Restoration of the River Kent

Bowston Weir

Design Method Statement (Rev 2.1)

Date: 19th March 2021

Project Number: 20-1053

Project Address: Bowston Weir, Bowston, Kendal, Cumbria

Client: South Cumbria Rivers Trust (SCRT)

Project Manager: Peter Evoy (SCRT)

Principal Designer: cbec eco-engineering UK Ltd

1 INTRODUCTION

This document summarises the rationale behind the development of the design for of the Bowston Weir removal scheme, the proposed methods of construction of the design and key considerations for the works.

cbec eco-engineering UK Ltd was commissioned by South Cumbria Rivers Trust (SCRT) to adapt designs for a site on the River Kent at Bowston, Cumbria. This latest design work follows a previous design phase completed in March 2018. Following community consultation undertaken by SCRT, it was determined that the previous weir removal design required revision in order to address concerns relating to ecological impacts in the weir pond of the proposed works.

The key elements of the final design are summarised below, with full details in Section 3:

1. Removal of the existing weir structure and associated fish passes
2. Installation of a 55 m long 'nature-like' rock ramp downstream of the existing weir
3. Excavation of a 'proto-channel' extending ~140 m upstream of the rock ramp.

The design has been based on cbec's evaluation of hydraulic performance and sediment transport processes to ensure that the project aims are met with minimal risks to the natural and built environment. Key aims of the project include:

- Providing a more naturally functioning channel in terms of morphology and habitat
- Reducing flood risk to property on the right bank immediately downstream of the weir
- Reduces risk of large sediment flux downstream during flood events through construction of 'proto-channel' and through removal of weir (avoiding potential future failure of the structure)
- Improving fish passage
- Improving public amenity and recreation.

Prior to the commencement of any physical works, an initial on-site start-up meeting is required to ensure that all parties involved are in agreement with the proposed construction process. cbec, as the designer, requires representation to supervise all phases of construction to ensure that the designs are executed appropriately and that any 'field-fitting' can be undertaken when it is determined necessary.

The principal contractor is responsible for liaising with the service providers regarding the location of local services within the construction area. This communication should cover all aspects of working near, crossing over and under services ensuring that the principal contractor is clear on which activities are permitted.

1.1 ABOUT THE SITE

As a result of historical engineering undertaken throughout the River Kent (including multiple weir structures), natural physical processes in this part of the system are considered to be significantly altered.

At the Bowston Weir site, the river's natural flow conditions, sediment dynamics and habitats have been heavily modified by the presence of the weir and its associated structures. As a consequence, the channel lacks the full range of physical features and associated habitats that would naturally occur. The weir also appears to be built on bedrock, exposures of which extend through the 100 m long section of the river downstream.

The study site falls within both the River Kent Special Area of Conservation (SAC) and the River Kent and Tributaries Site of Special Scientific Interest (SSSI). The proposed design aims to restore natural forms and processes to the river at Bowston Weir, helping to enhance ecological condition. With improved physical processes, the river reach currently directly impacted by the weir would develop a more diverse physical condition reflective of the pool-riffle 'reference state' for the site. Such conditions will provide a wider range of hydraulic (i.e. combinations of flow depths and velocities) and sedimentary conditions, with associated biodiversity benefits for invertebrates, fish, birds, amphibians, plants etc.

1.2 ECOLOGY

A preliminary ecological appraisal was conducted for the Bowston Weir reach by JBA in March 2017. The survey found a high likelihood of the presence of the following species, with the associated recommendations provided:

- Otter: Potential lay-up / holt sites in vicinity of works. Pre-construction survey should be undertaken (no time constraints identified)
- White-clawed crayfish: Pre-construction survey should be undertaken . Surveys and mitigation can only be conducted between July and September.
- Breeding birds: Dependent on tree removal prior to works beginning on site. Pre-construction survey should be undertaken between March and September.
- Migratory/ coarse fish: Redd survey to determine whether reaches immediately downstream of the weirs are used for spawning.

A resurvey will be required immediately prior to construction to provide up-to-date information on the presence of the above species and other protected species (e.g. bats, badger, great crested newt, red squirrel, water vole, etc) and Invasive Non-Native Species (INNS, e.g. Himalayan Balsam and Giant Hogweed) within the site boundary.

Any identified constraints relating to the potential presence of these species should be communicated by the ecologist to SCRT and the Principal Contractor prior to commencement of physical works and the necessary mitigation measures implemented and any required protected species license applications made.

2 DETAILED DESIGN

For the purposes of this Design Method Statement, the design refers to the proposed works on the reach of the River Kent in the vicinity of the existing Bowston Weir, illustrated in **Figure *1***. Technical design drawings are provided separate to this document.

The reach directly affected by the works extends approximately 210 m in longitudinal extent (i.e. between chainages 310 and 520 m), from 130 m upstream to 80 m downstream of Bowston Weir. Photographs illustrate the watercourse upstream (Figure 2) and downstream (Figure 3 and Figure 4) of the weir.

Summary of activities:

- Removal of sediment accumulated behind the weir and excavation of a design 'proto-channel'
- Demolition of the weir and two associated fish pass structures
- Bed regrading and installation of 'rock ramp' downstream of weir location.

Construction should be scheduled for when ecological sensitivity to disturbance is relatively low and there is a reduced risk of wet conditions impacting the works programme.

The programme should also allow sufficient time for bankside vegetation to re-establish post-works and prior to winter flows.

Assumptions

As with any construction that involves working in the natural environment, complete and spatially continuous supporting data sets (e.g. services, ground conditions etc) are not always available. It is therefore not uncommon for unexpected issues to arise once the construction phase has begun. Under such circumstance, we are required to make decisions at short notice as to how designs need to be modified to solve these issues. This process is known as 'field-fitting', with this term used throughout this document where necessary.

cbec, as the designer, requires regular representation to supervise construction associated with this contract, to ensure that the designs are executed appropriately and that any 'field-fitting' can be undertaken when it is determined necessary. As part of this commitment, cbec's Lead Geomorphologist, Dr Hamish Moir, will attend site at the commencement of specific components of the physical works (e.g. excavation of the 'proto-channel', removal of the weir and fish pass structures, and construction of the rock ramp), to ensure that all parties involved agree with and are clear on the proposed construction process.

An inevitable reality of implementing river restoration designs is the requisite stabilisation period following the initial completion of design works, which may be up to 3-5 years depending on flow regime over this period. During the stabilisation period, the site is more susceptible to adjustment as a result of high flows and therefore, monitoring of the condition of the constructed design should be conducted following any such event. Monitoring will determine if remedial 'adaptive management' work is required to mitigate any issues should they arise.

All designs referred to in this document are provided at a precision of 0.001 m. Given that this level of precision is unrealistic for construction of river restoration designs, tolerance of 50 mm deviation relative to the design specifications is considered appropriate.

In relation to construction of the rock ramp, it is assumed that the existing bedrock is sufficient to hold the baselayer of the structure in place. In the event that additional measures are required for securing the baselayer, a contingency of fixing steel pins to the existing channel bed, from which the basal particles of the rock ramp are secured, shall be employed.

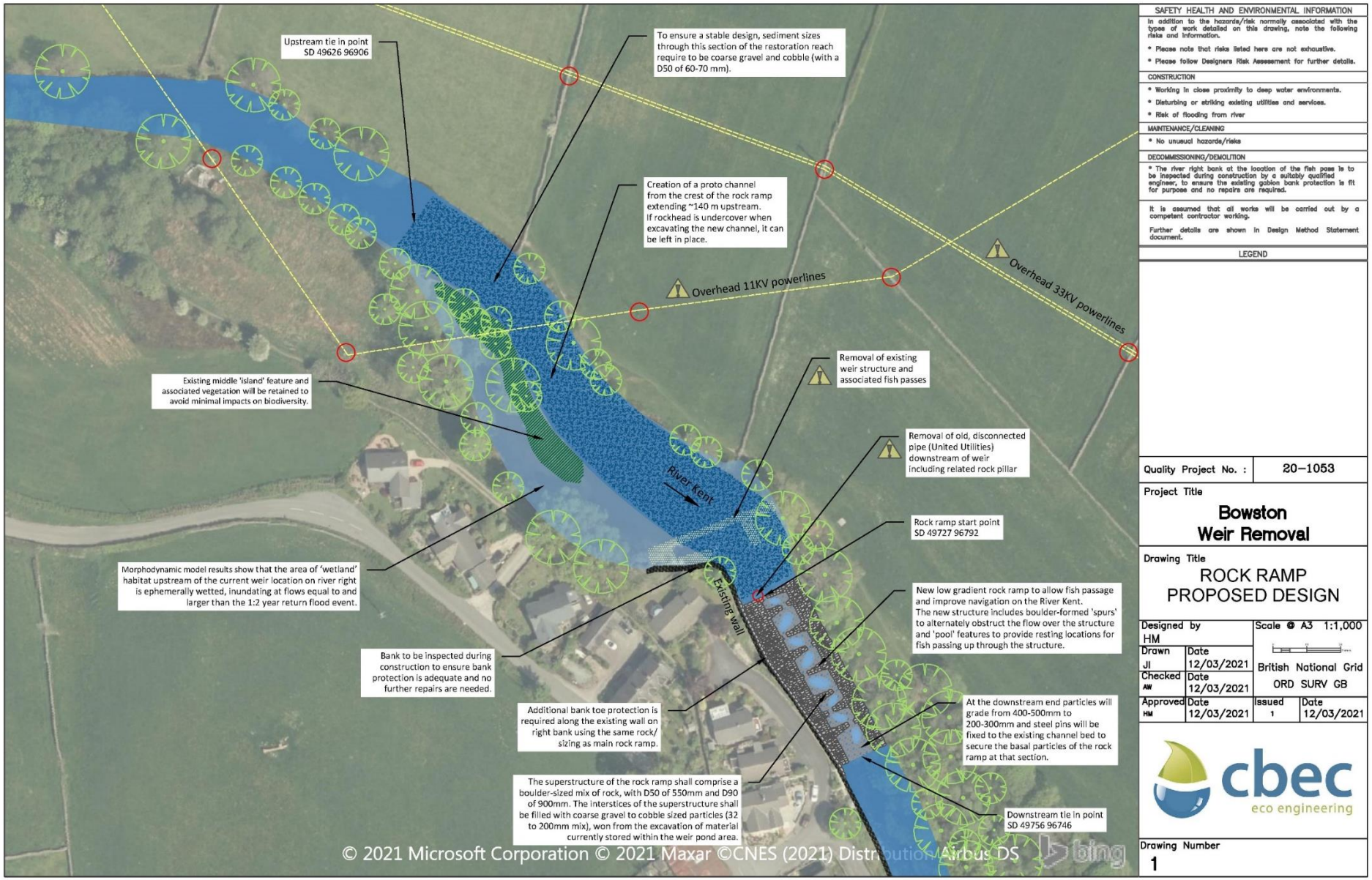

Figure 1. Bowston Weir design – plan view

Figure 2. View looking upstream into current weir pond, showing location of proposed 'proto-channel' (to the right of the photo) and ephemeral wetland environment (to the left)

Figure 3. View from right bank looking upstream towards Bowston Weir, showing section rock ramp is to be located

Figure 4. View from left bank downstream of the weir, indicating concrete pillar to be removed

3 METHOD STATEMENT OF DESIGN IMPLEMENTATION

Site: Bowston Weir, River Kent, (reach length: 210 m; chainage 310 to 520 m)

Extents: SD 49756 96746 (downstream) to SD 49593 96923 (upstream)

3.1 SITE ACCESS AND PREPARATION

Site access and welfare location will be as per Figure 4**.** Access will be from the through a field gate located at OS NGR SD 49943 96914 to the North East of the site. Final access routes and site storage locations should be agreed with South Cumbria Rivers Trust prior to mobilisation.

The appointed Site Manager should co-ordinate all deliveries of materials and plant which are to be planned and agreed with the landowner. Any specific times to avoid vehicular access should be adhered to.

3.1.1 Location of Existing Services

Following an online investigation of local services at feasibility phase, the following assets have been identified within the construction area.

- Overhead 11KV powerlines (Electricity North West Ltd) upstream of the weir (central channel crossing point: SD 49659 96874)
- Overhead 33KV powerlines (Electricity North West Ltd) within fields on left bank used for construction access (between OS NGR SD 49746 96921 and SD 49956 96795)
- Old, disconnected pipe (United Utilities) downstream of weir with related rock pillar (SD 49726 96794) currently situated within the channel (and within the proposed footprint of the rock ramp).

All utilities maps/ records obtained during the search will be provided to the Principal Contractor ahead of commencement of works.

The Principal Contractor is to ascertain the exact location, nature and extent of services using cable avoidance tools for future works and to carry out all necessary protection works to ensure that service assets are not disturbed, with any isolation or alteration to services carried out by competent persons.

3.1.2 Dales Way Footpath Diversion

The Dales Way footpath runs parallel to the works site along the left bank and falls within the planned construction site compound. An application for permission to create a route diversion during the works, will be made by SCRT prior to commencement of construction.

3.1.3 Riparian Management

The design does not involve the displacement of a large number of the trees located along either bank of the reach. However, it is expected that removal of a small number of trees will be required from the left bank (likely at the upstream extent of the proposed rock ramp, near to the current weir location) in order to allow access for construction.

During pre-construction preparation, an onsite discussion should take place between representatives of SCRT, the left bank landowner, cbec and the contractor to determine which trees are to be retained/

left in position during construction, and which are to be removed, to ensure that disturbance will be kept to a minimum.

Prior to commencement of the works, any trees that require removal will be marked by the Principal Contractor, to ensure that only the correct ones are removed. Tree removal during the construction phase should be strictly in accordance with the design to reduce the need for subsequent replanting.

3.1.4 Pre-condition assessment (i.e. Dilapidation survey) of wall/ bank protection

Prior to works commencing, a pre-condition assessment (i.e. dilapidation survey) should be undertaken for the wall on river right (adjacent to the rock ramp location). This inspection will allow for determination of any defects within the current structure and a formal log of these findings to be produced. In the event that defects are found, discussions between the wall owner(s) and SCRT should be held to ensure the owner(s) are made aware of the condition of the structure and their responsibility for such defects.

3.2 FLOW DIVERSION

3.2.1 Flow diversions will be required throughout the construction phase to minimise risk of sediment release and improve access/ease of construction within the upstream reach.

- It is recommended that flow is initially diverted down the right half of the channel and weir to allow for 'unpicking' of the weir from the left bank and excavation of substrate from the left half of the channel.
- Upon completion of the works on river left, flow should then be diverted down the right bank, allowing for the removal of the remaining weir and fish pass structure (and sediment excavation) throughout the right half of the channel.
- During construction of the rock ramp, there are a number of potential options for diverting river flows away from the area of works. A temporary diversion channel through the river left river margins is a possible option, although may require the removal of some mature trees. Alternatively, over-pumping of the works area may provide the most practicable approach; the rock ramp would likely best be constructed in stages (either laterally or longitudinally) with an associated cofferdam (formed from lined 'dumpy' bags) being repositioned in relation to each stage of the build.

Ultimately, it will be the responsibility of the Principal Contractor to propose a specific method for flow diversion, accounting for construction-specific constraints (including Health and Safety considerations). This proposed method would be agreed with the regulators, SCRT, cbec and, potentially, other stakeholders ahead of works commencing.

3.2.2 The Principal Contractor (PC) should employ appropriate sediment control measures to minimise sediment release relating to the construction process. Sediment release should be carefully monitored at all stages, with additional measures employed as required, to minimise risk of sediment release (i.e. and, potentially, the risk of pollution and channel aggradation downstream).

3.3 EXCAVATION OF STORED SEDIMENT/ CONSTRUCTION OF DESIGN 'PROTO-CHANNEL'

3.3.1 Sediment stored behind the weir structure is to be excavated in order to form a 'proto-channel'[1] incorporating simple 'trapeziodal' channel geometry, as illustrated in the design cross section drawings. It is anticipated that this channel geometry will quickly adjust to a dynamic equilibrium pool-riffle morphology, as predicted by sediment transport/morphodynamic modelling of moderately-sized flow events (i.e. a 1 in 2 year return period).

3.3.2 The 'proto-channel' tie-in elevation is 61.90 m AOD at the upstream extent (chainage 310 m) and 60.60 m AOD at the downstream extent (chainage 465 m). The new channel will grade from the current left bank to the riverside edge of the vegetated island bounding the current 'wetland' habitat on river right (see Figure 2).

3.3.3 To achieve this, approximately 1,710 m^3 of sediment[2] stored behind the weir is to be removed between chainage 310 and 438 m (See Drawing no. 3, Long Profile). In the unlikely event that bedrock is found to be situated at the required design bed level, this can be left in place.

3.3.4 Once the excavation has reached the design bed elevation of the 'proto channel', an assessment of the exposed substrate size will be required. The requirements of the top layer of sediment within the 'proto channel' are a coarse gravel/cobble mix, with a D_{50} of 70 mm. If it is determined that the in-situ substrate is not of a suitable grade, a further 500 mm will be excavated and the same volume replaced with the required grade of sediment (obtained from the material initially excavated from the surface of the sediment retained in the weir pond).

3.3.5 Approximately 590 m^3 of the excavated material is to be used for infilling the section of the channel between the location of the existing weir and the new rock ramp crest (chainage 438 m to 465 m). The 'proto-channel' will continue through this section, grading evenly into the rock ramp crest (i.e. with no sudden elevation changes which would increase the risk of progressive head-cut/ incision processes).

3.3.6 Approximately 200 m^3 of excavated sediment will be distributed within the rock ramp structure during construction (see the rock ramp construction method in Section 3.5 below).

3.3.7 Site-wide sediment control measures are to be implemented to protect the watercourse from potential sediment runoff via overland flow from the works area on the floodplain; see Section 4.1 for further details.

[1] Sediment transport/morphodynamic modelling has determined that the initial simple trapezoidal channel geometry will adjust to a dynamic equilibrium pool-riffle morphology as a consequence of moderately-sized flow events (i.e. the 2-year return interval flood event).

[2] This volume of sediment is an estimate based on topographic survey data from January 2021.

3.3.8 It is expected that the design will generate a net cut of approximately 920m^3. To limit the requirement for exportation off-site, it is recommended that discussions take place with the local landowner(s)/ farmers, to determine whether this material would be useable as aggregate.

3.4 DEMOLITION OF BOWSTON WEIR, FISH PASS STRUCTURES AND CONCRETE PIER

3.4.1 The weir, the two associated fish passes and a concrete pier downstream are to be removed in their entirety.

3.4.2 The weir and two fish passes should be unpicked gradually, with the structure monitored closely during the process to minimise risk of unexpected failure of the structure. Full details of the removal process for the structures should be detailed within the Principal Contractor's Construction Method Statement (CMS).

3.4.3 The river right bank at the location of the fish pass, is to be inspected during construction by a suitably qualified engineer, to ensure the existing gabion bank protection is fit for purpose and no repairs are required.

3.4.4 The concrete pier to be removed is located in the channel approximately 25 m downstream of the existing weir crest (chainage 460 to 465 m), shown in Figure 4. The pier had previously supported a pipeline crossing the river, but is now redundant.

3.4.5 Site-wide sediment control measures are to be implemented to protect the watercourse from potential sediment runoff via overland flow from the works area on the floodplain; see Section 4.1 for further details.

3.5 CONSTRUCTION OF 'ROCK RAMP'

3.5.1 A rock ramp will be constructed, spanning the full width of the existing channel between chainages 465 m and 520 m, a total length of 55 m. Design details for the rock ramp are shown in Drawing no. 4 (Rock Ramp Details) with representative cross sections given in Drawing no. 5 (Rock Ramp Sections).

3.5.2 The crest of the structure will be located 26 m downstream from the current weir crest location, at chainage 465 m. The channel tie-in elevation of the rock ramp is at 60.60 m AOD at the upstream extent (chainage 465 m) and 58.56 m AOD at the downstream extent (chainage 520 m). The average surface slope of the rock ramp is 3.70 %.

3.5.3 The superstructure of the rock ramp shall comprise a boulder-sized mix of rock, with D_{15} = 325 mm, D_{50} = 550 mm and D_{90} = 800 mm. The interstices of the superstructure shall be filled with coarse gravel to cobble sized particles (32 to 200 mm mix), won from the excavation of material currently stored within the weir pond area.

3.5.4 The rock ramp shall be built in layers of roughly even thickness, working from the base across the full length of the structure and progressively adding subsequent layers of decreasing extent downstream from the crest (i.e. to evenly increase elevation with distance upstream). It is expected that the construction of the rock ramp will require an element of 'field-fitting', given the uneven form of the basal surface (i.e. channel bed) and the irregular shape/ size of the boulders making up the structure.

3.5.5 The initial base layer of rock (approximately 800 mm diameter) will be positioned on the existing bed, in such a way that they are fixed/locked in position against existing bedrock outcrops exposed on the channel bed. (In the event that it is not possible to fix the rock ramp base layer to the bedrock, steel pins are to be used to secure the base layer to the existing channel bed, from which the basal particles of the rock ramp are to be secured.)

3.5.6 At the downstream extent of the rock ramp, a 5 m section of graded rock will be added across the width of the channel, to avoid sudden changes substrate side. Within this 5 m section, steel pins will be fixed to the existing channel bed, from which the basal particles of the rock ramp are to be secured. Particles will grade from 200 -300 mm at downstream end, increasing to 400-500 mm at the upstream end of the 5 m section, providing a fixing point for the rock ramp superstructure.

3.5.7 After each layer of coarse rock is positioned, the interstices within that layer are to be infilled with the finer grade (i.e. 32 to 250 mm) of material won from the weir pond area. This process of adding coarse then finer material to form layers is continued until the even rock ramp surface is achieved. The sequence of rock spurs are then superimposed into this surface, with intermediate pools excavated (see 3.4.7).

3.5.8 Informal boulder 'spurs' shall then be superimposed into the surface of the rock ramp (see Drawing no. 4). These mimic a natural 'cascade' channel form and act to alternately obstruct the flow through the 'low flow' centre of the rock ramp, increasing roughness and reducing mean velocities. With associated 'pool' type features providing resting locations between the alternating spurs, the opportunity for fish passage is greatly improved.

3.5.9 The spurs shall be structured around large 'key stones' (diameter 600 to 800 mm) buried approximately half of their diameter into the general surface of the rock ramp, with smaller particles lodged around these to form their prescribed geometry (see Drawing no. 4). The intermediate pools shall be formed by excavating material from the general surface of the rock ramp to form the prescribed geometry of these relative depressions (see Drawing no. 4 and 5).

3.5.10 The final surface of the central low flow section of the rock ramp shall be finished by filling in the exposed interstices amongst the larger particles with the smaller grade (i.e. 32 to 250 mm) of material obtained from weir pool sediments. Particularly, coarser gravel-sized material (i.e. 16 – 64 mm) shall be used to line the pool forms within the low flow thalweg of the rock ramp.

3.6 SCOUR PROTECTION (RIVER RIGHT) ADJACENT TO ROCK RAMP

3.6.1 The increased velocity within the rock ramp section due to construction of the structure, shall be partly mitigated by the addition of bank toe protection added to the margins of the rock ramp, on the river right. This will train the main body of flow away from the wall on river right and slow the near bank velocities. The revetment also protects the wall that is below the revetment.

3.6.2 This added protection shall comprise the same boulder-sized mix of rock as the rock ramp superstructure, with D_{15} = 325 mm, D_{50} = 550 mm and D_{90} = 800 mm and should be constructed at a 1.5:1 slope against the bank face. See Drawing no. 5 (Rock Ramp Sections).

3.6.3 The rock toe protection will extend downstream of the rock ramp structure and will grade out to bed level, (Drawing no. 4, Rock Ramp Detail). The smaller particles (grading from 500 mm down to 200 mm) will be secured in place using an appropriate method (e.g. grouting). Details of a specific approach for securing the graded rock should be provided in the Principal Contractor's CMS. Due to the nature of the existing bank protection at the upstream extent of the rock ramp (i.e. tiered gabion baskets), the upstream extent of the toe protection will be 'field fitted' where required.

4 ENVIRONMENTAL CONSIDERATIONS

4.1 SEDIMENT CONTROL MEASURES

Silt management will prevent suspended sediment load liberated as a result of the construction process being transported downstream to cause pollution or further sedimentation in sensitive sites.

Construction should be planned and phased in such a way as to minimise the risk of input of fine sediments to the active channel as a result of the works. This can be achieved through the following:

- Works should be undertaken during the summer months, to maximise chance of lower flow conditions.
- Flow diversion (as discussed in Section 3.2) implemented to allow phased excavation, structure removal works and rock ramp construction to be undertaken in dry conditions.

However, in the event that fine materials are released within the active channel (e.g. during excavation of the 'proto-channel' or under sufficiently high flow conditions to inundate the working area during the construction period), appropriate silt-trapping measures should be implemented along the length of the river impacted by the works and for an appropriate distance downstream. Please refer to the Principal Contractor's Construction Method Statement for further information on silt management measures during the build process.

A detailed sediment control plan and map (with contingencies) should be agreed between the Principal Contractor and SCRT prior to works commencing.

4.1.1 General site rules

- Appropriate construction methods should be employed to minimise risk of sediment release during the build phase (i.e. sediment capture measures should be used where works are undertaken in "live" flow).
- Plant running tracks to have suitable sediment control measures installed and well maintained around the side closest to the water course. Temporary haul roads/ trackways to be used if ground becomes too wet and sediment control measures are breached.
- Daily Briefings and Toolbox Talks to be given to ensure all site staff awareness is high.

4.2 BIOSECURITY MEASURES

A site walkover by the Environmental Clark of Works (ECoW) will be undertaken prior to works commencing to check the up to date risks on the site and the 'live' method statement and risk assessment adjusted accordingly.

A Biosecurity briefing will be given by the site supervisor and/or ECoW at all site inductions and would cover site-specific risks, including the presence of all potential invasive species. Himalayan balsam and signal crayfish should be specifically highlighted to all personnel.

All operatives should receive training and have detailed procedures to follow with respect to cleaning machinery and PPE.

Weekly Toolbox Talks should be given at morning briefings on the importance of following the Biosecurity measures.

4.2.1 Working Around Invasive Plant Species (based on potential presence of Himalayan Balsam).

All areas where Himalayan Balsam is present should be marked out and fenced with temporary fencing

where practical prior to works and these areas not used for access. All mechanical plant and site staff are to avoid areas where invasive species are identified and these areas marked out with fencing and site signage as out of bounds areas.

Detailed protocols for managing the risks associated with Himalayan Balsam and other invasive species shall be outlined in the Construction Method Statement, to be prepared by the Principal Contractor.

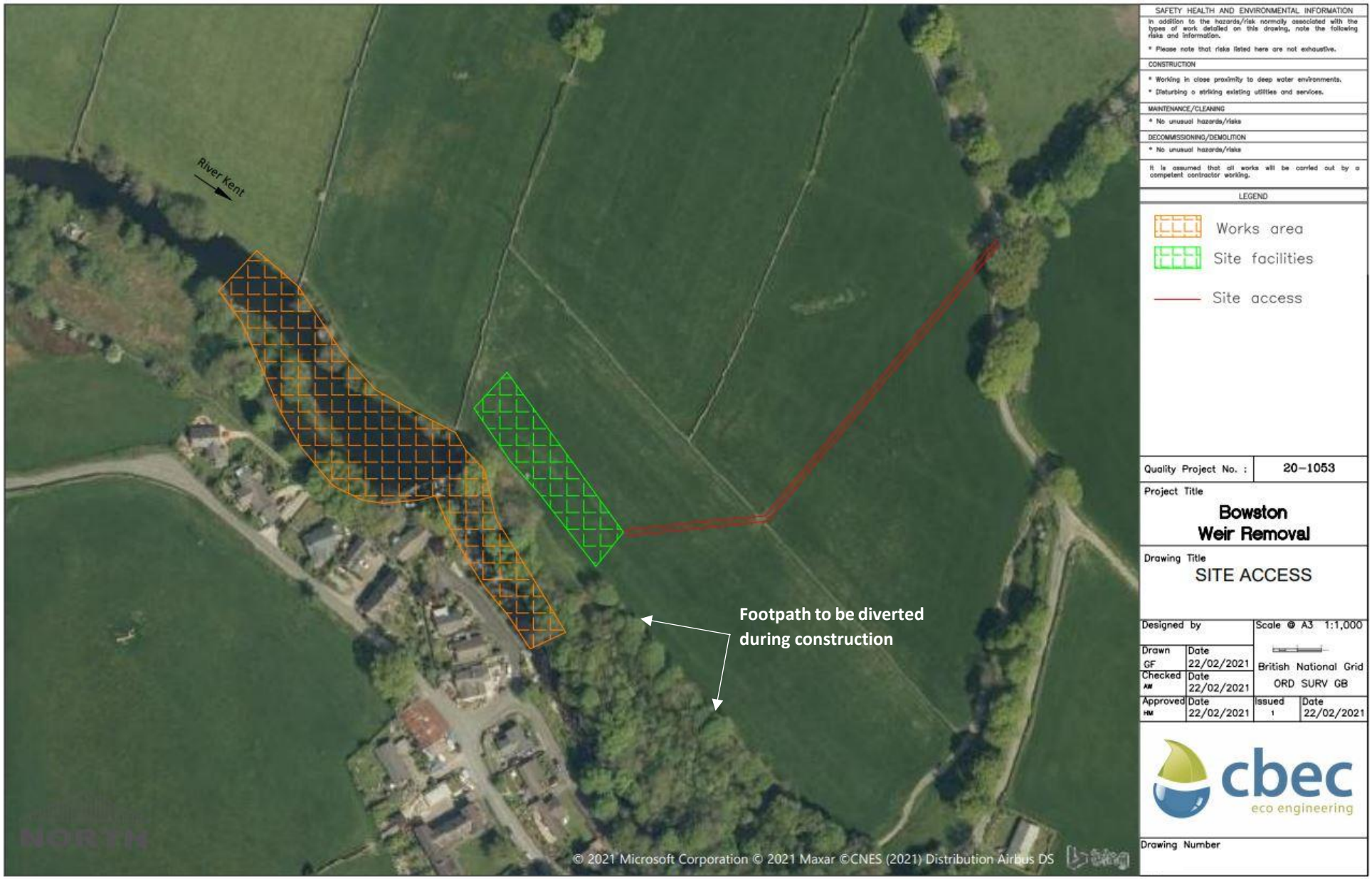

Figure 4: Proposed locations for site access and facilities