

Cerne Abbas Reservoir

Basis of Design

Environment Agency

April 2021

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This document has 11 pages including the cover.

Document history

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Client signoff

Client	Environment Agency
Project	Cerne Abbas Reservoir
Job number	ENV0001275C / 5192864
Client signature / date	

Glossary

CDM	Construction (Design and Management) Regulations 2015
CESWI	Civil Engineering Specification for the Water Industry
EAP	Environmental Action Plan
GI	Ground Investigation
NEAS	National Environmental Assessment Service
NGR	National Grid Reference
MIOS	Measures in the Interest Of Safety
O&M	Operations and Maintenance
PEA	Preliminary Ecological Assessment
PRoW	Public Right of Way
PSRA	Public Safety Risk Assessment
QCE	Qualified Civil Engineer
SLS	Serviceability Limit State
SSSI	Site of Special Scientific Interest (implanted under the Wildlife and Countryside Act 1981 and amended by the Countryside and Rights of Way Act 2000)
ULS	Ultimate Limit State
WFD	Water Framework Directive

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1. Overview

1.1. Purpose

The purpose of this document is to set out a common understanding of:

- The agreed requirements and deliverables.
- Consistent reference for key design information and values in relation to the project.
- Identify and comment on the key design processes and methods.
- The design elements that form the scheme.
- The objectives and constraints of each of the design elements, including but not limited to any client maintenance and operational requirements.
- The interfaces that exist between the design elements and other existing features.
- The standards and procedures that will be used to undertake the design detailing.
- Ensure a clear vision of the way the project will be delivered has been communicated to the entire team.

1.2. Scheme Description

The Cerne Abbas reservoir is a flood storage reservoir constructed on behalf of West Dorset District Council and subsequently adopted by the Environment Agency (EA). The flood storage area is formed by an earth embankment running east to west across the River Cerne immediately upstream of the village. The river passes through the embankment in a concrete 1200 diameter culvert that runs through the base of the spillway with flows throttled by a sluice gate at the inlet structure. The spillway is formed of gabions with a broad crest passing over the embankment, near the left (east) abutment. It is designated as 'High Risk' under the Reservoirs Act 1975.

An inspection of the reservoir was carried out by the Inspecting Engineer (IE) on 5th January 2017, under Section 10(2) of the Reservoirs Act 1975. Further to this a 'Section 10 report' dated June 2017 was issued. The following recommendations were made as '[Measures] in the Interests of Safety' (MIOS):

- i. The spillway stepped gabion basket erosion protection should be replaced.
- ii. A flood study specifically focussed on the 1 in 10,000 year flood and the Probable Maximum Flood is carried out for Cerne Abbas FDR to confirm the adequacy of the overflow capacity. Any required works arising from this study shall be implemented.

The studies relating to these recommendations must be completed by the end of June 2019 and the required works must be completed by the end of December 2021.

The flood study modelling element was completed in June 2019. This has revealed that the spillway capacity must be increased to accommodate the increased estimate of the 1 in 10,000 and Probable Maximum Flood (PMF) flows. The results are detailed in the Cerne Modelling Report prepared by JBA.

In March 2020, Atkins Ltd issued an Options Study report, ref ENV0001275C-ATK-SP-2XX-RP-C-000001 which set out: the results of a review of the recommendations made in the Section 10 report and Cerne Modelling Report; and details of various options developed to inform discussion with the EA and Qualified Civil Engineer (QCE) for the selection of a preferred option to be carried forward to detailed design. The preferred option comprises:

- Removal and re-construction of the gabion stepped weir using imported stone in-fill (maintaining the existing (or original) levels and profile);
- Removal of grass on the downstream face of the flood embankment and reinstate with turf reinforcement mat
- Raising the ground level along the left bank to contain flood flows (requiring earthworks outside the site boundary).

1.3. Site Location

Site Address: Cerne Abbas Reservoir,
Cerne Abbas,
Dorchester,
DT2 7GY

NGR: ST 66358 01480

Location Description

The reservoir is located north of the village of Cerne Abbas in Dorset (below the Cerne Abbas Giant). The reservoir is off Kettle Bridge Lane (accessible via Duck Street). The fenced site is accessed via the Kettle Bridge Carpark, which serves the Village Hall located on the opposite side of the road (and is used by tourists wishing to visit the Cerne Abbas Giant). Figures 1-1a and 1-1b show the site location.

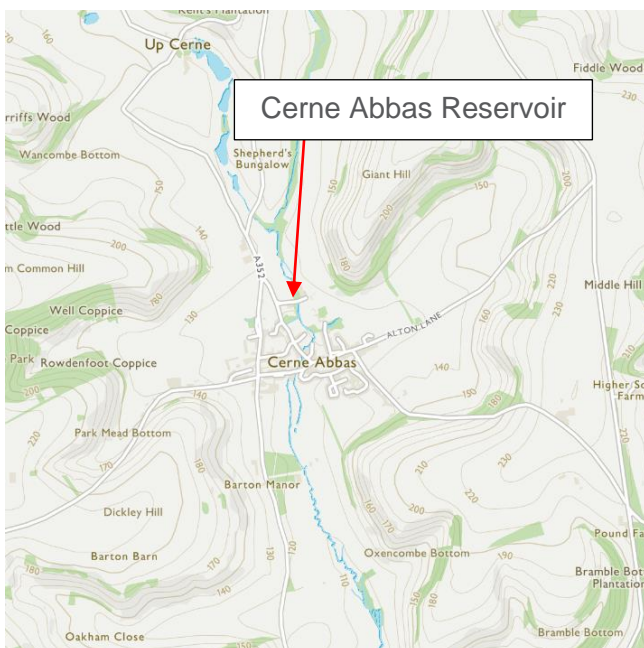


Figure 1-1a and 1-1b: Site Location

1.4. Common procedures and standards

The scheme elements have a number of common procedures and standards which need to be satisfied. These include:

- Consideration of all risks including operational and decommissioning risks, under Construction (Design and Management) Regulations 2015 (CDM) duties.
- National Environmental Assessment Service (NEAS) minimum technical requirements.
- Environment Agency Operational Instruction 412_12_SD01 – Minimum Technical Requirements

NEAS landscape and ecological design guidance.

Table 1-1 outlines other common standards and references expected to be used in the delivery of the Cerne Abbas work.

Table 1-1 - Common standards and references required

Reference	Title	Author	Version	Date
Operational Instruction 412_13_SD01	Minimum Technical Requirements	Environment Agency	9	29/08/2018
Operational Instruction 677_15	Safety, Health, Environment and Wellbeing (SHEW) Code of Practice (CoP)	Environment Agency	N/A	30/05/2018
Operational Instruction 992_14	Ride on plant working near water	Environment Agency	3	29/05/2019

Reference	Title	Author	Version	Date
Operational Instruction 733_11	Public safety risk assessment of assets in the water environment – recreation, water, and land access	Environment Agency	4	26/06/2015
Eurocode 7 BS EN 1997-1:2004 + A1:2013 & UK Annex	Geotechnical Design	BSI	1	2013
BS 6031:2009	Code of practice for earthworks	BSI	2	2009
BS 8002:2015	Code of practice for earth retaining structures	BSI		2015
	Civil Engineering Specification for the Water Industry (CESWI) 7 th Edition	UK Water Industry Research Ltd		2011
	Specification for Highways Works – Series 600. Earthworks			2016
CD 622	Managing Geotechnical Risk	Highways England		2020
Eurocode 2 BS EN 1992-1-1:2004+A1:2014	Design of Concrete Structures	BSI		2014

1.5. Source Information

The following information is available to support the design:

Table 1-2 - Source Information

Information	Source	Comment
Existing Service Information	Environment Agency	BT Scottish and Southern Electricity Linesearch SGN Wessex Water
Topographical Survey	Environment Agency	1007004_A3 1007216_CerneAbbasReservoirTopo 1007216_CerneAbbasReservoirTopoDTM EA111SVY05832_Report
Services Search (using electrolocation equipment)	Lewis Brown Surveyors	W15184_SX – Cerne Abbas
GPR Survey	Amco Giffen	00708_1
S10 and Flood Report	Jacobs Provided by EA	Cerne Abbas S10 2017 Rev 1 Final + Appendix B Section 10(6) Cert Cerne Abbas Final 2019_06_18+annexe 2017s7031-J-N002-1 - Oct19 delivery
Hydrology Report and Model	JBA Provided by EA	2017s7031 Cerne Abbas modelling report v3.0 Appendix A - 2017s7031 - Hydrology - Main stage_v3.0 (May 2019) JBA_Cerne Abbas Model
As-built Drawings	Environment Agency	Cerne Dam General Details Drg No AC2B Cerne_Culvert Section Inlet Channel Revetment Details AC1_Layout Plan AC2B_General Details AC3A_General Details AC4_Inlet Channel AC5A_Screen Details AC6A_Screen Chamber AC7A_Screen Chamber

2. Existing Structures

2.1. Embankment

The earth embankment is constructed across the valley with the main length being to the right of the river channel. Its crest is around 125.40mAOD. Available drawings indicate that the embankment was constructed with a 3m wide crest and 1v:2.5h side slopes. However, the topographical survey shows that the side slopes are in fact shallower and the crest is correspondingly narrower. This means that the raised crest is only around 1.5m wide at its narrowest point. There is a land drain at the toe of the embankment on the upstream side.

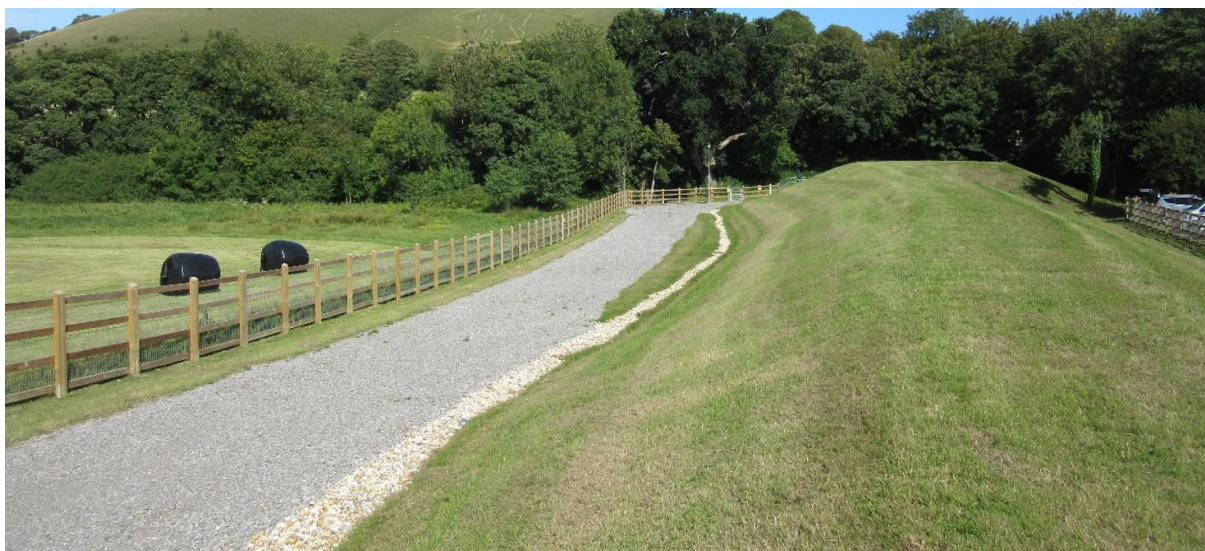


Figure 2-1: Existing embankment (photo taken August 2019)

2.2. Spillway

The spillway is formed of gabion baskets and mattresses and is set within the embankment at a level of 124.2mAOD. Along the length of the crest, there is a concrete cill which can be seen in Figure 2-5.

Figures 2-6 and 2-7 show the downstream, stepped spillway slope.

The gabions are of weldmesh type with a small gauge which has in places been supplemented with newer, thicker gauge mesh panels on the surface. Standard gabion sized stone has been used to fill the gabions – comprising a variety of rock types. The quality of the stone is variable with evidence of frequent breakage.



Figure 2-5: Upstream face of the spillway (photo taken August 2019)



Figure 2-6: Downstream face of the spillway (photo taken August 2019)

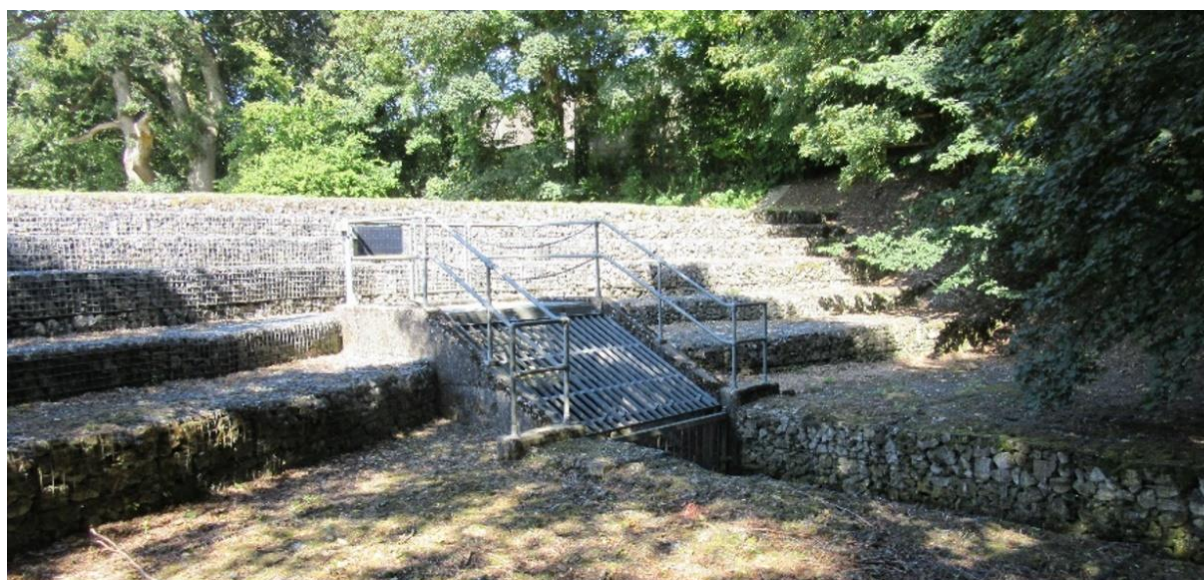


Figure 2-7: Downstream face of the spillway (photo taken August 2019)

2.3. River Channel

2.3.1. Upstream

The river channel upstream of the spillway is formed from gabion baskets and mattresses (of similar nature and condition as the spillway).

The channel is culverted through the embankment, and there is a trash screen and sluice gate on the upstream side to help reduce the risk of blockages and control flow – see Figure 2-3.

The channel crosses the site boundary approximately 15m upstream of the culvert inlet.



Figure 2-2: Upstream channel (photo taken August 2019)



Figure 2-3: Upstream culvert inlet (photo taken August 2019)

2.3.2. Downstream

The outlet of the culvert on the downstream end is a USBR type baffled headwall which incorporates a security screen which wraps around the baffle wall, see Figures 2-5.

The river channel downstream of the spillway is also formed from gabion baskets and mattresses (again of similar nature and condition as the spillway).

Approximately 27m further downstream from the outlet, the channel crosses under Kettle Bridge which is a listed structure, see Figure 2-6. This is where the river exists the site boundary.



Figure 2-5: Downstream culvert outlet (photo taken August 2019)



Figure 2-6: Downstream channel and Kettle Bridge (photo taken August 2019)

3. Site constraints

3.1. Site Access and Layout

The available land and access is limited and, whilst not directly necessarily influencing the design, does amplify the impact of other constraints discussed below.

- The embankment works shall be undertaken from within the carpark area, this will require removal of the existing fencing, this may require full closure of the car park for the duration of this element.
- The downstream channel replacement will require access off the car park for plant and for the removal and delivery of replacement materials. Clear access routing, limits of periods for bulk movement, full time attendance to manage traffic movement and temporary fencing will be required to limit public interaction.
- Replacement of the spillway will require access from both upstream and downstream with similar provisions as required for the downstream channel replacement.
- The upstream channel replacement will require access through the car park for plant and for the removal and delivery of replacement materials with similar provisions as required for the downstream channel replacement (albeit potentially less interaction as the location of the works is more easily separated from the public area).

3.2. Flooding

The reservoir is designed to impound during flood events but, for most of the time, it impounds little to no water.

The work is expected to take place in the summer months, but there is still a risk of storm events affecting the works:

- Reference will be made to Chapter 7 of Flood and Reservoir Safety (“FRS”) 4th Edition (ICE, 2014). It mainly focuses on the construction of new dams and flood risks during improvements on impounding reservoirs but the basic principal, that flood risk is considered, is accepted (it also states that CDM Regs should be referenced in all cases).
- Section 3.3.2 of the Options Study includes details on the existing standard of protection. It shows that, with the current controls in place, the reservoir spills just prior to the peak of the 500yr event and (more importantly) the flood level for the 200yr event is below the gabion formation level at the spillway crest.
- Considering the advice given in FRS Ch7, the percentage probability that a 200yr flood event would occur within the period of construction (say 6months) would be 0.25%. Despite this, is recommended that the existing concrete cill remains in place until the downstream stepped section and channel are complete (reducing probability for overflowing during construction to 0.1%).
- The EA’s minimum technical guidance document OI 412_13_SD01 has been used as the basis for the specification for the works. Clause 1.28 states that: “The Contractor’s operations shall not reduce the effectiveness of the existing flood defences. The existing defence level shall be maintained at all times during the works except where the existing defence needs to be broken out for construction of the new works. In this event the extent of existing defences to be broken out ahead of construction of the new defence will be agreed with the Project Manager in advance of the works being carried out.”
- It is recommended that the flow controls are maintained in their current arrangement (and the cill is kept in place as mentioned above), there is sufficient allowance to ensure that the contractor can satisfy the provisions of Clause 1.28. This will be sufficient to avoid having to further constrain the method/sequence of working (such as working in two parts) which would increase the H&S risks.
- There is also the possibility of passing more flow through the culvert if there is a danger of spilling. It is considered that this would be better managed by the EA as part of their flood action plan – the plan could include identifying persons at risk requiring evacuation prior to a controlled release of water.
- With regards to “dealing with water”:
 - measures to control flow (e.g. a pipe flume) would be required whilst working in the channel to replace the gabions. The measures would need to ensure they pass the test under Cluse 1.28 (that the measures do not reduce the effectiveness of the defence).
 - to satisfy Clause 3.4, measures to maintain flow in the channel will be required to prevent damage.

3.3. Ground conditions/Groundwater

A ground investigation was undertaken in February 2021 consisting of three window samples at the foot of the flood embankment on the upstream face. Dynamic probing was also undertaken. It was identified that the ground consists of made ground, peat and silty sandy clay. This led to a change in the design, from the original preferred solution (increase and widen the main embankment) to designing the embankment to spill.

3.4. Utilities

Service lines associated with the operations at the reservoir are known to be present and have been confirmed through a GPR survey. The results of the GPR & desktop survey can be found on drawing ENV0001275C-ATK-DE-2XX-DR-C-000002

3.5. Environmental / Ecological Designations

There are two trees on site that have high roost potential for bats, one of which is also a veteran oak tree. These trees are protected and are not to be felled or damaged, and any disturbances should be kept to a minimum. It is usual for restrictions to be in place such that no work occurs within the root zone of these trees, however this is not possible as the current footprint of the spillway and channel sits within these zones.

Three trees are to be removed, these are identified on drawing ENV0001275C-ATK-DE-2XX-DR-C-000003. An ECoW therefore must be present, and a local arboriculturist should be on call if necessary for all works around the effected trees.

Fifteen trees within the vicinity of the works have been identified as low roost potential for bats. These are not to be felled or damaged unless absolutely necessary for health and safety reasons and only with prior consent from a specialist.

A Phase 1 Habitat Survey and a PEA identified the potential for multiple other protected organisms on / near the works (including otters, badgers, reptiles etc.) which may constrain the works if their presence is confirmed.

American Signal Crayfish have been identified in the river, which means any plant or equipment which comes into contact with the water must be completely dried out and disinfected before use on another site in order to prevent the spread of 'crayfish plague'.

4. Design

4.1. Client / Stakeholder requirements

- The works are to be completed by December 2021.
- The Client and QCE have requested the spillway be replaced on a like-for-like basis where possible.
- The design to be accepted and agreed by the QCE

4.2. Design Elements

The design comprises the following primary elements:

- Replacement of inlet channel gabion baskets and mattress.
- Replacement of spillway crest and cill
- Replacement of downstream spillway face gabion baskets
- Replacement of outlet channel gabion baskets
- Reinforcement of downstream slope of embankment with grass reinforced turfmat (Salix P550)

4.3. Construction Assumptions

The following assumptions have been made during the design process regarding the construction of the scheme (also refer to Section 3.2 above). Any deviations from these assumptions may therefore have an impact on the design and as such the Designer should be notified:

- All works access is to be via Kettle Bridge Car Park to avoid plant/works vehicle loading on to the historic Kettle Bridge structure just downstream of the spillway.
- Site compound and welfare facilities are to be established within the Kettle Bridge Car Park.
- All asbestos previously identified on site along left bank has been removed and safely disposed of.
- GPR survey and desktop utility search has identified all known services on site and these have been overlaid on scheme drawing ENV0001275C-ATK-DE-2XX-DR-C-000002. The contractor shall undertake their own investigations, including desktop study, GPR and on-site scanning prior to works commencing to satisfy themselves as to the location of any services within the vicinity of their working area prior to starting work.
- Contractor will work / treat inlet channel, outlet channel, spillway works and the embankment re-turfing as separate phases of work which would be undertaken concurrently in the order given (no overlap or concurrent working).
- Contractor to sequence order of works to the spillway to ensure that removal and construction of the concrete spillway cill is not undertaken until the spillway gabions are complete.
- The spillway shall be constructed from formation layer 00 and rising in a stepped arrangement matching the details provided on drawing ENV0001275C-ATK-DE-2XX-DR-C-000006. The sequencing for Layer 06 needs to be considered carefully: the layer must be constructed along the full length of the spillway (at least half width) prior to removing the existing cill whilst the completion of the layer will need to be phased to work with the construction of the cill mentioned in the bullet point below.
- The concrete cill shall be cast directly against the gabion mattresses forming the permanent formwork. The gabion mattresses shall be located either side of the cill (upstream gabion mattress and Layer 06 as shown on drawing ENV0001275C-ATK-DE-2XX-DR-C-000006). This provides a physical connection between the concrete cill and the gabion baskets / stone and provides a more homogeneous structure at the crest of the dam.
- Contractor to monitor water levels, EA flood forecasting and sequence works accordingly to ensure that critical flow events are monitored and managed. This includes EA response and management of the existing sluice valve within inlet structure to enable more river water to pass if required reducing upstream attenuation (if required).

- Contractor to manage standard river flows to reduce risk of attenuating upstream during works and construct the scheme safely. The EA shall prepare an emergency flood plan of an extreme event that causes flooding to works area that cannot be managed.
- Works to the embankment will be undertaken largely using long reach excavator working on the downstream side to strip turf, regulate (trim or top up) topsoil and place proposed reinforced turfmat. The anchor trench on the upstream trench may require hand digging. The section to be raised adjacent to the spillway is again expected to be undertaken by placing fill from the downstream side and using a reversible wacker plate to compact the fill (trimmed using long reach excavator).

4.4. Risks introduced by the design

Refer to DRA (ENV0001275C-ATK-ZZ-3XX-RA-C-000001). Main risks envisaged are:

- Risk of standard of protection being compromised during works.
- Risk of striking live services during excavation or construction.
 - Services are marked on the hazard plans, and the risk is highlighted on other construction drawings with hazard triangles.
- Risk of accidents involving the public.
 - The site is adjacent to the Kettle Bridge car park and the compound will be located in the carpark. The Client has said the carpark is to remain open to the public throughout the construction period. Construction vehicles will need to use the same access as the public.
 - The Contractor should appropriately isolate the works with fencing and signage and also create a traffic management plan to reduce the interaction between construction vehicles and the public.

4.5. Reference Documents

In addition to the standards and procedures given in Section 1.4, Table 4-1 gives the additional design references which will be referred to in the design.

Table 4-1: Additional design references

	Title / Reference
Structural Calculations	CIRIA ; 2007; C660; Early-Age Thermal Crack Control in Concrete.
Hydraulic Calculations	ICE, 2015, Floods and Reservoir Safety, 4 th Edition
	Boes, R.; Hafer W.; 2003, Hydraulic Design of Stepped Spillways. Journal of Hydraulic Engineering September 2003
	Meireles, I, Matos G, 2009; Skimming Flow in the Nonaerated Region of Stepped Spillways over Embankment Dams; Journal of Hydraulic Engineering; August 2009.
	Peyras, L; Royet, P; Degoutte, G.;1992; Flow and Energy Dissipation Over Stepped Gabion Weirs; Journal of Hydraulic Engineering; 1992
	CIRIA ; 2007; C683; The Rock Manual-The use of rock in hydraulic engineering
	Maccaferri; 1985; Flexible linings in Reno mattress and gabions for canals and canalized water courses

4.6. Hydraulic

Section 5.2 of the Options Study report (ENV0001275C-ATK-SP-2XX-RP-C-000001) recommend the following:

- Reassessment of the 10,000year flood using the recently released ReFH2.3.
- Desk study of the hydraulic behaviour of the stepped spillway for the new design flows to support the development of the upgrade works.

The results of the additional modelling and desk study will be used to confirm the minimum freeboard and hence the proposed crest level.

The study results will also be compared against available guidance (see Table 4-1) to establish: suitable gabion stone size; stone type and quality; and type and structural requirements for the gabion baskets/mattresses. This will be used to inform the specification for construction.

4.7. Structural

Structural calculations have been carried out for the replacement RC Cill. Reinforcement details can be seen in structural drawings ENV0001275C-ATK-SP-2XX-DR-C-000001 & 000002 [11].

4.8. Geotechnical

It is proposed that the existing side slopes (1V:2.5H) are adopted in the raised section (no allowance has been made for undertaking any analysis of the stability of the existing or proposed embankments).

The EA are responsible for carrying out a GI prior to the design phase in order to confirm the conditions on site. Atkins produced the specification for the GI, which is detailed in Appendix A.

The results of the ground investigation will be reviewed to allow decisions to be made as to the nature of treatment of the formation (if any) and classify the fill to be used in the embankment raising.

4.9. Temporary Works

There are no temporary works to be designed by the designer. Refer to buildability statement ENV0001275C-ATK-ZZ-3XX-TM-C-000001 for assumptions and envisaged sequence of works.

The Contractor will be responsible for designing any necessary temporary works which are expected to include:

- Support for exposed surfaces during removal and replacement of the gabions (in channel and stepped spillway).
- Management of river flows
 - maximising flows during earthworks and works to the spillway; and
 - diverting/containing or restricting flows during works in-river.
- Maintaining the flood defence.

4.10. Operations and Maintenance

Operation and maintenance will remain unchanged (see existing O&M Manual) and Atkins are not contracted to produce an O&M manual for these works.

Appendices

Appendix A. Supplementary documents

The following documents and drawings have been issued prior to / along with this document

Reference No.	Document Title	File Name	Issue Date
1	Cerne Abbas Reservoir: Spillway Replacement – Options Study	ENV0001275C-ATK-SP-2XX-RP-C-000001	23/03/20
2	Cerne Abbas Spillway Replacement – Left bank raising	ENV0001275C-ATK-SP-3XX-TM-C-000001	23/07/20
3	Cerne Abbas Spillway Works Ground Investigation Specification	ENV0001275C-ATK-ZZ-2XX-SP-GT-000001	12/06/2020
4	Preliminary Ecological Assessment	ENV0001275C-ATK-ZZ-3XX-RP-EN-000001	11/11/2020
5	Cerne Abbas Reservoir Spillway Replacement – Hydraulic Study	ENV0001275C-ATK-SP-3XX-RP-HY-000001	04/12/2020
6	Technical Note - Grassland Establishment Measures to Compliment Acceptance	ENV0000727C-ATK-XX-XX-TM-Z-000001	08/02/2021
7	Civil Works Specification	ENV0001275C-ATK-ZZ-3XX-SP-C-000001	29/03/21
8	Designers Risk Assessment	ENV0001275C-ATK-ZZ-3XX-RA-C-000001	29/03/21
9	RAG List	ENV0001275C-ATK-ZZ-3XX-RA-C-000002	29/03/21
10	Civils Drawing Pack	ENV0001275C-ATK-DE-2XX-DR-C-000001 - 000101	
11	Structures Drawing Pack	ENV0001275C-ATK-SP-2XX-DR-C-000001 - 000002	

Appendix B. Cerne Abbas Flood Detention
Reservoir: REPORT ON AN
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ACT 1975, SECTION 10(2) OF THE ACT

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