0.356
25:00:00	0.000	0.000	0.000	0.000	0.347	0.347
26:00:00	0.000	0.000	0.000	0.000	0.338	0.338
27:00:00	0.000	0.000	0.000	0.000	0.330	0.330
28:00:00	0.000	0.000	0.000	0.000	0.322	0.322
29:00:00	0.000	0.000	0.000	0.000	0.314	0.314
30:00:00	0.000	0.000	0.000	0.000	0.306	0.306
31:00:00	0.000	0.000	0.000	0.000	0.299	0.299
32:00:00	0.000	0.000	0.000	0.000	0.291	0.291
33:00:00	0.000	0.000	0.000	0.000	0.284	0.284
34:00:00	0.000	0.000	0.000	0.000	0.277	0.277

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)
35:00:00	0.000	0.000	0.000	0.000	0.270	0.270
36:00:00	0.000	0.000	0.000	0.000	0.264	0.264
37:00:00	0.000	0.000	0.000	0.000	0.257	0.257
38:00:00	0.000	0.000	0.000	0.000	0.251	0.251
39:00:00	0.000	0.000	0.000	0.000	0.245	0.245
40:00:00	0.000	0.000	0.000	0.000	0.239	0.239
41:00:00	0.000	0.000	0.000	0.000	0.233	0.233
42:00:00	0.000	0.000	0.000	0.000	0.227	0.227
43:00:00	0.000	0.000	0.000	0.000	0.222	0.222
44:00:00	0.000	0.000	0.000	0.000	0.216	0.216
45:00:00	0.000	0.000	0.000	0.000	0.211	0.211
46:00:00	0.000	0.000	0.000	0.000	0.206	0.206
47:00:00	0.000	0.000	0.000	0.000	0.201	0.201
48:00:00	0.000	0.000	0.000	0.000	0.196	0.196
49:00:00	0.000	0.000	0.000	0.000	0.191	0.191
50:00:00	0.000	0.000	0.000	0.000	0.186	0.186
51:00:00	0.000	0.000	0.000	0.000	0.182	0.182
52:00:00	0.000	0.000	0.000	0.000	0.177	0.177
53:00:00	0.000	0.000	0.000	0.000	0.173	0.173
54:00:00	0.000	0.000	0.000	0.000	0.168	0.168
55:00:00	0.000	0.000	0.000	0.000	0.164	0.164

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:10:00 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH 2013 (mm):	68.22	Total runoff (ML):	77.62
Total Rainfall (mm):	43.83	Total flow (ML):	145.13
Peak Rainfall (mm):	14.81	Peak flow (m^3/s):	3.06

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	1.782	0.000	0.719	0.000	0.160	0.160
01:00:00	3.988	0.000	1.642	0.016	0.157	0.173
02:00:00	8.743	0.000	3.763	0.087	0.154	0.241
03:00:00	14.809	0.000	6.883	0.278	0.154	0.431
04:00:00	8.743	0.000	4.365	0.702	0.160	0.861
05:00:00	3.988	0.000	2.065	1.340	0.176	1.517
06:00:00	1.782	0.000	0.938	2.013	0.207	2.220
07:00:00	0.000	0.000	0.000	2.548	0.249	2.798
08:00:00	0.000	0.000	0.000	2.756	0.299	3.056
09:00:00	0.000	0.000	0.000	2.596	0.350	2.946
10:00:00	0.000	0.000	0.000	2.239	0.393	2.633
11:00:00	0.000	0.000	0.000	1.823	0.428	2.250
12:00:00	0.000	0.000	0.000	1.447	0.453	1.900
13:00:00	0.000	0.000	0.000	1.153	0.471	1.624
14:00:00	0.000	0.000	0.000	0.908	0.482	1.389
15:00:00	0.000	0.000	0.000	0.685	0.487	1.173
16:00:00	0.000	0.000	0.000	0.478	0.488	0.966
17:00:00	0.000	0.000	0.000	0.288	0.485	0.773
18:00:00	0.000	0.000	0.000	0.137	0.477	0.615
19:00:00	0.000	0.000	0.000	0.052	0.468	0.519
20:00:00	0.000	0.000	0.000	0.014	0.457	0.471
21:00:00	0.000	0.000	0.000	0.002	0.446	0.448
22:00:00	0.000	0.000	0.000	0.000	0.435	0.435
23:00:00	0.000	0.000	0.000	0.000	0.424	0.424
24:00:00	0.000	0.000	0.000	0.000	0.414	0.414
25:00:00	0.000	0.000	0.000	0.000	0.404	0.404
26:00:00	0.000	0.000	0.000	0.000	0.394	0.394
27:00:00	0.000	0.000	0.000	0.000	0.384	0.384
28:00:00	0.000	0.000	0.000	0.000	0.375	0.375
29:00:00	0.000	0.000	0.000	0.000	0.365	0.365
30:00:00	0.000	0.000	0.000	0.000	0.356	0.356
31:00:00	0.000	0.000	0.000	0.000	0.348	0.348
32:00:00	0.000	0.000	0.000	0.000	0.339	0.339
33:00:00	0.000	0.000	0.000	0.000	0.331	0.331
34:00:00	0.000	0.000	0.000	0.000	0.323	0.323

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)
35:00:00	0.000	0.000	0.000	0.000	0.315	0.315
36:00:00	0.000	0.000	0.000	0.000	0.307	0.307
37:00:00	0.000	0.000	0.000	0.000	0.299	0.299
38:00:00	0.000	0.000	0.000	0.000	0.292	0.292
39:00:00	0.000	0.000	0.000	0.000	0.285	0.285
40:00:00	0.000	0.000	0.000	0.000	0.278	0.278
41:00:00	0.000	0.000	0.000	0.000	0.271	0.271
42:00:00	0.000	0.000	0.000	0.000	0.264	0.264
43:00:00	0.000	0.000	0.000	0.000	0.258	0.258
44:00:00	0.000	0.000	0.000	0.000	0.251	0.251
45:00:00	0.000	0.000	0.000	0.000	0.245	0.245
46:00:00	0.000	0.000	0.000	0.000	0.239	0.239
47:00:00	0.000	0.000	0.000	0.000	0.233	0.233
48:00:00	0.000	0.000	0.000	0.000	0.228	0.228
49:00:00	0.000	0.000	0.000	0.000	0.222	0.222
50:00:00	0.000	0.000	0.000	0.000	0.217	0.217
51:00:00	0.000	0.000	0.000	0.000	0.211	0.211
52:00:00	0.000	0.000	0.000	0.000	0.206	0.206
53:00:00	0.000	0.000	0.000	0.000	0.201	0.201
54:00:00	0.000	0.000	0.000	0.000	0.196	0.196
55:00:00	0.000	0.000	0.000	0.000	0.191	0.191
56:00:00	0.000	0.000	0.000	0.000	0.186	0.186
57:00:00	0.000	0.000	0.000	0.000	0.182	0.182
58:00:00	0.000	0.000	0.000	0.000	0.177	0.177
59:00:00	0.000	0.000	0.000	0.000	0.173	0.173
60:00:00	0.000	0.000	0.000	0.000	0.169	0.169
61:00:00	0.000	0.000	0.000	0.000	0.165	0.165

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:11:22 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km²): 3.81

Using plot scale calculations: No

Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 (mm):	83.00	Total runoff (ML):	97.26
Total Rainfall (mm):	53.33	Total flow (ML):	182.29
Peak Rainfall (mm):	18.02	Peak flow (m³/s):	3.80

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	2.168	0.000	0.875	0.000	0.160	0.160
01:00:00	4.852	0.000	2.009	0.020	0.157	0.177
02:00:00	10.638	0.000	4.646	0.106	0.154	0.260
03:00:00	18.017	0.000	8.624	0.340	0.155	0.495
04:00:00	10.638	0.000	5.538	0.865	0.163	1.028
05:00:00	4.852	0.000	2.636	1.661	0.185	1.846
06:00:00	2.168	0.000	1.200	2.506	0.223	2.729
07:00:00	0.000	0.000	0.000	3.184	0.277	3.461
08:00:00	0.000	0.000	0.000	3.454	0.341	3.795
09:00:00	0.000	0.000	0.000	3.261	0.404	3.666
10:00:00	0.000	0.000	0.000	2.817	0.460	3.277
11:00:00	0.000	0.000	0.000	2.294	0.505	2.799
12:00:00	0.000	0.000	0.000	1.821	0.537	2.358
13:00:00	0.000	0.000	0.000	1.452	0.560	2.012
14:00:00	0.000	0.000	0.000	1.143	0.575	1.718
15:00:00	0.000	0.000	0.000	0.864	0.583	1.447
16:00:00	0.000	0.000	0.000	0.603	0.585	1.188
17:00:00	0.000	0.000	0.000	0.365	0.581	0.946
18:00:00	0.000	0.000	0.000	0.175	0.573	0.747
19:00:00	0.000	0.000	0.000	0.066	0.561	0.627
20:00:00	0.000	0.000	0.000	0.018	0.548	0.566
21:00:00	0.000	0.000	0.000	0.002	0.535	0.537
22:00:00	0.000	0.000	0.000	0.000	0.522	0.522
23:00:00	0.000	0.000	0.000	0.000	0.509	0.509
24:00:00	0.000	0.000	0.000	0.000	0.497	0.497
25:00:00	0.000	0.000	0.000	0.000	0.484	0.484
26:00:00	0.000	0.000	0.000	0.000	0.472	0.472
27:00:00	0.000	0.000	0.000	0.000	0.461	0.461
28:00:00	0.000	0.000	0.000	0.000	0.449	0.449
29:00:00	0.000	0.000	0.000	0.000	0.438	0.438
30:00:00	0.000	0.000	0.000	0.000	0.428	0.428
31:00:00	0.000	0.000	0.000	0.000	0.417	0.417
32:00:00	0.000	0.000	0.000	0.000	0.407	0.407
33:00:00	0.000	0.000	0.000	0.000	0.397	0.397
34:00:00	0.000	0.000	0.000	0.000	0.387	0.387

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)
35:00:00	0.000	0.000	0.000	0.000	0.378	0.378
36:00:00	0.000	0.000	0.000	0.000	0.368	0.368
37:00:00	0.000	0.000	0.000	0.000	0.359	0.359
38:00:00	0.000	0.000	0.000	0.000	0.350	0.350
39:00:00	0.000	0.000	0.000	0.000	0.342	0.342
40:00:00	0.000	0.000	0.000	0.000	0.333	0.333
41:00:00	0.000	0.000	0.000	0.000	0.325	0.325
42:00:00	0.000	0.000	0.000	0.000	0.317	0.317
43:00:00	0.000	0.000	0.000	0.000	0.309	0.309
44:00:00	0.000	0.000	0.000	0.000	0.302	0.302
45:00:00	0.000	0.000	0.000	0.000	0.294	0.294
46:00:00	0.000	0.000	0.000	0.000	0.287	0.287
47:00:00	0.000	0.000	0.000	0.000	0.280	0.280
48:00:00	0.000	0.000	0.000	0.000	0.273	0.273
49:00:00	0.000	0.000	0.000	0.000	0.266	0.266
50:00:00	0.000	0.000	0.000	0.000	0.260	0.260
51:00:00	0.000	0.000	0.000	0.000	0.253	0.253
52:00:00	0.000	0.000	0.000	0.000	0.247	0.247
53:00:00	0.000	0.000	0.000	0.000	0.241	0.241
54:00:00	0.000	0.000	0.000	0.000	0.235	0.235
55:00:00	0.000	0.000	0.000	0.000	0.229	0.229
56:00:00	0.000	0.000	0.000	0.000	0.224	0.224
57:00:00	0.000	0.000	0.000	0.000	0.218	0.218
58:00:00	0.000	0.000	0.000	0.000	0.213	0.213
59:00:00	0.000	0.000	0.000	0.000	0.208	0.208
60:00:00	0.000	0.000	0.000	0.000	0.203	0.203
61:00:00	0.000	0.000	0.000	0.000	0.198	0.198
62:00:00	0.000	0.000	0.000	0.000	0.193	0.193
63:00:00	0.000	0.000	0.000	0.000	0.188	0.188
64:00:00	0.000	0.000	0.000	0.000	0.183	0.183
65:00:00	0.000	0.000	0.000	0.000	0.179	0.179
66:00:00	0.000	0.000	0.000	0.000	0.174	0.174
67:00:00	0.000	0.000	0.000	0.000	0.170	0.170
68:00:00	0.000	0.000	0.000	0.000	0.166	0.166
69:00:00	0.000	0.000	0.000	0.000	0.162	0.162

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

UK Design Flood Estimation

Generated on Tuesday, August 15, 2017 2:11:33 PM by skirby
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

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

Site details Checksum: C366-A19A

Site name: Total Catchment_AMENDED_URBEXT_501100_241250

Easting: 501100

Northing: 241250

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 3.81

Using plot scale calculations: No

Site description: None

Model run: 1000 year

Summary of results

Rainfall - FEH 2013 (mm):	120.51	Total runoff (ML):	151.61
Total Rainfall (mm):	77.43	Total flow (ML):	283.90
Peak Rainfall (mm):	26.16	Peak flow (m^3/s):	5.84

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)	07:00:00 [06:30:00]	Yes
Timestep (hh:mm:ss)	01:00:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	135.24	No
Cmax (mm)	339.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	4.05	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.16	No
BL (hr)	40.14	No
BR	0.9	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.09	No
Urbext 2000	0.02	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	3.147	0.000	1.276	0.000	0.160	0.160
01:00:00	7.044	0.000	2.960	0.029	0.157	0.186
02:00:00	15.445	0.000	6.998	0.155	0.155	0.310
03:00:00	26.160	0.000	13.444	0.503	0.157	0.660
04:00:00	15.445	0.000	8.877	1.298	0.172	1.470
05:00:00	7.044	0.000	4.280	2.526	0.206	2.732
06:00:00	3.147	0.000	1.959	3.848	0.267	4.115
07:00:00	0.000	0.000	0.000	4.930	0.352	5.282
08:00:00	0.000	0.000	0.000	5.387	0.453	5.840
09:00:00	0.000	0.000	0.000	5.111	0.555	5.666
10:00:00	0.000	0.000	0.000	4.429	0.645	5.074
11:00:00	0.000	0.000	0.000	3.612	0.716	4.329
12:00:00	0.000	0.000	0.000	2.868	0.770	3.638
13:00:00	0.000	0.000	0.000	2.286	0.807	3.093
14:00:00	0.000	0.000	0.000	1.802	0.833	2.635
15:00:00	0.000	0.000	0.000	1.366	0.847	2.213
16:00:00	0.000	0.000	0.000	0.959	0.852	1.810
17:00:00	0.000	0.000	0.000	0.584	0.848	1.432
18:00:00	0.000	0.000	0.000	0.282	0.836	1.119
19:00:00	0.000	0.000	0.000	0.107	0.820	0.927
20:00:00	0.000	0.000	0.000	0.030	0.801	0.831
21:00:00	0.000	0.000	0.000	0.003	0.782	0.786
22:00:00	0.000	0.000	0.000	0.000	0.763	0.763
23:00:00	0.000	0.000	0.000	0.000	0.744	0.744
24:00:00	0.000	0.000	0.000	0.000	0.726	0.726
25:00:00	0.000	0.000	0.000	0.000	0.708	0.708
26:00:00	0.000	0.000	0.000	0.000	0.691	0.691
27:00:00	0.000	0.000	0.000	0.000	0.674	0.674
28:00:00	0.000	0.000	0.000	0.000	0.657	0.657
29:00:00	0.000	0.000	0.000	0.000	0.641	0.641
30:00:00	0.000	0.000	0.000	0.000	0.625	0.625
31:00:00	0.000	0.000	0.000	0.000	0.610	0.610
32:00:00	0.000	0.000	0.000	0.000	0.595	0.595
33:00:00	0.000	0.000	0.000	0.000	0.580	0.580
34:00:00	0.000	0.000	0.000	0.000	0.566	0.566

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)
35:00:00	0.000	0.000	0.000	0.000	0.552	0.552
36:00:00	0.000	0.000	0.000	0.000	0.538	0.538
37:00:00	0.000	0.000	0.000	0.000	0.525	0.525
38:00:00	0.000	0.000	0.000	0.000	0.512	0.512
39:00:00	0.000	0.000	0.000	0.000	0.500	0.500
40:00:00	0.000	0.000	0.000	0.000	0.487	0.487
41:00:00	0.000	0.000	0.000	0.000	0.475	0.475
42:00:00	0.000	0.000	0.000	0.000	0.464	0.464
43:00:00	0.000	0.000	0.000	0.000	0.452	0.452
44:00:00	0.000	0.000	0.000	0.000	0.441	0.441
45:00:00	0.000	0.000	0.000	0.000	0.430	0.430
46:00:00	0.000	0.000	0.000	0.000	0.420	0.420
47:00:00	0.000	0.000	0.000	0.000	0.409	0.409
48:00:00	0.000	0.000	0.000	0.000	0.399	0.399
49:00:00	0.000	0.000	0.000	0.000	0.389	0.389
50:00:00	0.000	0.000	0.000	0.000	0.380	0.380
51:00:00	0.000	0.000	0.000	0.000	0.370	0.370
52:00:00	0.000	0.000	0.000	0.000	0.361	0.361
53:00:00	0.000	0.000	0.000	0.000	0.352	0.352
54:00:00	0.000	0.000	0.000	0.000	0.344	0.344
55:00:00	0.000	0.000	0.000	0.000	0.335	0.335
56:00:00	0.000	0.000	0.000	0.000	0.327	0.327
57:00:00	0.000	0.000	0.000	0.000	0.319	0.319
58:00:00	0.000	0.000	0.000	0.000	0.311	0.311
59:00:00	0.000	0.000	0.000	0.000	0.304	0.304
60:00:00	0.000	0.000	0.000	0.000	0.296	0.296
61:00:00	0.000	0.000	0.000	0.000	0.289	0.289
62:00:00	0.000	0.000	0.000	0.000	0.282	0.282
63:00:00	0.000	0.000	0.000	0.000	0.275	0.275
64:00:00	0.000	0.000	0.000	0.000	0.268	0.268
65:00:00	0.000	0.000	0.000	0.000	0.261	0.261
66:00:00	0.000	0.000	0.000	0.000	0.255	0.255
67:00:00	0.000	0.000	0.000	0.000	0.249	0.249
68:00:00	0.000	0.000	0.000	0.000	0.243	0.243
69:00:00	0.000	0.000	0.000	0.000	0.237	0.237
70:00:00	0.000	0.000	0.000	0.000	0.231	0.231

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)
71:00:00	0.000	0.000	0.000	0.000	0.225	0.225
72:00:00	0.000	0.000	0.000	0.000	0.220	0.220
73:00:00	0.000	0.000	0.000	0.000	0.214	0.214
74:00:00	0.000	0.000	0.000	0.000	0.209	0.209
75:00:00	0.000	0.000	0.000	0.000	0.204	0.204
76:00:00	0.000	0.000	0.000	0.000	0.199	0.199
77:00:00	0.000	0.000	0.000	0.000	0.194	0.194
78:00:00	0.000	0.000	0.000	0.000	0.189	0.189
79:00:00	0.000	0.000	0.000	0.000	0.184	0.184
80:00:00	0.000	0.000	0.000	0.000	0.180	0.180
81:00:00	0.000	0.000	0.000	0.000	0.175	0.175
82:00:00	0.000	0.000	0.000	0.000	0.171	0.171
83:00:00	0.000	0.000	0.000	0.000	0.167	0.167
84:00:00	0.000	0.000	0.000	0.000	0.163	0.163

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	3.81	No
ALTBAR	74	No
ASPBAR	350	No
ASPVAR	0.44	No
BFIHOST	0.41	No
DPLBAR (km)	2.51	No
DPSBAR (mkm^{-1})	54.5	No
FARL	1	No
LDP	4.3	No
PROPWET (mm)	0.27	No
RMED1H	10.6	No
RMED1D	29.6	No
RMED2D	38.6	No
SAAR (mm)	594	No
SAAR4170 (mm)	589	No
SPRHOST	49.16	No
Urbext2000	0.02	No
Urbext1990	0.01	No
URBCONC	0.5	No
URBLOC	1.25	No
Urban Area (km^2)	0.09	No
DDF parameter C	-0.03	No
DDF parameter D1	0.33	No
DDF parameter D2	0.3	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.42	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.35	No
DDF parameter D2 (1km grid value)	0.28	No
DDF parameter D3 (1km grid value)	0.3	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.41	No

31116 Flow Summary - Total Catchment

2010 based on CA of 4.49km2 (pro rata of flows of 1.49km2 for trib inflow and 3km2 for Mill Brook inflow)
2017 based on CA of 3.81km2 (pro rata of flows for 0.86km2 trib inflow and 2.95km2 for Mill Brook inflow)

Timestep (hrs)	ReFH Flows														
	1000yr (m3/s)						100yr + 35% CC			100yr (m3/s)					
	2010			2017			2017			2010			2017		
	Total Catchment	Mill Brook I	Trib Inflow	Total Catchment	Mill Brook I	Trib Inflow	Total Catchment	Mill Brook Inf	Trib Inflow	Total Catchment	Mill Brook Inflow	Trib Inflow	Total Catchment	Mill Brook Inflow	Trib Inflow
0	0.2	0.13	0.07	0.16	0.12	0.04	0.22	0.17	0.05	0.2	0.13	0.07	0.16	0.12	0.04
1	0.2	0.13	0.07	0.19	0.14	0.04	0.23	0.18	0.05	0.2	0.13	0.07	0.17	0.13	0.04
2	0.2	0.13	0.07	0.31	0.24	0.07	0.33	0.25	0.07	0.2	0.13	0.07	0.24	0.19	0.05
3	0.4	0.27	0.13	0.66	0.51	0.15	0.58	0.45	0.13	0.3	0.2	0.1	0.43	0.33	0.10
4	0.7	0.47	0.23	1.48	1.14	0.33	1.17	0.90	0.26	0.5	0.33	0.17	0.86	0.67	0.20
5	1.2	0.80	0.40	2.74	2.12	0.62	2.05	1.59	0.46	0.8	0.53	0.27	1.52	1.18	0.34
6	2	1.34	0.66	4.12	3.19	0.93	3.00	2.33	0.68	1.3	0.87	0.43	2.22	1.72	0.50
7	3.2	2.14	1.06	5.29	4.10	1.19	3.78	2.93	0.85	1.9	1.27	0.63	2.80	2.17	0.63
8	4.5	3.01	1.49	5.84	4.53	1.32	4.13	3.20	0.93	2.6	1.74	0.86	3.06	2.37	0.69
9	5.5	3.67	1.83	5.67	4.39	1.28	3.98	3.08	0.90	3.1	2.07	1.03	2.95	2.28	0.67
10	5.9	3.94	1.96	5.07	3.93	1.15	3.55	2.75	0.80	3.3	2.2	1.1	2.63	2.04	0.59
11	5.8	3.88	1.92	4.33	3.35	0.98	3.04	2.35	0.69	3.2	2.14	1.06	2.25	1.74	0.51
12	5.3	3.54	1.76	3.64	2.82	0.82	2.56	1.99	0.58	2.9	1.94	0.96	1.90	1.47	0.43
13	4.6	3.07	1.53	3.09	2.39	0.70	2.19	1.70	0.49	2.5	1.67	0.83	1.62	1.26	0.37
14	3.9	2.61	1.29	2.63	2.04	0.59	1.87	1.45	0.42	2.1	1.4	0.7	1.39	1.08	0.31
15	3.2	2.14	1.06	2.21	1.71	0.50	1.58	1.23	0.36	1.7	1.14	0.56	1.17	0.91	0.26
16	2.6	1.74	0.86	1.81	1.40	0.41	1.30	1.01	0.29	1.4	0.94	0.46	0.97	0.75	0.22
17	2	1.34	0.66	1.43	1.11	0.32	1.04	0.81	0.24	1.1	0.73	0.37	0.77	0.60	0.17
18	1.6	1.07	0.53	1.12	0.87	0.25	0.83	0.64	0.19	0.9	0.6	0.3	0.61	0.48	0.14
19	1.3	0.87	0.43	0.93	0.72	0.21	0.70	0.54	0.16	0.7	0.47	0.23	0.52	0.40	0.12
20	1.1	0.73	0.37	0.83	0.64	0.19	0.64	0.49	0.14	0.6	0.4	0.2	0.47	0.36	0.11
21	1	0.67	0.33	0.79	0.61	0.18	0.60	0.47	0.14	0.6	0.4	0.2	0.45	0.35	0.10
22	0.9	0.60	0.30	0.76	0.59	0.17	0.59	0.45	0.13	0.5	0.33	0.17	0.43	0.34	0.10
23	0.8	0.53	0.27	0.74	0.58	0.17	0.57	0.44	0.13	0.5	0.33	0.17	0.42	0.33	0.10

2017

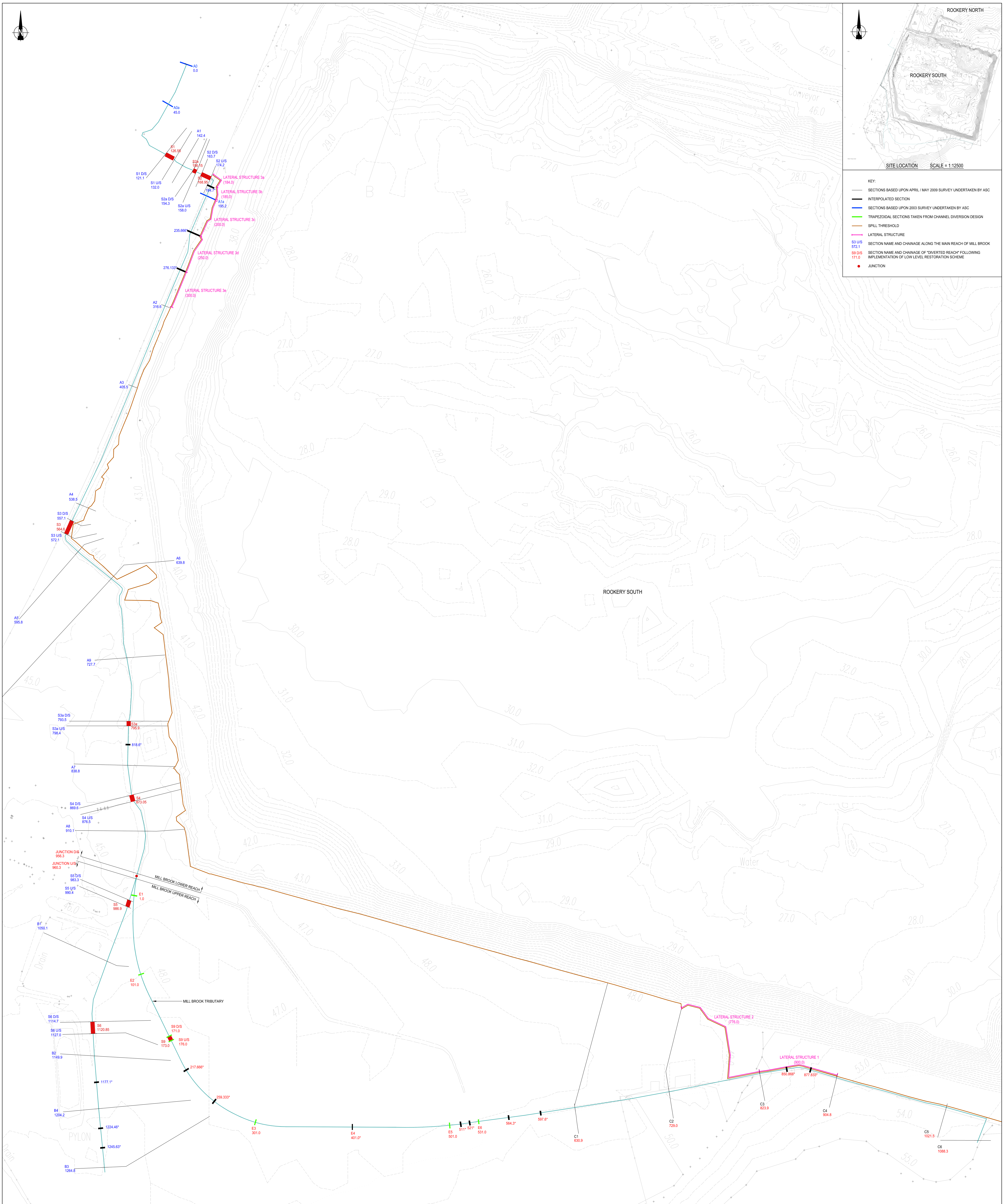
FEH	Default PG
Return Period yrs)	Peak Flow (m3/s)
2	0.66
5	0.92
10	1.11
20	1.32
50	1.64
100	1.92
200	2.25
1000	3.23

Appendix B

Hydraulic Modelling

Drawing 31116/3014/003 – HEC-RAS Hydraulic Model schematic

CD containing hydraulic model files



Mark	Revision	Drawn	Date	Chkd

SCALING NOTE: Do not scale from this drawing. If in doubt, ask.

UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status

FLOOD RISK ASSESSMENT

MILLBROOK POWER PROJECT

HEC-RAS HYDRAULIC MODEL SCHEMATIC

Client

Millbrook Power

Date of 1st Issue 06.02.15	Drawn by DB
A0 Scale 1:2000	Checked by SH
Drawing Number 31116/3014/003	Revision -

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