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Havant Thicket Reservoir Project

Engineering and Design Report

Portsmouth Water Ltd.

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Foreword

by Bob Taylor, Chief Executive of Portsmouth Water

I feel extremely privileged to be the Chief Executive Officer at Portsmouth Water at this moment as we submit our planning application for the Havant Thicket Reservoir.

It has taken some years to reach this stage and as a Havant-based company we're delighted to be in a position to deliver this vital strategic water resource for the South East and create a unique leisure and wildlife environment for local communities.

Portsmouth Water has a long history since 1857 of supplying water to this area, and we've continually maintained a proud record of some of the highest service standards and the lowest water supply charges of all the water companies in England and Wales.

We believe in 'doing the right thing', a belief further embedded in our Community Pledge, launched earlier this year, and our Community Partnership, to be launched in the Spring which ensures society benefit is considered in all our decisions. Our aim is to make sure our objectives are in line with those of our communities.

Nowhere is this more important than in the development and delivery of a large infrastructure project like a reservoir, the first to be progressed in the South East since the 1970s.

This project has always had the potential to provide many additional benefits, over and above its core purpose of securing vital water supplies for our customers and those of Southern Water – ensuring we're ready for housing growth, climate change and protecting two world-famous rare chalk streams in Hampshire.

We believe we've captured that potential in this application, not least through an environmental net gain, with the creation of a wetland for threatened bird species, extensive tree, hedgerow and wildflower planting, drought resilience and the educational, training and employment opportunities these also bring. Our plans also create a green leisure space with paths and play areas – offering priceless benefits for health and wellbeing – with a visitor centre aimed at bringing communities together.

And with our eye on future challenges, we've also considered the role we'll play in meeting our unique commitment as an industry to become carbon net zero by 2030

We've listened carefully to the ideas and thoughts of our customers, communities, partners and regulators – held discussion groups, drop-in sessions, delivered talks, chatted on Facebook, spent time with young people and engaged tirelessly with our regulators, environmental organisations and the planning authorities. We believe this is part of the reason we have such strong support.

We think this application embodies not only our hopes and aspirations for the reservoir, but also those of the communities who will benefit and be part of its delivery, and we look forward to continuing to work in partnership with our neighbours over the months and years to come.



Bob Taylor, Chief Executive Officer, Portsmouth Water

Executive Summary

The Havant Thicket Reservoir project, providing water resources for the water stressed region in the South East of England and the first new water resources reservoir in the South East for decades, demonstrates Portsmouth Water's commitment to the environment and to drive improvements in the industry's approach to major projects. The design, presented in this report, draws on Portsmouth Water's aspirations for an environmentally-led project, which delivers benefit to the local community, and provides a valuable new asset to secure water resilience in the region.

This Engineering and Design Report provides a summary of the preliminary design process and marks a point where key design parameters are fixed to inform the preparation of the planning documents and the Environmental Impact Assessment. The planning strategy is for submission of two outline planning applications (one for the reservoir site and one for the pipeline). Flexibility, within reasonable bounds, has been sought wherever possible, to permit future innovation and minimise risk from subsequent detailed design development.

This report presents the design to date of the reservoir, including embankment, wetland, access roads and control house; the visitor centre; and the pipeline. Each element includes the key parameters that will be presented in the planning application, including: the section along the boundary with Staunton Country Park where the embankment toe and gradient of the outside slope is to be fixed, erosion protection on the inner face of the embankment, land use layout and locations of buildings and structures, vehicle access points, and strategic landscape structure e.g. the advanced planting. Other elements will be submitted in outline with parameters including the building sizes, size and arrangement of the wetland, embankment slopes, and pipeline route. Flexibility will be achieved in these cases by showing maximum building envelopes and ranges where possible.

Optioneering was undertaken to address issues identified with the 2009 outline design layout of the embankment, the vehicular access route and the pipeline route. The key changes in current design from the 2009 reference design are presented and the rationale for these discussed. They include:

- Designing the embankment to integrate with the natural landscape.
- Realignment of the embankment to minimise the loss of ancient woodland at the Avenue and Round Wood, and avoiding ancient woodland on the site boundary through the inclusion of a 15 m no-dig zone and avoidance of root protection zones.
- Re-locating the car park to avoid Bells Copse ancient woodland.
- Retaining an area of ancient woodland within the wetland area along the northern shore of the reservoir as 'wet woodland'.
- Steepening the upstream (inside) slope to reduce visual impact of the exposed face during drawdown of the reservoir and reduce construction time and vehicle movements.
- Reducing the length of embankment culvert and pipelines.
- Reducing the size of the control house and embedding it into the embankment, ensuring a design that is sensitive to the surroundings.
- Enabling new non-vehicular access routes within the newly created habitats.
- Creating an attractive naturalistic setting for the visitor centre and car park.
- Including a viewing area close to Warren Park offering the residents somewhere nearby to sit and lookout across the reservoir.
- Providing the Avenue Staircase leading from Staunton Country Park to the top of the embankment to celebrate the interface between the reservoir and the park.
- Diverting the pipeline to avoid Great Copse ancient woodland.

Health and Safety by Design principles have been applied in the design and planning of the Scheme and considerations of buildability and associated safety issues have influenced proposed design changes, such as the relocation of the reservoir culvert to avoid groundwater issues and instability of the ground along the route.

This report demonstrates that through careful design, engagement with stakeholders and constant challenge of the assumptions and constraints, we have developed a solution that meets the project drivers and the budgetary requirements.

1. Project Overview

1.1. Overview

- 1.1.1 The goal of the Havant Thicket Reservoir (HTR) project is to provide a new resource to supply drinking water in the water-stressed South East of England, while maximising the community and environmental benefits of a new raw water reservoir.
- 1.1.2 The key elements of the scheme are as follows:
 - Havant Thicket Reservoir for raw water storage, complete with control house, visitor centre and recreational facilities for public amenity (Section 2 of this report).
 - A new pipeline from Bedhampton and Havant Springs to the reservoir site to allow the reservoir to be filled and for stored water to be provided for public water supply (Section 3 of this report).
- 1.1.3 This report provides details of the preliminary engineering design of these elements of the scheme and supports the outline planning applications for the reservoir and the new pipeline.
- 1.1.4 Other documents which accompany the planning applications include: a Design and Access Statement, which provides a less technical overview of the Scheme and how the design of the buildings and key focal points for visitors has developed; the Planning Statement which demonstrates the need for the scheme, the alternatives considered and assesses it against the national and local planning policy framework; the Development Specification which sets out what planning permission is being sought for; an Environmental Statement and a Transport Assessment which assess the environmental and transport impacts of the scheme; and a Statement of Community Involvement which summarises the engagement that has taken place to inform the scheme.

1.2. Project Drivers

- 1.2.1 Portsmouth Water's Project Drivers provide the high-level framework guiding the project. These drivers have informed the Design Principles which were developed to inform the reservoir design. Other drivers influencing the scheme design include the planning policy framework, which sets out the criteria against which the planning applications will be determined, and the planning application strategy, which identifies the level of detail required to inform the planning applications.

Portsmouth Water's Project Drivers

Quality: Quality in procurement, design and delivery to deliver an exemplar project to serve Customers in the short, medium and long term.

Timeliness: In service and operating by 2029 to support a major bulk transfer to Southern Water. Deliver efficiency in procurement.

Innovation: Develop best practice in the largest new reservoir project in the South East for decades. Capture learning from companies working in partnership deliver better value for customers.

Flexibility: Create a project that offers multiple uses and enables the Company to be a strategic water supplier for the South over the medium and long term.

Responsibility: Realise and build upon our health, safety and well-being goals.

Connectivity: Positive connection for all stakeholders – Customers, the local community, regulators, staff, contractors, shareholders, commercial partners, environment groups and individuals with a passion for the environment.

Environment: A positive contribution to local and internationally important habitats. Direct support for Government's objective to reduce the damaging abstraction of water from rivers.

Design Principles

1.2.2 As part of the design development, Design Principles were agreed to inform development of Scheme components ensuring that they reflected the project drivers, relevant legislation and policy, Portsmouth Water and stakeholder aspirations, constraints and opportunities:

- Create a safe environment to work and play. Use creative and intelligent design to minimise any short and long-term health and safety issues.
- Maintain and integrate with the rural landscape character and woodland setting, through the design layout and material selection process, and where possible developing soft engineering solutions - limiting structures and ancillary clutter.
- Design to be sympathetic to and blend in with the historic park and gardens landscape. Specifically considering impact on setting and views to and from the designated sites including the Grade II listed park and gardens, conservation area and South Downs National Park.
- Design to minimise whole life costs such as maintenance and need for replacement ensuring durability in a challenging public setting and flexibility in the design to manage future requirements.
- Maintain and enhance public access to the site, optimise opportunities to link to existing walking, cycling and bridleway routes.
- Design of the site and all facilities for all ages and abilities.
- Incorporate recreational facilities that are in keeping with the quiet enjoyment of the countryside setting, optimising health and wellbeing opportunities.
- Optimise educational opportunities in all design elements.
- Maximise opportunities for biodiversity in the design of the landscape and buildings and minimise and mitigate any conflict with wildlife through forward planning.
- Where possible avoid ancient woodland, an irreplaceable habitat, and maintain a minimum 15m gap as buffer along the boundary.
- Incorporate public art into the design in an innovative and robust way.
- Optimise opportunities for a sustainable design where practical to include:
- Improving energy efficiency in base design, consider decentralised low carbon energy sources to achieve an overall improvement in operational energy efficiency.
- Improving climate resilience of the reservoir, ensuring management of reservoir flows, considering whole life sustainability impacts.
- Minimising material quantities as much as possible and select alternative low carbon materials in design wherever possible.
- Support the UK's Net Zero Carbon target by minimising where practical greenhouse gas emissions at all stages of the infrastructure lifecycle, and maximising opportunities for greenhouse gas removals through sequestration by vegetation and renewable energy generation.
- Design infrastructure which is resilient to expected climate change and extreme weather events.

Planning Policy Framework

1.2.3 National and local planning policy identifies what should be included within any planning application and what the application will be assessed against. The table below summarises the key planning policy requirements and considerations which have been considered throughout the scheme development. These policies, and how the Scheme meets them, are considered in more detail in the Planning Statement which accompanies the planning applications.

Table 1-1 Key Planning Policy Requirements

Policy Themes	Summary of Key policy requirements / considerations
Leisure and recreation	• An attraction for local communities • Network of connected paths for walking, cycling and horse-riding • Green infrastructure links • Maximise opportunities for deprived areas • Opportunities for an improved quality of life • Provision of new facilities to promote tourism
Environment	• Avoid potential adverse impacts on wildlife sites, protected species and priority species • Create additional habitats • Compensate for loss of habitats and woodland • Avoid habitat fragmentation and severance of species migration and commuter routes • Consider opportunities for biodiversity enhancements at reservoir and along Hermitage stream • Improve network of multi-functional green and river corridors • Minimise impacts on Langstone and Chichester Harbours and Hermitage Stream • Minimise the risk of flooding • Avoid Great Copse • Consider the predicted future impacts of climate change. • Consider renewable energy • Improve local air quality • Minimise noise pollution
Transport	• Minimise construction traffic • Restrict the use of public vehicular traffic within the site • Ensure appropriate means of access • Promote sustainable transport
Heritage and Landscape	• Protect and enhance the Conservation Area • Integrate the reservoir and new landscape within the historic landscape and existing woodland • Minimise impact on Staunton Country Park and setting of South Downs National Park • Protect rights of way

2. Havant Thicket Reservoir

2.1. Overview and Design Parameters

2.1.1 Section 2 of this report sets out the preliminary design of the key elements of the proposed Havant Thicket Reservoir and associated engineering works, including:

- The embankment structure including the alignment route and reservoir capacity; crest protection and freeboard assessment; geotechnical design for stability; and upstream slope protection material;
- The wetland retaining structure;
- The control house and associated ancillaries including the functional requirements of the building and the emergency drawdown discharge chamber at the reservoir;
- The access road to the reservoir which will be used for both construction and visitor traffic in use;
- The Visitor Centre and Educational Bird Hide;
- Public Realm.

Design Parameters

2.1.2 The Basis of Design parameters of the current reservoir and embankment design proposed for planning application are given in Table 2-1 below. More detail on exactly what permission is being sought for is included within the Development Specification which accompanies the planning applications.

Table 2-1 Key reservoir data and performance criteria

Element	Parameter	Element type	Performance criteria
Reservoir capacity	9,600 Million litres (MI), including borrow pits volume, above low level outlet	Total capacity not including water below lowest draw-off level or retained in wetland	To exceed target operating capacity of 8,700MI
Supply rate to Farlington WTW	At least 21 MI/d in extreme (currently defined as 1:200 year) drought conditions	Inlet / outlet pipeline, varying 1.2m to 0.7m diameter	21 MI / day over the reservoir operational envelope. Flow rate measured at reservoir control house and Bedhampton Pumping Station
Filling rate of the reservoir (via Bedhampton reservoir fill pumps)	40MI / day	Inlet / outlet pipeline, varying 1.2m to 0.7m diameter	40MI/day filling rate from Bedhampton to the reservoir
Embankment	Max 20m high Crest level 40.5m Length 2,770m Upstream (inside slope) slope: to range from 1:5 to 1:7 Downstream (outside) slope: majority 1:7 with local variations to 1:5	Cohesive fill, with zoned clay core and outer shoulders, granular filter and drainage elements	Embankment slope stability factor of safety to be minimum 1.3 - 1.5 for the "end of construction" case.

	at Round Wood and the Avenue woodland Outer toe (edge): +/- 2m horizontal range (north to south) Crest line position: 0 – 37m horizontal range (to north) to accommodate any potential future need for reducing the outer face slope from 1:5 to 1:7		
Embankment adjacent to Staunton Country Park	Toe (edge) of the embankment is fixed at a minimum of 25m from the edge of woodland along the southern boundary of the Site (known as Hammond's Lands Copse). Length of embankment at 1:5 is approximately 185m along this stretch and 390m of embankment with slope varying from 1:5 to 1:7.		
Top Water Level (TWL)	39.5m AOD	Overflow level	1m freeboard (from TWL to embankment crest) to contain flood rise due to Design Flood and wave action
Lowest operating level	27.5m AOD	Top of lowest 20% of storage volume	Lowest 20% to be considered dead storage, minimum level before reservoir operationally fails
Spillway / overflow	3m long weir/ 700mm diameter pipe 1.6 cumecs capacity	Dropbox inlet discharging to pipe	Spillway to pass Design Flood (DF) and Safety Check Flood (SCF) with minimum flood freeboard to prevent/limit overtopping due to waves.
Available freeboard	1.0m	Height from TWL to crest level	Freeboard assessed to contain flood surcharge with minimum flood freeboard to prevent/limit overtopping for the DF and SCF.

Slope protection material	Range of up to 450mm thick layer of protection	Rip-rap (rock armour), D ₅₀ (average) size varying up to 225mm. Brushed with topsoil to allow planting.	Wave action contained below crest level during design flood, for the highest likely upstream slope.
Emergency drawdown facility	Discharge capacity of 10.9 m ³ /s Reservoir can be lowered by 1/3 of water depth in 6 days	1.4m dia scour pipe and submerged discharge valve discharging into Riders Lane Stream at control house 1.2m dia inlet /outlet pipe discharging into the Hermitage Stream 3km downstream.	Installed drawdown rate following Environment Agency guidance to be 0.85m in first 24 hours (5% of reservoir depth) Time to lower 1/3 of the water depth
Access to intake controls	Internal plan size of access shaft to be in range of 4-6m x 4-6m	Concrete shaft just upstream of crest / core of embankment	Valves to be accessible from embankment crest for emergency drawdown, with lockable hatch at crest level
Wetland retaining structure	A retained wetland extending for approximately 1.3km along the northern shoreline 4No. retained wetland compartments, plus provision of an area for wet grassland habitat creation to the east of the retained wetland Retained area of ~6.8ha at spillway level of 38.8m AOD	Embankment with cohesive fill	Retention of wetland during drought levels in main reservoir
Control house	Maximum width of building frontage = 33m Maximum height of building wall above external ground level = 6m Schedule of accommodation total area = 430m ²	Reinforced concrete outer structure with cladding, composite roof slab with green roof, steel frame /blockwork inner walls	Functional requirements and accessibility, security classification from Security and Emergency Measures Direction (SEMD) assessment

2.2. Reservoir Embankment Structure

Sustainability and Environment

2.2.1 The embankment design has been progressed with the key design philosophy which can be summarised as:

- Materials to be used in the embankment will be sourced from site as much as possible
- Off-site disposal of materials found on site will be avoided as much as possible

- Materials will be selected that will be sustainable and suitable for the rural context of the reservoir in a country park. Importing of materials not found on site will be minimised as much as possible; where required the aim will be to utilise local sources where appropriate
- The embankment has been designed to integrate with the natural landscape, taking account of the design principles in section 1.2 and slope gradients that reflect the local landform.
- Realignment of the embankment to respond to environmental constraints such as minimising the loss of ancient woodland at The Avenue and Round Wood, and avoiding ancient woodland on the site boundary through the inclusion of a 15 m no-dig zone and avoidance of root protection zones.

Health and Safety

- 2.2.2 Health and Safety by Design principles have been applied in the design and planning of the embankment construction. Key risks have been identified as:

Construction

- Flooding of borrow pits during construction from flow from northern streams – to be mitigated firstly by temporary dams on the northern streams allowing pumping to west of site, and secondly by constructing the wetland retaining structure in advance to enable management of inflows during remainder of the earthworks.
- Large flood events in the catchment during construction will be diverted through the culvert or the scour pipe. The floods that would be expected to be managed by the contractor have been quantified, given in later section on the flood study.

Operation and Maintenance risks

- Erosion of upstream face of the embankment – mitigated with slope protection material, provisionally rip-rap (rock armour).
- Overturning of grass cutting equipment on embankment – mitigated by considering new equipment such as remotely controlled lawnmowers to manage slopes up to 1:5.

Public Amenity Use

- Risk of small children falling into reservoir (as wave wall removed) – mitigated by safety fence with mesh on the embankment crest.
- Risk of drowning – Further consideration to be given as design develops through a PSRA (Public Safety Risk Assessment). This will incorporate consideration of guidance from the Environment Agency and best practice from similar assets including education in local schools on risks of swimming in deep open water, need for appropriate signage and public safety measures e.g. life rings.

- 2.2.3 Dam safety design has been ensured by compliance with the Reservoirs Act (1975) whereby an All Reservoirs Panel Engineer has been involved in supervising the design and a Construction Engineer will be appointed under the Act to supervise construction.
- 2.2.4 The design is also reviewed by an independent Panel of Experts including an All Reservoirs Panel Engineer.

Buildability

- 2.2.5 A construction sequence has been developed which informs the embankment design and vice versa. Environmental constraints in the programme have been a key consideration in this process. Managing protected species on the reservoir site, specifically within woodland areas, has influenced the timing and distribution of the earthworks construction on site.
- 2.2.6 Opportunities to optimise the construction programme will be investigated but have not yet been fully agreed for inclusion in the works information package for tender. Evaluation of the programme changes will need to ensure that any areas of habitat that do not need to be disturbed are protected, for example at the North-east corner. These potential changes could include:

- Construction of the culvert structure in the summer before the first earthworks season, for the provision of groundwater management
- Earthworks preparation (topsoil stripping and borrow pit preparation) brought forward to 2021, before tree felling but after reptile relocation in the areas of open grassland.
- Construction of the wetland retaining structure in the first earthworks season, to allow its use in retaining inflows from the three streams in the northern shore and allow pumping of these inflows away from the reservoir, as well as attenuating flooding from the streams
- The use of conveyor belts to accelerate the transport of cohesive material from the borrow pits and topsoil to the embankment construction, and minimise plant noise and movements

2.2.7 Considerations of buildability and associated safety issues have influenced proposed design changes, such as the relocation of the reservoir culvert to avoid groundwater issues and instability of the ground along the route in the reference design.

Innovation

2.2.8 The design of the embankment and associated structures has been carried out using an interface of several 3D modelling platforms:

- Civils 3D for modelling of the existing ground strata, allowing design of the borrowpit and cut/fill balance;
- Civils 3D allowing rapid measurement of reservoir volumes stored by embankment realignment options, and reduction in embankment volumes through realignment, notably south-west and eastern sections;
- Navisworks for a combined federated model;
- Webview GIS to allow rapid comparisons of options for embankment and structures realignment with geological data, and constraints such as designated conservation areas and ancient woodland no-dig zones.

Embankment Alignment

2.2.9 An options exercise was undertaken to address the following issues identified with the initial outline design layout of the embankment as developed previously in 2009:

- Encroachment onto the western site boundary and adjacent ancient woodland, with no space for access roads or tracks.
- Excessive loop in the route to the south west part of the embankment.
- Encroachment onto ancient woodland areas of Round Wood and The Avenue which could be minimised.

2.2.10 The options study concluded with a preferred combination of options to address these issues by realigning the embankment crest route and length, and by steepening downstream slope in places. This combination was for Options 1+3a+6+8, summarised in Table 2-2 below.

Table 2-2 Summary of preferred combination of embankment realignment options

Option	Change	Benefit
1	Move embankment to east (into the reservoir) by approx. 20m	Avoid tree loss and ancient woodland no-dig zone. Provide space for access roads including the southern public access route.
3a	Steepen downstream slope to 1:5 at the crossing with The Avenue and move crest inwards to avoid veteran trees and minimise impact on other valuable woodland habitats.	Retain trees in the southern end of The Avenue strip

6	Steepen downstream slope to 1:5 at Round Wood and near the valley. Straighten crest route to minimize loop to south west	Reduce length of culvert in embankment. Retain trees in Round Wood, providing screening of the relocated control house
8	Cut embankment tie-in at North-east end to tie in before north-east stream	Reduction in length and material. Allows extension of wetland compartments and creation of additional new habitats of value

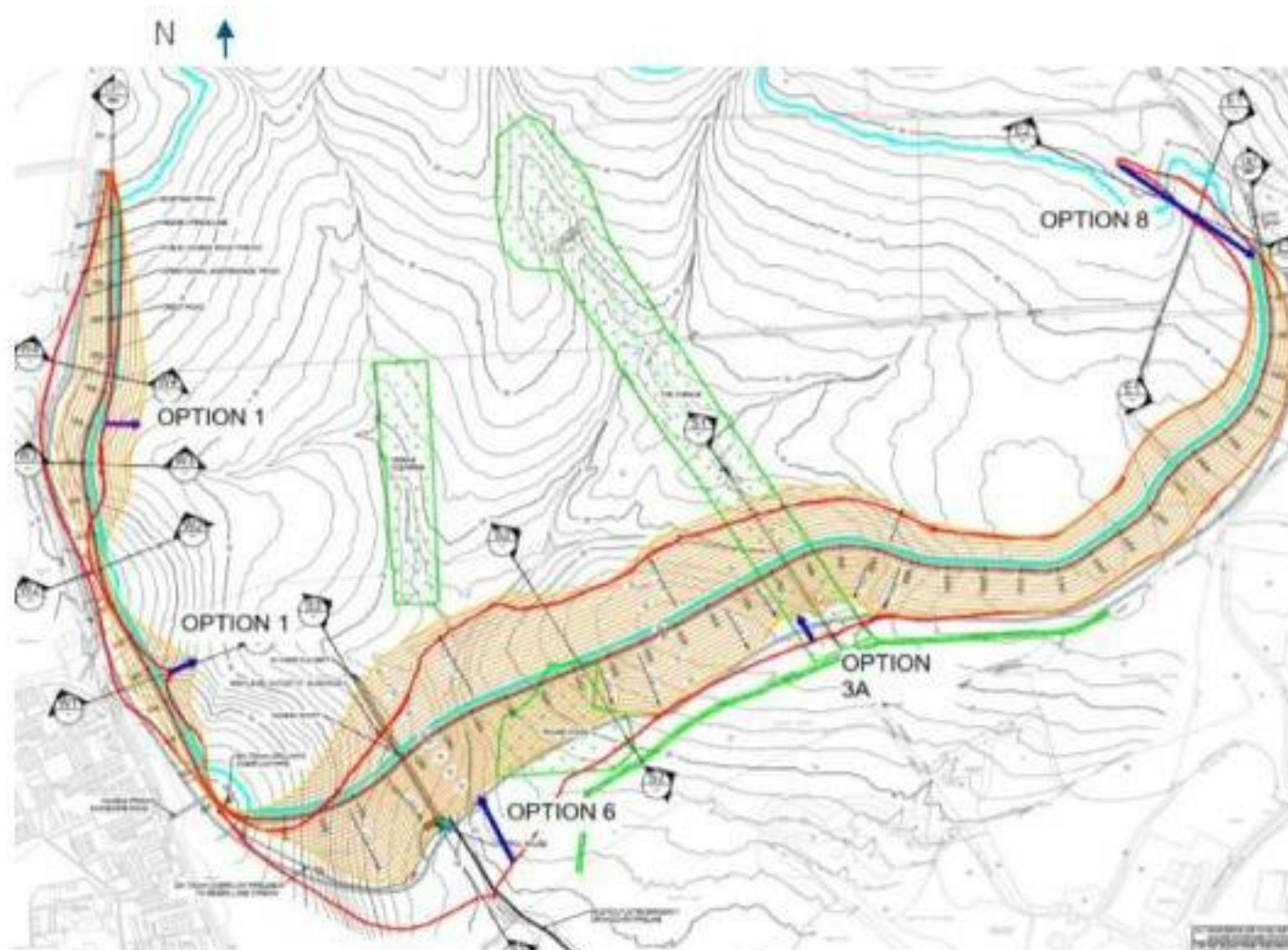


Figure 2-1 Effects of embankment realignment options combined (reference design embankment outline in red)

- 2.2.11 All options were considered individually for the change from the baseline total volume, which was the volume stored by the reference design embankment alignment, using new topographical survey information.
- 2.2.12 The net change in reservoir volume from the baseline total volume to the optimised combined option was -450MI, to 10,514MI. This included an estimate of 2,000MI for the borrow pits which has since been revised following redesign of the borrow pits, leading to an optimised volume of 9,320MI. The total volume capacity excludes the volume of water retained in the wetland area below the spillways of the wetland retaining structure, and the volume of the material of the wetland retaining structure itself.

Removal of wave wall following freeboard assessment

- 2.2.13 The reference design defined an embankment freeboard of 1m which was used to set the level of the crest of the dam above the TWL. The reference design drawings also included a 0.5m high concrete wave wall (effectively increasing dam freeboard).

- 2.2.14 An initial freeboard assessment showed that the 1m freeboard to the embankment crest was sufficient for the 1:7 upstream slope. The wave wall is not required for dam safety reasons and it was recommended that it therefore should be replaced with a safety fence.
- 2.2.15 The assessment concluded that the 1m freeboard between the reservoir TWL and the crest of the embankment is retained, to allow the clay core to be 0.5m above the TWL to contain the flood surcharge. This allows 0.5m above the clay core to allow for the crest road base and protection to the clay core.
- 2.2.16 The assessment concluded that this 1m freeboard would also provide flexibility during the design development for adopting steeper slopes. This flexibility was limited to a 1:6.5 slope for smooth surfaces (such as Open Stone Asphalt or interlocking concrete units) but would allow a 1:4 slope for rough surfaces, for which the only established material option is rip-rap (rock armour).
- 2.2.17 This initial freeboard assessment showed that rip-rap rock armour can be used if the slope is to be increased to 1:5 which has been the aim of slope stability analysis undertaken since. Slope protection material options and sizes were then considered in more detail in the subsequent options study summarised later in this section.

Flood study

- 2.2.18 The initial assessment of freeboard was carried out using the results of the previous flood study at the time of the reference design (2007) and since then there have been significant changes to the guidance to assess the freeboard of reservoirs.
- 2.2.19 The 4th Edition of Floods and Reservoirs Safety (ICE, 2015) defines two assessment conditions: Design Flood (DF) and Safety Check Flood (SCF) which for a Category A reservoir are the 10,000 year return period flood and the Probable Maximum Flood, respectively. The DF must be discharged under normal conditions with a safety margin provided by an accepted freeboard limit. The SCF is defined as the flood beyond which the safety of the dam cannot be assured, which in practice means that small wave overtopping is tolerated for this event.
- 2.2.20 The 1m freeboard was re-assessed through a new flood study for the proposed arrangement of the reservoir, with a 1v:5h upstream slope lined with rip rap.
- 2.2.21 Reservoir inflow hydrographs were derived and routed through the reservoir to evaluate the flood surcharge for the DF and SCF. An evaluation of the minimum flood freeboard and overtopping flows due to wave action were also carried out for these two flood conditions and also for a dry weather/extreme wind scenario.
- 2.2.22 The critical scenario for the assessment of the reservoir freeboard is the Design Flood. The 1m total freeboard is sufficient to contain the design flood surcharge (0.38m) and the significant wave height (0.53m). This currently allows 90mm for long-term settlement, which will be confirmed if sufficient as part of the outline design, with embankment height (and therefore freeboard) increased if required. The maximum flood rise for the SCF takes the peak water level to 39.96 mAOD which is contained below the top of the embankment clay core at 40.00mAOD.
- 2.2.23 The overflow capacity of the reservoir relies mostly on the attenuation effect provided by the large surface area of the reservoir at TWL. The spillway weir was defined with a relatively small length of 3m to limit the discharges downstream. The maximum discharge for the SCF is 1.59m³/s. The proposed pipe to convey the flows from the spillway crest to Riders Lane Stream will be designed for this flow.
- 2.2.24 For the design of the temporary diversion works during construction, the 30 year flood was assessed, which represents a risk of exceedance of about 10% during the 3 years estimated for the construction. The conveyance capacity of temporary pipes in the culvert under the embankment would need to be provided by the contractor for the peak flow of the 30 year flood (4.6m³/s).

Steepening of the upstream face

- 2.2.25 As part of the embankment optimisation considered for the reservoir, slope stability analysis was carried out to test the feasibility of increasing the upstream (inside) slope from 1:7 to 1:5.
- 2.2.26 This was carried out in two phases, an initial assessment using characteristic ground parameters and then a developed analysis using the material parameters as determined in the preparation of the Ground Investigation Report (GIR), following the completion of laboratory testing data and factual report from the ground investigation carried out in 2019. An edited selection of the geology found at the critical section is given in the table below:

Table 2-3 Geology at location of slope stability assessment

Strata	Descriptions
Head	Soft to firm light grey, mottled orangish brown sandy gravelly Clay. Note this material is believed to be derived from slope movement processes. Thus, there is the potential for continuous or semi continuous existing shear surfaces. Within this layer excessive pore water pressure exerted on the existing shear surface could reduce the slope stability dramatically.
Bognor Formation	Clayey gravelly Sand, at the base changing to brown sandy Clay.
London Clay	Soft, firm to very stiff fissured dark grey sandy silty Clay. Pyritic nodules present.

- 2.2.27 The initial assessment indicated that the critical condition was the end of construction scenario (where the embankment is complete before first reservoir filling has commenced).

The following embankment profiles were analysed:

- Option 1: 1(V):7(H) Downstream
- Option 2: 1(V):5(H) Downstream
- Option 3: 1(V):5(H) Upstream

As well as the material parameters, the GIR noted that the presence of relict shear surfaces in the Head layer, up to 3m below ground level, will have some effect on the bulk strength of various layers with some of the affected zone at residual (reduced) strength.

- 2.2.28 These effects were modelled by assuming the Head layer is at residual strength, and for other near-surface materials, shear strengths in effective stress terms have been reduced by around 10%, and cohesion limited to 1 kPa.
- 2.2.29 In addition, the soil close to ground surface, (within the upper 3 metres), was found to have a low undrained strength, (C_u), with a value less than 30 kPa. This will also influence the stability of the embankment during construction. Note that undrained strength is a way to characterise soils, that does not need to use predicted pore water pressures, (as is the case with effective stress parameters.)
- 2.2.30 For dealing with pore water pressure in limit state slope stability analyses, the analysis was based on the conventional lumped factor of safety approach.
- 2.2.31 For the purpose of these analyses, an overall stability with minimum factor of safety of 1.3 was considered appropriate for the new embankment at the end of construction case. This follows guidelines in An Engineering Guide to the Safety of Embankment Dams in the UK (BRE, 1991) which are based on accumulated best practice.
- 2.2.32 Controlling pore water pressure in both embankment and underlying soils was shown to be important, particularly in the construction phase when soils are subjected to relatively rapid loading and there will be insufficient time for the full dissipation of excess pore water. This

will lead to an increase in pore water pressure within the Head layer, and underlying soils, and excessive pore water pressure exerted on the existing shear surface would reduce the slope stability.

- 2.2.33 As part of the process to control stability of the shoulders, digging out and replacing the Head and low undrained strength material will be part of the construction. The determining of the extent is part of the developing design process.
- 2.2.34 A range of piezometric lines, representing varying levels of pore water pressure profiles within the foundation, were applied in analyses. For foundation materials, four cases for piezometric surfaces were adopted to represent the confined pore water pressures generated within the confined randomly sheared surfaces of the Head layer caused by loading by the new embankment. The lower the profile is a reflection of the dissipation of pore pressure with time. This will lead to a gain in strength in effective stress terms. This will also be reflected in a gain in strength in total stress terms, (i.e. in C_u).
- 2.2.35 The results of the slope stability analysis are summarised in the table below:

Table 2-4 Summary of factors of safety achieved in slope stability analysis with confirmed ground parameters

	Factors of safety (approx.) – In situ Head Foundation material	Factors of safety (approx.) – Replaced Foundation material
1:7 downstream/upstream slope (end of construction case)	1.45 - 1.0	2.1 - 1.6
1:5 downstream/upstream slope (end of construction case)	1.2 – 0.95	1.6 – 1.3
1:5 upstream slope (filled reservoir case)	1.8	2.2

- 2.2.36 The conclusions of the revised slope stability analysis were:
- 1:7 Downstream slope: Stability increased when in situ Head (with shear surfaces) is excavated and replaced with engineered cohesive fill
 - Cannot be achieved with Head left in situ as the foundation material for the range of porewater pressures tested
 - 1:5 Downstream slope is achievable if porewater pressure is managed in underlying material during construction
 - A steeper 1(V):5(H) slope is possible for both sides of the embankment in the end of construction case, provided that the potentially sheared in-situ Head is dug out, replaced and compacted, and porewater pressure in underlying material is controlled.
 - The dig out of potentially sheared material will also help deal with low undrained strength at the near surface.
 - Placement of a drainage blanket at formation level beneath each shoulder
 - By building the embankment in a controlled manner (with a restriction on the rate of construction), there will be beneficial gain in stability by dissipation of pore water pressures.
 - An appropriate inspection and monitoring regime
 - Enhancement of the dissipation using vertical and drains below the drainage blanket
 - Lateral drains placed within the fill of each shoulder. These will also help control the stability in rapid drawdown
- 2.2.37 Steepening the upstream slope has the following engineering and environmental benefits:
- Reduced construction time of earthworks
 - Reduced visual impact of exposed upstream face during drawdown of the reservoir (with slope length reduced by around 2m for every 1m drop in water level)
 - Reduced length of embankment culvert and pipelines (by approximately 38m)
 - Increased space for topsoil and other material storage between the embankment footprint and the borrow pits

- Reduced vehicle movements / emissions

2.2.38 Further analysis is required to design the drainage blanket and filter zones within the embankment and foundation, to manage the downstream pore water pressures in the embankment as indicated by the slope stability analysis.

Slope protection material

2.2.39 An options exercise was undertaken to evaluate which materials would be feasible, sustainable and suitable for the rural context of the reservoir in a country park and conservation area. Materials considered were:

- Open Stone Asphalt (OSA)
- Elastocoast (similar to OSA but with a resin binding the aggregate)
- Concrete Block Revetment (cable-tied)
- Concrete Slabs
- Rip-Rap (rock armour)

2.2.40 Evaluating these options with the scoring system based on the seven project drivers indicated that Elastocoast and rip-rap (rock armour) were the best materials, followed by OSA. However, OSA and Elastocoast were both more expensive than rip-rap, based on rates per unit area (which allowed comparison since the same areas of embankment would require protection independent of the material type to be used). As it might be possible to increase the upstream slope of the embankment from 1:7 to 1:5, this limited the selection of material type to those with rough surfaces. The required roughness would only be provided by rip-rap of the options available, unless:

- the upper slope (the top 2m of the embankment) was kept at 1:7 with the remainder below at 1:5,
- the decision to remove the crest wave wall was reversed, or
- further innovative methods could be developed by adding roughness elements to the smooth surface of the OSA or Elastocoast to limit the wave run-up/overtopping flows.

Given that keeping the upper upstream slope at 1:7 would reduce the saving provided by steepening the upstream slope, led to rip-rap being identified as the recommended option.

2.2.41 Sourcing of the rock for rip-rap is ongoing, with a sustainability, cost and carbon footprint assessment commenced for different options, which are bringing in limestone by truck from quarries in Somerset, Dorset or Kent, or by boat to Portsmouth from northern France. Local quarries (e.g. Butser Hill) in Hampshire and the region predominantly produce chalk, and therefore are only suitable for the gravels and sands in the embankment filters and drainage layers.

2.2.42 A solution to green the rock armour was identified where rock mattresses would be brushed with topsoil allowing planting with aquatic / marginal species such as reeds and sedge grasses. This detail, used at Thames Water's Lockwood Reservoir, and shown in Figure 2-2 below, was found to be feasible for the south section of the embankment, where the wave fetch and height (and therefore rock size) would be smallest.

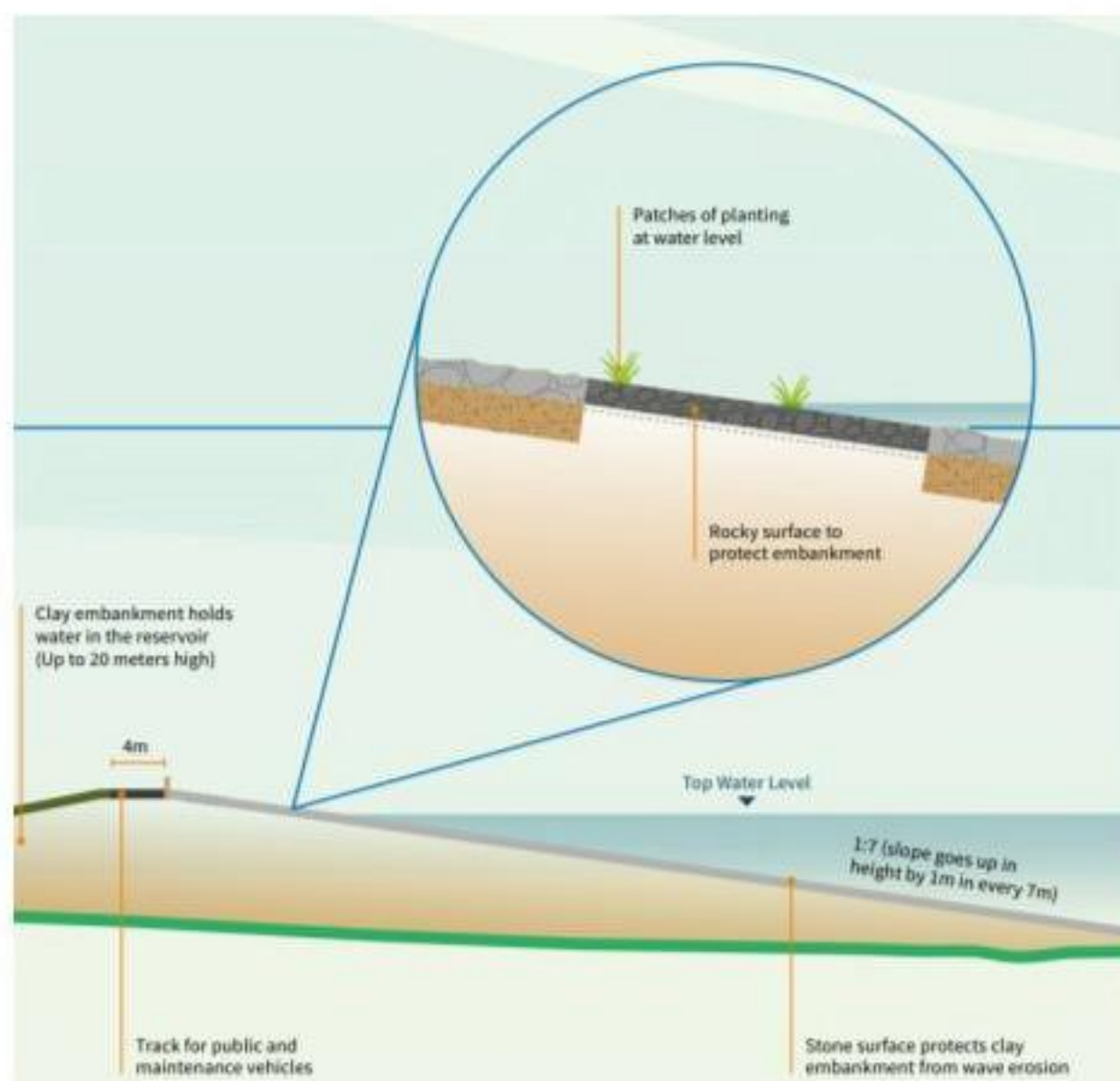
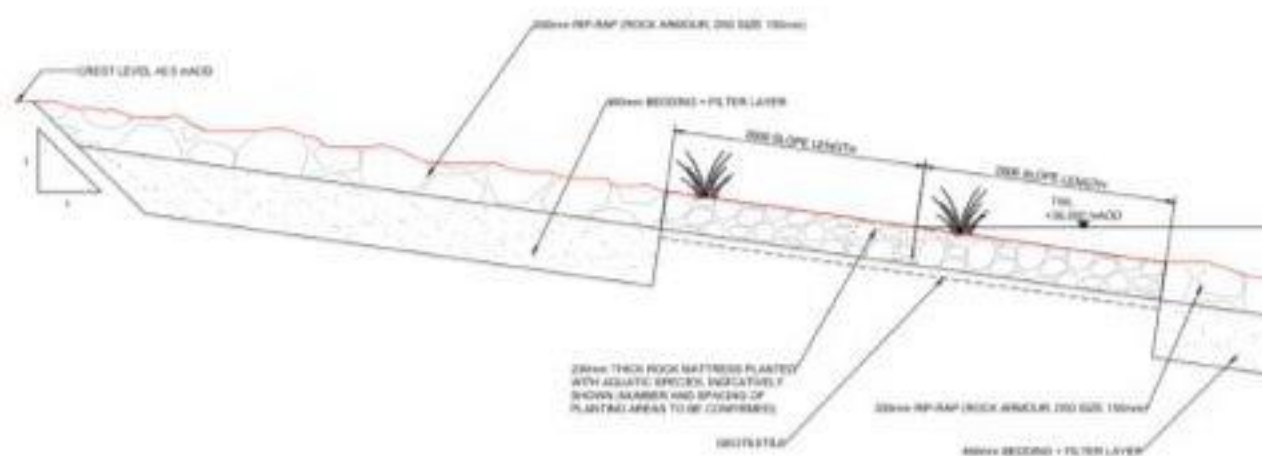


Figure 2-2 Embankment upstream slope protection with planting detail

- 2.2.43 The planting detail may require further development at detailed design stage, to mitigate the potential for a relative increase in wave-run up due to the surface of the rock mattresses being smoother than the rip-rap. This may be achievable with a detail such as a slight inset in the rock mattresses, a low timber or kerbing edge detail, or by inclusion of the beneficial effect of the planted reeds in dissipating wave energy.
- 2.2.44 The question of the sustainability of the rip-rap option has also been addressed by re-evaluating the need for granular filter and bedding layers and considering replacement of these with a geotextile, which would reduce the importing of granular material not available at the site.

Programme

2.2.45 The key programme phases for the reservoir are:

Dates	Key activity / milestone
Spring 2021	Planning permission expected
Spring 2021 – November 2022	Species relocation, tree felling, preparatory work on habitats avoiding breeding / nesting seasons, enabling works including access road construction.
March 2023 – September 2026	Construction of culvert structure, embankment and reservoir control house
Autumn 2026 – Spring 2029	Filling of reservoir in stages with pumped water from Bedhampton Springs

2.2.46 The construction programme is currently under review for opportunities to optimise the programme by re-evaluating the construction sequence, as summarised in the buildability section above. For example, moving the construction of the embankment culvert structure earlier, to the summer of 2022, could avoid the potential risk of delays due to difficult ground conditions in the winter before the first embankment season.

2.2.47 The rate of construction has significant influence on the behaviour of the embankment during construction, and monitoring will be carried out to check that behaviour is in line with design expectations.

2.3. Wetland Retaining Structure

2.3.1 The outline design of the wetland has built upon and extended the outline concept plan (2009). Whilst there are no specific standards and/or specifications for wetland habitat design, it has been stress-tested at key points in the outline design development to deliver a robust, workable, buildable and locally-relevant design that reflects the full range of environmental, recreational and stakeholder requirements of the scheme.

2.3.2 The HTR wetland area is one of the key delivery mechanisms for offsetting biodiversity losses associated with the project and in combination with the overall mitigation package will provide a Project that accords with local and national planning policy.

2.3.3 The following sections summarise the key elements and design parameters of the wetland as shown in Figure 2-3 and 2-4.



Figure 2-3 Visualisation of the retained wetland area

The wetland outline design includes the following approved design elements:

- Provision of a wetland retention structure and concomitant retained wetland area
- Alignment of the retention structure and resulting compartmentalisation as shown in Figure 2-4 – plus an area for wet grassland habitat development to the east of the retained wetland
- Requirement for vehicular access and access routes to and along part of the wetland retaining structure

- Provision of spillways for passive water level management control

2.3.4 The following aspects are included in the outline design concept. These require further development during detailed design.

- Provision of piped controls with penstocks or gate valves to facilitate active water level management
- Approaches to add wetland habitat value to both the upstream and downstream face of the retention structure
- Provision of seasonally inundated bird nesting islands to provide greater depth and habitat variability (compartments 2, 3 and 4)
- Measures to improve habitat complexity in Compartment 1 for reed bed development
- Development of wet grassland habitat outside of the retained wetland area and required ground manipulation to create ephemeral shallows and raised areas
- Exact spillway location and alignment relative to landscaping and access control requirements
- Use of retained wetland area for surface water management during construction and consideration of vehicular access requirements along the retention structure

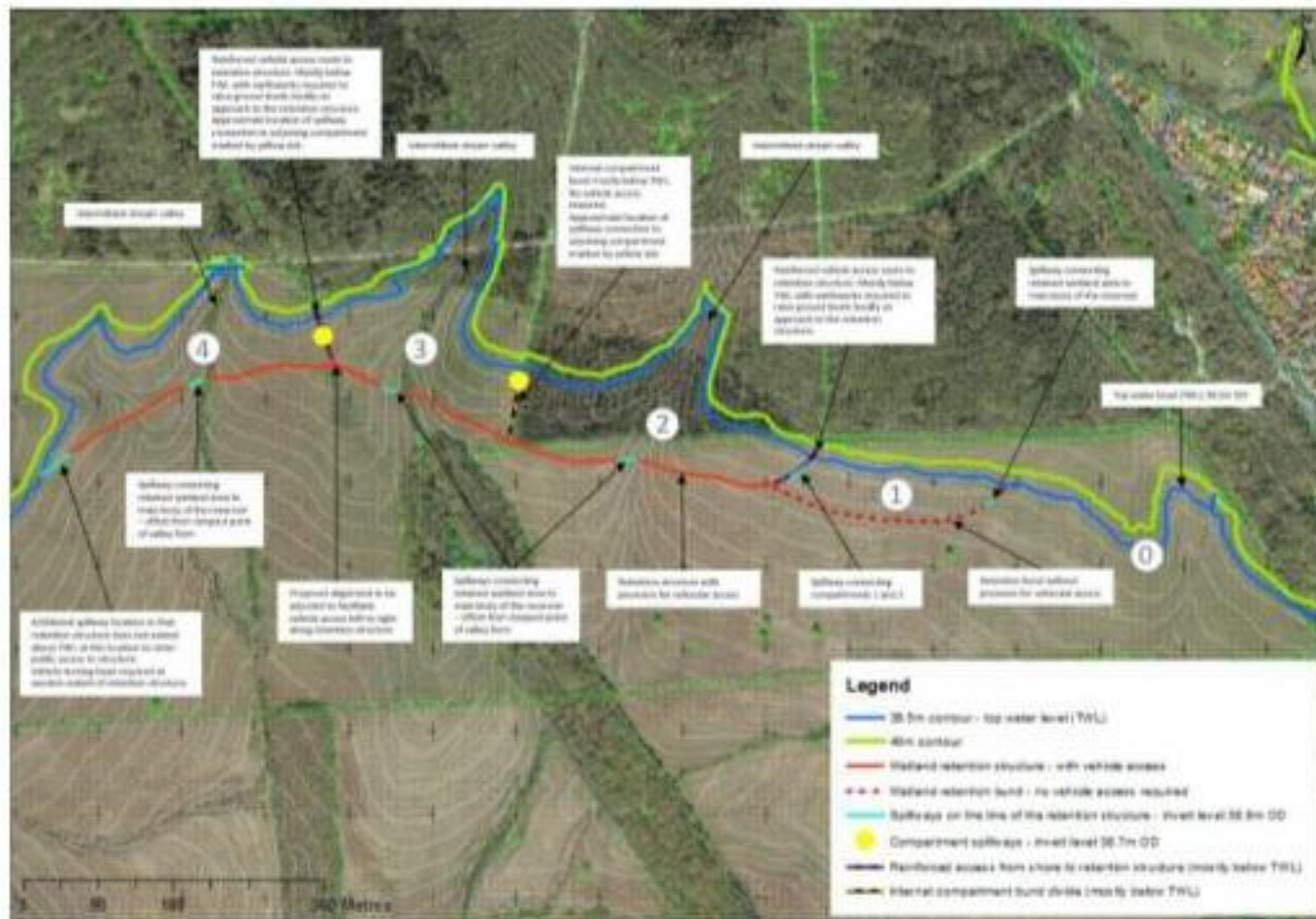


Figure 2-4 Proposed alignment of the wetland retention structure and key features

- 2.3.5 The wetland retaining structure would come within the Reservoirs Act as it can store more than the threshold volume limit in the Act below the spillways. There are no significant issues associated with this other than the certification process and eventual "not high risk" designation. After the construction of the main reservoir embankment, the wetland retaining structure would stay on the register but not require ongoing Reservoirs Act compliance.
- 2.3.6 The key design parameters of the outline wetland design are presented in the following sections and summarised in Table 2-5.

Table 2-5 Summary of outline design wetland parameters

Element	Parameter/details
Need for retention	To facilitate wetland habitat development, provide resilience to reservoir level changes and to ensure viable habitat that meets biodiversity net gain requirements
Retention structure extent	Extending for ~1.3km along the northern shoreline, at a distance from Top Water Level (TWL) of between 60m – 80m (excluding the extremes of the stream valleys) Structure returns to the shoreline at strategic locations to allow for vehicle access and to provide compartmentalisation
Retained wetland layout	4No. retained wetland compartments – habitat elements as detailed in Table 2-6
Retention structure form	Two typologies (see Figure 2-4): 1. Wetland retention structure: - Formed of clay - with the core extending below existing ground level to form a cut-off to prevent seepage loss from the wetland - Top level of retention structure = 40.0m AOD 4m top width, armoured surface - Armoured 1 in 4 downstream slope - Stepped profile within retained wetland area - Spillways, armoured - Provision for piped control - Around compartments 2, 3 and 4 2. Wetland retention bund (as above except) - Around Compartment 1, clay core cut-off may be required 3m top width, no vehicle access - No armouring required, except for at the single spillway location - Tree planting on top of bund
Compartment bund	Earth bund with associated spillway which rises to meet with the wetland retention structure forming the divide compartments 2 and 3
Wetland spillways	Two typologies associated with the wetland retention structures (see Figure 2-4): 1. Wetland spillways: 6No. armoured wetland spillways along the line of the retention structures - Invert level 38.8m AOD 2. Compartment spillways: 2No. armoured internal compartment spillways - Inverts of the two compartment spillways set at 38.7m AOD, 100mm below the retained wetland level
Retained wetland water level management/control	Achieved through passive control over wetland spillways and through provision of active piped control between retained wetland area and main body of the reservoir (4No. pipes in outline design)
Retained wetland level	38.8m AOD – the level at which the retaining structure starts to hold back water within the retained wetland area as reservoir levels fall
Retained wetland size	At TWL (39.5m AOD): - A retained wetland area of ~10.2ha At retained water level (38.8m AOD): - A retained wetland area of ~6.8ha
Wetland habitat provision	Minimum area of retained wetland provided ~10ha. Includes following key habitat typologies:

	• Open water • Shallow water with emergent wetland vegetation • Reed and sedge beds • Seasonally inundated bird nesting islands • Wet woodland Plus, an area of wet grassland habitat creation to the east of the retained wetland (Area 0) ~1.3ha in size. Includes ephemeral shallows and raised areas. Natural colonisation preferred approach for wetland species establishment, although some import of wetland plants will be required for key landscaping elements e.g. around the visitor centre in Compartment 4
Wetland islands	Seasonally inundated islands to provide wetland bird nesting habitat, nominally 30m x 16m in size Islands to be constructed from localised ground manipulation within the retained wetland area
Wet grassland – ephemeral shallows	Provision of shallows and raised area within wet grassland habitat area. Features to be constructed from localised ground manipulation outside of retained wetland area

Retained wetland and wet grassland area

- 2.3.7 The need for retention has been identified based on the hydrological characteristics of the reservoir. Provision of a wetland retaining structure is the most viable solution to support the requirement for wetland habitat provision in the reservoir and to buffer against the anticipated operational water level fluctuations.
- 2.3.8 Through the mechanism of water retention, wetland habitat resilience will be provided and the wetland future proofed against the influence of, and uncertainties surrounding, climate change and reservoir operational requirements. Furthermore, provision of a wetland retention structure provides opportunities to control water levels and facilitate wetland habitat management.
- 2.3.9 The retaining structure alignment as shown in [Figure 2-4](#) results in:
- A retained wetland extending for approximately 1.3km along the northern shoreline
 - 4No. retained wetland compartments, plus provision of an area for wet grassland habitat creation to the east of the retained wetland
 - A retained wetland area of approximately 10.2ha at TWL condition
 - A retained wetland volume of approximately 131,000m³ at TWL
- 2.3.10 The key features of each of the retained wetland compartments are provided in [Table 2-6](#).

Table 2-6 Retained wetland compartments

Compartment	Description	Hydrology
1	Retained wetland habitat area formed by a wetland retention bund that does not require vehicular access Proposed as predominantly reed with some sedge habitat with wetland channels and tree e.g. osier willow planting on retaining bund Anticipated that trees will self-seed along the northern shore to provide a more graded wet woodland edge	Hydrological connectivity to main body of the reservoir and to Compartment 2 through passive water level control - spillway/s Plus, active water level control (pipe) to main body of the reservoir
2	Wetland habitat area retained to the east and south by a wetland	Seasonal inflows from intermittent stream

	retention structure requiring vehicular access Bunded to the west by natural topography and an earth internal compartment bund divide Wetland compartment with open water and marginal habitat, including wet woodland – local ground manipulation to improve complexity, including island creation	Hydrological connectivity to main body of the reservoir through passive water level control (spillway) and active water level control (pipe) Plus, passive water level control (spillway and compartment spillway) to adjoining compartments 1 and 3
3	Wetland habitat area retained to the west and south by a wetland retention structure requiring vehicular access Bunded to the east by natural topography and an earth internal compartment bund divide Wetland compartment with open water and marginal habitat – local ground manipulation to improve complexity, including island creation Wet woodland habitat creation to the north of the existing access route crossing	Seasonal inflows from intermittent stream Hydrological connectivity to main body of the reservoir through passive water level control (spillway) and active water level control (pipe) Plus, passive water level control (compartment spillways) to adjoining compartments 2 and 4
4	Wetland habitat area in front of proposed visitor centre and educational bird hide location, retained to the east and south by a wetland retention structure requiring vehicular access Wetland compartment with open water and marginal habitat – local ground manipulation to improve complexity, including island creation	Seasonal inflows from intermittent stream Hydrological connectivity to main body of the reservoir through passive water level control (spillways) and active water level control (pipe) Plus, passive water level control (compartment spillway) to adjoining Compartment 3

- 2.3.11 Area 0, to the east of the retained wetland, is identified as an area of wet grassland habitat creation of approximately 1.3ha.

Wetland retention structures

- 2.3.12 There are two wetland retaining structure typologies. These are the wetland retention structure and the wetland retention bund (see Figure 2-4 for their respective alignment). The wetland retention structure is designed primarily as an engineered feature with incorporated wetland spillways along its length. These spillways are required at strategic locations to provide hydrological connectivity between the main reservoir water body and the retained wetland, to control access to the wetland and to facilitate landscape views. There is vehicular access for maintenance and inspection purposes along the top of the wetland retention structure.
- 2.3.13 Vehicles will be able to access the structure from the shoreline at two locations which have been aligned to tie in with existing access tracks. These access locations provide the boundary between wetland compartments 1 and 2 and compartments 3 and 4 as shown in Figure 2-4. Figure 2-5 provides an indicative section through the retention structure along which vehicular access is required.

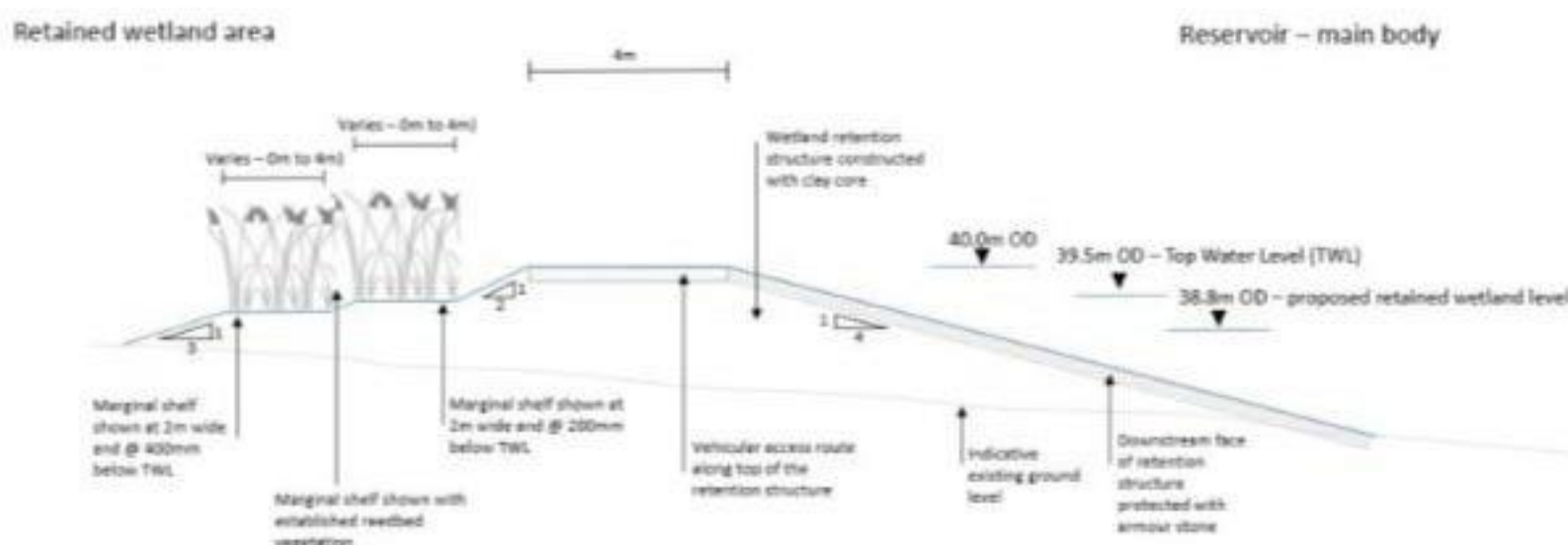


Figure 2-5 Wetland retention structure – with vehicular access

2.3.14 The key dimensions and engineering features of the wetland retention structure are:

- Retention structure formed of clay - with the core extending below existing ground level to form a cut-off to prevent seepage loss from the wetland into reservoir or to the land beyond the eastern and western extent of the wetland
- Top level of retention structure is set at 40.0m AOD - providing a 500mm freeboard relative to TWL
- Armoured 1 in 4 downstream slope into the main body of the reservoir
- Shown indicatively as armour stone in Figure 2-5, but could also be stone filled turf reinforcement matting
- See Figure 2-2 for detail of planting treatment which could be applied to downstream slope of retention structure by providing breaks within the armour treatment
- 4m top width, with armoured surface to provide vehicular access
- Surface armour of compacted gravel on stone sub-base
- Stepped profile within retained wetland area to provide marginal shelves and slopes for wetland vegetation establishment - widths and elevations of marginal shelves vary to provide wetland habitat complexity

2.3.15 The retention structure bund, associated with Compartment 1, is designed as a less formal structure, along which vehicular access is not required. As a retaining structure its design life is not as critical as the lengths of the wetland retention structure requiring vehicular access.

2.3.16 In outline, the retention bund is designed with a function of diversifying the landscape and biodiversity opportunities. The key engineering differences from the wetland retention structure include the absence of downstream face armour protection (except at the location of the spillway connecting the compartment to the main body of the reservoir) and the narrower top width of 3m. The top of the bund is planted with trees to provide additional biodiversity value.

Retained wetland spillways

2.3.17 6No. armoured (with stone or stone filled reinforcement matting) wetland spillways along the retention structures set with an invert level of 38.8m AOD are included in the outline design (see Figure 2-4 for spillway typologies and location). Spillways are required to maintain hydrological connectivity between the retained wetland area and the main body of the reservoir during the normal water level regime and connectivity between compartments 1 and 2.

- 2.3.18 The invert level of 38.8m AOD equates to level at which the wetland is retained as reservoir levels fall. Under normal water level conditions (i.e. yearly fluctuation of 500mm from 39.5m AOD to 39.0m AOD) the wetland spillways provide a connectivity water depth ranging from 700mm to 200mm between the retained wetland area and the main body of the reservoir. This connectivity will act to reduce the potential for deterioration in wetland water quality and provide ecological connectivity with the main body of the reservoir. Figure 2-6 provides an indicative plan and section of a wetland spillway along the wetland retention structure. It shows the proposed location of a water level control pipe, offset from the spillway.

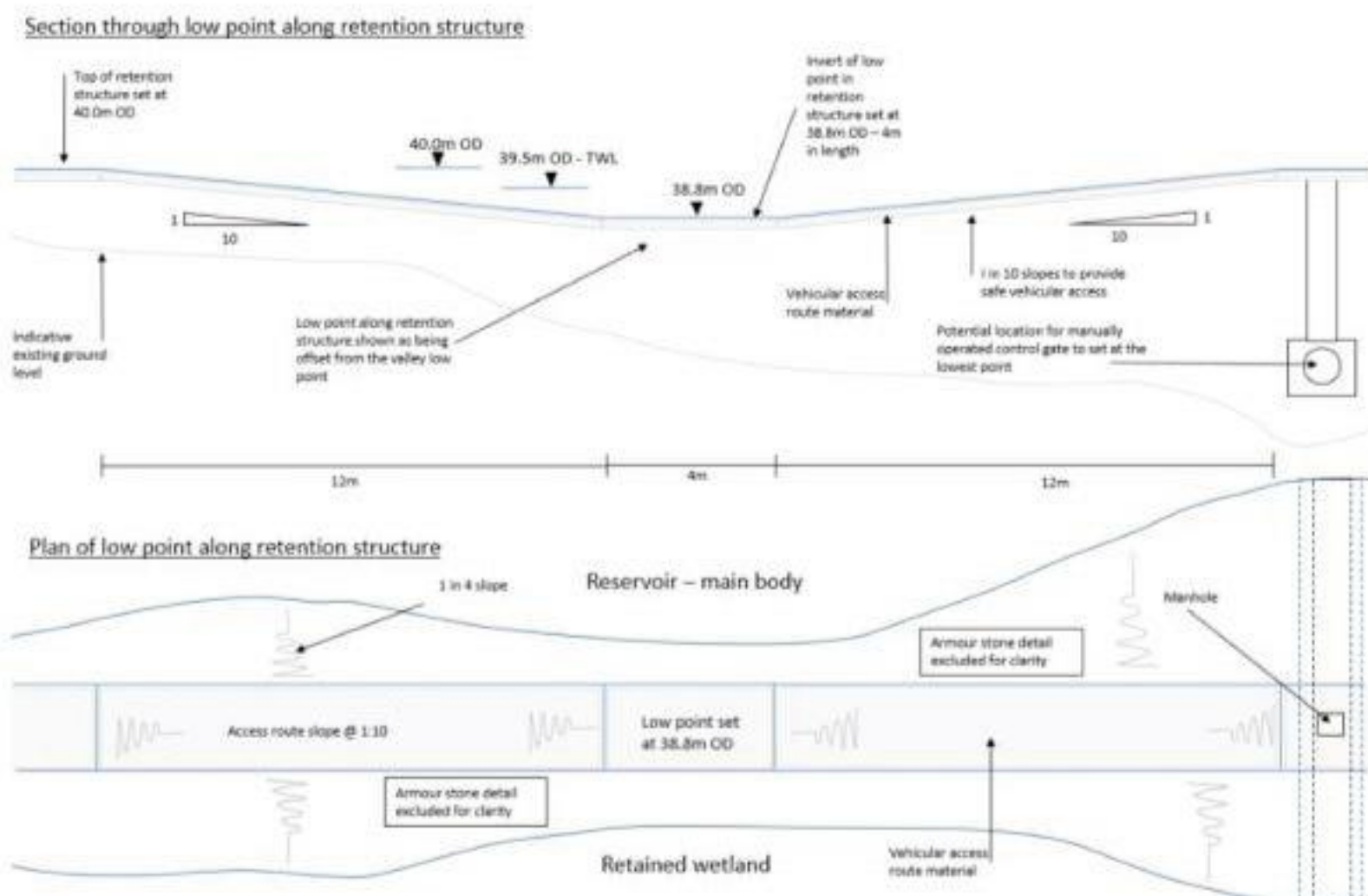


Figure 2-6 Wetland retention structure spillway - section and plan

- 2.3.19 A further 2No. armoured (with stone or stone filled reinforcement matting) compartment spillways are included, allowing flow over the bunds dividing compartments 2 and 3 and compartments 3 and 4. The inverts of the two compartment spillways are set in outline design at 38.7m AOD, 100mm below the retained wetland level, to provide hydrological connectivity between compartments 2, 3 and 4 when the wetland is in its retained state and to provide the means of passive water level control.

Water level management

- 2.3.20 Passive control of levels using spillways along the retention structure and within the retained wetland compartments provides a sustainable, low operational input way by which the wetland can be maintained and managed.
- 2.3.21 The outline wetland design concept also provides for active water level management through the provision of piped controls at strategic locations along the retention structure, that connect the retained wetland to the main body of the reservoir at naturally occurring low points in the topography. Active control would allow for more rapid filling of the wetland compartments during periods of reservoir level recovery, facilitate drawdown of compartment/s and under normal reservoir levels improve mixing of the wetland.

- 2.3.22 When combined, passive and active approaches act to improve the resilience of the retained wetland area and provide the means by which water level, water quality and habitat management could be achieved under a greater range of water level scenarios.

Retained wetland Compartment 1

- 2.3.23 Compartment 1 is being progressed as an area predominantly for reed bed habitat creation with some sedge that grades to scrub/wet woodland to the north. It is proposed that the existing topography within the compartment is locally manipulated to improve habitat complexity, through for example provision of peripheral and interconnecting ditch systems.

Island design within retained wetland area

- 2.3.24 The concept of wetland islands is a key habitat feature providing valuable nesting sites for a range of wetland bird species. The outline design concept includes for the provision of seasonally inundated islands, each nominally 30m x 16m, within the retained wetland area. The wetland retention structure will act to protect the island habitats from wave action reducing the requirements for armouring of the islands.
- 2.3.25 Further work is required to determine the number, size and exact location of islands within the retained wetland area. Island concepts shall be developed through detailed design with a target of achieving a neutral cut and fill balance and to increase the range of depth/habitat provision within the retained wetland area.

Wet grassland - ephemeral shallows

- 2.3.26 In order to improve habitat complexity in the proposed wet grassland area and provide resilience to water level fluctuation it is proposed that local ground manipulation is undertaken in Area 0 to create ephemeral shallows and raised areas. During detailed design options shall be explored to link in the ditch drainage system to the north, to keep the habitats wetter for longer.

Sustainability and Environment

- 2.3.27 The outline wetland design has been progressed with reference to the following key design objectives:
- Creation of resilient wetland habitat which will thrive and can be managed and maintained so that it provides a viable asset for the design life of the reservoir and its operational scenarios
 - To create a diverse wetland ecosystem which provides wider habitat connectivity within the context of the site
 - To provide a site for people and education
- 2.3.28 The wetland retaining structure design has been progressed with the following sustainable design principles:
- Materials to be used in its construction to be sourced from site as far as practically possible to limit the requirement for material imports
 - Its siting to allow for what will be the operational area of the wetland area to be used for surface water management during construction
 - Any wetland vegetation that establishes within the surface water management system is retained for inclusion in the operational wetland
 - Associated surface water management pipework will be designed so that in operation it can be adapted to provide the required active wetland water level management control
 - The structure will be designed primarily as an engineering feature with built-in wetland habitat complexity (i.e. berms and shelves to facilitate wetland vegetation establishment) to retain water and to protect the retained wetland area from the effects of wave action
 - Retaining structures will be designed to incorporate predominantly passive (no operation required) control as the mechanism by which water level management can be provided. This will be achieved through the provision of appropriately armoured spillways

- The design and indicative location of seasonally inundated island (within the retained wetland area) and ephemeral shallows and raised areas has been developed with a target of achieving a neutral cut and fill balance
- Existing intermittent stream inflows and high points in topography will be utilised to both inform the alignment and compartmentalisation of the retained wetland – thus reducing required material for construction and improving sustainability in the long-term
- The armoured downstream face of the retention structure has been designed to allow for the integration of bioengineered solution to 'green' the armoured face
- Compartmentalisation of retained wetland improves resilience and protects against failure of the retention structure i.e. not all wetland would empty should part of the retention structure fail
- Preference is for natural vegetation/wetland species colonisation as this often results in improved species complexity, although it is recognised that some over planting from imported nursery stock may be required at key locations.

Health and Safety

2.3.29 Safety by design principles have been applied to the outline design of the wetland, such that during:

Construction

- Constructing wetland retaining structure will be in advance of main borrow pit and embankment works to facilitate safe management of flows from ephemeral streams and preventing flooding to working area
- Earthworks are programmed to be carried out within drier season of March – September, to avoid groundwater issues and instability of excavations
- Reduction in need for additional earthworks and hence vehicular movements through:
- provision of an outline design balances retention structure extent/size/distance from TWL, against appropriate depth/habitat provision
- Alignment of retaining structures against existing highpoints in topography
- Development of wetland island concepts that produce a localised neutral cut and fill balance

Operation and Maintenance

- Retaining structure includes for the provision for safe vehicular access (4m top width) to allow for maintenance and inspections when spillways are above wetland water level, eliminating the need for access by boat during such periods. Its formation includes shallow slopes and shelves for safety purposes
- Need for access to the retention structure has been reduced through:
- provision of passive water level control (spillways along retention structure) as the predominant mechanism of water level management in the retained wetland during operation. This "hands-off" approach to water level control reduces the need for frequent operational intervention
- active water level control structures (pipes) have been incorporated in the outline design of the retaining structure to facilitate habitat management and more rapid filling of the retained wetland. Their design premise is one of infrequent operational to balance appropriately H&S with the biodiversity objectives of the wetland area
- Vehicular access requirements will be revisited at the detailed design stage.

Public amenity

- To discourage unsolicited access to the retention structure and retained wetland area access routes to the retention structure are shown in concept as being submerged under normal water level condition. Shelves around margin of wetland will be gently sloping to reduce risk to public.

Buildability

- 2.3.30 A construction sequence has been developed which includes for construction of the wetland retaining structure in the first earthworks season to allow its use for surface water management.
- 2.3.31 The proposal is to construct the wetland retaining structures to intercept and manage inflows from the three intermittent stream system draining the Havant Thicket catchment to the north of the reservoir site allowing for the pumping of these inflows away from the reservoir, as well as attenuating flooding from the streams. Pipe infrastructure required for surface water management will in operation be utilised as an active water level management control for the wetland.
- 2.3.32 Subsequent construction works will involve addition of habitat detail and complexity to both the retaining structure and the retained wetland area to forward its development through into the wetland operation phase.

Innovation

- 2.3.33 The design of the wetland and associated spillways has been carried out using an interface of several 3D modelling platforms as detailed in paragraph 2.2.8. The use of this approach has facilitated the calculation of outline material requirements for the retention structure.
- 2.3.34 The model was developed further for the purpose of calculating water depth variability within the retained wetland compartments under various wetland and reservoir water level scenarios. The outputs informed on the requirement for additional localised earth movements within the retained footprint to improve the range of depth provision which could be delivered alongside the creation of seasonally inundated bird nesting islands.
- 2.3.35 The outputs were also used to generate visualisations, including the production of water level animations to communicate the implications of anticipated reservoir level fluctuations on wetland resilience and as a tool to ground truth the locations of proposed wetland features during site visit workshop with stakeholders.
- 2.3.36 The use of spillways to provide a passive means by which water levels are managed within the retained wetland area is an approach that acts to limit the potential for disturbance to the wetland area and its species. At the same time, this innovative approach acts to reduce the operational and maintenance burden associated with more traditional wetland water control structure management systems.

2.4. Control house and associated structures

- 2.4.1 The control house is required to house operating equipment for the control of potential emergency discharge of the reservoir, and the routine operation equipment required for day-to-day running of the reservoir, including sampling instrumentation and mixing equipment.
- 2.4.2 A culvert is required to convey the inlet / outlet supply pipes and the scour pipe through the embankment. Guard and control valves are located on the mid-level intake and scour pipes within a central valve access shaft which is joined by the upper level intake pipe. The spillway is designed as an overflow weir on the west bank at the shallowest point. The weir discharges into a pipe which runs around the outside of the embankment and discharges into Riders Lane Stream.

Schedule of Accommodation

- 2.4.3 A schedule of accommodation as given in Table 2-7 below, has been developed reflecting discussions of the room requirements with Portsmouth Water to provide the worst-case scenario of mass for the outline planning application.

Table 2-7 Schedule of Accommodation

Room	Minimum Footprint	Min Heights (m)	Adjacency	Points to Consider
MCC room	Footprint 6m x 8m or 12m x 5m – internal room space (to accommodate double or single sided MCC). Includes equipment and safe working areas.	4m room height based on MCC height + clearance + ducting space	Transformer and Compressor room (ideally)	Forced, thermostatic ventilation (note heat generated from MCC) 2 points of access/egress for fire safety due to fire safety regs (dependent on room length)
Electronic security room	Footprint 3m x 2m – internal room space. Includes equipment and safe working areas.	2.4m		May have higher security rating than rest of building. Could be in secure cage within MCC room.
Compressor room	Footprint 14m x 8m - internal room space (Expected to suffice for 2 x compressors of up to 4m x 4m x 4m per compressor with 2m clearance space around each). Includes equipment and safe working areas.	5m room height - note need for further design of access for lifting	MCC room	Forced ventilation Noise attenuation Note need for further design of access for lifting in (construction) and out (maintenance/ end of life)
Transformer Area	Footprint 7m x 7m – external area (Expected to suffice for transformer size 3m x 3m with 2m clearance all around). Includes equipment and safe working areas.	4m height	Transformer external to building, needs to be adjacent to metering room	Ventilation Must have 2 points of access/egress for safety Transformer must be accessible to DNO (electricity company) For external transformer, metering space needs to be allowed within an enclosure which DNO need access to (security implications).
Transformer metering room / cupboard	1 x 2m internal / weatherproof housing.	2m room height	Transformer	DNO needs external access to this

	Required as transformer is external			
Sampling & monitoring room	5m x 5m, Includes equipment and safe working areas.	2m room height	MCC room	Includes instrumentation for embankment
Culvert pipework outlet / bends	9m x 6.5m	4m room height	Culvert opening	Space required between pipes for vehicle access
Maintenance workshop	Storage of grass cutting equipment etc	2m room height	None (for external access)	
Laydown /entrance area	116 m ²	4m room height		To include room for truck and Hi-Ab crane operation
Cleaners store	6m ²	2m room height		
WC (for PW staff)	3m ²	2m room height	None (for external access)	
WC (for maintenance volunteers)	3m ²	2m room height		

Control house functionality

2.4.4 The following functionality is required at the Control Building:

- Control interface to allow remote or local control of valves to enable:
- Reservoir filling and replenishment from Bedhampton springs via new pumps
- Supply of reservoir water to Farlington via new Bedhampton booster pumps
- Compensation flow to local Riders Lane stream
- Emergency drawdown of the reservoir
- Equipment to enable in-reservoir mixing, to prevent stratification of the reservoir and associated water quality risks to drinking water safety (e.g. solubilisation of metals compromising treatment) and environmental water quality deterioration (e.g. increased algal blooms).
- Abstraction sampling, monitoring and control equipment to mitigate hydrocarbon and nitrate risks
- Embankment monitoring instrumentation
- Power supply for the above equipment

2.4.5 During periods of warm weather, with light winds, large water bodies are prone to thermal stratification. The Water Quality Modelling report carried out in the early stages of the project concluded that in light of analysis by other water companies which has shown that significant stratification can occur in relatively shallow lakes, coupled with the presence of a deep borrow pit in Havant Thicket Reservoir, there is a risk of thermal stratification. Thermal stratification is associated with water quality risks to drinking water safety (e.g. solubilisation of metals compromising treatment) and environmental water quality deterioration (e.g. increased algal blooms).

2.4.6 In order to mitigate the risks associated with thermal stratification, the preventative measure of reservoir mixing is considered to be best practice. This study examined the costs, benefits and disadvantages of surface mixing, submerged mixing and air-type mixing technologies against the Project Drivers. The conclusion of this study was that an air-type mixing system would be most appropriate for the Havant Thicket reservoir, due to its lack of visual impact, improved operational safety and the expected ability to locate the necessary maintainable plant (compressors and valves) in the control house / culvert, reducing the total number of structures on the reservoir site.

- 2.4.7 Air-type mixing uses a system of perforated pipes at low level in the reservoir, through which compressed air is pumped to create regions of lower density water which will rise and create circulation currents.
- 2.4.8 Operational efficiency (minimising the electrical costs) of the mixing system will be achieved by provision of water temperature and potentially dissolved oxygen concentration monitoring at various depths within the reservoir, to allow the mixing system to be run when signs of stratification are detected (expected to be during the thermal stratification high-risk period from spring to early autumn). A query has been raised regarding the opportunity to delay installation of the reservoir mixing system until such time as water quality data confirms that stratification is occurring (i.e. after the reservoir has been filled). Risks exist with such an approach.
- 2.4.9 If stratification is allowed to occur, and the associated water quality risks materialise (e.g. soluble metals, algal blooms, poor environmental water quality), subsequent destratification of the reservoir is unlikely to reverse these effects as mixing of the reservoir should be preventative rather than reactive. The resulting large volume of poor quality water could require either disposal or additional treatment not included within the proposed treatment process.
- 2.4.10 Additionally, there are health and safety risks associated with the retrospective fitting of a mixing system to an in-service raw water reservoir. These risks are understood to be one of the reasons that other water companies retrofitting mixing systems to existing reservoirs have favoured surface mixing techniques (e.g. the ResMix system). During the options study Portsmouth Water has indicated that the visual impact of such surface mixing systems would be considered a major disadvantage for the Havant Thicket reservoir, as well as the ongoing maintenance hazards with maintaining equipment over deep water.
- 2.4.11 For an air-type mixing system it would be necessary to install the submerged compressed air pipework both within the reservoir and through the bulkhead prior to first filling of the reservoir, to minimise health and safety issues associated with the use of divers once the reservoir is filled. However, an opportunity may exist to delay installation of some elements of the reservoir mixing system (e.g. compressors).
- 2.4.12 Phased installation of the preferred air-type mixing system would be a potentially viable opportunity provided; careful review of the elements to be installed prior to initial reservoir fill, identification of stratification early-warning water quality alerts, and a rapid deployment plan for the remaining mixing elements to reduce the risk of a large volume of water with realised water quality risks requiring either disposal or additional treatment.

Building design: Control house vision

- 2.4.13 The proposed control house is located in the conservation area. This is dictated by the embankment design and culvert positioning. To adhere to the Planning Policy Framework and Design Principles, Atkins is proposing a design that is sensitive to the surroundings, with the use of natural stone and large areas of living green roofs to embed into the embankment.

Control house users

- 2.4.14 The control house will be used infrequently by trained Portsmouth Water staff for inspection checks lasting short periods of time. A maintenance area for volunteer staff is also proposed in the building footprint for day-to-day management. Separate access is proposed to maintain security of the main compound.

Appearance

- 2.4.15 The control house is located in a country park, conservation area and registered park and garden. As this is a sensitive area the control house is being proposed to use natural materials to help reduce the visual impact of this structure in this location on its setting and visual amenity of users of the proposed public rights of way.
- 2.4.16 The aspiration is for the control house is to use a limited palette of materials and to be sympathetic to its surroundings. The building will have large areas of living roof and a clad front façade. The Design and Access Statement which accompanies the planning

applications includes more detail on the evolution of the control house design and the final outline design parameters. Figure 2-7 provides an indicative layout.

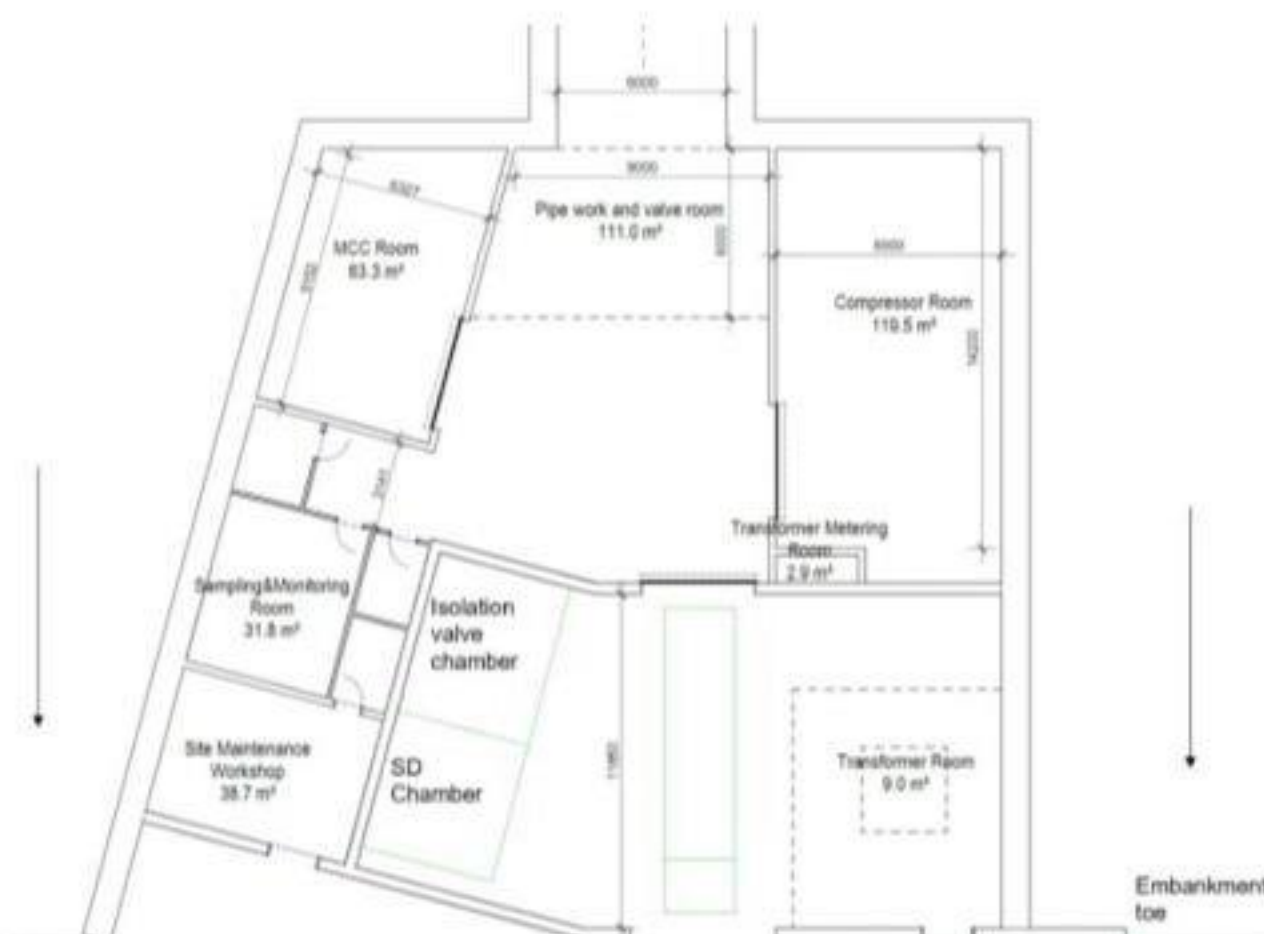


Figure 2-7 Outline plan of the control building including submerged discharge chamber (SD Chamber)

Accessibility

- 2.4.17 The control house is designed to be single storey with level access. An external area provides access for a HGV for future plant replacement.

Roof

- 2.4.18 A living green roof is proposed for the control building. This embeds the building into the embankment, reducing visual impact and provides additional wildlife habitat and enhances biodiversity.
- 2.4.19 Roof plant and fencing may be required and will project above the roof profile. This detail needs to be developed and where possible the visual impact will be minimised.

Security

- 2.4.20 A Security and Emergency Measures Direction (SEMD) review of the reservoir site has been undertaken by Atkins and is under review by Portsmouth Water. Pending acceptance of the site classification outlined therein, the Preliminary Design of the control house includes for a suitably secure compound. Further design and specification of the necessary security measures will be undertaken in Works Information design.
- 2.4.21 The form of the building creates an internalised secure courtyard. Perimeter security fencing is required around all accessible sides of the building. The front elevation facing Staunton Country Park is a 4.5m high wall with secure access gates and doors.

Sustainability and Environment

- 2.4.22 The embankment culvert and control house structure design has been progressed with the following considerations in mind:

- Structures to be sensitively designed in the context of being either near to or in the Conservation Area, the Staunton Country Park and Registered Park and Garden.
- The location of any structures within the Conservation Area would require justification and minimisation of their visual and environmental impact
- The ancient woodland areas of the Avenue and the Round Wood are irreplaceable and so any loss of trees must be minimised as far as reasonably possible
- the visual amenity of visitors to the reservoir site using the public rights of way

Health and Safety

2.4.23 Safety by design principles have been followed in the assessment of the location of the culvert, and the design of the control house layout, with risks highlighted throughout a review process which engaged Portsmouth Water operations managers. Key risks have been identified as:

Construction risk

- Instability of ground close to river, covered in reasoning for relocation of culvert

Operation and maintenance risk

- Confined space created in culvert – mitigated by reducing frequency of access – consider removal of lifting gantry which would need regular inspection by providing wider culvert with room to remove pipes on a trolley. Options for additional ventilation will be considered as the details of the design are developed
- Theft/ vandalism of assets resulting in injury to perpetrators, risk of fire – mitigated by locating discharge valves within control house secure wall.

2.4.24 The risk assessment of the layout of the control house focused on the safety of operating the building and the public.

Operation and maintenance risks

- Ability to drive a flatbed truck with mounted crane into the building for lifting out pipes, valves or other equipment
- A change suggested to the culvert layout where the reference design of a walkway above the larger pipe would be rearranged by having a wider culvert allowing a small vehicle and personnel to pass between the pipes. To be further considered post preliminary design phase.
- Access to the flat roof for cutting the grass – provision of edge protection
- Interface of 3rd party staff (from reservoir maintenance group, or electricity distribution network operators) with building security – provision of separate access points
- Public Amenity Use
- Risk to the public of accessing the building and falling off edges of flat roofs. The proposed location embedded into the landscape means that a security fence will be required around the perimeter of the building to prevent access onto the roof.
- Risk of public being swept away by the discharge of water in an emergency discharge scenario – to be mitigated by including a procedure for a staff member to check the channel is clear before opening the valves.

Buildability

2.4.25 The key construction elements considered in the embankment culvert and control house design included:

- Ground conditions at the culvert route, with the reference design route requiring excavations into softer silty material below the stream level, and the heavy seepage from the Bognor Sand Member ground in the hillside on the west side of the stream
- Stability of excavations for the culvert being more achievable on the more stable, uniform and stronger London Clay found to the east of the reference design route
- More of culvert will not be founded on the embankment fill

- Timing of the construction of the culvert structure, in the summer before the first earthworks season, for easier construction of access roads and groundwater management
- The construction sequence required for the submerged discharge chamber at the control house, which varied depending on the position of the chamber inside or outside the building compound walls.

Innovation

- 2.4.26 The sizing of the building has been undertaken using a collaborative design process. The design of the embankment culvert and control house has been carried out using an interface of several 3D modelling platforms, with the Revit model of the control house being transferred into 3D Civils AutoCAD which facilitated the evaluation of the discharge chamber position.
- 2.4.27 The proposed structure buried on three sides is an innovative departure from the previous reference design, as it allows a lightweight solution that gives the appearance of a buried structure with a living roof.

Design Development

- 2.4.28 The previous 2009 design for the control house was proposed as a 2 storey concrete structure, not embedded in the landscape, and with a prominent external discharge pool area.
- 2.4.29 The building has developed from the original reference design, with a more developed schedule of accommodation and a more deeply buried structure. Atkins and Portsmouth Water have had a series of meetings to discuss the evolution of this building.

Relocation of culvert and control house

- 2.4.30 An options exercise was undertaken to address the following issues identified with the reference design culvert location, which was immediately west of Riders Lane Stream:
- High risk of groundwater problems due to seepage from the Bognor Sand Member hillside
 - More likely to be in softer superficial deposits close to the stream
 - Variable foundation geology along the route
 - Extensive earthworks and retaining structures would be needed at the inlet, with the invert level around 2.5m below the existing ground level
 - Low lying ground could be water-logged giving rise to unstable trench sides along the hillside and along the foot of the hillside.
 - Control house location is very close to conservation area and still has visual impact (can be seen from the conservation area).
- 2.4.31 It was concluded that the culvert and control house should be moved eastwards, to the edge of Round Wood. The control house would be within the realigned embankment so it would not require further tree removal outside of the part of Round Wood which would be removed to allow for the embankment construction.
- 2.4.32 The relocation was recommended as it had advantages from construction and buildability, and environmental perspective including:
- Culvert length shortened by 22m
 - More stable and uniform foundation geology, with more of the culvert likely to be on firmer London Clay and off the Head (softer superficial deposits), with benefits for long term stability
 - Less ground water problems than the west side of the valley, where groundwater seepage occurs through the Bognor Sand Member hillside and away from spring line flows
 - No significant structures required at the culvert inlet in the reservoir, as the culvert level will be close to existing ground level
 - The culvert location has less impact on the conservation area, as the control house can be screened behind the retained trees in the Round Wood and the Hammond's Lands

Coppice from strategic viewpoints in the Historic Park and Gardens and within the Conservation Area, particularly from the south and east

- The location of the control house higher up the valley side allows creation of a 250m long ephemeral stream for compensation flow to be carried to Rider's Lane Stream. This open channel would contribute to biodiversity net gain by offsetting the loss of streams within the reservoir or under the embankment.

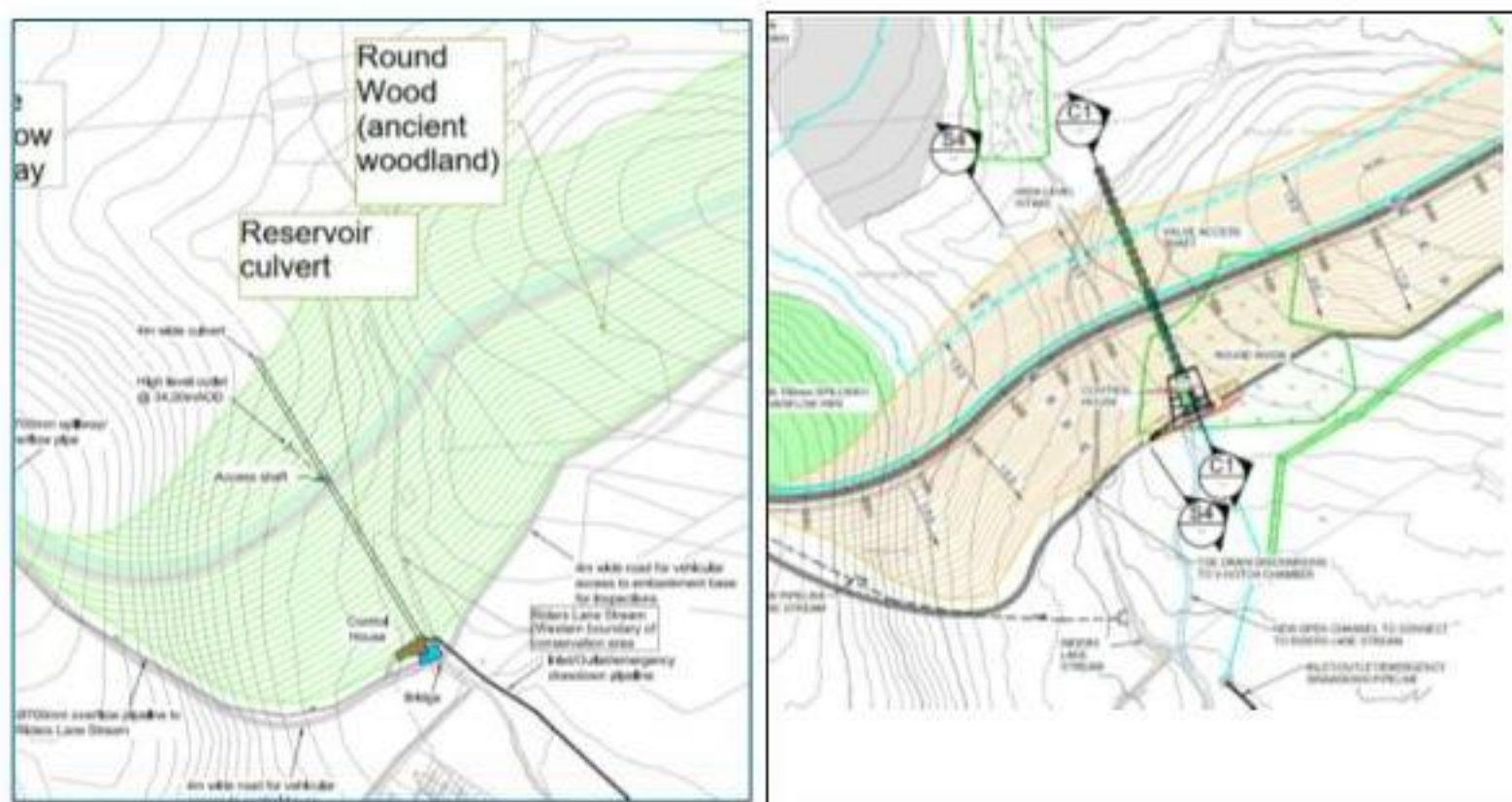


Figure 2-8 Embankment culvert and control house location (2009 design, left, current design, right)

Table 2-8 Key dimensions of culvert options

Culvert Option	Length m	Starting Level	Finish Level mAOD	Existing Ground Level at finish mAOD
Option A (preliminary design)	227	22.7	20	20
Option B (Round Wood location)	205	22.7	22.2	24.0

Control house layout changes for submerged discharge chamber

2.4.33 The development of the control house layout included a larger total area in the schedule of accommodation, to suit current requirements as confirmed by the operations managers.

2.4.34 The following issues were identified as requiring addressing to improve or update the reference design of the control house:

- The control house building should be moved further into the embankment (to reduce visual impact).
- More space in the building was required for the rooms and facilities not included in the reference design plan.
- The wide-open discharge pool should be replaced with a smaller structure without the associated open body of water (to reduce the safety risk of people seeing it as a swimming pool and drowning).

- The valves for the isolation / emergency discharge and compensation flow pipes should be made more accessible and also more secure.

2.4.35 The following changes were made to the control house:

- Building rooms were rearranged either side of a central courtyard / laying-down area, to form a long inverted L-shape (reducing the length of the frontage and the front wall height)
- Building frontage height was reduced by splitting the roofs into two levels, with the front roof reduced to the minimum allowed above the transformer.
- The culvert was widened from 4m to 6m, currently an assumption based on likely future requirements, which provides 2.1m space between the two pipes to allow for pipe sections to be lifted out on a low vehicle or trolley, and 700mm space outside of the pipes to allow for manual inspection of the whole pipe.
- The discharge pool was changed to a submerged discharge valve in a deep chamber for the emergency drawdown discharge facility.
- The emergency drawdown flow to be discharged at the control house was increased, from 2.5 m³/s (in the reference design) up to 7 m³/s. This was to reduce the size of the pipeline between the reservoir and the emergency discharge structure 3km downstream, where the remainder of the emergency discharge flows were to be discharged.
- Given the driving head of around 18m, the emergency discharge at the control house needs to have energy dissipated before entering the stream to prevent a large jet from eroding the ground back to the embankment. The arrangement of a vertical submerged discharge chamber was chosen as it was the most compact solution to allow minimisation of the visual and cost impact.
- An options study was carried out to evaluate different positions of the submerged discharge chamber, which affected the overall size of the building layout. These options were summarised as:
 - Option 1: Chamber outside of building
 - Option 2: Chamber at building front wall, but within wingwalls
 - Option 3: Chamber inside building front wall.

2.4.36 Option 3 is preferred because of the visual impact and security aspects of keeping the discharge valves within the compound wall.

2.4.37 It was considered that the visual impact would outweigh other criteria when considering the potential for delay or refusal of the planning permission for the reservoir if the statutory consultees deem that the visual impact in the conservation area has not been minimised as much as possible.

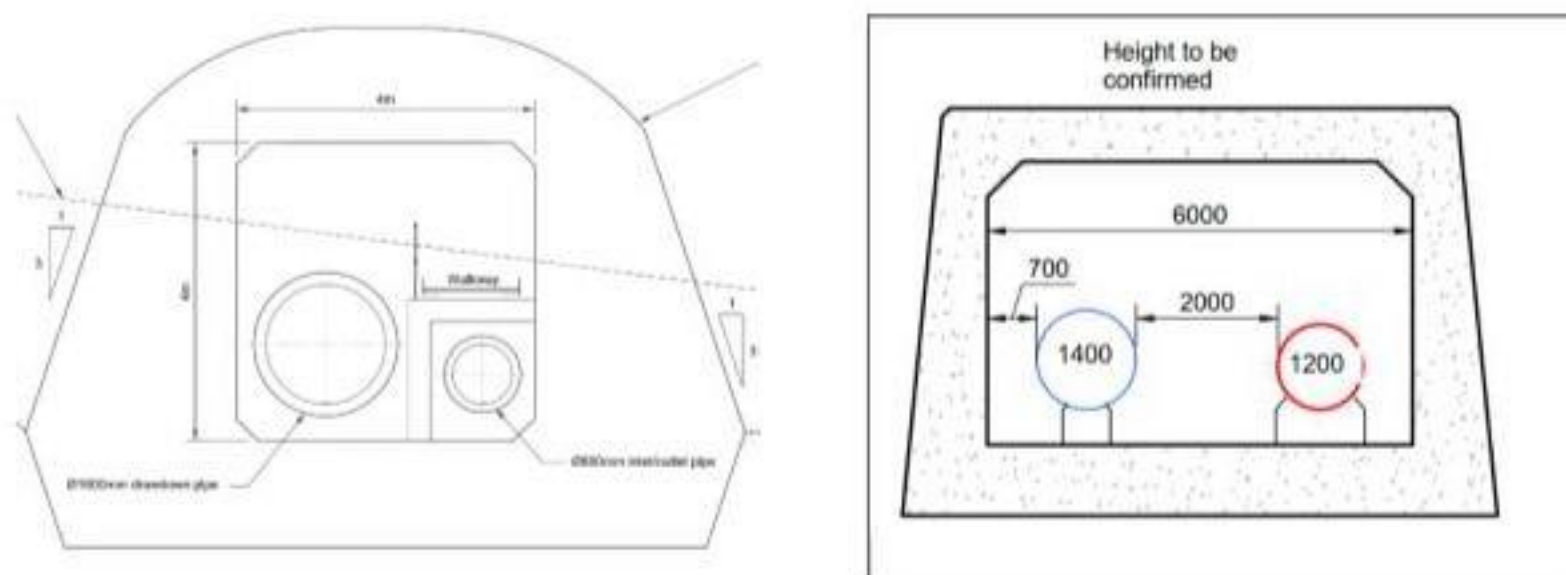


Figure 2-9 Change in culvert arrangement, 2009 Design (left), current proposal (right)

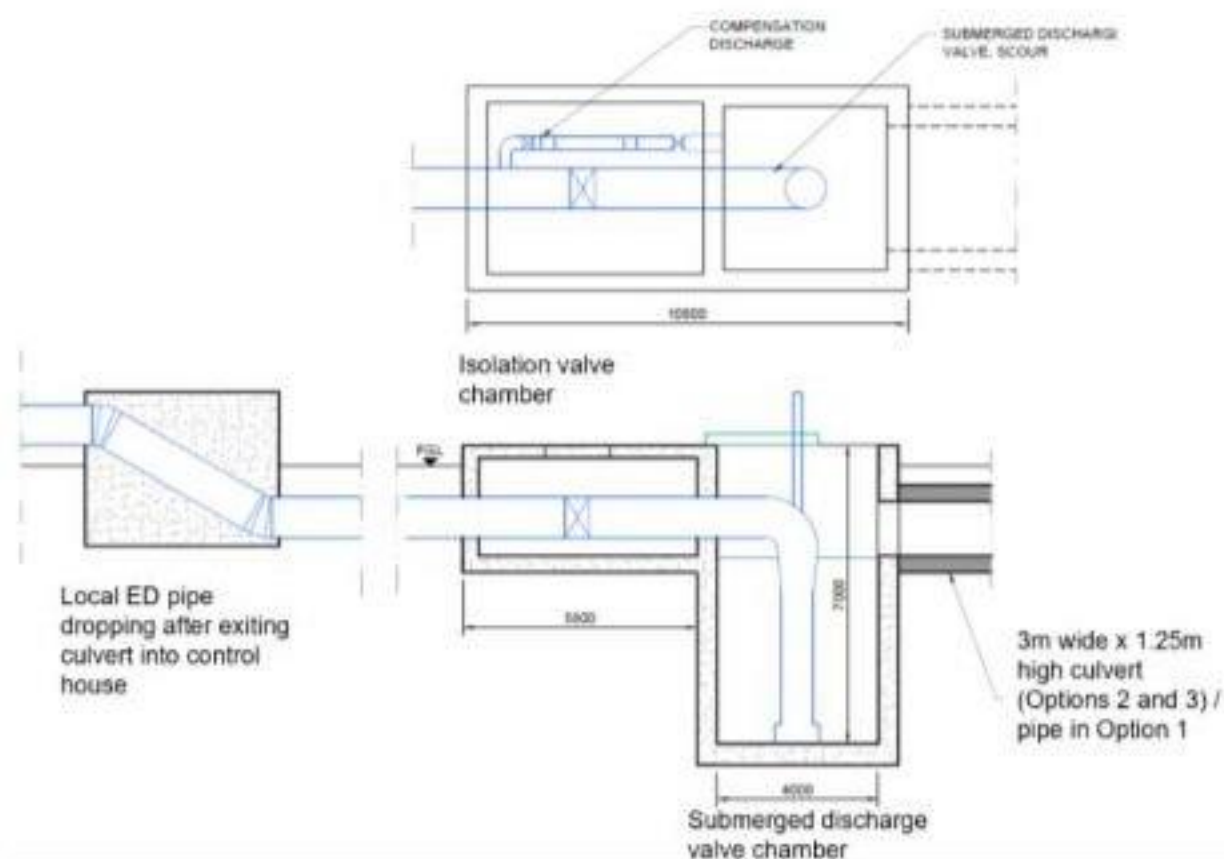


Figure 2-10 Outline concept of the isolation valve and submerged discharge chamber

- 2.4.38 Option 3 is the preferred option. In future stages of design, consideration will need to be given to introducing flexibility (for future changes) by optimising the submerged discharge chamber design.



Figure 2-11 Visualisation, with indicative control house within the embankment

2.5. Reservoir Access Road

- 2.5.1 Two preferred access routes have been identified: a south option and north option. Both were shortlisted as the preferred options following a route option evaluation exercise. This covered the evaluation of 11 possible options that were assessed against: environmental, engineering, safety and project drivers.
- 2.5.2 As the construction traffic assessment for the reservoir and pipeline has developed it has influenced the access road provision. In the interest of impact mitigation, both options will be developed to spread the impact of the construction traffic and consequentially reduce the impact in any one area.
- 2.5.3 The south option comes off Swanmore Road and along the western boundary of the site to the visitor car park. The north option comprises a single lane single carriageway with passing bays, following the alignment of an existing track through woodland between the B2149 and the visitor car park. The verges to the access road have been reduced in width to reduce overall construction width and impact on the woodland.
- 2.5.4 Construction traffic accessing the reservoir site will use both the north option with the use of temporary traffic signals used in conjunction with the passing bays, and the south option.
- 2.5.5 The use in practice of a single lane single carriageway with passing bays is described in the Traffic Advisory Leaflet 2/04 Rural Traffic Calming: Bird Lane Essex (by Department for Transport). The leaflet gives evidence supporting the use of a single lane single carriageway in terms of performance and traffic capacity. The proposed levels of traffic, both construction and visitor, are less than that described in the document.

Sustainability and Environment

South Option

- 2.5.6 An Environmental appraisal of the access routes has shown that the south option has a low-moderate risk of an adverse impact. The South option consists of an east link from the visitor centre car park to Swanmore Road.
- 2.5.7 The car park to Swanmore Road link will follow the western embankment of the reservoir, largely avoiding the 15 m no dig zone associated with the ancient woodland. There will be some very minor infringement on the no dig zone as the option forms a junction with Swanmore Road.

North Option

- 2.5.8 The Environmental appraisal of the options has shown that the north option has a moderate to high risk of an adverse impact. North option – this option starts at the old logging track gate and passes southward through ancient woodland where it then connects to the existing Forestry England track that runs north to south. There will be some loss of ancient woodland, including tree loss but the alignment has been developed such that it avoids trees of high importance and value.
- 2.5.9 From inspection of historic maps it appears that the logging track has been in existence in this vicinity since the 1880s. In the interest of limiting ancient woodland loss the road width will be kept to a single lane 3.65m wide where possible. At locations where there are sharp bends there will be a need to widen the carriageway to prevent verge over-run. In order to mitigate the impact of construction traffic it is desirable to maintain two-way access for both access options. For the north, access would require the location of passing laybys at suitable locations coupled with the use of temporary traffic signals. These layby footprints could be reduced post construction and areas re-gained with ancient woodland soil. Laybys are to be located in areas that cause least environmental impact.
- 2.5.10 The approach to pavement construction will use a proprietary system to protect tree root zones, an example of which is Cellweb. This section of the pavement is likely to be granular. This methodology, whilst protecting the tree root zones, will mean that maintenance interventions will be more frequent and pavement life reduced in comparison to the south option.

- 2.5.11 In order to mitigate ancient woodland loss it is proposed to make up the embankments/ verges with ancient woodland soil translocated from areas within the reservoir site where ancient woodland will be removed.

Health and Safety

- 2.5.12 Both south and north junction locations are compliant with the requirements of the DMRB CD123 standard, for the design of at grade priority junctions. The north option will require some canopy pruning/lifting so will involve working at height. The north option will involve constructing a new junction adjacent to a national speed limit road (60 mph). It is anticipated that a temporary traffic regulation order to reduce the speed limit (expected to be 40mph) will be applied for and made to reduce the risk to construction operatives, road users and public. This will be used in conjunction with temporary 2 way traffic signals to introduce single alternate one way traffic flow and minimise the risk.

2.6. Visitor Centre and Educational Bird Hide

Design development

- 2.6.1 The local planning authorities have included a policy which states a need for the Havant Thicket Reservoir development to provide leisure and recreational activities for the community. Portsmouth Water has therefore proposed a visitor centre and educational bird hide to be located at the North West corner of the reservoir site to satisfy this requirement.
- 2.6.2 The buildings and landscaping will form the public face of the reservoir scheme and Portsmouth Water. Providing facilities and activities for a wide range of users and the local community to use and enjoy. Key principles and design parameters are included here, More information on the design of the visitor centre is included within the Design and Access Statement which accompanies the planning applications.

Table 2-9 Key Design Parameters

Building	Maximum Building Zone (metres)	Maximum Height (metres)
Visitor Centre	30 x 55	10
Educational Bird Hide	9 x 20	5

Sustainability and Environment

- 2.6.3 The visitor centre building will aim for a minimum target of BREEAM (Building Research Establishment Environmental Assessment Method) **Very Good**. A BREEAM assessor will be appointed during detailed design (currently 60% complete) to maximise early available credits that are more costly as the design develops.

Visitor Centre Design Principles

- 2.6.4 Design Principles for the overall reservoir project are set out in Section 1. The visitor centre and educational bird hide will observe all of these principles with focus on the following:
- Design of the site and all facilities for all ages and abilities;
 - Incorporate recreational facilities that are in keeping with the quiet enjoyment of the countryside setting, optimising health and wellbeing opportunities;
 - Optimise educational opportunities in all design elements;
 - Maximise opportunities for biodiversity in the design of the landscape and buildings and minimise and mitigate any conflict with wildlife through forward planning;
 - Optimise opportunities for a sustainable design;

- Support the UK's Net Zero Carbon target by minimising where practical greenhouse gas emissions at all stages of the infrastructure lifecycle, and maximising opportunities for greenhouse gas removals through sequestration by vegetation and renewable energy generation.

Visitor Centre Vision

- 2.6.5 Clear objectives for the visitor centre and educational bird hide emerged from a background review and discussions with Portsmouth Water. Figure 2-12 displays the main drivers and vision for the visitor centre, which are discussed in more detail below:



Figure 2-12 The Visitor Centre Vision

- 2.6.6 The aspects of the vision are summarised below.

Community: This site sits between two established communities, Rowlands Castle (north east) and Warren Park (south west). The visitor centre is in a key location to be used by the local community and will inform a wide range of people about Portsmouth Water's work and resource management. The reservoir and visitor centre will form an important recreational facility which should enhance visitors' health and well-being.

Nature: The site will consist of a variety of habitats; woodlands, grasslands, and wetlands. The building will sit within this landscape and will complement the natural setting. The centre will showcase nature and the reservoir through siting and materiality.

Heritage: The Site is adjacent to Grade II* Leigh Park Registered Park and Garden and Sir George Staunton Conservation Area and would remove features associated with these heritage assets. The visitors centre will provide information to visitors about the history and archaeology of the Site.

Water: The creation of a water body and wetland habitat are key benefits which will attract a range of different wildlife and bird species to the site. The visitor centre will help to exhibit and inform visitors about water resource management and the protection of wetland environments.

Adjacency

- 2.6.7 The adjacency diagram below shows the relationship and connectivity between the areas. This shows the principles merging to form a design with a clear entrance, flexibility between the café and educational space, access to a terrace, and an outside educational space.

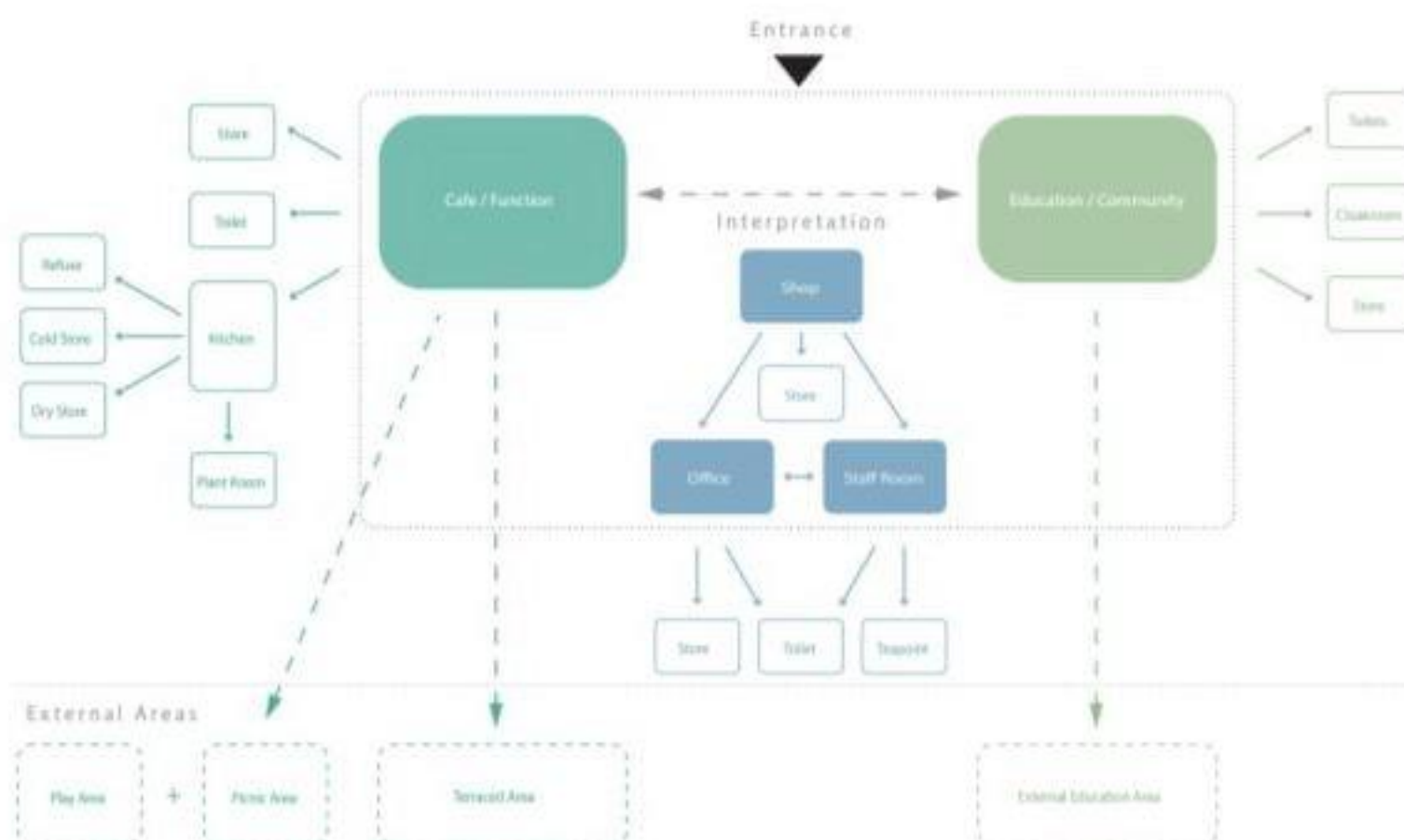


Figure 2-13 Visitor centre adjacency diagram

Schedule of Accommodation

2.6.8 Visitor Centre - Below is an approximate schedule of accommodation in line with the room requirements which have been developed with Portsmouth Water for the visitor centre.

Table 2-10 Visitor Centre Schedule of Accommodation

Room	Area(m ²)	Comments
Reception		
Reception / Entrance	30	To include reception desk + visitor information
Shop	20	Shop adjacent to reception. Exact size depending on use (tbc by Portsmouth Water)
Stock Room (Shop)	10	Stock room to shop
Visitor Toilets	20	Assumed Unisex WC (4 -5 WC's) - numbers based on visitors to café.
Family WC	4	To have baby change facilities
Accessible WC	4	
Changing Places	12	Changing Places room with ceiling hoists (3 x 4m)
Staff		
Staff Room	35	Social staff and volunteer room. Staff room to provide break area for approximately 10-12 people (including 5m ² tea point area)
Staff Office	20	Staff Office for 4 staff (5m ² per person)
Staff Toilets / Change	6	Assumed 1-5 staff in total. 1 toilet/changing facilities provided, including lobby and coat hooks
Staff and cleaners store	10	Staff store with 2m ² cleaners store
Café		

Café	90	Commercial Café with self-service, possibly licensed for sale of alcohol. Assumed single line counter. Assumed 50 covers (1.5m ² area per seat + 0.2m ² for counter service)
Servery Counter	15	Servery Counter
Store	20	Associated with Café
Kitchen	60	Midmarket restaurant - 0.6 x covers (maximum covers assumed 100)
Kitchen Store	5	
Refuse	5	
Education / Community		
Education / Community	60	Adaptable space with flexible furniture to enable use by other community groups. For a classroom group up to 30 pupils
Cloak Room	5	Cloak room for school groups
Hand washing	5	Area for hand washing
Store	10	Store for tables and chairs - will furniture need to be stored? Or will teaching be less informal? tbc
Toilets	12	2 individual toilets of 3m ² for school groups
Accessible Toilet	4	
Other		
Plant	25	TBC. Plant room as required. May be larger depending on servicing strategy.
IT Comms	10	Lockable racks or comms cabinets. Requirements tbc
Total excluding non-net area	497*	Total excluding non-net area
Non net area	25%	Non net area for circulation calculated at 25% therefore an additional 125m ²
Total	622	Approximate internal area

Educational Bird Hide

- 2.6.9 The educational bird hide is being designed to accommodate a school group with a lobby area giving an approximate internal area of 70m².

Embedded in Nature

- 2.6.10 To maximise the visitor experience and the connection with water and nature, the centre is positioned in the water and surrounded by the wetland environment. The location of the educational bird hide away from the centre provides a quieter area to observe wildlife.

Natural Defence

- 2.6.11 Placing the visitor centre into the wetland and surrounding it with water offers a natural defence. Bridge links which are raised and lowered increase security of the building.

Promontory

- 2.6.12 The visitor centre is positioned to deliver clear views across the wetlands and reservoir, to connect visitors with the landscape and wider surroundings.

Landscape setting

- 2.6.13 The visitor centre is set on the water's edge within or adjacent to compartment 4 of the wetlands. Water will be retained around all or part of the centre. Two promontories either side of the centre provide access and offer visitors vantage points.

- 2.6.14 Boardwalk access to the educational bird hide offers visitors an intimate journey through the wetlands to a more secluded part of the site. The hide faces eastwards with near and distant views over and along the wetlands.

Emergency vehicles and day to day access

- 2.6.15 A refuse area in the kitchen provides daily storage. External bins and recycling are secured within a small enclosure near the main car parking area. This allows rubbish to be stored close to the kitchen and moved at the end of the day via a small utility vehicle, such as a Kawasaki Mule.
- 2.6.16 Access for emergency vehicles is from the car park. This hard-landscaped area provides sufficient room to accommodate a turning circle and paving specification to support all emergency vehicles.

Health and Safety

- 2.6.17 Risks to health and safety will need to be continually considered as the design develops into RIBA stage 2 and eliminated/ mitigated as appropriate. Key risks that present at this early stage are as follows:

Construction

- 2.6.18 The timing of the construction of the visitor centre in relation to the filling of the wetland will need careful consideration when determining construction sequencing to enable effective management of risks.

Public Amenity

- 2.6.19 The waterside location of the centre represents a risk of falling in water and drowning, as per other locations around the reservoir. This is minimised through the use of a balustrade and handrail around the building at the water's edge. This gives a clear message that access to the water is prohibited. Safety rings would be provided as additional protection.

Operation and maintenance

- 2.6.20 A living roof requires regular maintenance; safe access and protection for trained personnel is required to undertake checks and weeding, typically twice a year. The design proposes the use of large areas of glazing. Terraces around the building allow access to windows for cleaning.

Buildability

- 2.6.21 The waterside location of the visitor centre is commonplace across other similar facilities in the UK, providing numerous examples of possible construction, foundation and servicing solutions.
- 2.6.22 Further review of construction techniques and constructability will be explored as the design develops.

Innovation

- 2.6.23 The sizing of the building has been a collaborative design process with Portsmouth Water, and various teams within Atkins including the wetlands specialist and landscape architect to provide an approach which is embedded in nature. The building design is now being developed in 3D software, with the Revit model of the visitor centre and educational bird hide being placed into the federated model to review the aesthetics of the placement and design. Sustainability tools have been used to establish the most sustainable structure for the roof, to reduce carbon.



Figure 2-14 Indicative view of north west corner with visitor centre

Appearance

- 2.6.24 The aspiration of the visitor centre is to be a prestigious sustainable building nestled within the wetland habitat. The external materiality of the visitor centre and educational bird hide will respond to the locality through use of natural materials where possible to reflect the surrounding habitats, with large areas of glazing to provide views across the wetlands and reservoir. Internally, a neutral palette and exposed timber will provide warmth in public areas. See the Design and Access Statement for more detail on how the outline design has developed including visualisations.

2.7. Public Realm

Sustainability and Environment

- 2.7.1 The environmental design development continues to provide a site-specific response to the existing character of the landscape. One of the core objectives is to preserve the unique setting and rural character of the landscape. Both the landscape design and amenities provided within it have been progressed with the key design principles at the heart of the process are set out at the start of this document (Section 1). These can be summarised as;
- The design to be sympathetic to the historic park and gardens whilst working with and around the ancient woodland
 - To maintain and integrate the rural landscape character and woodland setting
 - To ensure design is appropriate for all abilities and ages
 - To maintain and enhance public access
 - To create a safe environment
 - To incorporate recreational facilities in keeping with the local context
 - To optimise educational opportunities
 - To maximise biodiversity
 - To minimise maintenance costs
 - To incorporate public art
- 2.7.2 Complementary to its infrastructure resilience function, the reservoir will provide a new recreational facility/resource adjacent to one of the more deprived areas in South East Hampshire.
- 2.7.3 The whole community will be able to access this new facility and the amenity resources it provides through sustainable, active travel, on foot, by bike, or through existing bus routes. The reservoir offers further opportunities to improve the public right of way networks in the wider area. More than 29,500 people live within walking distance of the site (1.5km) and 120,000 people live within cycling distance of the site (4.5km).

The Outline Plan

- 2.7.4 The environmental design proposals enable new access routes within the newly created habitats.
- 2.7.5 Within the Borough, opportunities for walking and access for the elderly is currently undersupplied, working with the design principles and making access for all a priority, Havant Borough Council specifically expressed a need to ensure provision for improved opportunities.
- 2.7.6 In terms of access, recent engagement has included the following parties who have helped shape the overall design with their expertise and knowledge;
- Conservation, Access and Recreation (CAR) Workshop with representatives from the UK water companies;
 - Stakeholder engagement meetings; and
 - Meetings with Harry Goodchild (HCC Definitive Map Manager), Elliott Rowe (HCC Area Manager), Tim Speller (HCC Manager of SCP) and Sue Montila (British Horse Society)
- 2.7.7 Our design response has been to provide a design with an extensive network of walks identified of varying lengths forming circular walks; consideration was given to suitable distances for short and long walks that connect into existing long distance paths.
- 2.7.8 The environmental design approach has always been to enhance the existing landscape. To help achieve this a brand-new wetland habitat to encourage different wildlife to the site has been created. The area can be used as an educational resource, to assist in providing teaching experiences through the school curriculum and adult education, to help educate the community about nature and our impact on the environment. Attraction of different bird species will encourage bird watchers. Boardwalks through natural wetland planting will bring the community closer to nature and viewing locations for the wetlands will be at the end of gated pathways preventing access for dogs.
- 2.7.9 The access will be single tracks with no connectivity so people will have to make a conscious decision to go down them and stray from the main routes.
- 2.7.10 Along with the advanced planting areas at Gipsies Plain and the south west corner additional areas of woodland, wet woodland, scrub, wet grassland and wildflower meadows have been identified to improve the biodiversity contribution.
- 2.7.11 The Design and Access Statement includes more detail on the design of the internal movement network and other focal points within the site which include:

The North West Corner – This area is key to the visitor experience (see Figure 2-14). The landscape design has been created to assist in providing an attractive naturalistic setting for a number of activities around the visitor centre, a playground, picnic area and car park.

The Viewing Area - The location of this viewing area has been chosen because of its proximity to the neighbouring Warren Park, it offers the residents somewhere nearby to site and lookout across the reservoir.

The Avenue Staircase - The staircase leading from Staunton Country Park to the top of the embankment is seen as a key opportunity to celebrate the interface between the reservoir and the park.

Health and Safety

- 2.7.12 Safety by design principles have been applied in the design and planning of the landscape and amenity facilities. Further consideration and development of the Public Safety Risk Assessment will be undertaken in the next phase.

Buildability

- 2.7.13 A construction sequence has been developed which informs the landscape and amenity design and vice versa. Some advanced mitigation planting works have already taken place to aid with the loss of woodland. The landscape design will look to reuse materials where possible including reclaimed timber for planters and benches.

Innovation

2.7.14 Local materials will be utilised within the landscape and amenity design.

2.7.15 The design of the site and associated structures has been carried out using an interface of several 3D modelling platforms:

- Civils 3D generating varying sections through embankment realignments and retaining structures
- Navisworks for a combined federated model allowing a single point of truth
- Webview GIS to allow rapid comparisons of embankment and structures alignment with geological data, and constraints such as designated conservation areas and ancient woodland no-dig zones and habitats
- The outputs were also used to generate visualisations and sections for stakeholders to better understand the design.

3. Bedhampton to Havant Thicket Reservoir Pipeline

3.1. Design Overview

3.1.1 A bi-directional pipeline of minimum 700mm diameter is required to pump spring flows from Bedhampton Springs to Havant Thicket reservoir. Flows will gravitate back down in the same pipeline from the reservoir to Bedhampton, where they will be boosted and transferred to Farlington water treatment works (WTW) for treatment prior to distribution across Portsmouth Water's supply network.

- Normal operational fill of the reservoir during winter months at 40 MI/d
- Normal operational emptying of the reservoir during summer months when required at 25 MI/d

3.1.2 The same pipeline also provides a conduit for the balance of flows not discharged at the reservoir emergency discharge point at Riders Lane stream. This flow to be conveyed over halfway along the route, into the Hermitage Stream at its confluence with the Riders Lane Stream. This section of pipeline is decreased in size to 1200mm diameter (previously 1500mm).

3.1.3 The design to date has included the following:

- Review of design flows and steady state hydraulics
- Assessment of existing known utilities (from services plans) and how they may affect the design and construction.
- Assessment of ground conditions to be expected, based on historical records of local geology
- Assessment of buildability of the pipeline at pinch point locations along the route
- Development of existing route alignment (ongoing)

Pipeline route options

3.1.4 Building on the optioneering undertaken in 2009, a comprehensive review of the proposed route and alternative routes was undertaken. It was concluded that as the alternative routes did not appear to offer significant overall advantages, the original reference design route would be progressed for outline design.

3.1.5 The solution was further optimised to mitigate the increases in costs arising from additional constraints identified that were not appreciated in the reference design.

Pipeline route

3.1.6 The following actions were taken to further develop confidence in the route:

- Develop the combined utilities plan (from utilities returned maps) with more accurate detail including size of pipelines and cables.
- Modify route where possible to avoid obvious service clashes.
- Avoid planning conflicts with ancient woodland site by diverting the pipeline along High Lawn Way.
- Allowing for temporary works to improve constructability alongside the Hermitage Stream.
- Proposing stream crossings in open cut during low flow conditions.
- Proposing concrete sleeve pipe jacked pipe across Under Track Crossing (UTX) at Bedhampton
- Improve constructability of the drawdown section of pipeline by reducing its capacity requirement and therefore size, by diverting more flow to the Riders Stream

- 3.1.7 The proposed 4.4 km pipeline route from Bedhampton to the reservoir site follows a fairly sinuous course along the bank of the Hermitage Stream and through several residential roads with a key aim, wherever possible, to avoid major thoroughfares and minimise impacts to residents and the travelling public. A trenchless crossing of the railway line has been proposed with possible additional sections of trenchless installation to facilitate construction through other pinch points, e.g. adjacent to the Hermitage Stream.
- 3.1.8 The pipeline includes a 700mm diameter pipe (1,650m in length) for normal pump-and-return flows with this increased to 1200mm diameter (2,750m in length) for the section where it is to accommodate the emergency drawdown flow from the reservoir site to a discharge structure at the Hermitage Stream.

Hydraulics

- 3.1.9 An optimisation exercise was undertaken to explore opportunities to reduce the size of the pipeline. This study resulted in a reduction in pipe size for the emergency draw down section of pipeline from 1500mm to 1200mm diameter; this is achieved by increasing discharge flows at the reservoir emergency discharge point. To ensure that the Riders Lane Stream has adequate capacity to accommodate the additional flow without increased risk of flooding, improvements will likely need to be made to three culverted road crossings at Middle Park Way, Dunsbury Way and Brubrook Way to remove local restrictions.
- 3.1.10 The revised discharge flows to the watercourses, estimated in accordance with appropriate design requirements, are summarised in the table below.

Table 3-1 Emergency discharge flows

	Hermitage Stream (Discharge via pipeline)	Riders Lane Stream (Reservoir Emergency Discharge Point)
Emergency discharge flows	3.85 m ³ /s	7.05 m ³ /s

- 3.1.11 The depth of construction in High Lawn Way was reduced by allowing for 100% of emergency discharge flows to Riders Lane Stream once the reservoir level drops below bottom operating level. Normal operation is still achieved down to bottom water level gravitating to Bedhampton PS.
- 3.1.12 The initial study also showed that it is unlikely that the diameter of the 700mm diameter section of pipeline between Bedhampton PS and the Hermitage Stream outfall can be reduced without significantly increasing whole life costs.

Pipeline materials

- 3.1.13 The 700mm diameter section of pipeline between Bedhampton PS and the Hermitage Stream outfall could be constructed in ductile iron (DI) or HDPE, both are suitable pipeline materials in service. However, it is considered that DI with self-anchored joints may be easier to install in an urban environment with narrow trenches as it can be installed and jointed in shorter (6-7m) lengths particularly where there are existing utilities and traffic management considerations. DI being a semi-rigid material, also requires less imported pipe bedding.
- 3.1.14 The 1200mm diameter section of pipeline between the Hermitage Stream outfall and Havant reservoir could potentially be constructed in DI or steel, both are suitable pipeline materials in service.

Geology

- 3.1.15 The topography of the pipe route rises from a level of approximately 6m AOD at the Bedhampton Springs to 25.5m AOD at the highest point at High Lawn Way and 22.5m AOD at the reservoir. The proposed top water level in the reservoir is 39.5m AOD and the low level draw-off is 23m AOD.

- 3.1.16 A desk study of the Havant geology shows that the reservoir and pipeline lie within the Bere Forest / Chichester syncline which is underlain by cretaceous chalk deposits. The general stratigraphy along the middle section of the pipeline route (also the middle of the syncline) comprises Head overlying London Clay, Harwich Formation, Reading Formation, and then Chalk. Each of these layers lens out over a relatively short distance (where the syncline outcrops to the south), outcropping between Bedhampton Road and the southern end of the pipeline. There are superficial deposits of alluvium immediately underlain by chalk at the southern end of the pipeline (where it crosses the rail line). At the northern end of the pipeline, there is an overlying layer of the Bognor Sand Formation, followed by the remainder of the stratigraphy. Free groundwater is expected within the Harwich Formation, and may be encountered in the Bognor Formation Member, in claystone bands within the London Clay Formation, and through seepages in sand horizons within the Reading Formation.
- 3.1.17 The majority of shallow excavation is expected in Head material, which is highly variable, and alluvial deposits. Trench boxes are assumed to be suitable for excavation in the Head but there is high risk of running sands in the alluvial deposits, therefore sheet piles are required in this geology.
- 3.1.18 Bedrock geology includes Bognor Sands, a silty sand which when saturated could result in running sands in the excavation (observed in ground investigation), risking settlement or damage to other utilities in the road. This affects approximately 20% of the route length (noting that geological maps can only give approximate locations for the boundaries of different ground conditions). Therefore, an allowance for sheet piling should be expected, with a risk allowance for dewatering, assuming construction occurs only in summer months.
- 3.1.19 The underlying strata is London Clay. In areas where sheet piles are not required and where the easement is sufficient and away from other existing utilities, an angle of repose of 1:1 may be achieved but there is a risk of shear faces in the clay, therefore any in pipelaying works trench support should always be provided for safety of the pipelayers.
- 3.1.20 Head is variable but likely some can be re-used as S4 pipe bedding/fill material, subject to selection and testing on-site. Some of the Bognor Sand Member might suit S5 requirements subject to selection and testing.
- 3.1.21 A Ground Investigation is proposed to confirm actual geology at critical locations and along the route of the pipeline.

Sustainability and Environment

- 3.1.22 Mitigating and minimising the negative impacts to the environment and developing a sustainable design has been fundamental in assessing the viability of the pipeline route. This has been achieved through liaison with contractors through early contractor involvement, choice of pipeline material and offsetting unavoidable negative impacts by incorporation of environmental improvements within the design proposal.
- 3.1.23 North of Middle Park Way the route would impact on the Sir George Staunton Conservation Area (CA, Thicket Lawn and High Lawn Sites of Importance for Nature Conservation (SINC), Staunton Country Park (SCP) and a small watercourse. Mitigation measures that should be adopted during construction, including minimising the construction footprint in these designated areas, would have the potential to limit and mitigate short term temporary impacts on these sensitive receptors including footpath users and their visual amenity.
- 3.1.24 The route would have the potential to adversely impact open grassland and tree planting where located within open spaces and along watercourses. Mitigation measures adopted during construction, including avoiding root protection zones of existing trees, would have the potential to limit and mitigate significant impacts on these sensitive receptors.
- 3.1.25 The original route is improved by avoiding construction across the ancient woodland at Great Copse, which is considered an irreplaceable habitat in accordance with UK national planning policy.

- 3.1.26 Considerable improvement in scheme's carbon footprint is achieved by optimising the size of pipeline sections through challenging the reservoir's peak drawdown flow, and distribution of drawdown flows between the pipeline and emergency discharge point at the reservoir.
- 3.1.27 Construction noise and traffic is likely to be an issue that requires careful management through the construction works. Much of the route in public highway will need to be undertaken under road closure with limited access for residents only.
- 3.1.28 The pipeline will cross Riders Lane stream and Hermitage stream, both designated as 'main rivers' by the Environment Agency. Both river channels are relatively narrow at these crossing points, hence a dry open cut trench methodology is selected at this stage, as part of which flow will be maintained through damming and using of temporary "flume" pipes installed in the bed of watercourse. This methodology will require environmental permitting and will be developed in consultation with the Environment Agency.
- 3.1.29 The pipeline route passes through an Inner Zone (Zone 1c) Source Protection Zone (SPZ) and crosses an Inner Zone (Zone 1) SPZ to the south of Bedhampton Road associated with the underlying regional Chalk Principal Bedrock Aquifer. Depending on the depth of excavation and any tunnelling, there is the potential to impact on groundwater and flows within adjacent watercourses, noting that a deeper excavation is more likely to impact on groundwater.
- 3.1.30 The construction of the main in close proximity to St Chads Well Spring could impact water quality. Vibration to be limited from construction work not to comprise the integrity of the wells. Construction of deep shafts in SPZ (Zone 1) requires approval from the EA. To better understand the geology at the Chads Well Spring area for construction of UTX, two boreholes have been commissioned. This information will be compared with the source well as-built records, if available, to further understand the risk and suitable mitigation methods. To further reduce the risk, we are seeking to locate the UTX as far away from the production wells as possible.
- 3.1.31 The use of selected as-dug materials will be adopted wherever possible in the construction of the pipeline to minimise the quantities of imported pipeline bedding material.

Health and Safety

- 3.1.32 Road closures will be required in narrow residential roads to ensure safe installation of the pipeline. The trench width will be optimised to ensure safe installation of the pipeline whilst minimising disturbance to residents.
- 3.1.33 A typical installation arrangement has been proposed to ensure pipelaying can safely be undertaken at pinch point locations near the streams. This involves installation of approximately 200m of sheet pile sections to combat slope stability. However there remains a degree of risk with this alignment.

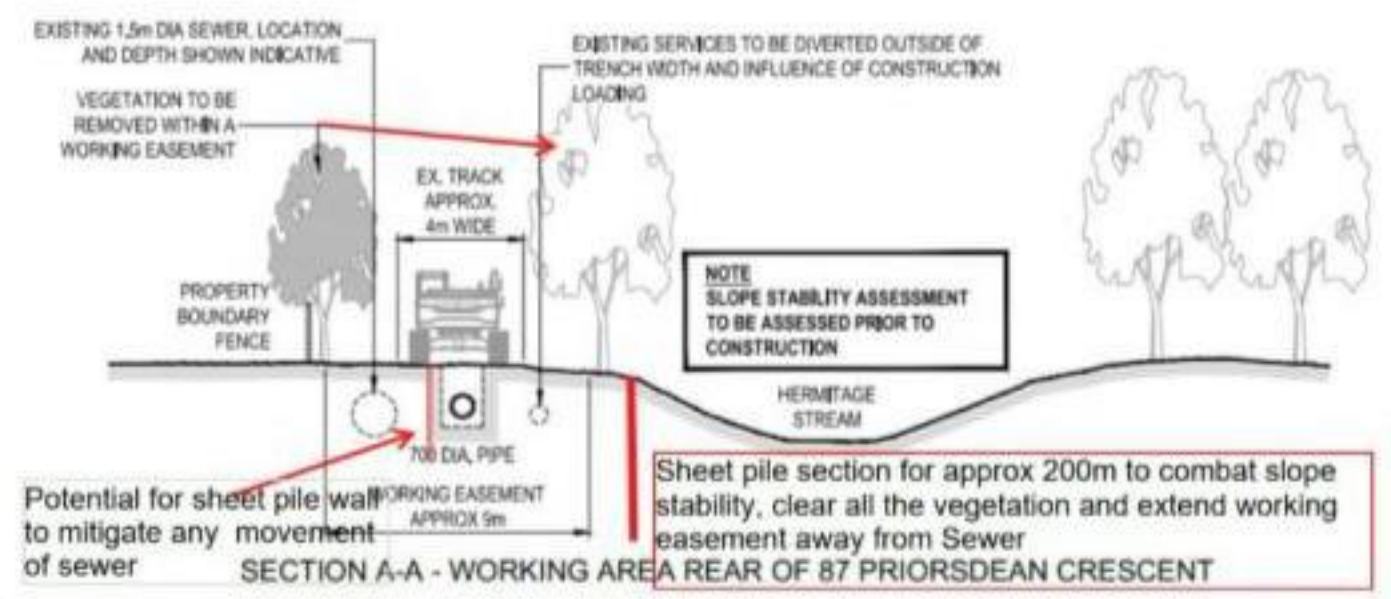


Figure 3-1 Typical installation proposal in pinch point section close to the stream

- 3.1.34 Alternatively, the route could possibly be diverted to the other side of the stream to avoid these pinch points altogether.
- 3.1.35 The programmed works in the vicinity of the watercourses are to be carried out within the drier season of March to September, to avoid groundwater issues and instability of excavations, also encountering high flows at stream crossings. The following locations to be included:
- Proposed remedial/upsizing works on existing culverts on Riders stream
 - Riders Lane stream crossing
 - Hermitage stream crossing
 - Installation of pipe adjacent to the Hermitage Stream
- 3.1.36 Construction safety principles should be applied during the outline design of the pipeline, such that:
- Safety of the construction team and public is always achievable
 - Access maintained to vulnerable residents as required
 - Minimise depth of dig where possible
 - Choice of construction methods, materials and programme to mitigate or minimises risks
- 3.1.37 Significant existing underground services/utilities have been identified along the proposed route from reviewing utilities providers service plans. A Ground Penetration Radar (GPR) survey of the entire route will be undertaken to verify utility locations for design development.
- 3.1.38 There will be a lack of working space along some of the route, with working in proximity to live traffic. Road closures and traffic management should be used as much as possible to remove or reduce this risk.
- 3.1.39 Where feasible valve and inspection chambers shall be designed to be accessible from safe working areas, e.g. footpaths or green space instead of the road.
- 3.1.40 Potential impact on water quality, asset life or harm to construction workforce can be anticipated if contaminated land or highly aggressive soils are present on pipeline route. A GI is planned to inform design on appropriate material selection and mitigation measures.
- 3.1.41 There will be some disruption to the community by closing of public amenities e.g. parks, disruption to businesses and restricted access to schools. Public engagement will start as early as possible. A clear programme of the construction works will be developed to minimise the effect of construction on the public where possible. Construction work near schools will be planned during school holidays, if possible, to minimise impact.
- 3.1.42 Higher groundwater levels can be expected in deep excavations in proximity of St Chads Well Spring, i.e. Under Track Crossing (UTX) shafts, at Bedhampton. GI investigation will inform the design and required mitigation measures.
- 3.1.43 The design has minimised the risk of ground settlement at the UTX by selecting pipe jacking as a proven system used for track crossings. A detailed ground investigation will be undertaken as part of the outline design to inform design and construction of UTX whilst adhering to Network Rail's standards and procedures.

Buildability

- 3.1.44 Pipeline buildability has been improved by reducing the size of the discharge pipe to be installed in narrow residential areas. Utilising a narrower trench construction width than is typical has also been considered in order to reduce construction footprint and spoil volumes.

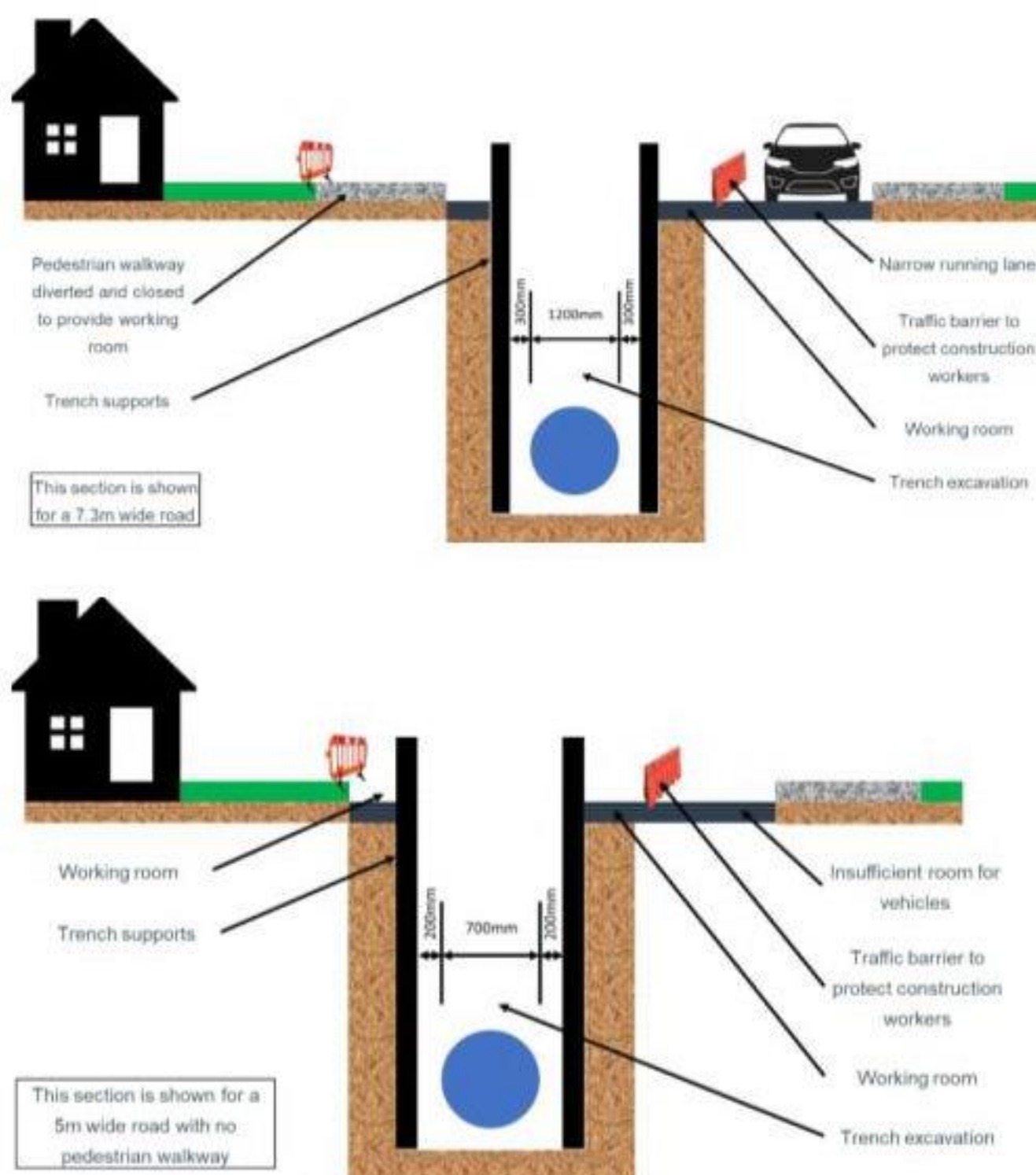


Figure 3-2 Typical trench sections

- 3.1.45 Self-compacting granular material will be required under the pipeline haunches where mechanical compaction cannot be achieved.
- 3.1.46 A significant amount of existing underground services/utilities have been identified along the proposed route. Permanent/temporary diversions of those assets and temporary new connections that may be required for construction activities need to be avoided where possible but where unavoidable will be planned and agreed with utility providers in advance of construction works commencing.
- 3.1.47 The high number of changes in direction of the pipeline could be challenging due to the difficulty in locating and constructing suitable thrust restraining blocks in this congested environment. Undertaking an assessment of the available options the design has progressed adopting the use of DI pipes with self-anchored joints to relieve this buildability constraint in busy urban settings.
- 3.1.48 Development of the design has been influenced by buildability considerations and early contractor involvement. It should be noted that the contractor consulted on the constructability and budget cost for the selected route assumed that road closures would be available, as required, throughout the route.

- 3.1.49 Consideration will be given during outline design to the relocation of the discharge point to Hermitage Stream northwards. This will have the benefit of reducing the length of DN1200 pipe with DN700 which will have a narrower construction footprint alongside the stream.
- 3.1.50 When working adjacent to the Hermitage Stream there will be additional temporary and permanent works associated with construction and installation of the pipeline. There are the additional complexities of several pinch points between 3rd party properties and the stream, and proximity to an existing trunk sewer. It should be noted that future access will need to be provided to the sewer for maintenance and repair.
- 3.1.51 There are flooding risks for activities that require deep excavations (shafts for UTX and other deep trenches) that must be reviewed for requirements for dewatering and management of groundwater and surface water.
- 3.1.52 There will be construction work undertaken in residential areas in narrow roads. Particularly the large diameter pipe installation will encounter some difficult buildability issues. Close working between the contractor and the designer will be essential to reduce delays where changes are required according to site conditions as the construction develops.
- 3.1.53 There will be some disruption to residents caused by prolonged possession of the roads, the number of vehicle movements for exporting and importing material, disturbance from heavy plant, parking restrictions and potential damage to properties. Bin collections, bus routes, emergency services etc. will also need careful consideration.

Innovation

- 3.1.54 Designs are being developed based on high density 3D topographical mapping of the route. This has been generated from image processing of high-resolution aerial surveys. Application of this digital technology allows faster collection of data and better visualisation of key features along the route.
- 3.1.55 Design is considering the use of Trimble Viewer enabling 3D visualisation of the proposed pipe and the chartered services encountered on site. The tool should allow the designer and contractors to explore potential design clashes early.
- 3.1.56 Opportunity to collaborate with other utility companies to enable these stakeholders to access and/or maintain their assets at the same time. This will avoid future work and disruption and could offer savings to both parties.
- 3.1.57 Design of the emergency drawdown arrangements have been optimised to enable the reduction in pipe size.

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