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BOW FARM SURFACE WATER DRAINAGE SCHEME
For
MORETON C CULLIMORE (GRAVELS) LIMITED

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BOW FARM SURFACE WATER DRAINAGE SCHEME

1. INTRODUCTION

GWP Consultants LLP (GWP) have been instructed by Moreton C Cullimore Group (MCCG) to prepare a Surface Water Drainage Scheme, including design drawings, for the development at Bow Farm, operated by MCCG, as required under Planning Pre-Commencement Condition 20 of Planning Permission Number 19/000048/CM (Worcestershire County Council).

In addition, Pre-Commencement Condition 26 of Planning Permission Number 19/0081/TWMAJM (Gloucestershire County Council) requires the submission of detailed design drawings for surface water drainage. The wording of Pre-Commencement Condition 26 in Planning Permission Number 19/0081/TWMAJM is almost identical to that of Pre-Commencement Condition 20 of Planning Permission Number 19/000048/CM (Worcestershire County Council). Planning Permission 19/0081/TWMAJM was approved by Gloucestershire County Council through the successful appeal (Appeal Ref. APP/T1600/W/23/3324695) by the applicant following initial refusal of Planning Permission 19/0081/TWMAJM.

Both Planning Permissions provide for the development of the Bow Farm site as the site straddles the Worcestershire/Gloucestershire county boundaries.

1.1 Pre-Commencement Condition Wording

The wording of Pre-Commencement Condition 20 of Planning Permission Number 19/000048/CM is provided below:

"Notwithstanding the submitted details, no development shall commence until detailed design drawings for surface water drainage have been submitted to and approved in writing by the Mineral Planning Authority. Thereafter the development shall be carried out in accordance with the approved details."

1.2 Previous Reporting

A Hydrogeological and Hydrological Impact Assessment (HIA) and Flood Risk Assessment (FRA) report (Report No. 190714 v.02) was prepared by GWP Consultants LLP (GWP) in August 2019 and submitted in support of the approved Planning Application.

A Report Letter (Report No. 200714 v.02) was then submitted by GWP in August 2020 which included technical responses to water-related matters raised in comments made by the two local planning authorities (LPAs) – Gloucestershire County Council (letter ref: 19/0081/TWMAJM) and Worcestershire County Council (letter ref: 19/000048/CM) – in their separate but identical letters dated 7th May 2020.

A further Report Letter (Report No. 220420 v.01) was prepared by GWP in April 2022 providing a technical review of the Environmental Statement submitted by CEMEX as part of their planning application for sand and gravel extraction and low-level restoration at Ripple East with respect to water-related impacts and mitigation, and the assessment of the potential for cumulative impacts of the CEMEX and Bow Farm developments to occur simultaneously. The CEMEX site is located immediately north of the M50 motorway, whereas the Bow Farm site is situated immediately south of the M50 motorway and immediately south of the CEMEX site. The Report Letter summarised that there will be no increased cumulative impact with respect to water related matters from the simultaneous developments.

This report and Surface Water Drainage Scheme refer to the original Planning Application.

Site location and site setting details are provided within the HIA and FRA report (GWP Report No. 190714 v.02) and so are not repeated here.

2. SITE DEVELOPMENT PHASING

Details of the proposed quarry working phases for the Bow Farm site can be found in the HIA and FRA Report (GWP Report No. 190714 v.02).

The site location and land under the applicant's control are shown on Drawing No. BOWFHIA2407-1.

The site will extract approximately 1.5 million tonnes of sand and gravel over an 8 to 9 year period, at approximately 200,000 to 250,000 tonnes per annum. The part of the proposed excavation area currently lying above the flood plain will be worked in 9 phases (Excavation Phases 1 to 9) and restored to existing ground level with a combination of site derived material and imported inert fill. To extract the sand and gravel resource within Phases 1 to 9, the Applicant has previously advised the site will use a clay cut-off around its perimeter, keyed into the underlying clay to hydraulically separate the site from the surrounding aquifer. Therefore, no groundwater dewatering will be required.

Two excavation areas (Flexible Working Areas A and B) located on the flood plain, will be restored to open water and wetlands using only site derived mineral waste (silts and clays) and will have a final landform below pre-extraction ground levels. Sand and gravel within Flexible Working Areas A and B will be worked wet, as no clay cut-off will be installed around these areas.

The excavated sand and gravel mineral will be moved from the excavation phases to a processing plant area in the southeast of the application area *via* a radial conveyor to Phase 9, before transportation by dump truck. The processing plant area of the site will be located within Gloucestershire, whereas Excavation Phases 1 to 9 are situated within Worcestershire. A site context drawing showing the locations of the excavation areas and the processing plant area is provided as Drawing No. BOWFHIA2407-2. The approaches to surface water management within the Excavation Phases 1 to 9 area and within the processing plant area differ. The details of how surface water is managed within these respective areas are therefore provided in separate sections of this report.

3. EXCAVATION PHASES 1 TO 9 SURFACE WATER MANAGEMENT APPROACH

The surface water management design concept for Excavation Phases 1 to 9, during the excavation and restoration stages, is underpinned by the following guiding principles.

Excavation of sand and gravel material from Phases 1 to 9, and restoration in these areas using site derived material and imported inert fill, will be undertaken in accordance with the approved phasing plans (see David Jarvis Associates (DJA) drawings in Appendix 1). The phasing plans show that excavations and restoration will occur progressively, starting in Phase 1 in the north of the site and moving south to end in Phase 9.

Prior to the commencement of mineral extraction, the clay cut-off will be installed around the perimeter of the mineral extraction area. When installed, the clay cut-off will extend from the base of the mineral extraction void, where it will be keyed into the underlying Branscombe Mudstone Formation of the Mercia Mudstone Group, up to the surrounding ground level. The clay cut-off will be installed 'inside' (to the east of) the infiltration pond described in Section 8.

Also before excavations commence, a surface water interceptor ditch will be constructed along the eastern perimeter of the Excavation Phases 1 to 9 area, between the site boundary and a screening bund, and will extend along the northern and southern extents of the Excavation Phases 1 to 9 area to the west of the site (see approved phasing plans provided in Appendix 1). The ditch will capture runoff from the bund to protect off-site properties to the east (Bow Farm and Bowfields), plus any which flows onto site from the east. Water within the interceptor ditch will be routed around the northern and southern extents of the Excavation Phases 1 to 9 area to the west where it will infiltrate through the base of the ditch into the underlying sand and gravel aquifer. This ensures no runoff external to the site will enter the excavation phases.

During mineral extraction, surface water captured within the mineral excavation voids will be routed to a quarry sump in the base of the currently worked excavation Phase(s). The sump will be excavated 1m into the Branscombe Mudstone Formation at the base of the excavations by overdigging the floor of the quarry.

Captured surface water within the sump will be pumped out from the extraction void at a low, controlled rate (maximum 10 l/s) into an open ditch running south of the worked excavation Phases along the western edge of this part of the site.

This ditch will convey the pumped water from the sump southward, directing the intercepted water from each excavation phase to a temporary silt pond (Silt Pond 2) located in the south of the site, where suspended solid particles will be allowed to settle out. Once clarified, this clean water will either evaporate or flow over a weir to a nearby temporary infiltration pond, where it will infiltrate into the underlying *in situ* sand and gravel aquifer. The temporary silt pond and infiltration pond will

be initially located in the Phase 9 area, which will be the last phase to be excavated. Therefore, these temporary structures can remain within Phase 9 until this phase needs to be excavated. Prior to the excavation of Phases 8 and 9, Silt Pond 2 will be moved to restored Phase 7. Surface water from the sump in excavation Phases 8 and 9 will be pumped to this replacement silt pond, with subsequent discharge to the restoration infiltration basin feature along the western boundary of the site. The restoration infiltration basin will be progressively constructed from north to south within fully restored phases and will replace the open ditch in these completed phases.

As progressive extraction and restoration occurs, the clay cut-off will be removed from the western side of each phase as it is restored to allow for the restoration infiltration basin along the western side of Excavation Phases 1 to 9 to be constructed. This ensures that the restoration infiltration basin will discharge surface water into *in situ* sand and gravel and it can flow freely away from the site, to the west. It is only necessary to remove the clay cut-off from the western side of the excavation area because the infill material used to restore the excavations will be low permeability and will act as a barrier to groundwater flow.

3.1 Phases 1 to 8 Extraction

Drawing Nos. BOWFHIA2407-3 to 6 show the location of mineral extraction works within Phases 1 to 8, including surface water management features. The drawings are split into the following mineral extraction phases:

- Phases 1 and 2 – Drawing No. BOWFHIA2407-3
- Phases 3 and 4 – Drawing No. BOWFHIA2407-4
- Phases 5 and 6 – Drawing No. BOWFHIA2407-5
- Phases 7 and 8 – Drawing No. BOWFHIA2407-6

The following surface water management process and features will apply to mineral extraction in Phases 1 to 8:

- Prior to commencement of excavation, the surface water interceptor ditch will be constructed along the eastern perimeter of the Excavation Phases 1 to 9 area, between the site boundary and the eastern screening bund, and will extend around the northern and southern extents of the Excavation Phases 1 to 9 area to the west of the site.
- Surface water collected within worked phase excavation voids and routed to the quarry sump in the base of the excavation.
- Water pumped at a controlled rate from the quarry sump through flexible pipework to the out-of-pit open ditch located to the south of the current mineral extraction phases. The open ditch will be situated along the western edges of phases yet to be excavated.
- The open ditch conveys the water southeast to Silt Pond 2 in Phase 9 for settlement.
- Clean water discharged from Silt Pond 2 to the adjacent temporary infiltration pond, also located in Phase 9, through a weir.
- Water infiltrates down into the underlying sand and gravel through the temporary infiltration pond.
- Sumps within fully excavated phases will be decommissioned and the pump infrastructure moved to the new excavation phase prior to the restoration of the fully excavated phases by infilling with a combination of site derived material and imported inert fill.
- The progressive excavation and restoration of the site from north to south means the out-of-pit open ditch will be at its longest during the Phase 1 and 2 mineral extraction and will shorten through the working of the site. During Phase 7 and 8 mineral extraction the water from the sump will either be directed to the remaining short section of open ditch or pumped directly through the flexible pipework to the Silt Pond 2.
- Construction of the restoration infiltration basin on the western side of fully restored phases to capture surface water runoff from phases infilled with site derived material and imported inert fill. This only applies after the restoration of the first phase is complete.

- Erosion protection, such as gabion mattresses and polythene damp proof membrane (DPM), will be applied to the inlet of the open ditch, the inlet of Silt Pond 2, the weir connecting Silt Pond 2 to the infiltration pond, and any emergency overflow pathways to watercourses.

3.2 Phase 9 Extraction

Drawing No. BOWFHIA2407-7 shows the mineral extraction works within Phase 9, including surface water management features.

The surface water management process and features during Phase 9 mineral extraction will be similar to those during the Phases 1 to 8 mineral extraction, however there are some differences. These variations mainly involve the moving of Silt Pond 2 from Phase 9 to Phase 7 and the removal of the temporary infiltration pond, as outlined below:

- Prior to the commencement of mineral extraction from Phase 9, Silt Pond 2 and the adjacent infiltration pond located within this phase will be decommissioned.
- A replacement Silt Pond 2 constructed in restored Phase 7 with an outfall to the adjacent restoration infiltration basin.
- Once extraction of mineral from Phase 9 is undertaken, surface water will be collected within the Phase 9 excavation void and routed to the quarry sump in the base of the excavation.
- Water pumped at a controlled rate from the quarry sump through flexible pipework to Silt Pond 2 in Phase 7.
- Clean water discharged from Silt Pond 2 to the adjacent restoration infiltration basin.
- Water infiltrates into the underlying sand and gravel through the restoration infiltration basin.

3.3 Restored Phases 1 to 9

Once Phases 1 to 9 have been restored back to original ground level using site derived material and imported inert fill, the restoration infiltration basin, which will have been constructed progressively along the western edge of Phases 1 to 9, will be fully complete and operational.

All temporary surface water management features within the Phase 1 to 9 area will be decommissioned/removed. This includes any sumps, the temporary Silt Pond 2, and pumping equipment.

The surface water interceptor ditch located around the eastern, northern and southern perimeters of the Excavation Phases 1 to 9 area is to be retained following site restoration. Further details are given in Section 4.

The site restoration layout, including surface water management features, is shown on Drawing No. BOWFHIA2407-8.

Approved details of the restoration infiltration basin, including sizing specification, can be found in the previously submitted HIA and FRA report (GWP Report No. 190714 v.02). The restoration infiltration basin has been sized to accommodate for the infilling of Phases 1 to 9 with low permeability imported inert fill material. Cross sections through the restoration infiltration basin are provided on Drawing No. BOWFHIA1907-18 within Appendix 2.

4. SURFACE WATER INTERCEPTION DITCH

The approved phasing plans provided in Appendix 1 show a surface water interceptor ditch between the eastern site boundary and the screening bund situated along the eastern part of the Excavation Phases 1 to 9 area and extends along the northern and southern extents of the Excavation Phases 1 to 9 area to the west of the site. The interceptor ditch will be constructed prior to any mineral excavations in the Excavation Phases 1 to 9 area. This interceptor ditch will capture any surface water runoff flowing east off the screening bund to protect off-site properties to the east (Bow Farm and Bowfields), as well as any eastern off-site runoff which flows from east to west onto the site. Water within the interceptor ditch will be routed around the northern and southern extents of the Excavation Phases 1 to 9 area to the west where it will infiltrate through the base of the ditch into the underlying sand and gravel aquifer. At both ends of the interception ditch a 150mm high level overflow pipe will be installed to convey any water back to the surface water environment which does not infiltrate due to high groundwater levels. This interception ditch ensures no external runoff

will enter the excavation phases and does not have to be accounted for in the sizing of the temporary on-site surface water management features (sump, open ditch, silt pond and infiltration pond).

A drawing showing cross sections through the interceptor ditch is provided within Appendix 3.

The interceptor ditch is to be retained following restoration of Excavation Phases 1 to 9 and maintained in accordance with the Detailed Restoration Proposals and Landscape and Ecological Management Plan (LEMP) (David Jarvis Associates report reference 2636-4-5-LM-0001 Detailed Restoration Proposals and Landscape Management Plan rev. P4, dated December 2021), approved under Planning Permission 19/000048/CM.

5. QUARRY SUMP

As outlined within Section 3, the quarry sump will be located within the base of whichever excavation phase is being worked at the time. The sump will be excavated 1m into the Branscombe Mudstone Formation at the base of the excavations by overdigging the floor of the quarry. The sump will receive surface water runoff routed to it within the excavation and direct rainfall. The water in the quarry sump will be pumped out of the pit to the open ditch which conveys this water to Silt Pond 2. Silt Pond 2 will be located firstly in the Phase 9 area, and then in Phase 7 once excavations progress to Phase 9. This clean water is then discharged *via* infiltration through the temporary infiltration pond or the restoration infiltration basin.

The locations of the quarry sumps shown within the excavation phases on Drawing Nos. BOWFHIA2407-3 to BOWFHIA2407-7 are indicative. On-site working areas will dictate the actual on-ground quarry sump locations within the excavation voids.

A generalised long section through excavation Phases 1 and 2, and the quarry sump and associated infrastructure, is shown on Drawing No. BOWFHIA2407-9.

5.1 Maximum Required Quarry Sump Storage

During the working of the site the water accumulated in the quarry sump will be pumped out to the open ditch/Silt Pond 2 at a maximum rate of 10 l/s, so as to not exceed the silt pond capacity (see Section 7). The maximum storage required within the quarry sump to allow for the 10 l/s outflow rate has been determined based on a catchment area, rainfall depth and duration statistics, and runoff coefficient.

As outlined in Section 3, the phasing plans within Appendix 1 show that progressive excavation and restoration works will progress north to south. The greatest adjacent excavation areas constitute Phases 2 and 3, which cover c. 40,470m² and 39,590m², respectively (Geology and Mineral Resource Assessment, Bow Farm GWP Report No. 190504 v.01). These excavation phases therefore demonstrate the greatest (worst-case) excavation catchment area of any of the working phases. The maximum catchment area contributing to any of the quarry sumps during the excavation of the site has therefore been determined as 80,060m² by combining the areas of excavation Phases 2 and 3. The sump will be sized to accommodate this worst-case catchment area and so sumps within all other phases of working will be able to accommodate the required storage.

Surface water runoff outside of the excavation phases will be kept out of the pit as safety bunds will be required outside of the pit walls at the northern and southern extents. Within phases yet to be excavated, surface water will infiltrate into the underlying sand and gravel aquifer as it does pre-development. Following completion of restored phases, surface water runoff will be directed to the restoration infiltration basin at the western perimeter.

A suitable runoff coefficient for the excavation phases was determined to be 0.68, based on the conservative estimates for 'bare earth' land use (during excavations) with 'clay/loam' representing the Branscombe Mudstone Formation base material, which is the lowest permeability material that will be present within the excavation areas (Mining Department National Coal Board. 1982).

The Depth Duration Curve (DDC) for the 1 in 100-year rainfall events up to the maximum 96 hours (4 days) rainfall duration have been obtained from the Flood Estimation Handbook (FEH) web service for the site.

Using the 1 in 100-year rainfall depths, the largest (worst-case) contributing area and the runoff coefficient, the quarry sump inflow volumes have been calculated up to the 96-hour rainfall duration. To determine the critical storm duration, and therefore the maximum storage requirement for the

quarry sumps, the outflows from the quarry sumps based on a constant 10 l/s pumping rate have also been calculated for all storm durations.

The 17-hour duration rainfall represents the maximum required storage volume within the quarry sump before the required storage decreases: known as the critical storm duration. Table 1 provides details of the quarry sump storage for a number of storm durations, including the 17-hour critical storm. It includes the rainfall durations, 1 in 100-year rainfall depths, maximum (Phases 2 and 3) catchment area, runoff coefficient, inflows, outflows and the required sump storages up to the 24-hour rainfall duration. For ease of reference, the 17-hour critical storm duration required storage is presented in bold.

Table 1 – Maximum quarry sump storage details (critical storm duration in bold)

Rainfall duration (hours)	1 in 100-year rainfall depth (mm)	Catchment area (m ²)	Runoff Coefficient	Inflow (m ³)	Outflow (m ³)	Required storage (m ³)
0.5	35.04	80,060	0.68	1,908	18	1,890
1	44.49	80,060	0.68	2,422	36	2,386
2	53.15	80,060	0.68	2,894	72	2,822
3	58.48	80,060	0.68	3,184	108	3,076
4	62.28	80,060	0.68	3,391	144	3,247
5	65.19	80,060	0.68	3,549	180	3,369
6	67.52	80,060	0.68	3,676	216	3,460
7	69.45	80,060	0.68	3,781	252	3,529
8	71.1	80,060	0.68	3,871	288	3,583
9	72.53	80,060	0.68	3,949	324	3,625
10	73.79	80,060	0.68	4,017	360	3,657
11	74.92	80,060	0.68	4,079	396	3,683
12	75.94	80,060	0.68	4,134	432	3,702
13	76.86	80,060	0.68	4,184	468	3,716
14	77.71	80,060	0.68	4,231	504	3,727
15	78.5	80,060	0.68	4,274	540	3,734
16	79.23	80,060	0.68	4,313	576	3,737
17	79.92	80,060	0.68	4,351	612	3,739
18	80.56	80,060	0.68	4,386	648	3,738
19	81.16	80,060	0.68	4,418	684	3,734
20	81.73	80,060	0.68	4,449	720	3,729

21	82.27	80,060	0.68	4,479	756	3,723
22	82.79	80,060	0.68	4,507	792	3,715
23	83.29	80,060	0.68	4,534	828	3,706
24	83.77	80,060	0.68	4,561	864	3,697

The generalised long section through the excavation and quarry sump shown on Drawing No. BOWFHIA2407-9 indicates indicative basal dimensions of the sump of 65m x 60m, with 1m depth. This represents a minimum storage volume of 3,900m³.

The maximum required quarry sump storage of 3,740m³ will therefore be accommodated within all the excavated pit phases.

5.1.1 Sump Pump

The pump type and model used to transfer water from the sump in the base of the quarry excavation to Silt Pond 2 *via* the out-of-pit open ditch will be decided by the site operator. It is proposed that the pump will be placed outside of the sump (non-submersible pump) on a dedicated platform to keep it above the water level in the sump/excavation. The pump should be capable of pumping water containing solids with a diameter of up to 20mm. The pump should be rated or throttled to deliver a flow rate of 10 l/s (the silt pond has been designed to operate at 10 l/s) from the sump to the Silt Pond 2, requiring a lift of approximately 9m.

Pumping will be managed so that if the water in the sump is highly turbid it can be left longer to settle, so that water transferred to the silt pond contains lower amounts of suspended solids. If the pump fails or pumping stops, the flood risk is to the quarry floor only, which can be managed safely.

6. SUMP WATER DITCH

During the excavation works there will be the requirement for the construction of an open ditch located to the south of the currently worked mineral extraction phases. This ditch will be situated on *in situ* material and will convey the surface water from the quarry sump to the silt pond for clarification. The water will be pumped from the quarry sump to the open ditch at a controlled maximum rate of 10 l/s.

The open ditch will be excavated to maintain a shallow fall (1v:800h) to be able to discharge the water to the receiving Silt Pond 2.

The ditch will have suitable erosion protection applied at the inlets and outlets, as necessary.

The location of the open ditch shown on Drawing Nos. BOWFHIA2407-3 to BOWFHIA2407-5 is indicative only. Site and excavation area access requirements, locations of stockpiles and any other site infrastructure may mean the actual on-site location of the open ditch may vary.

In addition, during Phase 7 and 8 mineral extraction the water from the sump will either be directed to a remaining short section of open ditch or pumped directly through flexible pipework to the silt pond. Therefore, the open ditch is not shown on Drawing Nos. BOWFHIA2407-6 and BOWFHIA2407-7. Actual on-site workings will dictate which method is used during excavation of these phases, at the discretion of the operator.

The generalised long section through excavation Phases 1 and 2 shown on Drawing No. BOWFHIA2407-9 also shows the indicative location of the open ditch, situated outside of the excavation area and receiving the water pumped through flexible pipework from the quarry sump.

6.1 Open Ditch Design

To ensure the proposed open ditch has sufficient capacity to convey the pumped quarry sump water, the following open channel flow equations have been used to determine the peak flow depth through the proposed ditch design.

$$Q = v * A \quad \text{(Eq. 1)}$$

Where:

$$Q = \text{Discharge (m}^3\text{/s)}$$

v = Velocity of flow (m/s)

A = Cross-sectional area (m²)

The velocity of the flow is calculated with the following Manning's flow equation (see Equation 2).

$$v = \frac{R^{0.67} \sqrt{S}}{n} \quad (\text{Eq. 2})$$

Where:

v = Velocity of flow (m/s)

R = Hydraulic radius (m)

S = Channel gradient (m/m)

n = Manning's roughness coefficient (s/m^{1/3})

The proposed open ditch design assumes a minimum gradient of 0.00125 (1v:800h), a basal width of 0.5m, and a side batter of 1v:1h. A depth of 0.5m has been calculated dependent on conveyance requirements. The ditch has been designed assuming a Manning's Roughness Coefficient (n) of 0.035 ('earth with weeds and stones'). Table 2 shows the open ditch design specifications which will be more than enough to convey the 10 l/s receiving pumped flow from the quarry sump.

Drawing No. BOWFHIA2407-10 shows the design details, including cross section, for the open ditch.

Table 2 – Excavation Phases 1 to 9 open ditch design details

Gradient (v:h)	Manning's coefficient	Bed width (m)	Bank full depth (m)	Side batter (v:h)	Ditch width (crest to crest) (m)	Ditch flow capacity volume (l/s)
1:800	0.035	0.5	0.5	1:1	1.5	205

Surface water runoff outside of the excavation phases will be kept out of the pit as safety bunds will be required outside of the pit walls at the northern and southern extents. Within phases yet to be excavated, which will also contain the open ditch on their western edges, surface water will infiltrate into the underlying sand and gravel aquifer as it does pre-development. If any surface water runoff from unexcavated phases enters the open ditch, then there is sufficient capacity to convey this in addition to the 10 l/s of water pumped from the quarry sump to the open ditch.

Following completion of restored phases the open ditch will have been removed from these particular phases and surface water runoff will be directed to the restoration infiltration basin at the western perimeter of the site.

7. TEMPORARY SILT POND

A temporary silt pond (Silt Pond 2) will be constructed during the excavation phases of the development to allow settlement of fines from surface water captured within the mineral extraction areas. The design details, and any associated assumptions, are provided below.

7.1 Design Assumptions

Silt particles descend through the water at a rate governed by Stokes' Law. They descend under the influence of gravity, the force depending on the mass of the particle. The downward movement is retarded by the viscous drag of the water flowing around the particles which depends on the surface area of the particles. A terminal velocity is soon reached. As the mass increases at a rate controlled by the cube of the radius, whilst the surface area only increases at a rate controlled by the square of the radius, large particles fall far faster than small ones. The result is that the ability of a particle to settle out of the water in a silt pond depends on the area of the pond and the flow rate through that pond – the depth of the pond is immaterial.

For practical purposes, the flow rate in m³/hr that can be clarified for a pond is:

- 0.036 of pond area (m²) for fine silt particles of 0.004mm diameter;
- 0.081 of pond area (m²) for medium silt particles of 0.006mm diameter;

- 0.90 of pond area (m²) for coarse silt particles of 0.02mm diameter.

As a consequence, the flow rate needs to be low for a normal size pond to clarify fine and medium silt particles from water by gravity alone. To clarify fine silt from water with a flow rate of 36m³/hr (10 l/s pumped rate from the quarry sump to the silt pond, as outlined in the surface water management sections above) requires a pond with a surface area of 1,000m². Table 3 provides details of the settling rates for various size particles and the required pond surface area based on the 10 l/s inflow and outflow rates.

Table 3 – Required surface area for Silt Pond 2 based on silt settling rates for various size particles

Particle diameter (mm)	Settling velocity (m/s)	Settling velocity (m/hr)	Flow rate (l/s)	Silt pond required surface area (m ²)
0.004	0.00001	0.036	10	1,000
0.006	0.0000225	0.081	10	444
0.02	0.00025	0.90	10	40

The specifications outlined in Table 3 mean the silt pond will be able to settle out fine silt. The ability of the silt pond to settle out clay particles has not been accounted for as it is envisaged that significant quantities of clay particles will not be transferred to the silt pond. However, if significant quantities of clay particles are found to be entering the silt pond then the silt pond will be resized accordingly. The quarry sumps will also provide initial settlement of fines that might be entrained in the water during the pumping process. It is conservatively assumed there will be no losses through the base of the silt pond during its life.

For optimal efficiency, the inlet from the open ditch and outlet to the infiltration pond will be at opposite ends of the silt pond.

The locations of Silt Pond 2 shown on Drawing Nos. BOWFHIA2407-3 to BOWFHIA2407-7 are indicative only. Site and excavation area access requirements, locations of stockpiles and any other site infrastructure may mean the actual on-site locations of Silt Pond 2 may vary.

7.2 **Specification for Construction**

Drawing No. BOWFHIA2407-9 shows a schematic layout for Silt Pond 2, including the ditch inlet and weir outlet to the adjacent infiltration pond. A generalised long section through the silt pond and infiltration pond system is also included on Drawing No. BOWFHIA2407-9. It is proposed that the depth of Silt Pond 2 shall be a minimum of 1m. Using a surface area of 1,000m² (see Table 3 above), this results in a total minimum volume of water of 1,000m³ that will be catered for within Silt Pond 2. Whilst the flow rate is low, as it is planned for Silt Pond 2 to remain in Phase 9 of the site for the majority of the extractive phases, with the silt pond moving to Phase 7 when Phase 9 is excavated, it is possible that Silt Pond 2 can be greater than 1m deep to reduce the frequency of having to de-silt the pond.

The principal source of water to enter Silt Pond 2 will be surface water runoff from the excavation quarry sump pumped to the open ditch, and consequently will be easily controlled (direct rainfall will give little inflow).

The side slopes of Silt Pond 2 shall be formed at a gradient no steeper than 1v:2h.

If Silt Pond 2 requires lining to ensure it retains water, the material shall be selected and engineered in accordance with a site-specific specification for material selection and construction.

7.2.1 **Silt Pond Inlet**

The surface water within the quarry sump will be discharged to Silt Pond 2 *via* pumping to the out-of-pit open ditch. This allows the incoming flow to be laminar flow (instead of turbulent flow) which reduces the risk of erosion and maximises the effectiveness of the silt pond.

If there are times when the pump will discharge water from the sump directly into the silt pond through flexible pipework instead of *via* the open ditch then the incoming flow must be converted

from turbulent flow (that occurs in the pipework when being pumped) to laminar flow, for the silt to settle.

To encourage laminar flow in this instance, it is recommended that the inlet includes some form of energy dissipation, which can be achieved using a gabion mattress and polythene damp proof membrane (DPM).

7.2.2 **Silt Pond Outlet**

The silt pond outlet will be *via* a weir with erosion protection applied, located on the opposite side of the pond from the inlet. The weir will discharge clean water from Silt Pond 2 to the temporary infiltration pond (during excavation of Phases 1 to 8) or the restoration infiltration basin (during Phase 9 excavation). The arrangement is shown on Drawing No. BOWFHIA2407-9.

8. **TEMPORARY INFILTRATION POND**

A temporary infiltration pond will be constructed within Phase 9 during excavation of Phases 1 to 8 of the development to allow for the infiltration of clean surface water received from Silt Pond 2. During Phase 9 excavations the temporary infiltration pond will be decommissioned, with water from a replacement Silt Pond 2 in Phase 7 discharged to the restoration infiltration basin.

The design details of the temporary infiltration pond are provided below.

8.1 **Infiltration Pond Sizing**

The input water to the infiltration pond comes from the adjacent Silt Pond 2, with a weir connecting the two features. There is no pumping that will occur between the two ponds and so the maximum flow rate that will be received by the infiltration pond will be 10 l/s; the same rate Silt Pond 2 receives.

The required area of the temporary infiltration pond to allow infiltration of the clean water received from Silt Pond 2, is dictated by the flow rate divided by the vertical infiltration rate of the underlying strata. The flow rate is chosen as the maximum inflow to the pond (10 l/s), whilst the infiltration rate has been selected as 1×10^{-5} m/s based on the lowest value for an underlying *in situ* material of Slightly silty slightly clayey SAND from Table 25.1 of The SuDS Manual C753 (Woods Ballard, B., *et al.* 2015).

Table 4 provides details of the required infiltration pond surface area based on these parameters.

Table 4 – Temporary infiltration pond surface area based on inflow and infiltration rates

Inflow rate (l/s)	Infiltration rate (m/s)	Temporary infiltration pond required area (m²)
10	0.00001	1,000

The surface area of the temporary infiltration pond therefore needs to be the same area as Silt Pond 2. A minimum depth of 1m is required for the infiltration pond, which will allow for a storage capacity of 1,000m³. The infiltration pond will need to be checked and have the base scraped periodically to ensure effective infiltration is occurring. Drawing No. BOWFHIA2407-9 shows a schematic layout and long section of the temporary infiltration pond and its connection to Silt Pond 2.

The locations of the temporary infiltration pond shown on Drawing Nos. BOWFHIA2407-3 to BOWFHIA2407-6 are indicative only. Site and excavation area access requirements, locations of stockpiles and any other site infrastructure may mean the actual on-site location of the temporary infiltration pond may vary.

9. **PROCESSING PLANT AREA SURFACE WATER MANAGEMENT APPROACH**

As outlined in Section 2, Excavation Phases 1 to 9 are situated within Worcestershire in the central part of the site, and the processing plant area is located in Gloucestershire in the southeast of the site (see Drawing No. BOWFHIA2407-2). A site access road links the two areas and allows transportation of excavated material from Excavation Phases 1 to 9 to the processing plant area for stockpiling, sorting and washing.

Details of surface water management within the processing plant area differ to those for Excavation Phases 1 to 9.

The surface water management design concept for the processing plant area, during the working life of the site, is underpinned by the following guiding principles.

To reduce the on-site surface water runoff management requirement, 'clean' external surface water will be intercepted at up-gradient boundaries of the site. This water will be conveyed to a watercourse through a suitably sized open ditch which will discharge to the watercourse at or below greenfield runoff rates (GRRs).

Potentially turbid site runoff resulting from rain falling within the processing plant area will be intercepted through the use of internal ditches at suitable locations and routed to on-site runoff management facilities. These runoff management facilities will include storage to attenuate flow peaks so that discharges from site will be at, or below, corresponding GRRs.

The processing plant area runoff will be managed separately to the water used by the processing/washing plant itself. Water utilised by the processing/washing plant will be circulated through silt pond and clean water pond structures before being reused for the plant.

9.1 External Surface Water Management Design Assumptions

In accordance with the principles described in Section 9, an external clean water ditch/drain is required at the 'up-gradient' site boundary, to intercept clean water to reduce on-site water management infrastructure requirements. The design approach is outlined below:

- Topographic analysis in a Geographic Information System (GIS) determines all off-site surface water sub-catchments that intersect with the site.
- Hydrological routing analysis in GIS determines the off-site hydrological overland flow paths which intersect the site boundary. Overland flow ingress locations entering the site are identified, and clean water drain locations are delineated to intercept water at these ingress points.
- The total contributing area to a clean water drain is delineated through hydrological analysis in GIS.
- Any clean drain discharge location is determined based on the site boundary, local topography and the presence of potential receiving watercourses – with a view to minimising the impacts on the hydrological regimes of pre-existing drains and/or watercourses at or downstream of the site.
- The clean drain locations provided are illustrative as they have been conceptually delineated upon the site boundary. In reality, they will be set inside the site boundary to enable walking access to both sides. Areas outside of the clean drains will not be disturbed.
- The routing of a clean drain is illustrative, but will aim to minimise any potential impact on any features which could interact with the drain, for example any Public Rights of Way.
- No additional flow attenuation is applied to clean water drains. However, clean water drains are designed to ensure low to moderate flow velocities along the drain.
- Clean drains are sized to convey flows based on the 100-year return period GRR for the upstream catchment. The clean drains are sized using appropriate hydrologic and hydraulic methodologies, described in the relevant methodological section of this report (see Section 10). If any section of a clean drain requires a culvert installed, then this will also be sized to convey 100-year return period GRR flows.

9.2 On-Site Surface Water Management Design Assumptions

On-site internal drains are required to capture surface water runoff originating within the processing plant area and route this water to an attenuation storage facility, before discharging this water at a controlled rate to a nearby watercourse. The design approach is outlined below:

- The contributing area to an attenuation pond is delineated through hydrological analysis in GIS, using the processing plant area, and any tops of perimeter bund features in this area, as a catchment boundary, providing worst-case attenuation storage requirements.
- The design return period for attenuation pond storage is 100 years (+40% uplift as a climate change allowance), with an additional freeboard allowance. Residual risk is managed by designing an overflow weir structure to safely discharge water to a nearby watercourse *via* an

exceedance route from the pond. In practice, the required pond volume may be less than the design volume as the effective runoff area is assumed to contribute 100% of rainfall as runoff. Therefore, the actual contributing catchment may be less than the area used in attenuation pond volume calculations.

- The internal drains are sized to convey peak flows based on the 100-year return period rainfall-runoff. This again represents the worst-case assumption that the whole processing plant area represents the runoff contributing area and requires conveyance to a single point. In reality, the site is unlikely to contribute 100% runoff to the drains as this assumes the entire area is hardstanding and also does not account for evaporation losses. The final design of internal drains can be amended based on their actual catchment areas, such that they will always convey the 100-year return period.
- The attenuation pond and internal drains are sized using appropriate hydrologic and hydraulic methodologies, described in the relevant methodological section of this report (see Section 11).
- The processing/washing plant – silt pond – clean water pond system within the processing plant area is kept as a closed system. Therefore, this separate silt management system is not incorporated into the processing plant area surface water runoff management proposals.

10. PROCESSING PLANT AREA – EXTERNAL SURFACE WATER MANAGEMENT

As described in Section 9.1, the processing plant area surface water management scheme includes the conceptual delineation of clean water drains at locations up-gradient of the processing plant area to prevent clean off-site surface water runoff from entering the site.

Drawing No. BOWFHIA2407-11 illustrates the extent of the processing plant area. A Digital Terrain Model (DTM) based on Environment Agency LiDAR data has been used to delineate surface water flow paths generated through hydrologic routing analysis within GIS. This has allowed resulting identified points of surface water ingress to the processing plant area.

Based on the GIS analysis of baseline hydrology, the up-gradient area which would contribute surface water runoff to the processing plant area of the site, without any intervention, is to the southeast of the site area.

Clean surface water runoff from this area to the southeast of the processing plant area site boundary will be routed through an 'external open ditch'. This ditch will be constructed along the eastern site boundary, initially at the foot of a perimeter bund in the processing plant area, before being routed west around the southern edges of the silt and attenuation ponds. From here, the ditch will convey the water north along the boundary of the silt and attenuation ponds, outside of any bunds surrounding these ponds. This external open ditch will then direct captured surface water runoff to the nearest watercourse, that being a tributary of the Mythe Brook situated just to the northwest of this part of the site (see Drawing No. BOWFHIA2407-11). The full length of the ditch will be constructed within the approved site boundary.

The proposed location of the external open ditch is shown on Drawing No. BOWFHIA2407-11, but this is indicative only. The final design and alignment of the external ditch will require on-the-ground confirmation of local topography. The proposed alignment of the ditch intersects the existing ATW/37 Bridleway, which crosses north to south over the approved planning boundary near to a proposed clean water pond and the attenuation pond. Therefore, this part of the ditch will require a pipe/culvert installed to allow continued public access along the bridleway. A cross section of the external open ditch is provided on Drawing No. BOWFHIA2407-12.

The methodology and results in Section 10.1 describe the approach to developing the design for the external open ditch, which will be capable of conveying the 100-year return period GRR. This covers both ditched and any piped sections of the ditch. The outfall location from the external open ditch to the receiving watercourse (tributary of the Mythe Brook) illustrated on Drawing No. BOWFHIA2407-11 is the location where intercepted clean water is reconnected with the existing drainage system. The schematic design for the outfall/junction from the external open ditch to the receiving watercourse is shown on Drawing No. BOWFHIA2407-13.

By capturing runoff originating outside the application site boundary, it prevents external water from entering the processing plant area, eliminating the need to account for it in the sizing of any on-site water management features (internal ditches and attenuation pond – see Section 11).

If required, following the final restoration of the site the external open ditch and any associated pipes/culverts will be decommissioned.

10.1 External Open Ditch Design

10.1.1 Greenfield Runoff Rate

The peak GRR has been estimated for the site using the FEH ReFH2 method for runoff estimation, as recommended by the SuDS Manual (Woods Ballard, B., *et al.* 2015).

The following site-specific catchment descriptor values, obtained from the FEH Web Service, have been used as model parameters:

- SAAR 61-90 (mm) of 622.
- PROPWET (mm) of 0.33.
- BFIHOST of 0.638.

The up-gradient catchment that will contribute surface water runoff to the external open ditch, based on surface water runoff routing delineation, has been calculated as 70,361m² (7.04ha).

ReFH2 software (Wallingford HydroSolutions Limited) has been used to calculate the GRR for the 1 in 100-year rainfall event for the external open ditch catchment, based on the descriptor values given above and the contributing area to the ditch (see Table 5 below).

Due to the short-term nature of the development and need for the processing plant area, the potential (long-term) impacts of climate change have not been taken into account.

Table 5 – Pre-development greenfield runoff rate for the external open ditch catchment based on the 1 in 100-year design rainfall event

External open ditch catchment area (m²)	External open ditch catchment area (ha)	Return Period (year)	GRR (l/s)
70,361	7.04	100	62.0

10.1.2 Open Channel Flow

To ensure the proposed external open ditch has sufficient capacity to convey the 1 in 100-year GRR, the open channel flow equations (Equation 1 and Equation 2 in Section 6.1) are used to determine peak flow depth for the calculated GRR. The same approach has been used for both ditch and pipe flow calculations, as any pipes are sized to flow under open channel conditions (*i.e.* they do not flow full under pressure).

10.1.3 Ditch Design

The proposed external open ditch design assumes a minimum gradient of 0.01 (1v:100h), a basal width of 0.5m, and a side batter of 1v:1h. A depth of 0.5m has been calculated dependent on conveyance requirements. The ditch has been designed assuming a Manning's Roughness Coefficient (*n*) of 0.035 ('earth with weeds and stones'). Table 6 shows the design specifications for the external open ditch.

The GRR of the contributing catchment area (62.0 l/s) has been used to calculate the peak depth of flow for the ditch based on the design parameters (Table 6). Table 6 shows the external open ditch design specifications will be able to convey the 1 in 100-year return period GRR flow of 62.0 l/s at a peak depth of 0.15m. The design parameters of the ditch allow a maximum flow capacity of 581 l/s within the ditch.

Drawing No. BOWFHIA2407-12 shows the design details, including cross section, for the external open ditch.

Table 6 – External open ditch design details

Gradient (v:h)	Manning's coefficient	Approximate full ditch length (m)	Bed width (m)	Bank full depth (m)	Side batter (v:h)	Flow depth at peak (100-year RP GRR) (m)	Ditch maximum flow capacity volume (l/s)
1:100	0.035	876	0.5	0.5	1:1	0.15	581

10.1.4 Pipe Sizing

The proposed surface water drainage external open ditch will require the use of a pipe or culvert under the existing ATW/37 Bridleway, which runs north to south and is located across the site access road near to a proposed clean water pond and attenuation pond, as the proposed location of the ditch will intersect this Public Right of Way (see Drawing No. BOWFHIA2407-11).

For design purposes, the required culvert or pipe under the ATW/37 Bridleway has been sized using the same open channel flow equations as for the external open ditch, described in Section 10.1.2. This assumes no full flowing pressurised pipes. As the external open ditch system will be constructed to a minimum gradient and maintained regularly, the assumption that there are no submerged pipe inlets and outlets is valid, and therefore inlet and outlet head losses are not calculated.

The minimum slope for the culvert or pipe has been set to 1:50 (v:h), and the Manning's roughness coefficient has been set to 0.010 for twin-wall polyethylene.

The required culvert/pipe diameter has been calculated, based on the range of pipe diameters readily available in the UK market. A proposed pipe diameter of 0.225m allows a maximum flow conveyance of 88.0 l/s through the pipe, which exceeds the 1 in 100-year return period GRR of 62.0 l/s. The pipe design details are presented in Table 7, along with the 1 in 100-year GRR and the maximum capacity of the pipe in non-pressurised conditions.

Table 7 – External open ditch pipe/culvert design details

Gradient (v:h)	Manning's coefficient	GRR (100-year RP) (l/s)	Required pipe diameter (m)	Capacity of pipe (l/s)
1:50	0.010	62.0	0.225	88.0

11. PROCESSING PLANT AREA – INTERNAL SURFACE WATER MANAGEMENT

As described in Section 9.2, the processing plant area requires internal water management to ensure surface water runoff originating within this part of the site does not have a detrimental impact on the site workings and is managed and discharged off-site in a controlled manner.

Drawing No. BOWFHIA2407-11 shows the extent of the processing plant area. Bunds (maximum height 5m) will be present around the perimeter of the processing plant area to provide visual and acoustic barriers to external public and residential areas, but will also safeguard against runoff leaving this part of the site.

Within the processing plant area, surface water from any roofs, parking areas, stockpiles and hardstanding will be collected *via* internal drains and routed to an attenuation pond to the southwest of the main processing plant area. The attenuation pond will be situated just to the west of a silt pond (Silt Pond 1), and adjacent to the north of a secondary silt pond. The secondary silt pond will only be required for use if necessary; it is anticipated that the capacity of Silt Pond 1 will be sufficient for the needs of silt settlement prior to recirculation of this water through the mineral processing/washing plant – silt pond – clean water pond system. As the processing/washing plant – silt pond – clean water pond system is kept as a closed system, the silt ponds and 'clean water ponds' shown on Drawing No. BOWFHIA2407-11 are not incorporated into the processing plant area surface water runoff management requirements.

The captured surface water runoff will flow out through a pipe with an orifice plate attached to the inlet to control the outflow rates from the northwest corner of the attenuation pond. The pipe will discharge to the final section of the external open ditch (described in Section 10) before eventual discharge into the tributary of Mythe Brook. Surface water runoff routed *via* internal drains will pass through a petrol/oil interceptor prior to entering the attenuation pond to ensure the water has been cleaned. Discharge from the attenuation pond *via* the external open ditch will be controlled so that the combined rates of water captured up-gradient of the site and that from the attenuation pond do not exceed corresponding GRRs for the design storms. The locations of the internal drains, attenuation pond and discharge to the tributary of the Mythe Brook are shown on Drawing No. BOWFHIA2407-11. The processing plant area access requirements, locations of stockpiles and any other site infrastructure may mean the actual on-site locations of the internal drains may vary. Where any internal drains are required to cross a feature, such as a site access or haul road, then a pipe/culvert will be installed to allow the continued flow of water to the attenuation pond.

The methodology and results in Section 11 describe the approach to calculating the required attenuation storage volume within the attenuation pond to be able to store and discharge surface water runoff from the processing plant area. This is based on a suitably controlled gravity-fed outflow rate from the attenuation pond that does not exceed the corresponding GRRs for return period events up to the 1 in 100-year (plus suitable climate change allowances), as well as designs (both ditched and piped) for internal drains based on peak inflows to the attenuation pond.

During the final restoration of the site, the silt ponds and clean water ponds near to the decommissioned processing plant area will be converted into attenuation ponds. The attenuation pond used during the site operational phase will also be left as an attenuation pond following final completion of the site. The attenuation pond and former silt ponds will be maintained in accordance with the Detailed Restoration Proposals and Landscape and Ecological Management Plan (LEMP) (David Jarvis Associates report reference 2636-4-5-LM-0001 Detailed Restoration Proposals and Landscape Management Plan rev. P4, dated December 2021), approved under Planning Permission 19/000048/CM. The processing plant area part of the site will be restored back to arable farmland at pre-development ground levels, with the area to the southeast of the approved Planning boundary undisturbed (see Drawing No. BOWFHIA2407-8). Therefore, surface water runoff in this area will be directed to these attenuation/open water ponds, and proposed adjacent wet grassland and scrub, providing a post-development flood risk benefit.

11.1 Internal Drains Design

11.1.1 Greenfield Runoff Rates

The peak GRRs have been estimated for the site using the FEH ReFH2 method for runoff estimation, as recommended by the SuDS Manual (Woods Ballard, B., *et al.* 2015).

The same site-specific catchment descriptor values as used for the external open ditch in Section 10.1.1 have been used as model parameters.

Surface water runoff within the processing plant area will be contained through the presence of the perimeter bunds (see Section 11). The catchment is therefore represented by the main body of the processing plant area up to the crests of these bunds (37,781m²). Runoff within this catchment (PPAC01) will be directed to an internal drain located along the inside toe of the northwest bund which will convey the water to the attenuation pond. An additional small catchment area (1,156m²) has also been included which caters for runoff southwards off the southernmost bund of the processing plant area (PPAC02), which will be captured by an internal drain along the southern toe of this bund. These internal drains are conceptually located on Drawing No. BOWFHIA2407-11. The total processing plant area catchment that will contribute surface water runoff to internal drains, and to the attenuation pond, has therefore been calculated as 38,937m² (3.89ha).

ReFH2 software (Wallingford HydroSolutions Limited) has been used to calculate GRRs for the 1 in 2 (2-year design rainfall has been used as FEH synthetic rainfall method does not model 1-year rainfall events), 1 in 30 and 1 in 100-year rainfall events for the two internal catchments described above, based on the descriptor values and the respective areas of these catchments (see Table 8 below).

Unlike the attenuation pond, which will remain following the completion of the site restoration, the internal drains will only be required during the operational phase of the development. Therefore, the potential (long-term) impacts of climate change have not been taken into account for GRRs and sizing of the internal drains.

Table 8 – Greenfield runoff rates for the 1 in 2, 1 in 30, and 1 in 100-year design rainfall events for internal catchment areas

Internal catchment area name	Catchment area (m ²)	Return period event GRR (l/s)		
		2 Years*	30 Years	100 Years
PPAC01	37,781	9.7	23.6	33.3
PPAC02	1,156	0.3	0.7	1.0
Total	38,937	10.0	24.3	34.3

* 2-year design rainfall used as FEH synthetic rainfall method does not model 1-year rainfall events

11.1.2 Open Channel Flow

To ensure the proposed internal drains have sufficient capacity to convey the peak GRRs (1 in 100-year return period), the open channel flow equations (Equation 1 and Equation 2 in Section 6.1) have been used to determine peak flow depth for the calculated peak GRRs. The same approach has been used for both ditch and pipe flow calculations, as any pipes are sized to flow under open channel conditions (*i.e.* they do not flow full under pressure).

11.1.3 Internal Drains Design

Internal drain PPAID01 will capture surface water runoff from catchment PPAC01 and internal drain PPAID02 will capture surface water runoff from catchment PPAID02. PPAID01 and PPAID02 connect prior to discharge into the attenuation pond. Drawing No. BOWFHIA2407-11 shows the locations of the internal drains.

The proposed design for both of the two identified internal drains assumes a minimum gradient of 0.01 (1v:100h), a basal width of 0.1m, and a side batter of 1v:1h. A depth of 0.5m has been calculated dependent on conveyance requirements. The drains have been designed assuming a Manning's Roughness Coefficient (*n*) of 0.035 ('earth with weeds and stones'). Table 9 shows the design specifications for the internal drains.

The GRRs of the contributing catchment areas from Table 8 have been used to calculate the peak depth of flow for the internal drains based on the design parameters (Table 9). Table 9 shows the internal drains design specifications will be able to convey the 1 in 100-year return period GRR flows at peak depth.

Drawing No. BOWFHIA2407-14 shows the design details, including cross section, for the internal drains.

Table 9 – Internal drains design details

Internal drain ID	Gradient (v:h)	Manning's coefficient	Bed width (m)	Bank full depth (m)	Side batter (v:h)	Flow depth at peak (100 year RP GRR) (m)	Drain maximum flow capacity volume (l/s)
PPAID01	1:100	0.035	0.1	0.5	1:1	0.20	289
PPAID02	1:100	0.035	0.1	0.5	1:1	0.03	289

11.1.4 Pipe Sizing

It is envisaged that a section of the PPAID01 internal drain will need to cross the proposed site access/haul road, where this road passes between a 'clean water pond' to the west and the

processing plant area southern bund to the east (see Drawing No. BOWFHIA2407-11). PPAID01 will connect with internal drain PPAID02 just to the south of the proposed pipe/culvert location.

For design purposes, this required pipe within PPAID01 has been sized using the same open channel flow equations as for the internal drains, described in Section 11.1.2. This assumes no full flowing pressurised pipes. As the external open ditch system will be constructed to a minimum gradient and maintained regularly, the assumption that there are no submerged pipe inlets and outlets is valid, and therefore inlet and outlet head losses are not calculated.

The minimum slope for the pipe has been set to 1:50 (v:h), and the Manning's roughness coefficient has been set to 0.010 for twin-wall polyethylene.

The required culvert/pipe diameter has been calculated, based on the range of pipe diameters readily available in the UK market. A proposed pipe diameter of 0.225m allows a maximum flow conveyance of 88.0 l/s through the pipe, which exceeds the 1 in 100-year return period GRR of 33.3 l/s for PPAID01 (see Table 8). The pipe design details are presented in Table 10, along with the 1 in 100-year GRR and the maximum capacity of the pipe in non-pressurised conditions.

Should any other sections of the proposed internal drains require the use of a pipe or culvert, the details provided in Table 10 will ensure the design conveyance capacities will be provided for.

Table 10 – Internal drain pipe/culvert design details

Gradient (v:h)	Manning's coefficient	GRR (100-year RP) (l/s)	Required pipe diameter (m)	Capacity of pipe (l/s)
1:50	0.010	33.3	0.225	88.0

11.2 Attenuation Pond Design

The proposed internal drains outlined within Section 11.1 are designed to convey surface water runoff captured within the processing plant area to an attenuation pond located to the southwest of the main processing plant area. Suitable erosion protection will be applied to the attenuation pond inlet. The attenuation pond will be situated just to the west of Silt Pond 1, and adjacent to the north of the secondary silt pond. The location of the attenuation pond, within the context of the processing plant area, is shown on Drawing No. BOWFHIA2407-11. The attenuation pond is shown in detail on Drawing No. BOWFHIA2407-15.

Outflow from the pond will be controlled through the use of an orifice plate attached to the outlet, with gravity-fed flow through a pipe where it discharges to the external surface water ditch which flows northwest to the tributary of the Mythe Brook.

The attenuation pond is designed to function up to a 100-year return period design storm, plus an additional 40% climate change allowance uplift. A freeboard allowance will be provided above the maximum design storm, however an emergency overflow is designed into the attenuation pond to safely discharge any exceedance flows. Design details for the attenuation pond are provided in the sections below.

11.2.1 Attenuation Pond Sizing

Methodology

The Source Control component of XP Solutions Micro Drainage software has been used to design the attenuation pond. The objective of the attenuation scheme is to restrict discharge to below the GRR of the processing plant area total catchment area (38,937m²), outlined within Section 11.1.1, for all storms up to a 1 in 100-year rainfall event (+40% rainfall increase to account for climate change). Source Control employs a full hydrograph routing method to enable design of Sustainable Drainage Systems (SuDS) storage structures, utilising both FSR and FEH derived rainfall profiles to generate inflow hydrographs, based on a time area diagram.

It has been assumed that 100% of the surface water runoff within the processing plant area catchment contributes to the attenuation pond, *via* the internal drains. This is a conservative approach as this assumes the entire processing plant area is hardstanding and does not account for evaporation losses.

Based on the processing plant area runoff catchment area, a time of concentration of 8 minutes has been estimated and has been used in the integrated (hydrological and hydraulic) catchment modelling undertaken to model the hydrologic behaviour of the site and the hydraulic performance of the proposed attenuation pond.

Based on attenuation pond inflows and outflows, Source Control runs hydrograph routing analysis for a range of storm durations to select the critical storm duration - the storm duration which has the greatest storage requirement for the given inflow and outflow parameters. The storm depth and outflow details for the attenuation pond are selected for the critical storm duration for each modelled return period, up to the 1 in 100-year event (+40% climate change allowance).

An emergency overflow from the attenuation pond has been included to provide residual risk management.

Design

The attenuation pond has been designed with a base area of c. 5,500m² and a crest area of c. 7,588m². The maximum area at the elevation of an emergency overflow weir in the northwest corner of the attenuation pond is c. 6,351m². The attenuation pond will have an estimated basal elevation of c. 10.25mAOD, a minimum crest elevation of c. 11.4mAOD and a side slope gradient of 1:3 (v:h).

The pond outlet in the northwest corner of the attenuation pond consists of an orifice plate comprising a plastic plug with an 85mm diameter circular hole to control outflow rates. Water flowing through the orifice plate is then conveyed away from the site *via* an underground pipe (200mm diameter) to the external surface water ditch which flows to the tributary of the Mythe Brook.

To reduce potential blockage of the pond outlet, an inlet screen will be installed on the inlet headwall at the pond outlet location.

The outlet pipe length from the attenuation pond to the external open ditch is approximately 13.7m, with a gradient of 1:100 (v:h). The invert level of the orifice/outlet pipe inlet is proposed as c. 10.5mAOD. The pipe is anticipated to be twin-wall polyethylene.

The orifice plate intake will be set to 0.25m above the base of the attenuation pond to avoid clogging issues, creating dead storage in the pond which will retain silt.

An emergency overflow weir in the northwest of the attenuation pond is designed to safely discharge any flows exceeding the maximum design storm into the nearby external open ditch (see Section 10.1). The external open ditch has excess capacity to be able to take additional flows. The overflow weir crest elevation is specified at 11.2mAOD, 0.2m below the minimum crest elevation of the pond (11.4mAOD) to manage residual flood risks (*i.e.* to ensure controlled discharge of overflows during extreme events above the 1 in 100-year return period +40% climate change allowance). The width of the weir is set as 2.0m.

Table 11 provides design details of the attenuation pond. These parameters have been used in the modelling of the attenuation pond within Source Control.

Cross sections showing the attenuation pond design details are provided on Drawing No. BOWFHIA2407-16.

Table 11 – Attenuation pond design details

Parameter	Value
Minimum pond crest elevation (mAOD)	11.40
Pond base elevation (mAOD)	10.25
Pond top area – crest (m ²)	7,588
Pond top area – at overflow weir elevation (m ²)	6,351
Pond base area (m ²)	5,500
Pond side slope gradient (v:h)	1(v):3(h)
Orifice elevation (mAOD)	10.50
Orifice diameter (mm)	85
Pond depth – base to minimum crest elevation (m)	1.15
Pond depth – base to overflow weir elevation (m)	0.95
Pond depth – orifice to overflow weir elevation (m)	0.70
Outlet pipe diameter (mm)	200
Outlet pipe length (m)	50
Outlet pipe gradient (v:h)	1:100
Overflow weir elevation (mAOD)	11.20
Overflow weir width (m)	2.0

Results

Table 12 shows a summary of the modelling results for the attenuation pond. For ease of reference, the table includes the catchment area, the runoff coefficient (equivalent to 100% runoff), the maximum critical water depths, attenuation storage volumes and peak outflows (+40% climate change rainfall allowance). Table 12 also states the GRRs for the total processing plant area catchment to show that the attenuated surface water runoff will be discharged below the corresponding GRRs.

The critical storm water depths within the pond provide over 300mm freeboard to the overflow weir elevation for all modelled scenarios.

Also included in Table 12 are the weir overflow output rates (all at 0 l/s) to demonstrate that the attenuation pond will accommodate the runoff up to the 1 in 100-year return period (+40% climate change rainfall allowance) without any flow over the weir *i.e.* all water captured by the attenuation pond is effectively controlled by the orifice plate and flows out through the outflow pipe to the external open ditch, with eventual discharge to the tributary of the Mythe Brook located approximately 50m to the northwest of the attenuation pond.

Table 12 – Attenuation pond modelling results

Parameter	2-year return period*	30-year return period	100-year return period
Catchment area (m ²)	38,937		
Runoff coefficient	1.00		
Critical attenuation volume (m ³)	1,128	2,313	3,052
Critical water depth (m)	0.202	0.409	0.536
Peak outflow (with +40% uplift for climate change) (l/s)	9.7	11.8	13.0
Weir overflow (l/s)	0	0	0
GRR (l/s)	10.0	24.3	34.3

* 2-year design rainfall used as FEH synthetic rainfall method does not model 1-year rainfall events

Modelling results for the 1 in 2-year (2-year design rainfall used as FEH synthetic rainfall method does not model 1-year rainfall events), 1 in 30-year and 1 in 100-year rainfall events (+40% climate change rainfall allowance) are presented in Appendix 4.

The modelling results indicate that the proposed attenuation pond will provide adequate storage of runoff generated within the processing plant area for all rainfall events up to the 1 in 100-year design return event (+40% climate change rainfall allowance applied to all return periods) and that discharge will be below the corresponding GRRs.

11.2.2 External Open Ditch Capacity Including Attenuation Pond Outflows

The final section of the external open ditch (see Section 10) will take the flows from the attenuation pond *via* the outlet pipe, in addition to the off-site surface water runoff, and discharge it to the tributary of the Mythe Brook to the northwest of the attenuation pond location.

All water entering the external open ditch will be 'clean' as it will either be captured off-site surface water runoff that will not have interacted with the site processing plant area, or will be discharge from the attenuation pond which will consist of settled site surface water runoff that will have passed through a petrol/oil interceptor.

The 1 in 100-year return period GRR for only the external runoff is 62.0 l/s (see Section 10.1.1). The calculated outflow of captured internal surface water runoff from the attenuation pond for the 1 in 100-year return period rainfall event (+40% climate change rainfall allowance) is 13.0 l/s (see Table 12). This represents a design conveyance capacity of 75.0 l/s for the section of the external open ditch from the attenuation pond to the discharge point at the tributary of the Mythe Brook.

Table 6 shows the external open ditch design specifications will be able to convey the external off-site runoff 1 in 100-year return period GRR flow of 62.0 l/s at a peak depth of 0.15m. The addition of the peak design outflows from the attenuation pond (13.0 l/s) mean the total 75.0 l/s peak flow depth within the ditch equates to 0.17m. The depth of the ditch has been designed as 0.5m which enables 0.33m of freeboard for the combined flows. For context, the design parameters of the ditch allow a maximum flow capacity of 581 l/s at the bank full depth of 0.5m. The section of the external open ditch between the attenuation pond and the tributary of the Mythe Brook will be able to convey the combined flows from the off-site surface water runoff and attenuation pond outflows.

In addition, the pipe culvert required for the section of the external open ditch under the existing ATW/37 Bridleway will have a capacity of 88.0 l/s (see Table 7). This exceeds the required capacity for the combined flows of 75.0 l/s, and therefore ensures enough flow conveyance capacity is provided.

12. CONCLUSIONS

This report presents a Surface Water Drainage Scheme, including design drawings, for the approved development at Bow Farm, as required under Planning Pre-Commencement Condition 20 of Planning Permission Number 19/000048/CM (Worcestershire County Council).

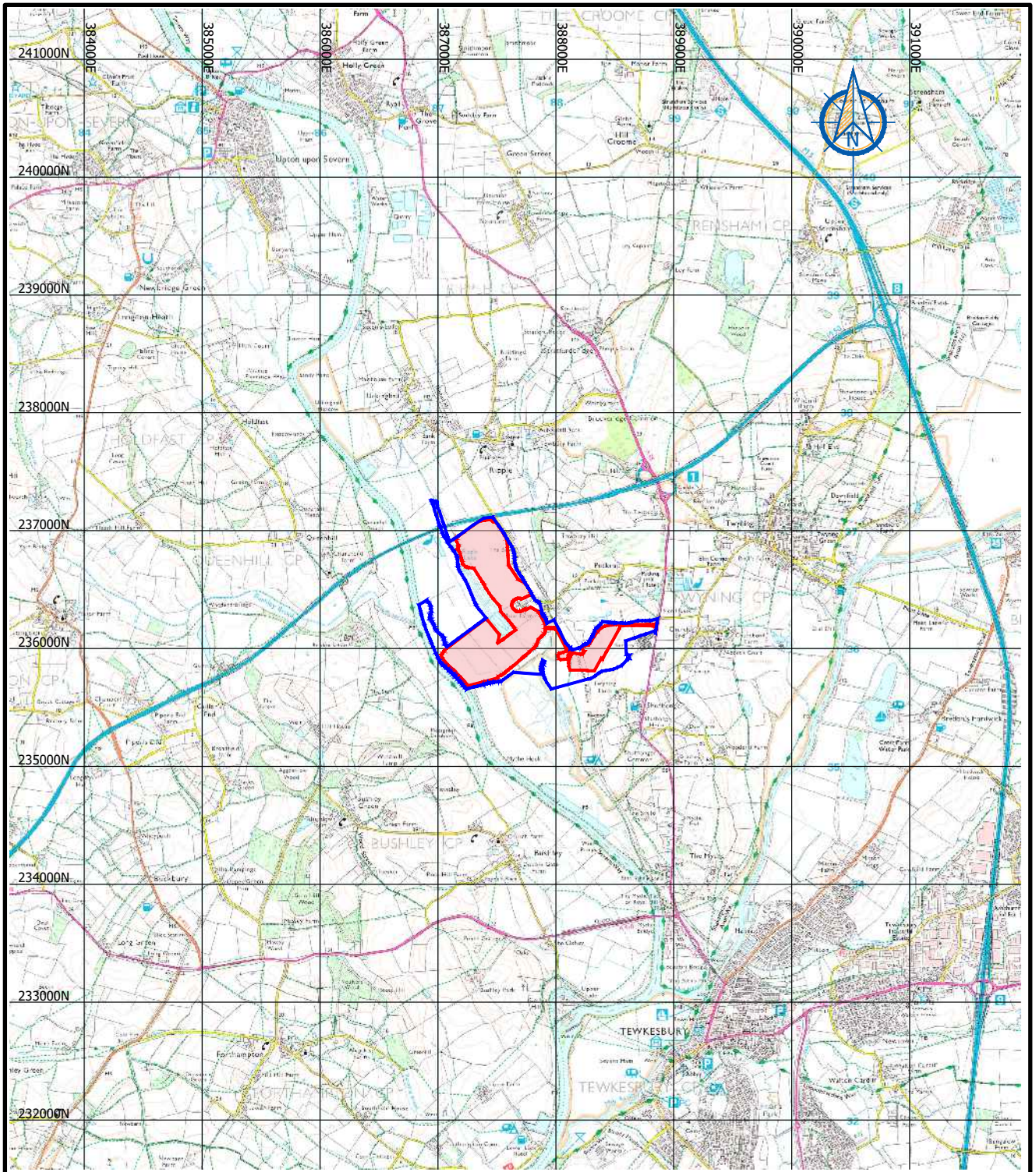
The approved development provides for the extraction of sand and gravel from the site, and restoration of the excavation void in the Phase 1 to 9 area using imported inert fill material and site derived soils. Additional Flexible Working Areas A and B will be restored to open water and wetlands using only site derived mineral waste and will have a final landform below pre-extraction ground levels.

The surface water management scheme has been designed to manage all surface water runoff falling and interacting with the site area during the operation of the site. This includes water captured within the progressive mineral extraction and subsequent infilling areas of Excavation Phases 1 to 9 located in the centre of the site, and the processing plant area in the east of the site. This ensures that surface water is managed efficiently and there are no increases in off-site flood risk.

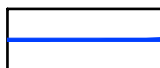

13. REFERENCES

Woods Ballard, B, Wilson, S, Udale-Clarke, H, Illman, S, Scott, T, Ashley, R, Kellagher, R. 2015. The SuDS Manual (C753). CIRIA. p. 968.

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APRIL 2025



LEGEND

-  Ownership boundary
-  Application Site Boundary

Version	Revision and compilation notes	Date
a	Issued	15.11.2024

Client
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Project
Bow Farm: Surface Water Drainage Scheme

Site location

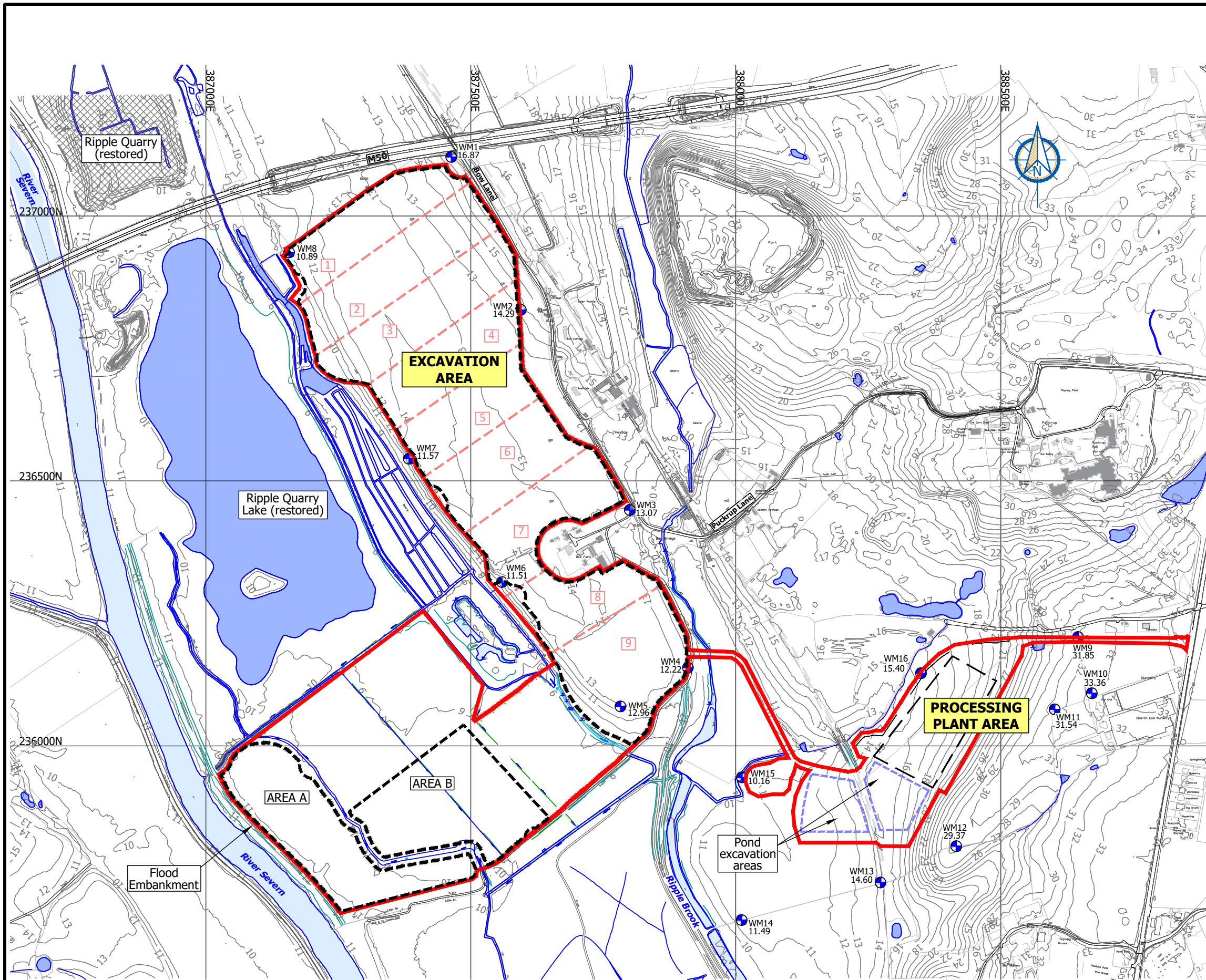


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Drawing Ref BOWFIA2407		Drawing No 1	Version a



LEGEND

- Application Site Boundary
- Proposed excavation limit (DJA Dec 2021)
- Proposed Phase boundary
- 32 Ground surface contour 1m intervals mAOD
- WM10 33.36 2010 water monitoring borehole with ground level (mAOD)
- Water courses
- Ponds

NOTES

- Composite plan based on surveys by Shyres Rural in 2010 and 2018 with contours from 1m Lidar DTM and additional detail from orthorectified Google images
- Excavation and phase boundaries supplied by David Jarvis Associates December 2021

Version	Revision and compilation notes	Date
a	Issued	15.11.2024

Client
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Project
Bow Farm: Surface Water Drainage Scheme

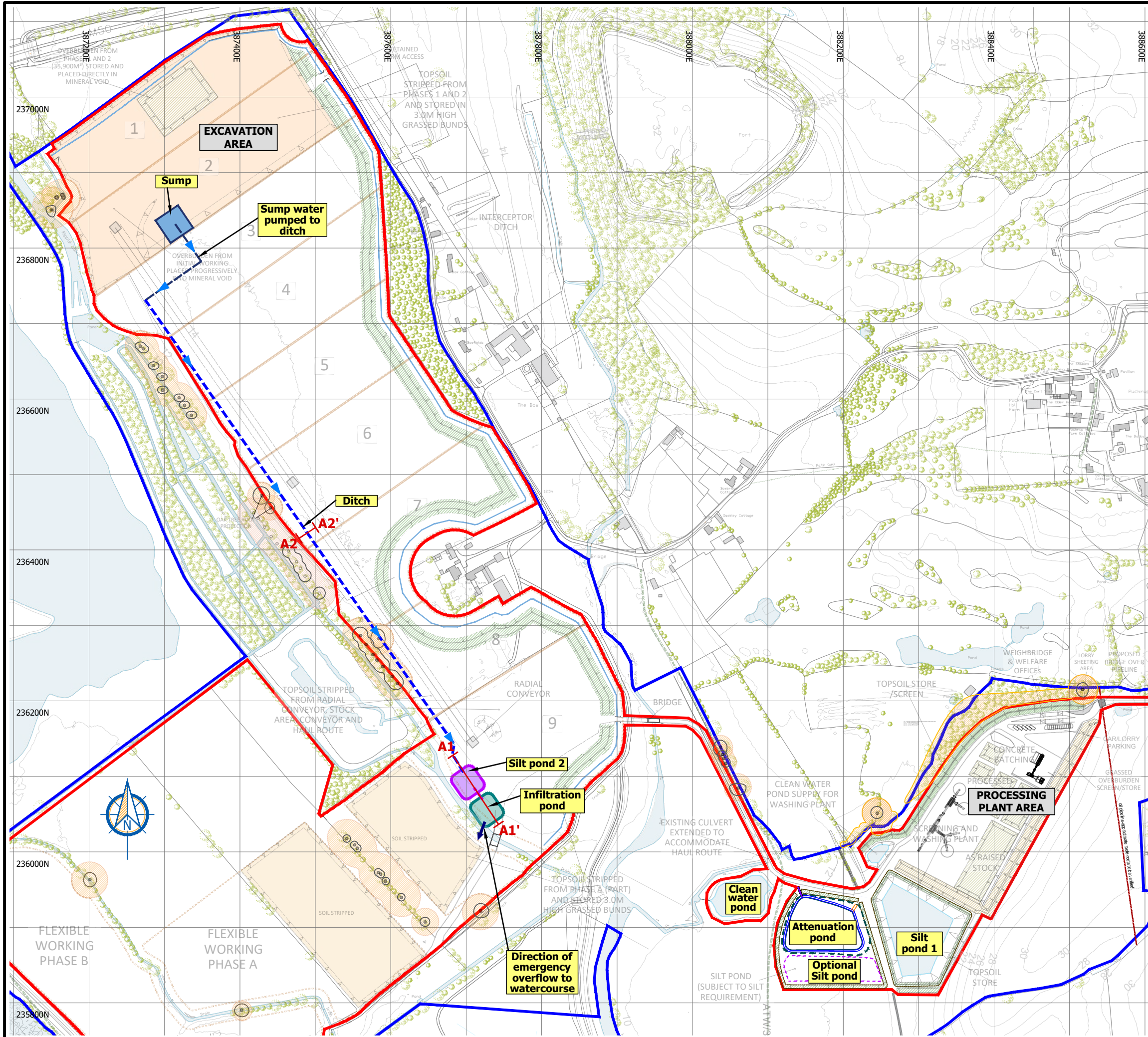
Site context

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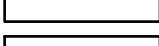




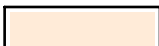



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LEGEND

-  Application Site Boundary
-  Ownership Boundary
-  Existing vegetation
-  Existing bridleway and reference
-  Proposed limit of mineral extraction
-  Proposed mineral extraction phase
-  Existing contours at 2.0m intervals
-  Tree root protection area
-  Extraction area
-  Sump
-  Silt pond 2
-  Infiltration pond
-  Cross section - see Drawing Nos. BOWFHIA2407 - 9 and 10

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0002 S4-P9 'INITIAL WORKS AND PHASE 1 EXTRACTION' dated December 2021

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
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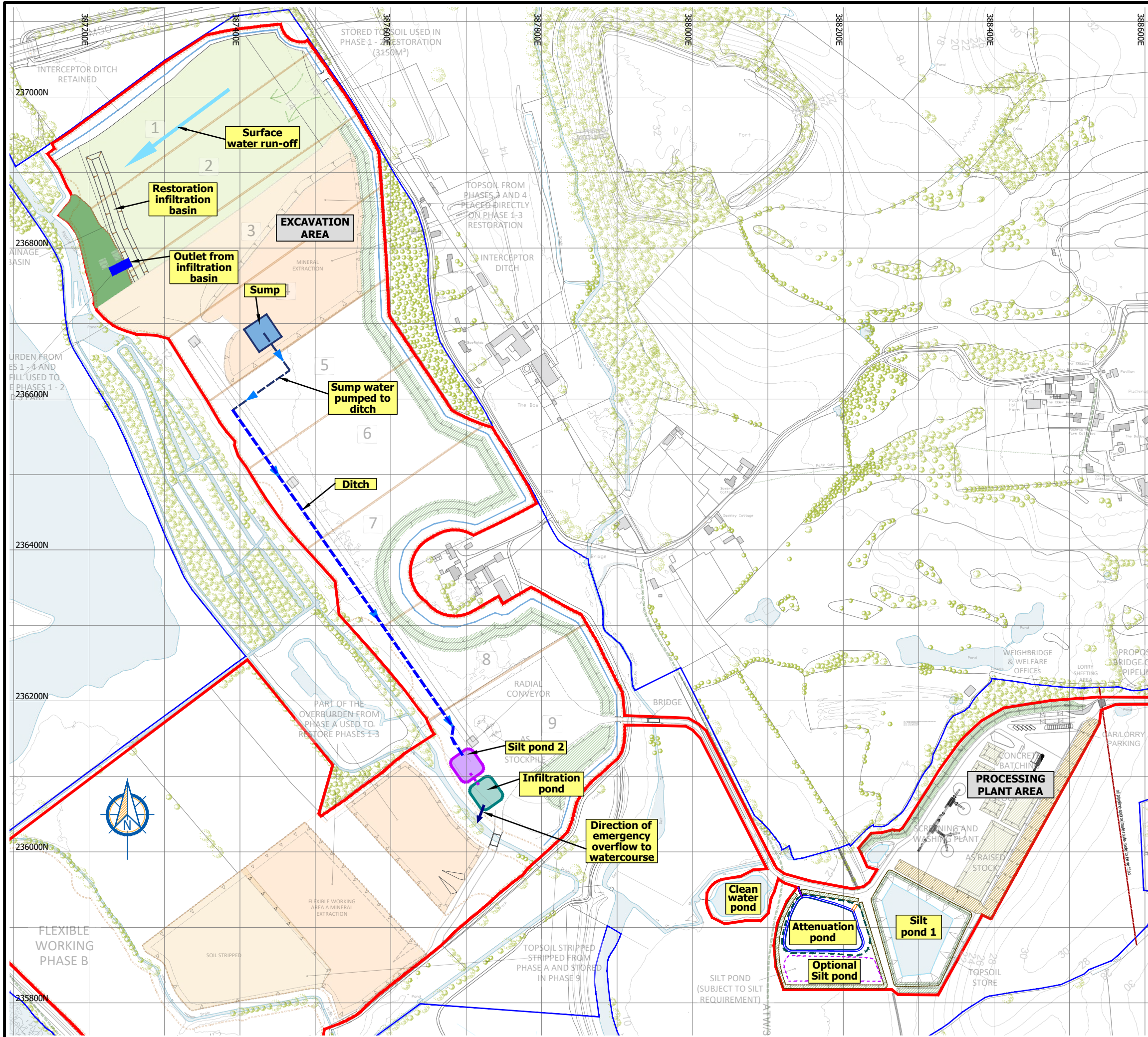
Project
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Excavation area drainage system - Phases 1 and 2 extraction



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LEGEND

- Application Site Boundary
- Ownership Boundary
- Existing vegetation
- Existing bridleway and reference
- Proposed limit of mineral extraction
- Proposed mineral extraction phase
- Existing contours at 2.0m intervals
- Extraction area
- Restored surface
- Sump
- Silt pond 2
- Infiltration pond

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0003 S4-P8 'PHASES 3 AND 4 EXTRACTION' dated December 2021

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

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Project
Bow Farm: Surface Water Drainage Scheme

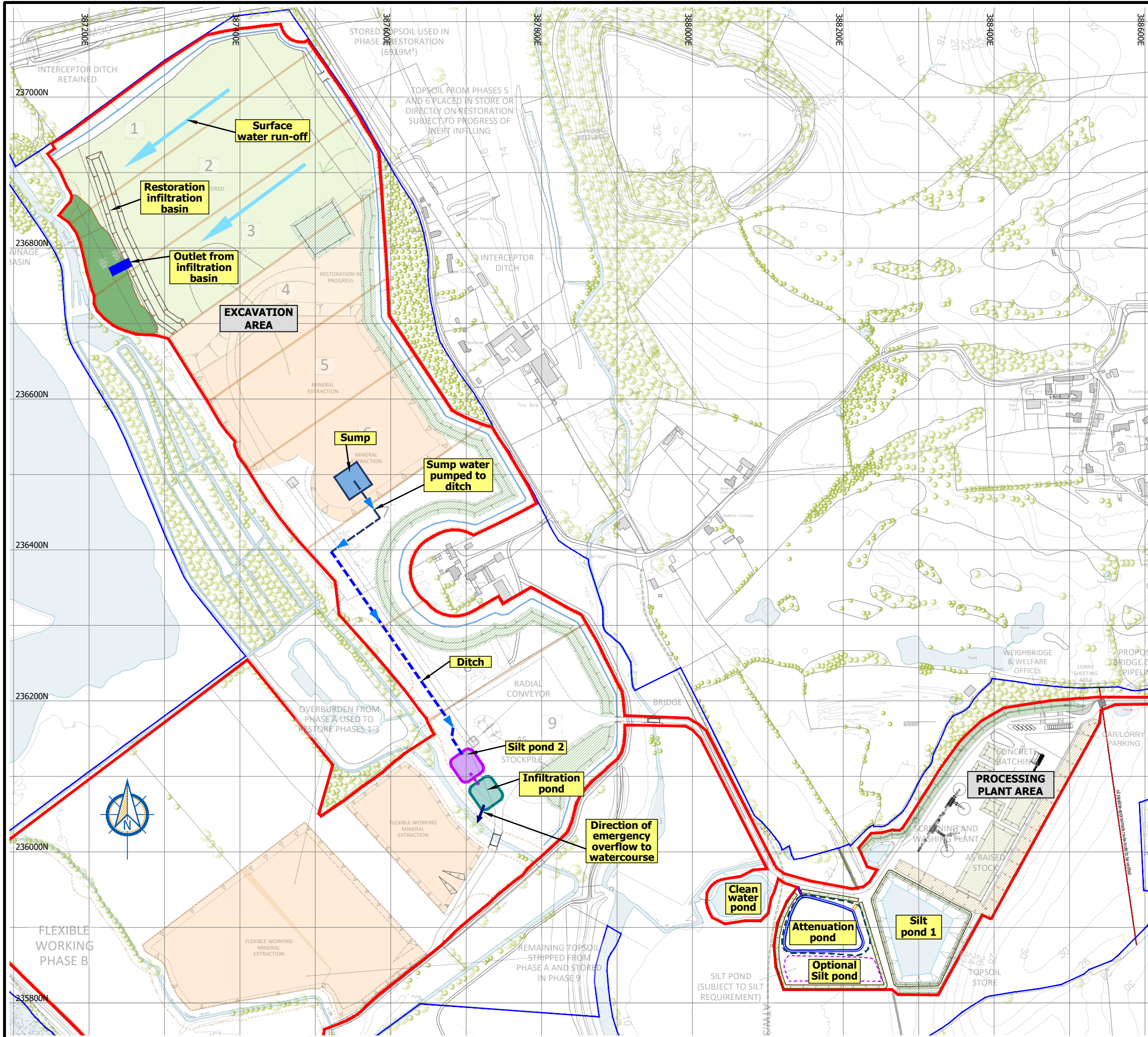
Excavation area drainage system - Phases 3 and 4 extraction

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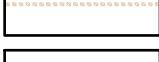
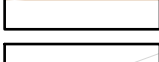
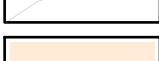





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LEGEND

-  Application Site Boundary
-  Ownership Boundary
-  Existing vegetation
-  Existing brideway and reference
-  Proposed limit of mineral extraction
-  Proposed mineral extraction phase
-  Existing contours at 2.0m intervals
-  Extraction area
-  Restored surface
-  Sump
-  Silt pond 2
-  Infiltration pond

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0004 S4-P8 'PHASES 5 AND 6 EXTRACTION' dated December 2021.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

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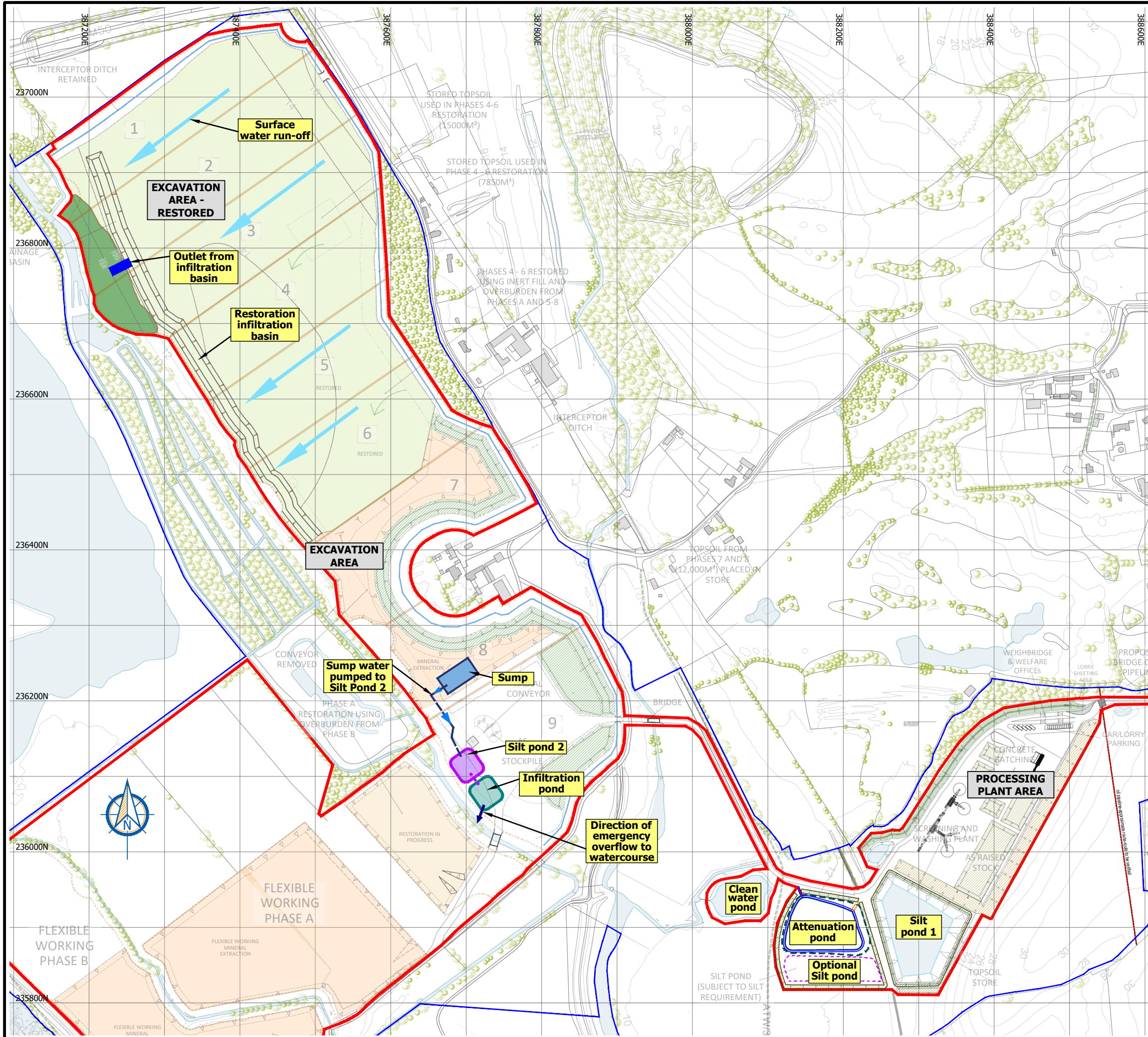
Project
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Excavation area drainage system - Phases 5 and 6 extraction



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LEGEND

- Application Site Boundary
- Ownership Boundary
- Existing vegetation
- Existing bridleway and reference
- Proposed limit of mineral extraction
- Proposed mineral extraction phase
- Existing contours at 2.0m intervals
- Extraction area
- Restored surface
- Sump
- Silt pond 2
- Infiltration pond

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0005 S4-P8 'PHASES 7, 8 AND B EXTRACTION' dated December 2021.

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Project
Bow Farm: Surface Water Drainage Scheme

Excavation area drainage system - Phases 7 and 8 extraction

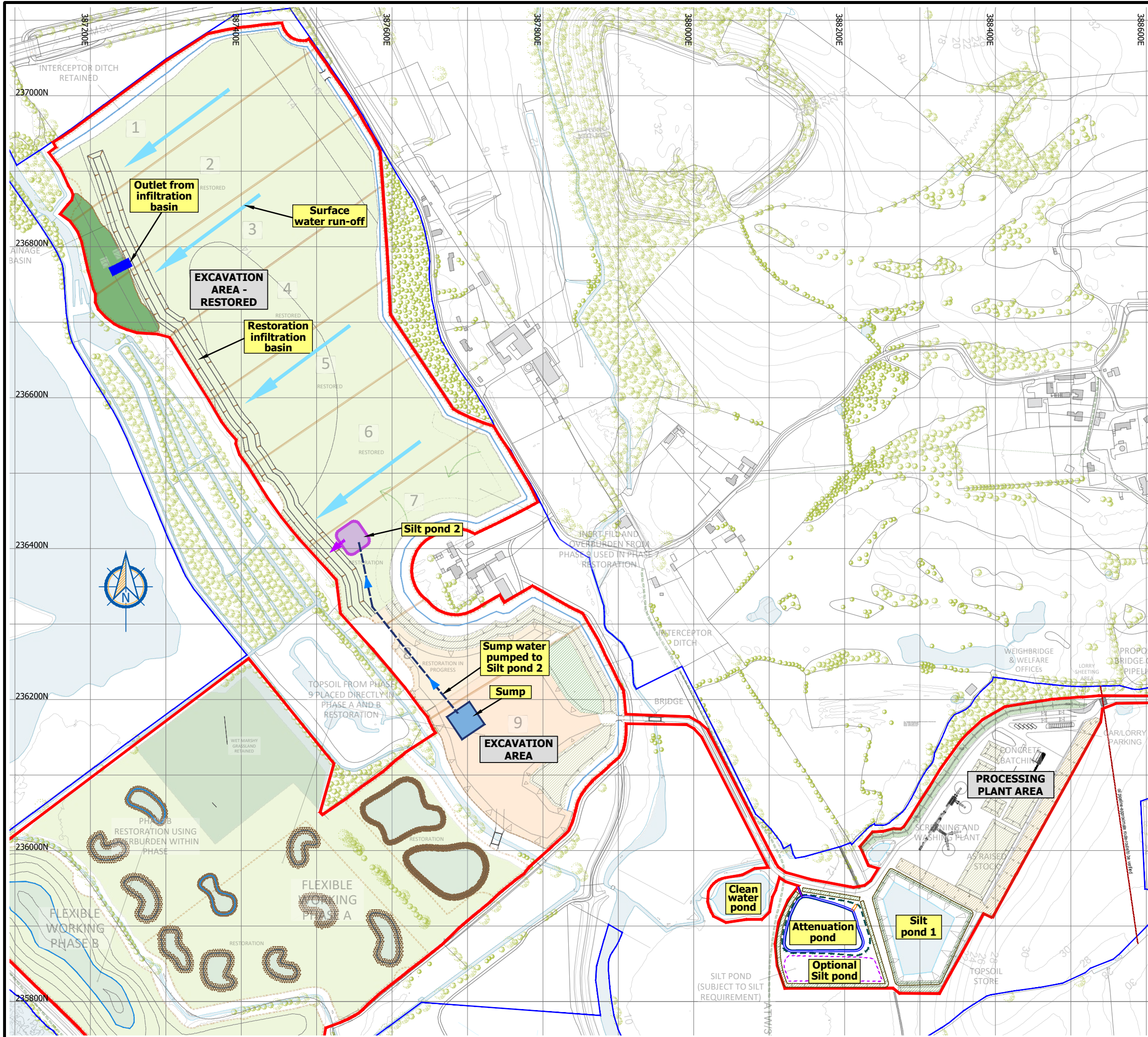
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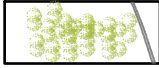








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LEGEND

-  Application Site Boundary
-  Ownership Boundary
-  Existing vegetation
-  Existing bridleway and reference
-  Proposed limit of mineral extraction
-  Proposed mineral extraction phase
-  Existing contours at 2.0m intervals
-  Extraction area
-  Restored surface
-  Sump
-  Silt pond 2

NOTES

• Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0006 S4-P9 'PHASE 9 EXTRACTION' dated December 2021

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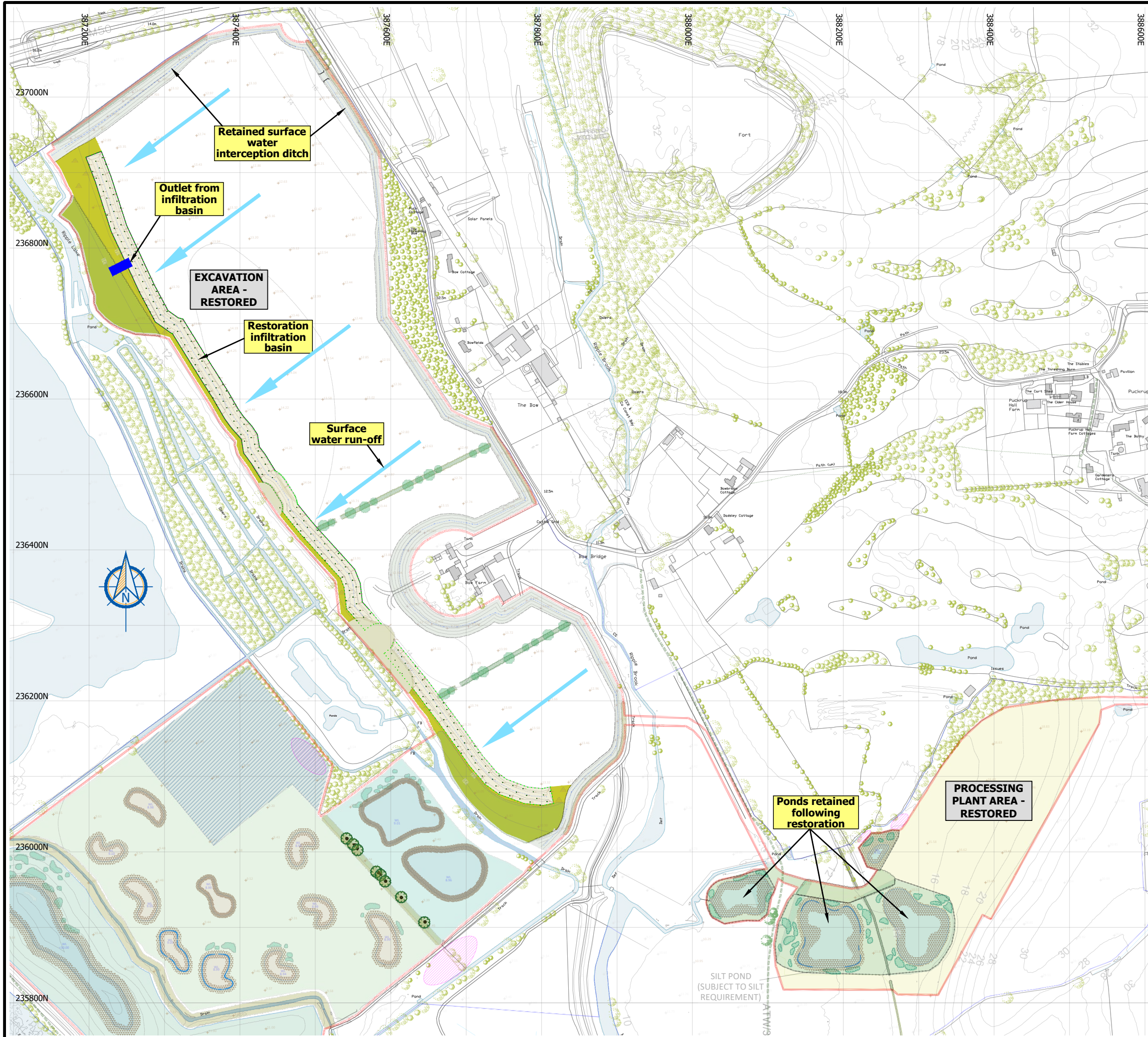
Project
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Excavation area drainage system - Phase 9 extraction



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LEGEND

	Application Site Boundary
	Ownership Boundary
	Existing vegetation
	Existing bridleway and reference
	Existing contours at 2.0m intervals

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1 DR-0007 S4-P9 'PROPOSED RESTORATION' dated December 2021.

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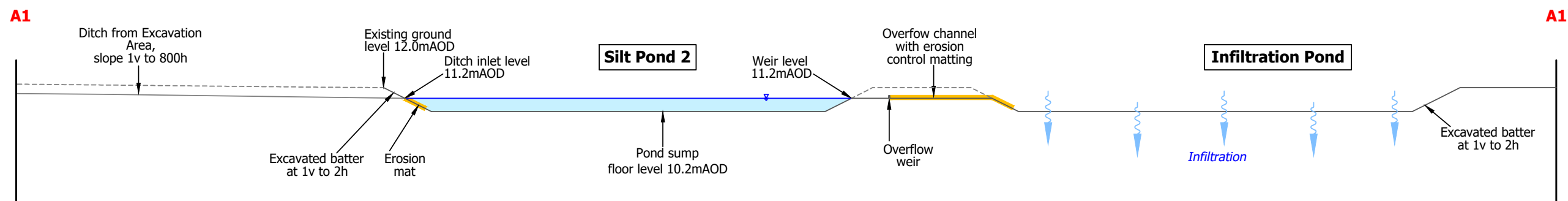
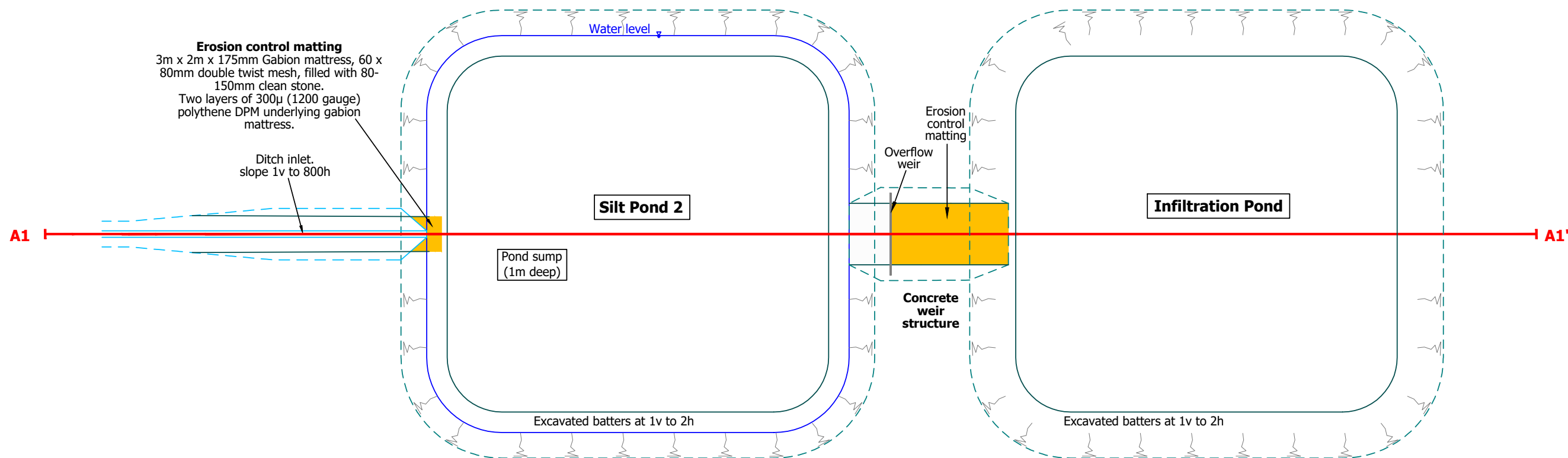
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Project
Bow Farm: Surface Water Drainage Scheme

Restored site surface water management

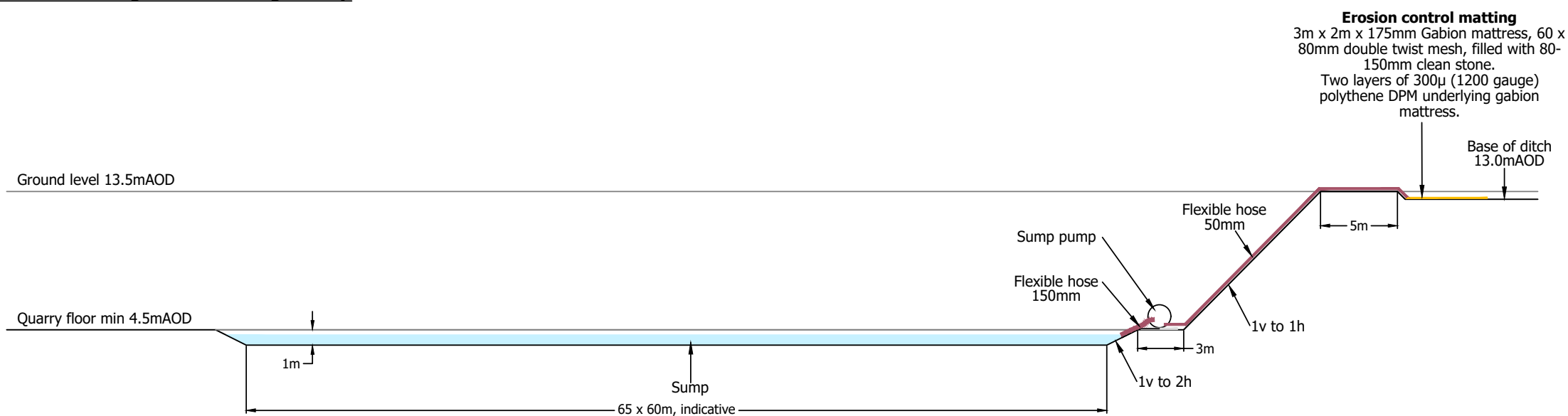
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Generalised long section through Silt Pond 2 and Infiltration Pond

Generalised long section through Sump



NOTES

- See Drawings No. BOWFHIA2407-3 for location of cross section A1 to A1'.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

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Project
Bow Farm: Surface Water Drainage Scheme

Excavation Area - Drainage system
Sump, Silt pond 2 and Infiltration pond design

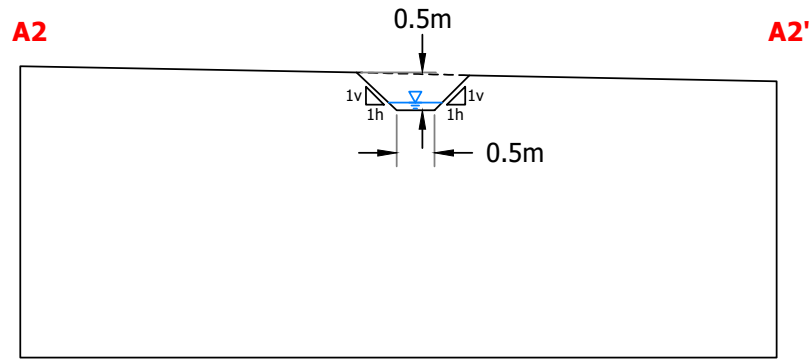
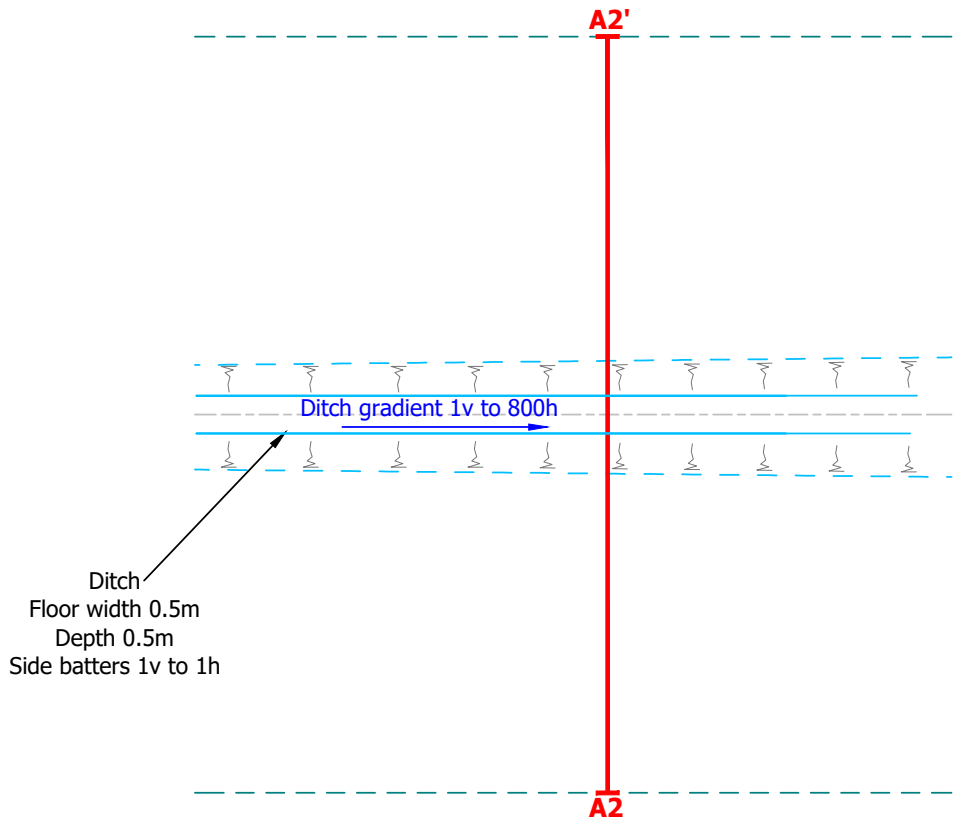
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NOTES

- See Drawings No. BOWFHIA2407-3 for location of cross section A2 to A2'.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
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Project
Bow Farm: Surface Water Drainage Scheme

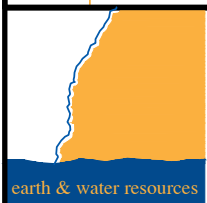


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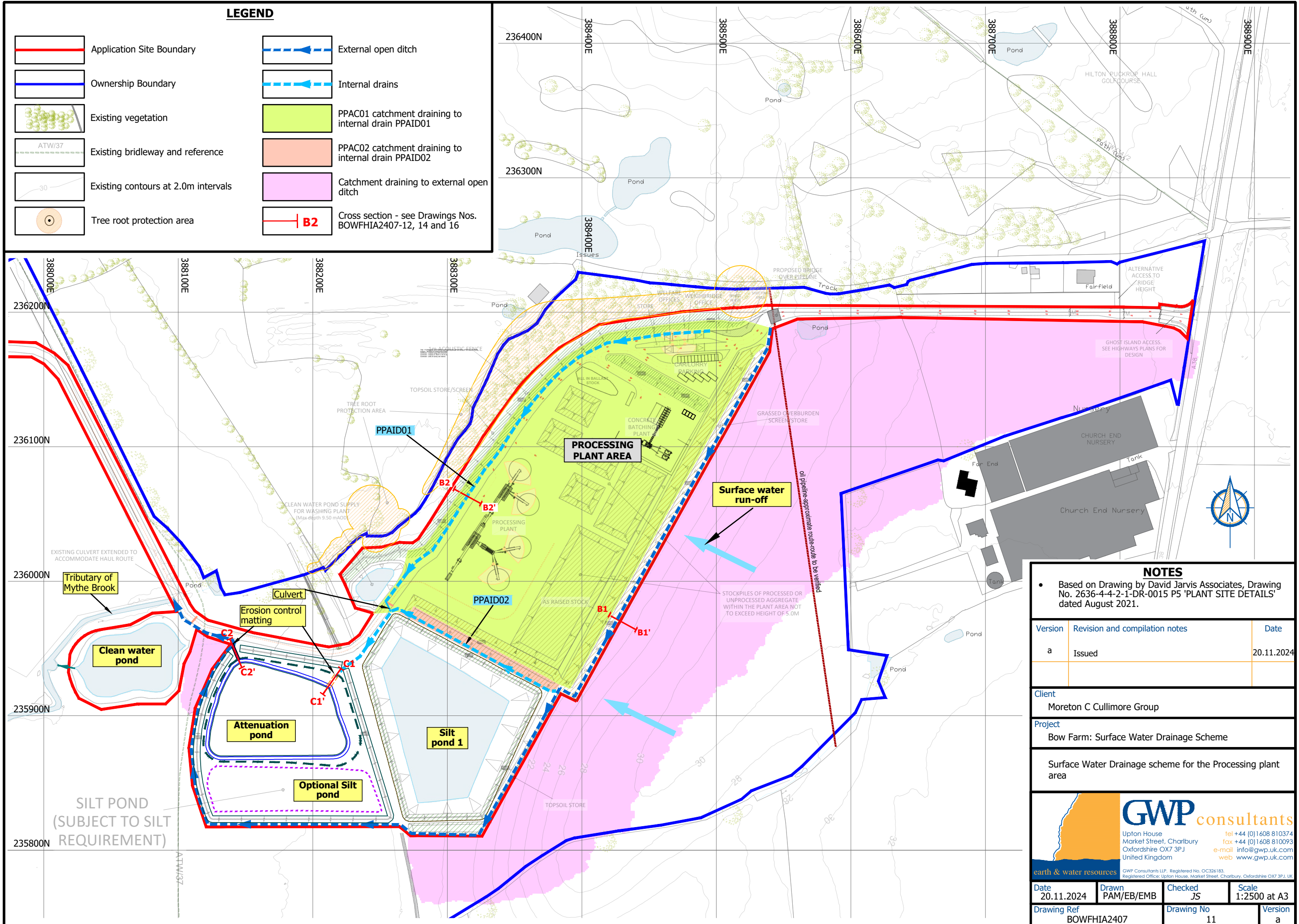
Excavation area - Drainage system
Open ditch design

Date	Drawn	Checked	Scale
20.11.2024	AEC/EMB	JS	1:100 at A4
Drawing Ref		Drawing No	Version
BOWFHIA2407		10	a



LEGEND

-  Application Site Boundary
-  Ownership Boundary
-  Existing vegetation
-  Existing bridleway and reference
-  Existing contours at 2.0m intervals
-  Tree root protection area
-  External open ditch
-  Internal drains
-  PPAC01 catchment draining to internal drain PPAID01
-  PPAC02 catchment draining to internal drain PPAID02
-  Catchment draining to external open ditch
-  Cross section - see Drawings Nos. BOWFHIA2407-12, 14 and 16



NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1-DR-0015 P5 'PLANT SITE DETAILS' dated August 2021.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
Moreton C Cullimore Group

Project
Bow Farm: Surface Water Drainage Scheme

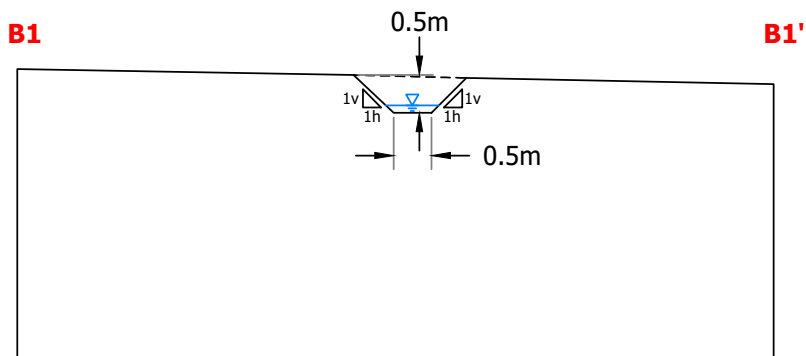
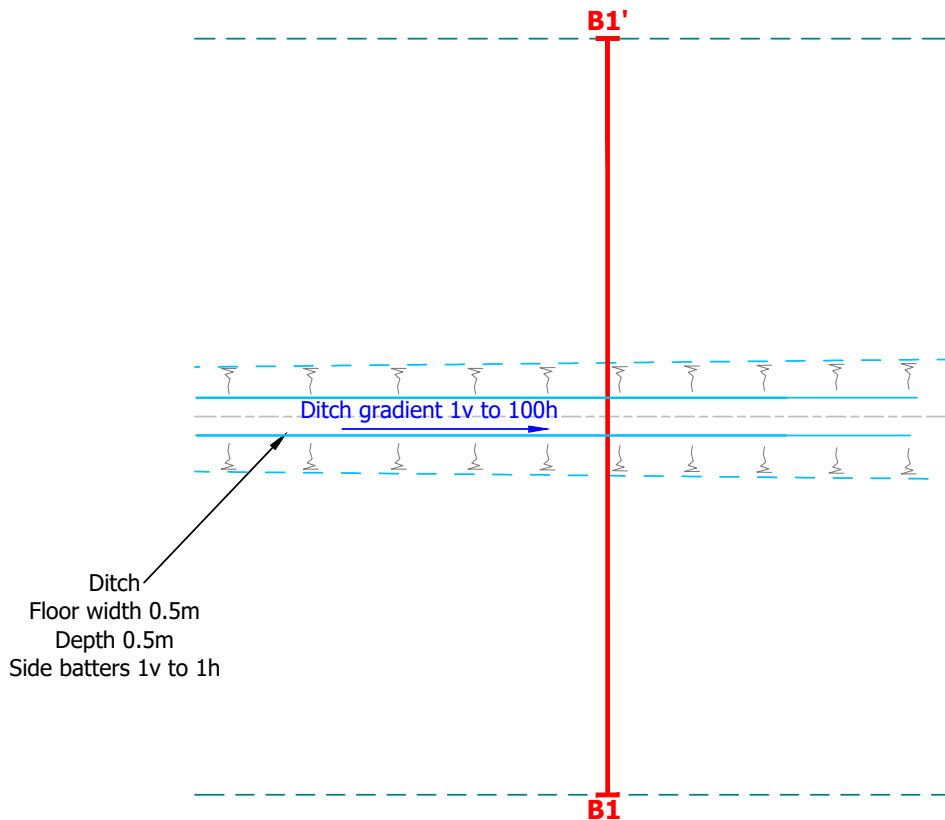
Surface Water Drainage scheme for the Processing plant area



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web www.gwp.uk.com

Date 20.11.2024	Drawn PAM/EB/EMB	Checked JS	Scale 1:2500 at A3
Drawing Ref BOWFHIA2407	Drawing No 11	Version a	




NOTES

- See Drawings No. BOWFHIA2407-11 for location of cross section B1 to B1'.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
Moreton C Cullimore Group

Project
Bow Farm: Surface Water Drainage Scheme

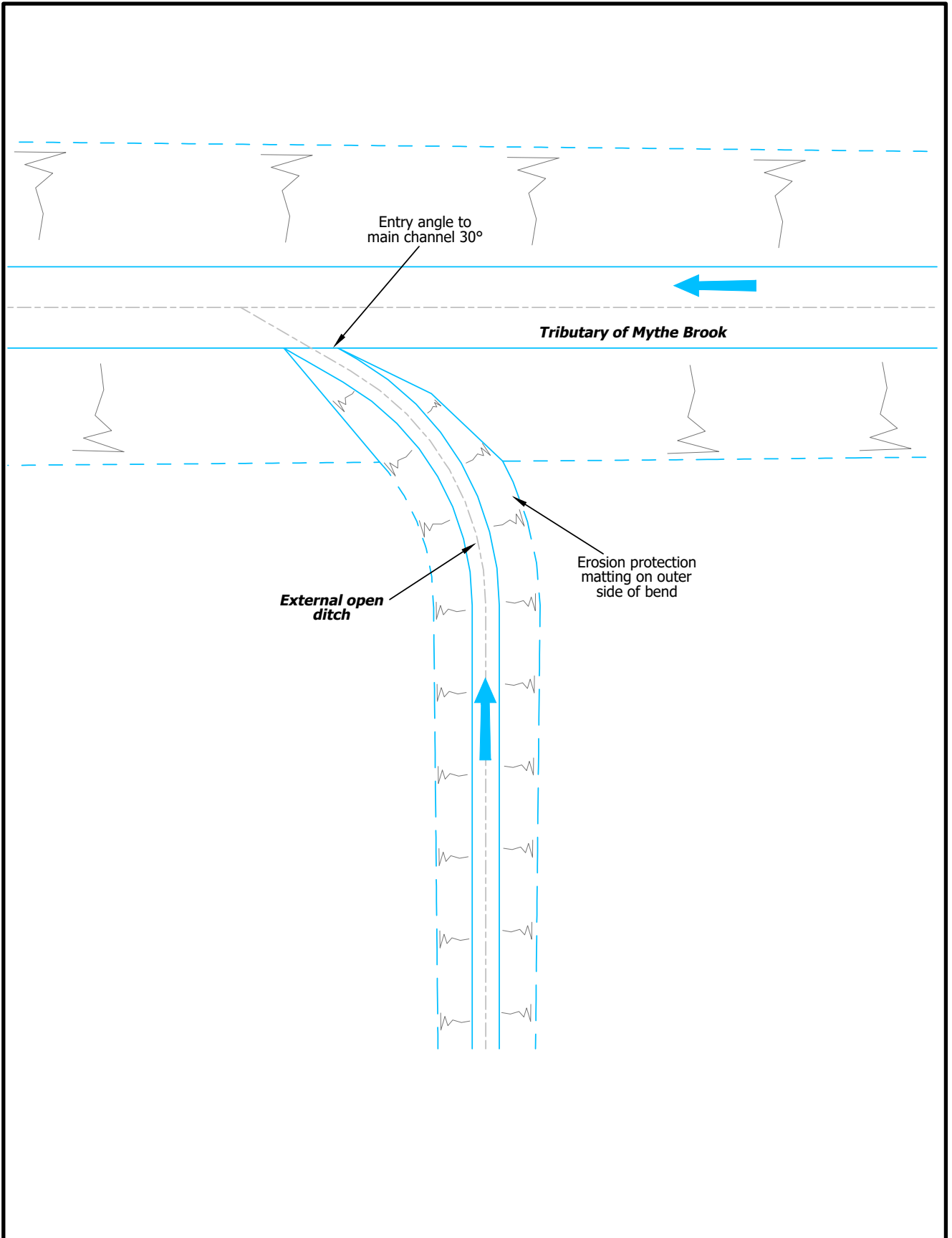


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United Kingdom web www.gwp.uk.com

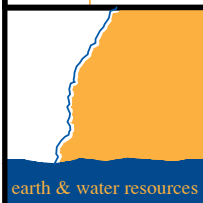
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Processing Plant Area - Drainage system
External open ditch design

Date	Drawn	Checked	Scale
20.11.2024	AEC/PA	JS	1:100 at A4
Drawing Ref		Drawing No	Version
BOWFHIA2407		12	a



Version a	Revision and compilation notes Issued	Date 20.11.2024	Client Moreton C Cullimore Group		
			Project Bow Farm: Surface Water Drainage Scheme		
			Processing Plant Area - Drainage system External open ditch connection to receiving watercourse		
Date 20.11.2024	Drawn EB/EMB	Checked JS	Scale 1:100 at A4		
Drawing Ref BOWFHIA2407		Drawing No 13	Version a		

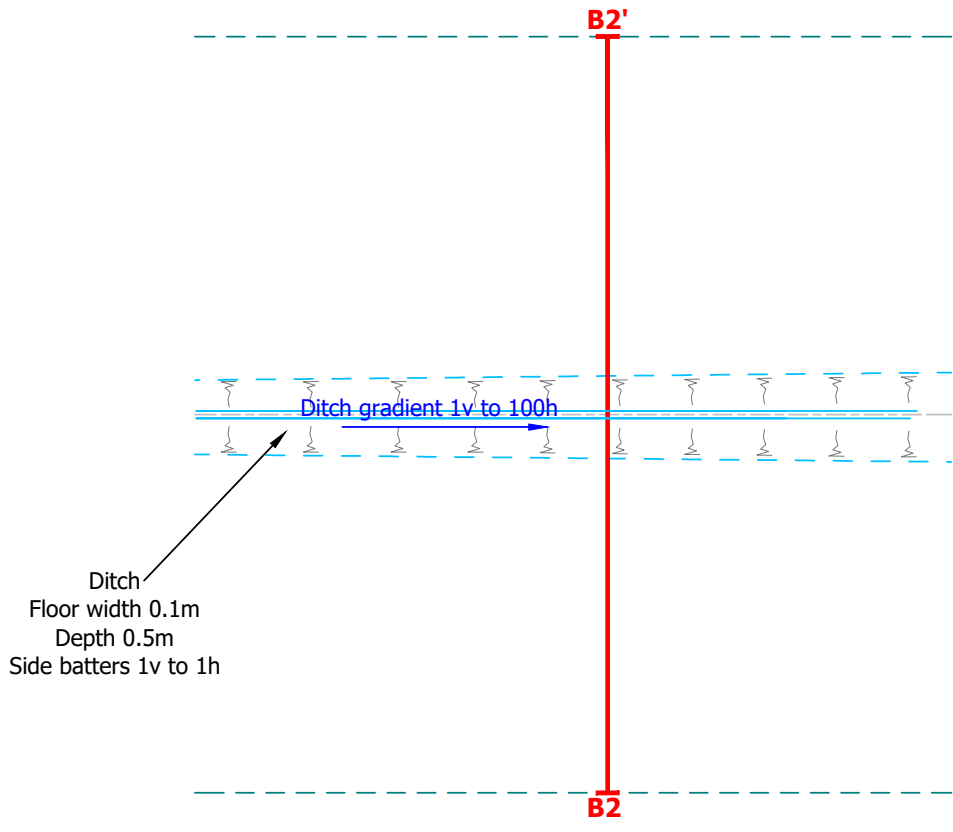


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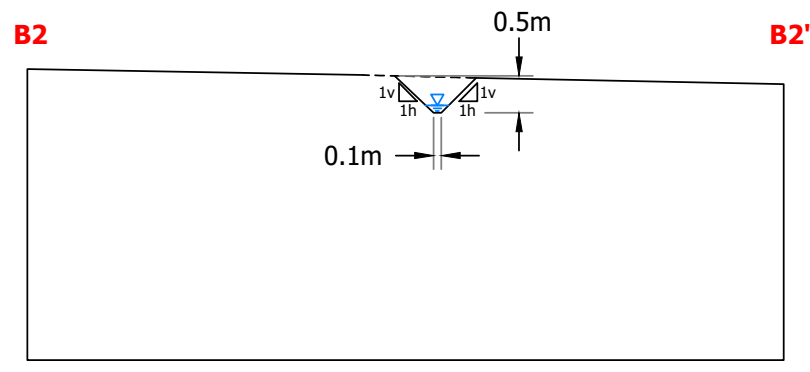
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Ditch
 Floor width 0.1m
 Depth 0.5m
 Side batters 1v to 1h



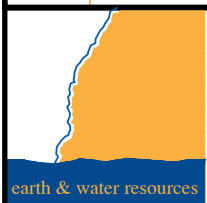
NOTES

- See Drawings No. BOWFHIA2407-11 for location of cross section B2 to B2'.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
 Moreton C Cullimore Group

Project
 Bow Farm: Surface Water Drainage Scheme



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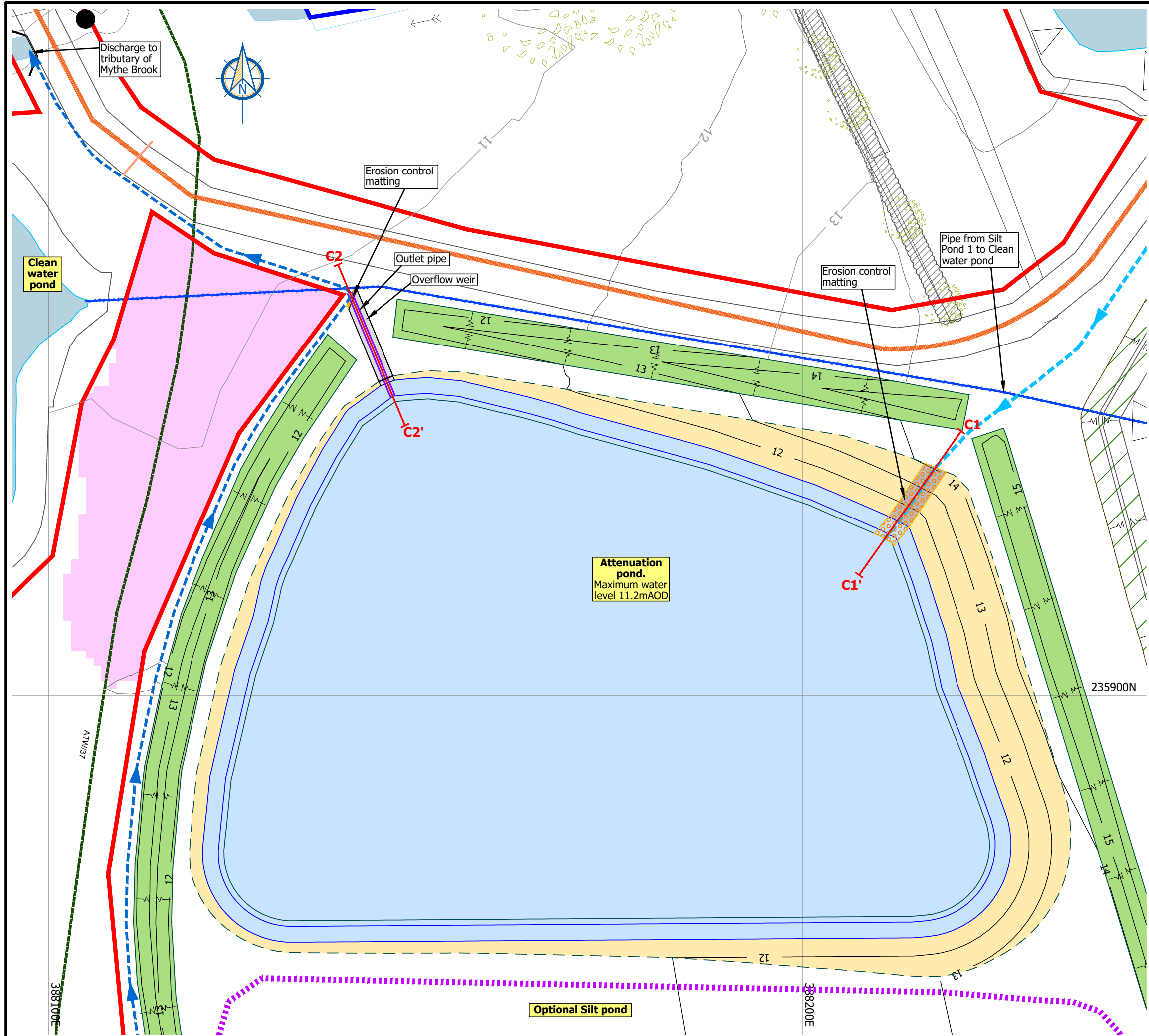
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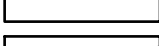




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Processing Plant Area - Drainage system
 Internal drains design

Date	Drawn	Checked	Scale
20.11.2024	EB/EMB	JS	1:100 at A4
Drawing Ref		Drawing No	Version
BOWFHIA2407		14	a



LEGEND

-  Application Site Boundary
-  Ownership Boundary
-  Existing vegetation
-  ATW/37 Existing bridleway and reference
-  Existing contours at 2.0m intervals
-  External open ditch
-  Internal drains
-  Catchment draining to external open ditch
-  Cross section - see Drawings Nos. BOWFHIA2407-15

NOTES

- Based on Drawing by David Jarvis Associates, Drawing No. 2636-4-4-2-1-DR-0015 P5 'PLANT SITE DETAILS' dated August 2021.

Version	Revision and compilation notes	Date
a	Issued	20.11.2024

Client
Moreton C Cullimore Group

Project
Bow Farm: Surface Water Drainage Scheme

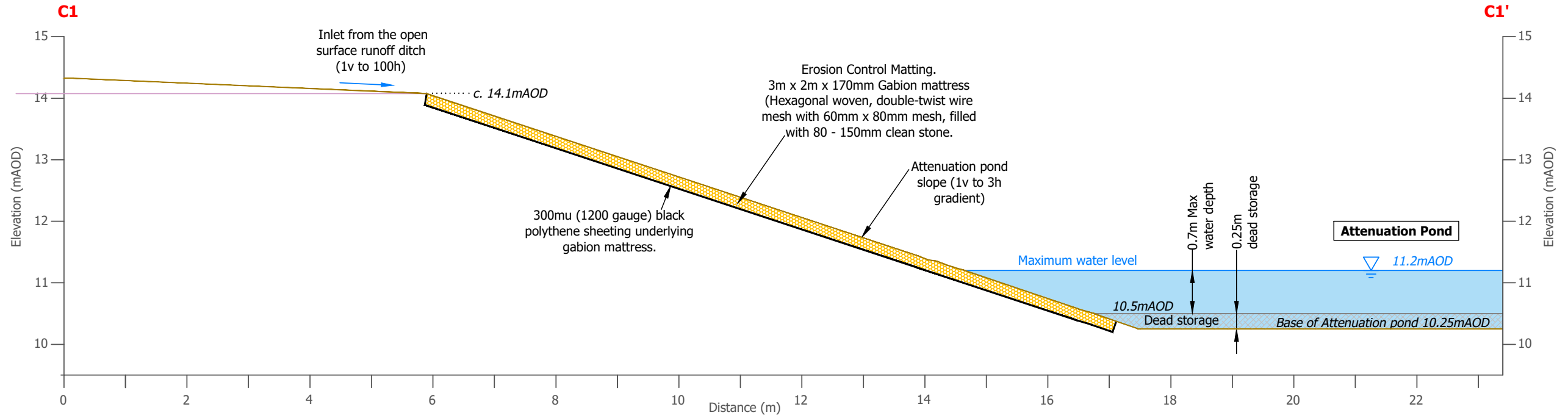
Processing Plant Area - Drainage system
Attenuation Pond detail



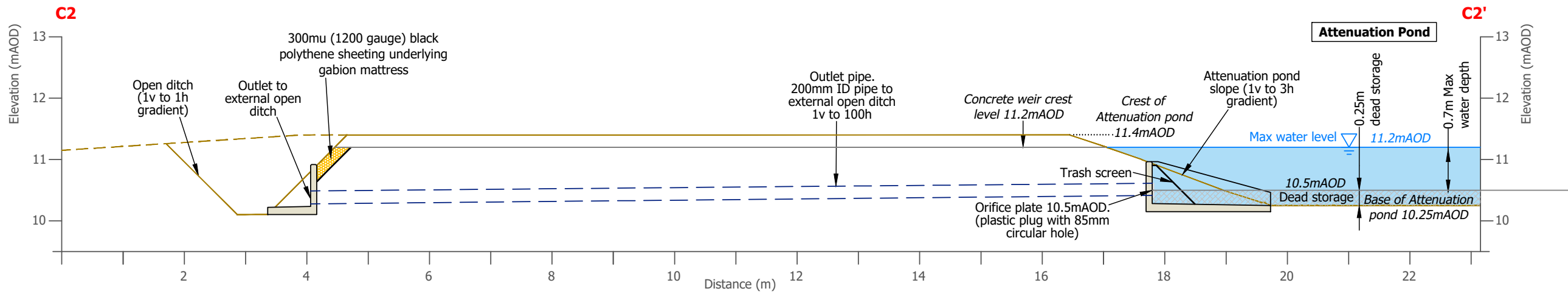
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Date 20.11.2024	Drawn AEC/EMB	Checked JS	Scale 1:500 at A3
Drawing Ref BOWFHIA2407	Drawing No 15	Version a	

Inlet to Attenuation pond



Outlet to Attenuation pond



Version	Revision and compilation notes	Date
a	Issued	20.11.2024

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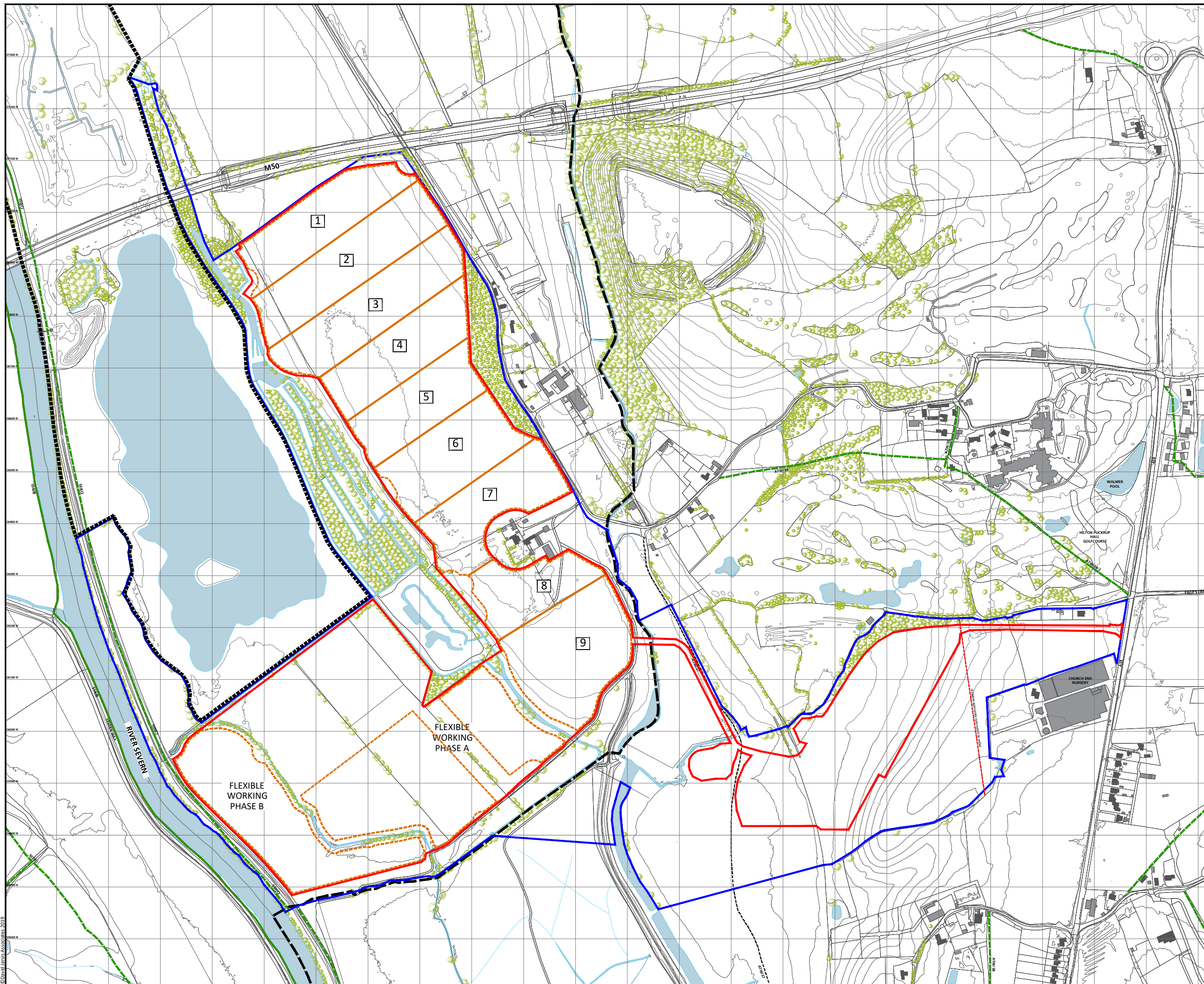
Processing Plant Area - Drainage system
 Attenuation Pond inlet and outlet

- NOTES**
- See Drawings No. BOWFHIA2407-15 for location of cross section C1-C1' and C2-C2'.

Client	Moreton C Cullimore Group		
Project	Bow Farm: Surface Water Drainage Scheme		
Date	20.11.2024	Drawn	AEC/EMB
Checked	JS	Scale	1:75 at A3
Drawing Ref	BOWFHIA2407	Drawing No	16
Version	a		

APPENDIX 1

David Jarvis Associates (DJA) approved site phasing plans



- KEY**
- BOUNDARY: APPLICATION SITE
 - BOUNDARY: OTHER LAND IN THE CONTROL OF THE APPLICANT
 - BOUNDARY: CONSENTED CEMEX MINERAL EXTRACTION
 - BOUNDARY: COUNTY
 - BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
 - EXISTING CONTOURS AT 2.0M INTERVALS
 - EXISTING FOOTPATH AND REFERENCE
 - EXISTING BRIDLEWAY AND REFERENCE
 - EXISTING VEGETATION
 - BUILDINGS: RESIDENTIAL
 - BUILDINGS: NON-RESIDENTIAL

Notes

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Status **FINAL ISSUE**

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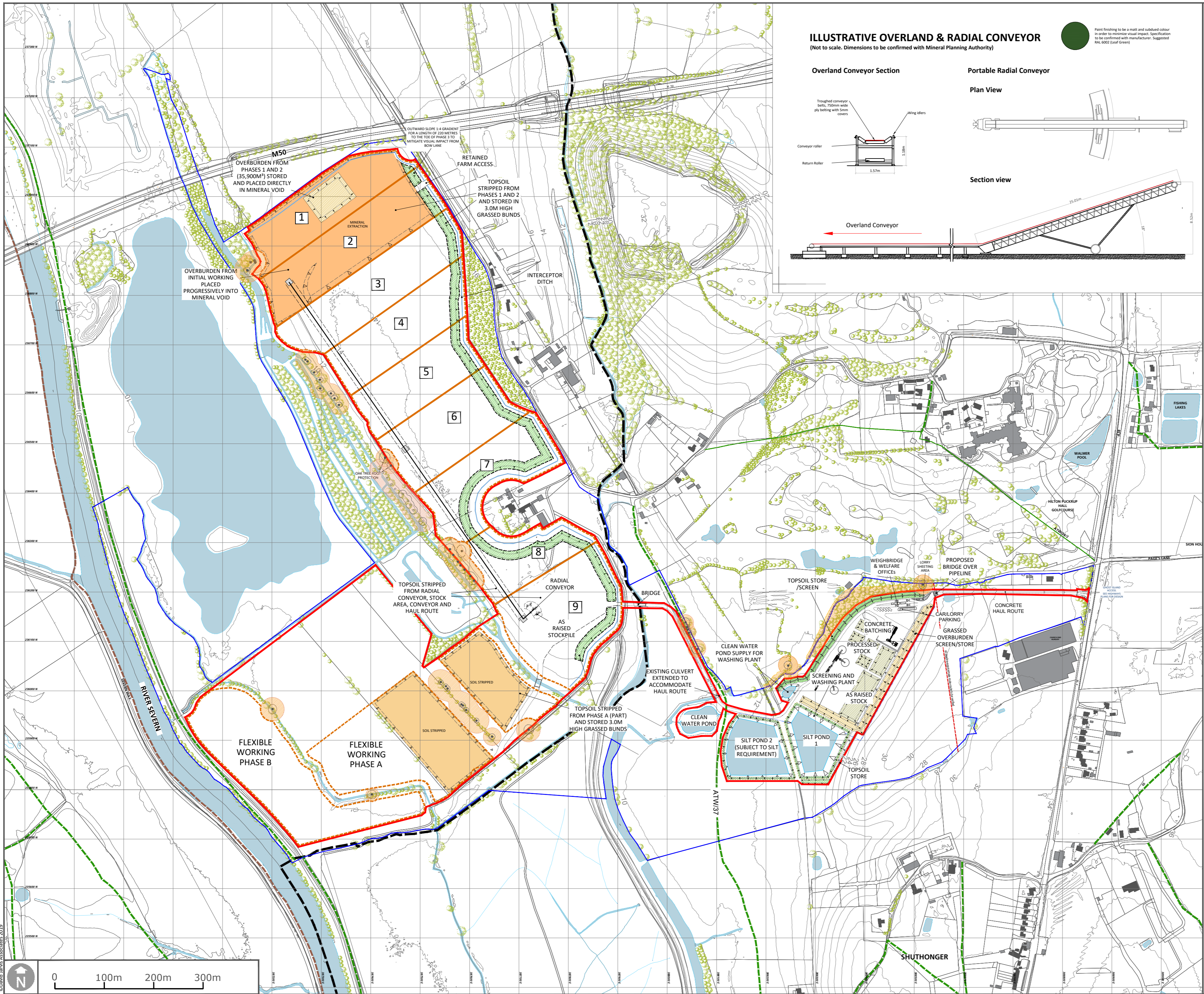
Client
M.C. CULLIMORE (GRAVELS) LTD

Project
BOW FARM

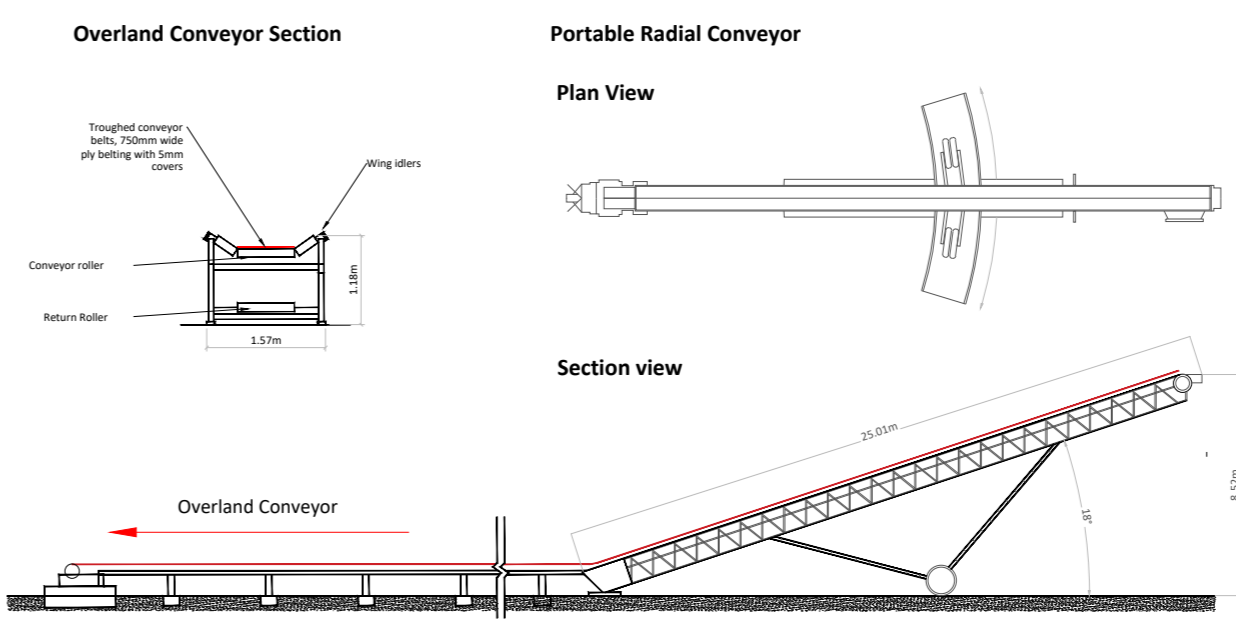
Drawing Title
EXISTING CONDITIONS

Scale NTS	Sheet Size A3	Date DEC 2021
Client Ref. -	Drawing Ref. 2636-4-4-3	Drawing No. Fig. 2
		Status S4-P6

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ILLUSTRATIVE OVERLAND & RADIAL CONVEYOR
(Not to scale. Dimensions to be confirmed with Mineral Planning Authority)



Paint finishing to be a matt and subdued colour in order to minimize visual impact. Specification to be confirmed with manufacturer. Suggested R4, G22 (Leaf Green)

KEY

	BOUNDARY: APPLICATION SITE
	BOUNDARY: OWNERSHIP
	EXISTING VEGETATION
	EXISTING BRIDLEWAY AND REFERENCE
	BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
	BOUNDARY: PROPOSED MINERAL EXTRACTION PHASE
	EXISTING CONTOURS AT 2.0M INTERVALS
	TREE ROOT PROTECTION AREA

Notes
Existing hedgerow enhancement works to be enacted prior to the commencement of Phase 1 Restoration

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Drawing Revision

Rev.	Date	Description	Drawn	Checked
P4	29/03/19	Changes to Silt Lagoons	JL	AC
P5	21/07/20	Interceptor ditch extension	MP	AC
P6	08/12/20	Extraction boundary revision	MP	AC
P7	19/01/21	Overland conveyor alignment	MP	AC
P8	17/08/21	Crack willow exclusion	MP	AC
P9	08/12/21	Veteran tree exclusion	MP	AC

Status
FINAL ISSUE

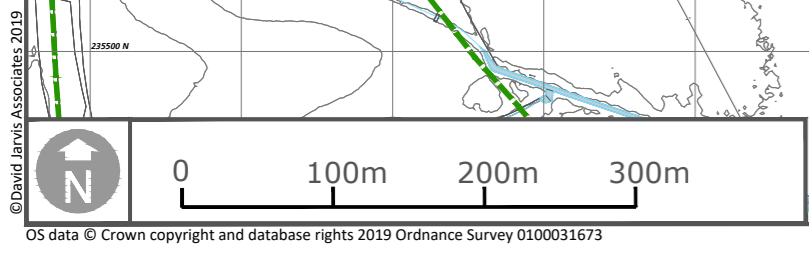
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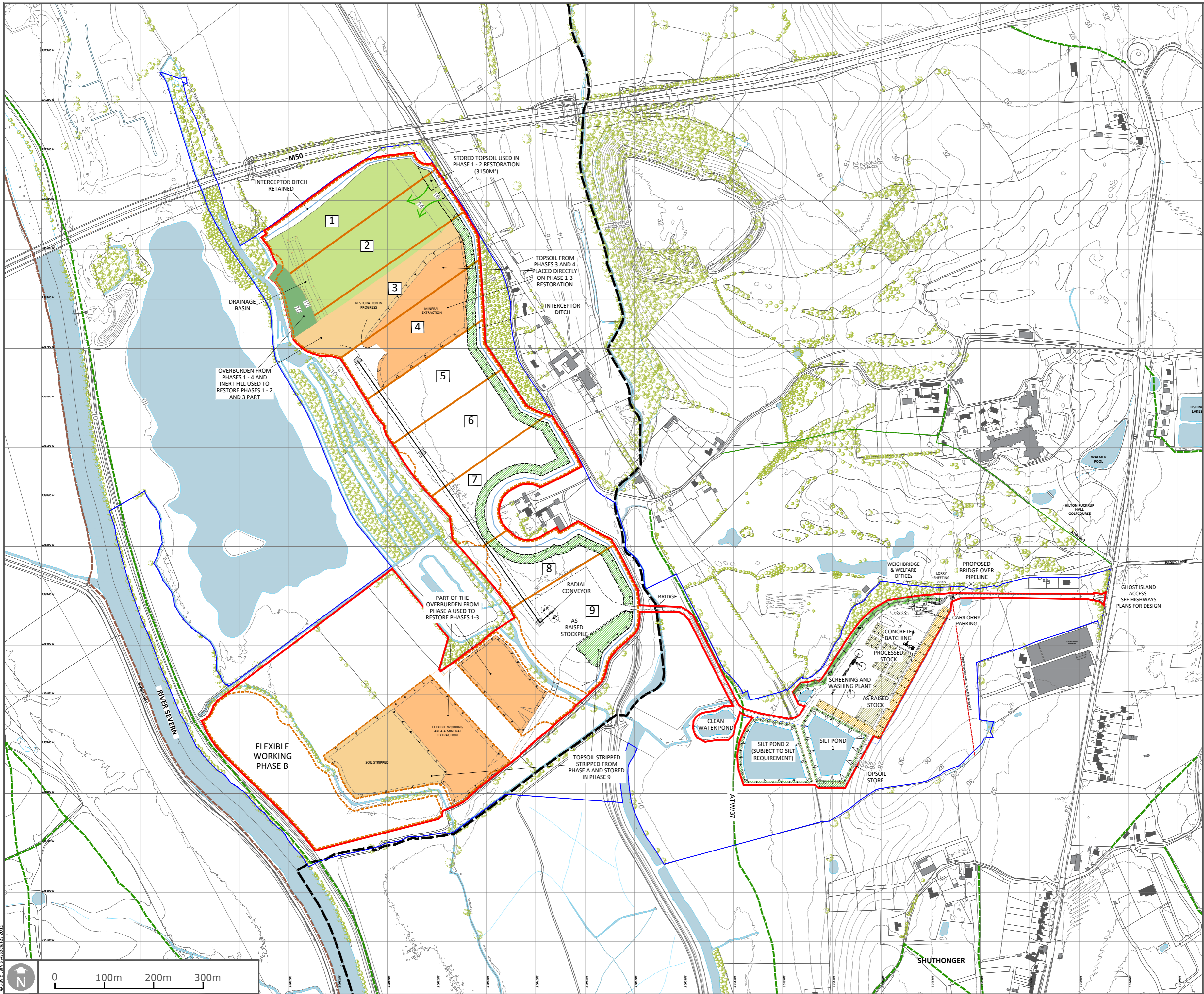
Client
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Project
BOW FARM

Drawing Title
INITIAL WORKS AND PHASE 1 EXTRACTION

Scale 1:5,000	Sheet Size A2	Date DEC 2021
Client Ref. -	Drawing Ref. 2636-4-4-2-1	Drawing No. DR-0002
	Status S4-P9	





KEY

- BOUNDARY: APPLICATION SITE
- BOUNDARY: OWNERSHIP
- EXISTING VEGETATION
- ATW/37 EXISTING BRIDLEWAY AND REFERENCE
- BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
- BOUNDARY: PROPOSED MINERAL EXTRACTION PHASE
- EXISTING CONTOURS AT 2.0M INTERVALS

Notes

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Scaling: Do not scale this drawing. Use given dimensions only.

Drawing Revision

Rev.	Date	Description	Drawn	Checked
P4	29/03/19	Changes to Silt Lagoons	JL	AC
P2	19/06/18	Changes to topsoil bunds	JL	JM
P3	19/02/19	Application boundary added	JL	AC
P4	05/11/19	Interceptor ditch addition	MP	AC
P5	21/07/20	Interceptor ditch extension	MP	AC
P6	19/02/21	Overland Conveyor alignment	MP	AC
P7	17/08/21	Crack willow exclusion	MP	AC
P8	08/12/21	Veteran tree exclusion	MP	AC

Status

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Client

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Project

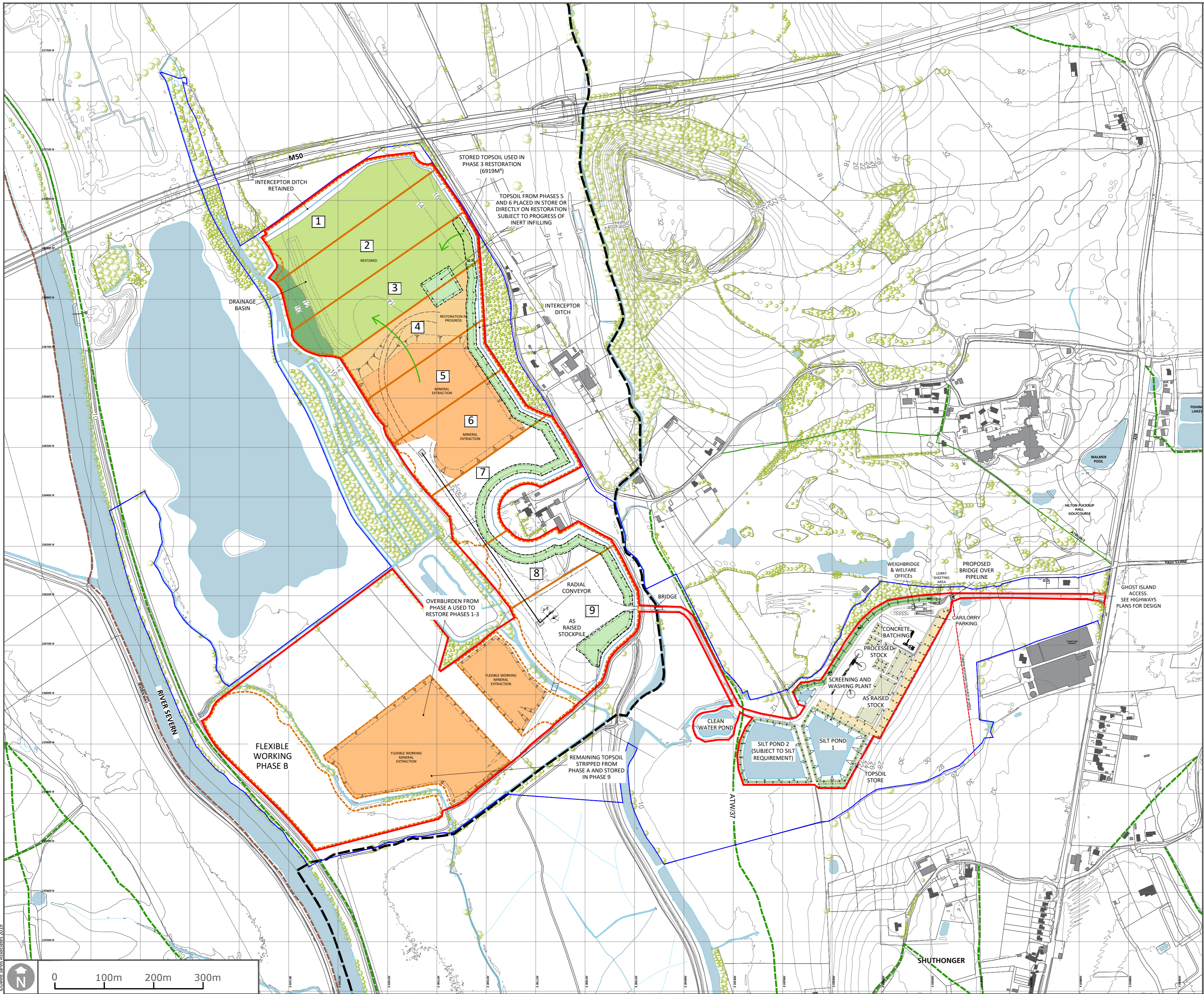
BOW FARM

Drawing Title

PHASES 3 AND 4 EXTRACTION

Scale	Sheet Size	Date
1:5,000	A2	DEC 2021
Client Ref.	Drawing Ref.	Drawing No.
-	2636-4-4-2-1	DR-0003
Status	S4-P8	

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KEY

- BOUNDARY: APPLICATION SITE
- BOUNDARY: OWNERSHIP
- EXISTING VEGETATION
- ATW/37
- BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
- BOUNDARY: PROPOSED MINERAL EXTRACTION PHASE
- EXISTING CONTOURS AT 2.0M INTERVALS

Notes

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Drawing Revision

Rev.	Date	Description	Drawn	Checked
P2	19/06/18	Changes to topsoil bunds	JL	JM
P3	19/02/19	Application boundary added	JL	AC
P4	05/11/19	Interceptor ditch addition	MP	AC
P5	21/07/20	Interceptor ditch extension	MP	AC
P6	19/02/21	Overland Conveyor alignment	MP	AC
P7	17/08/21	Crack willow exclusion	MP	AC
P8	08/12/21	Veteran tree exclusion	MP	AC

Status

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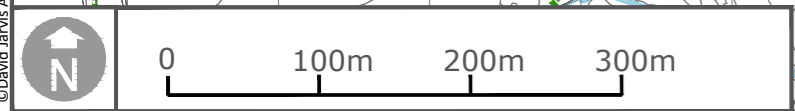
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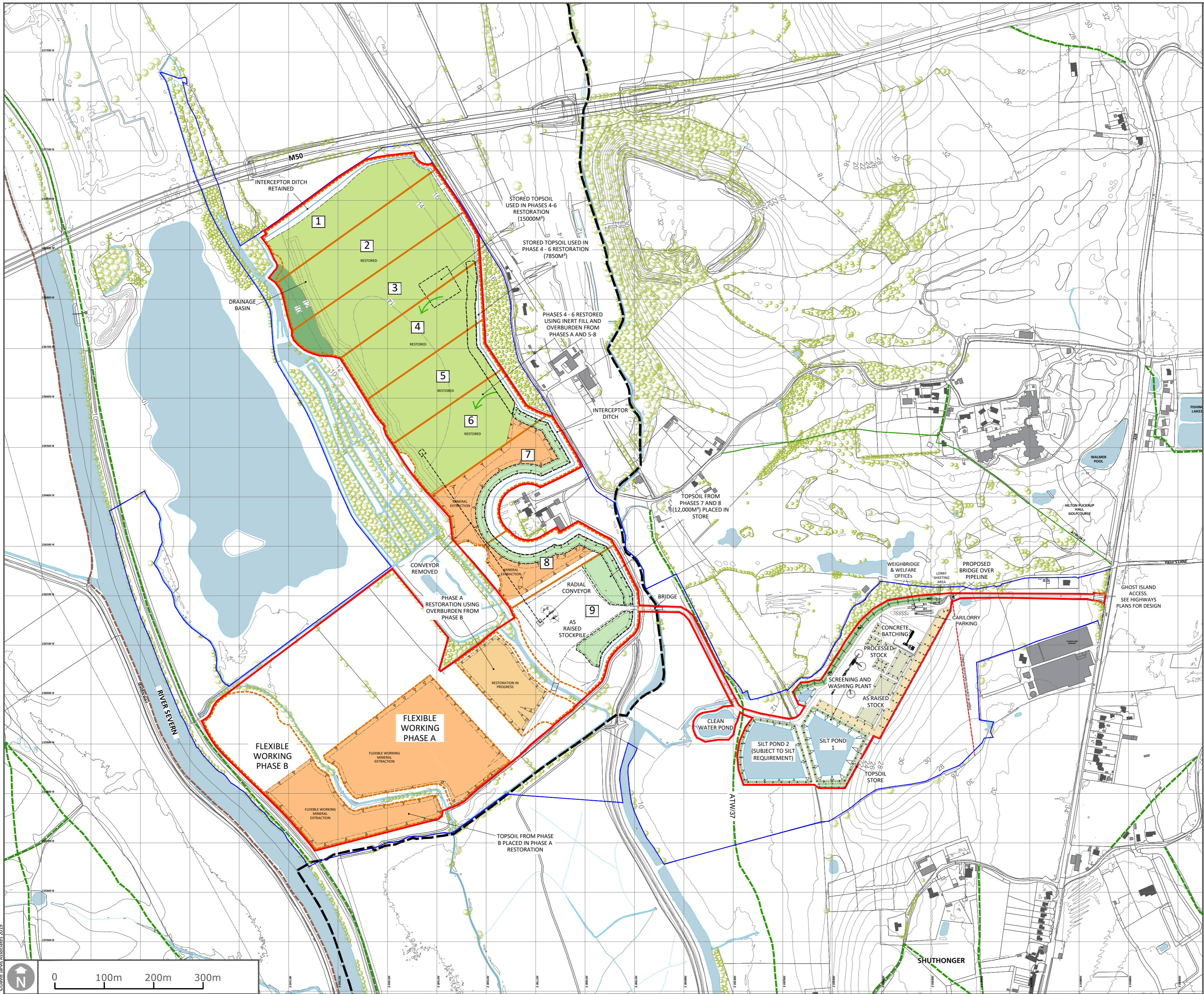
BOW FARM

Drawing Title

PHASES 5 AND 6 EXTRACTION

Scale	Sheet Size	Date
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Client Ref.	Drawing Ref.	Drawing No.
-	2636-4-4-2-1	DR-0004
Status	S4-P8	





KEY

	BOUNDARY: APPLICATION SITE
	BOUNDARY: OWNERSHIP
	EXISTING VEGETATION
	ATW/37 EXISTING BRIDLEWAY AND REFERENCE
	BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
	BOUNDARY: PROPOSED MINERAL EXTRACTION PHASE
	EXISTING CONTOURS AT 2.0M INTERVALS

Notes

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Scaling: Do not scale this drawing. Use given dimensions only.

Rev.	Date	Description	Drawn	Checked
P2	19/06/18	Changes to topsoil bunds	JL	JM
P3	19/02/19	Application boundary added	JL	AC
P4	05/11/19	Interceptor ditch addition	MP	AC
P5	21/07/20	Interceptor ditch extension	MP	AC
P6	19/02/21	Overland Conveyor alignment	MP	AC
P7	17/08/21	Crack willow exclusion	MP	AC
P8	08/12/21	Veteran tree exclusion	MP	AC

Status

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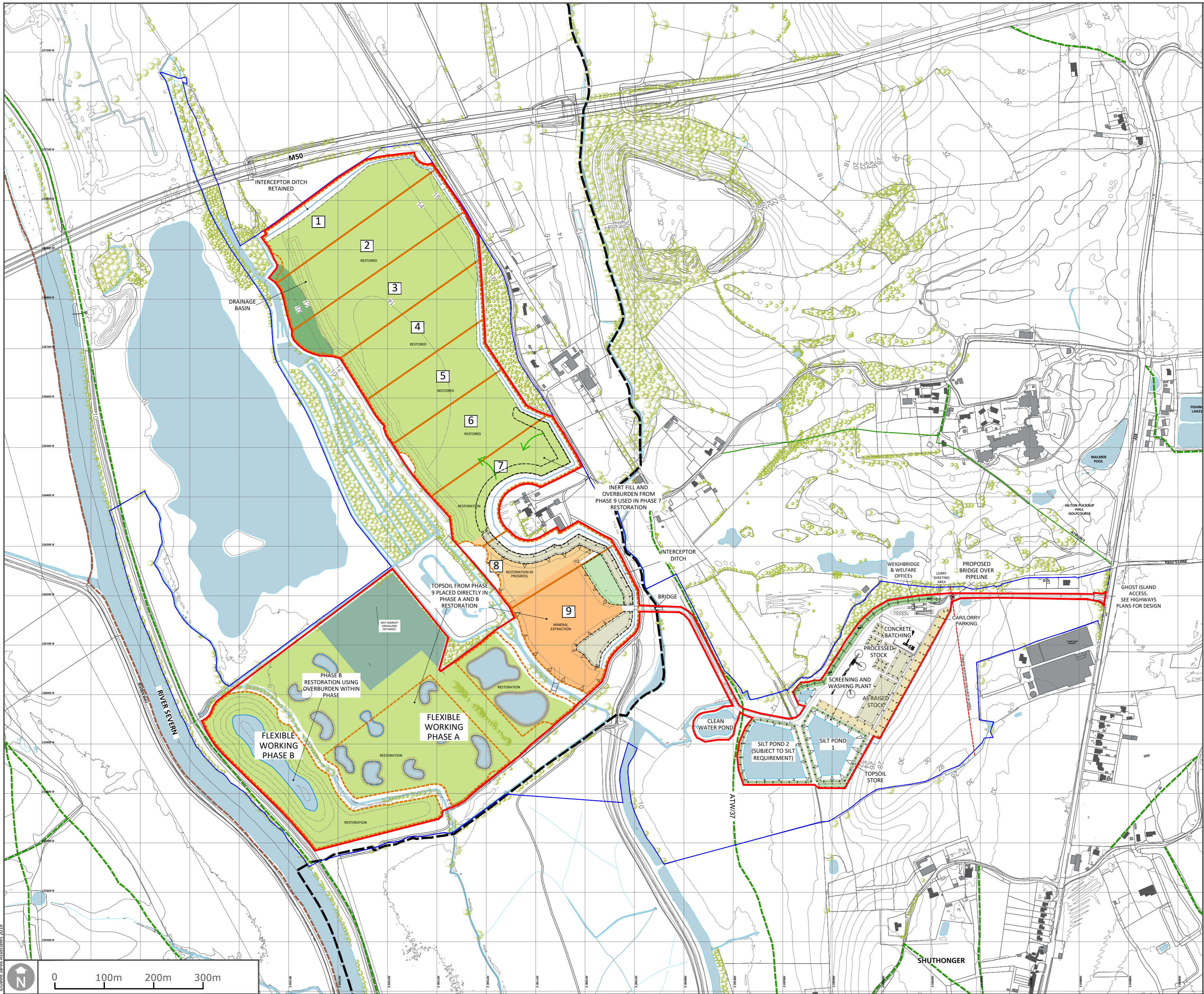
Project

BOW FARM

Drawing Title

PHASES 7, 8 AND B EXTRACTION

Scale	Sheet Size	Date	
1:5,000	A2	DEC 2021	
Client Ref.	Drawing Ref.	Drawing No.	Status
-	2636-4-4-2-1	DR-0005	S4-P8



KEY

- BOUNDARY: APPLICATION SITE
- BOUNDARY: OWNERSHIP
- EXISTING VEGETATION
- ATW/37 EXISTING BRIDLEWAY AND REFERENCE
- BOUNDARY: PROPOSED LIMIT OF MINERAL EXTRACTION
- BOUNDARY: PROPOSED MINERAL EXTRACTION PHASE
- EXISTING CONTOURS AT 2.0M INTERVALS
- PROPOSED WATERBODIES
- RETAINED MARSHY GRASSLAND

Notes

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Scaling: Do not scale this drawing. Use given dimensions only.

Drawing Revision

Rev.	Date	Description	Drawn	Checked
P2	19/06/18	Changes to topsoil bunds	JL	JM
P3	19/02/19	Application boundary added	JL	AC
P4	05/11/19	Interceptor ditch addition	MP	AC
P5	21/07/20	Interceptor ditch extension	MP	AC
P6	19/02/21	Overland Conveyor alignment	MP	AC
P7	19/02/21	Drainage basin and Wet Marsh retained	MP	AC
P8	17/08/21	Crack willow exclusion	MP	AC
P9	08/12/21	Veteran tree exclusion & island removal	MP	AC

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Client

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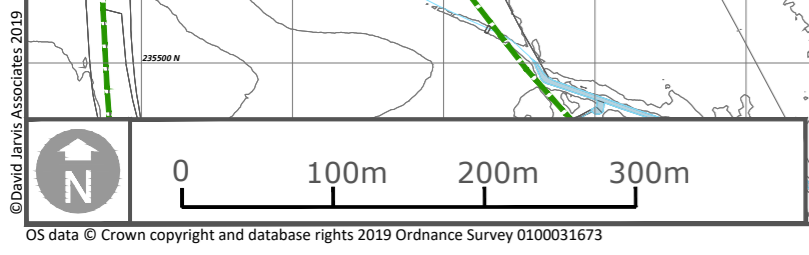
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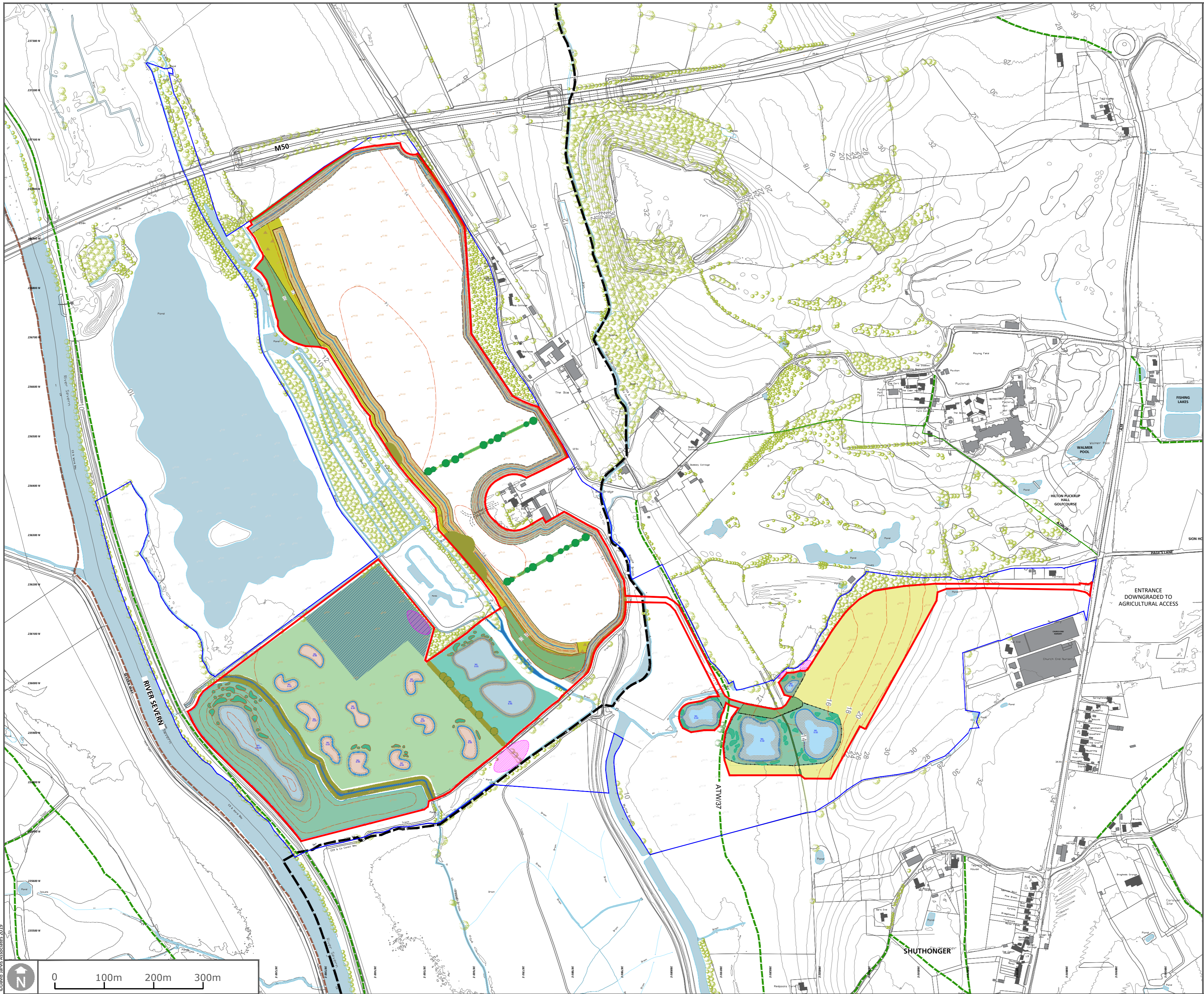
BOW FARM

Drawing Title

PHASE 9 EXTRACTION

Scale	Sheet Size	Date
1:5,000	A2	DEC 2021
Client Ref.	Drawing Ref.	Drawing No.
-	2636-4-4-2-1	DR-0006
Status	S4-P9	





- KEY**
- BOUNDARY: APPLICATION SITE
 - BOUNDARY: OWNERSHIP
 - EXISTING VEGETATION
 - ATW/37 EXISTING BRIDLEWAY AND REFERENCE
 - EXISTING CONTOURS AT 2.0M INTERVALS
 - PROPOSED CONTOURS AT 2.0M INTERVALS
 - REINSTATED ARABLE FARMLAND
 - ARABLE FIELD MARGINS & HIBERNACULA TIMBER PILES
 - PROPOSED WET GRASSLAND & SCRAPES
 - PROPOSED OPEN WATER, SCRUB & WATERBODIES
 - PROPOSED WET GRASSLAND & SCRUB
 - PROPOSED DECIDUOUS WOODLAND
 - EXISTING HEDGEROW & TREES
 - REINSTATED NATIVE HEDGEROW
 - PROPOSED WATERBODIES
 - EXISTING WATERCOURSE
 - RETAINED DRAINAGE BASIN
 - RETAINED INTERCEPTOR DITCH
 - RETAINED MARSHY GRASSLAND
 - HIBERNACULA FELLED TIMBER

Notes

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Scaling: Do not scale this drawing. Use given dimensions only.

Drawing Revision

Rev.	Date	Description	Drawn	Checked
P2	19/06/18	Updates to restoration	JL	JM
P3	19/02/19	Updates to restoration	JL	AC
P4	04/11/19	Addition of infiltration basin	MP	AC
P5	06/08/20	Changes to reflect ecologist report	MP	AC
P6	19/01/21	Root protection areas	MP	AC
P7	27/01/21	Drainage basin and marshy grassland	MP	AC
P8	17/08/21	Hibernacula piles	MP	AC
P9	08/12/21	Veteran tree exclusion & island removal	MP	AC

Status

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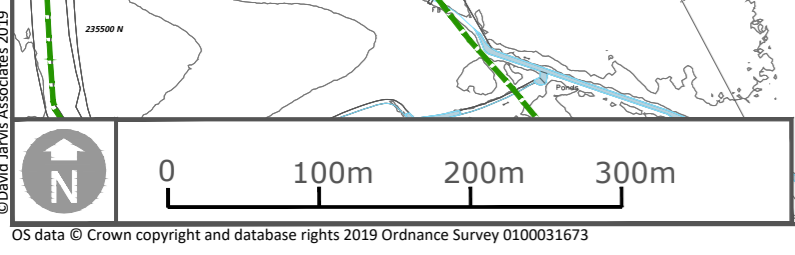
Project

BOW FARM

Drawing Title

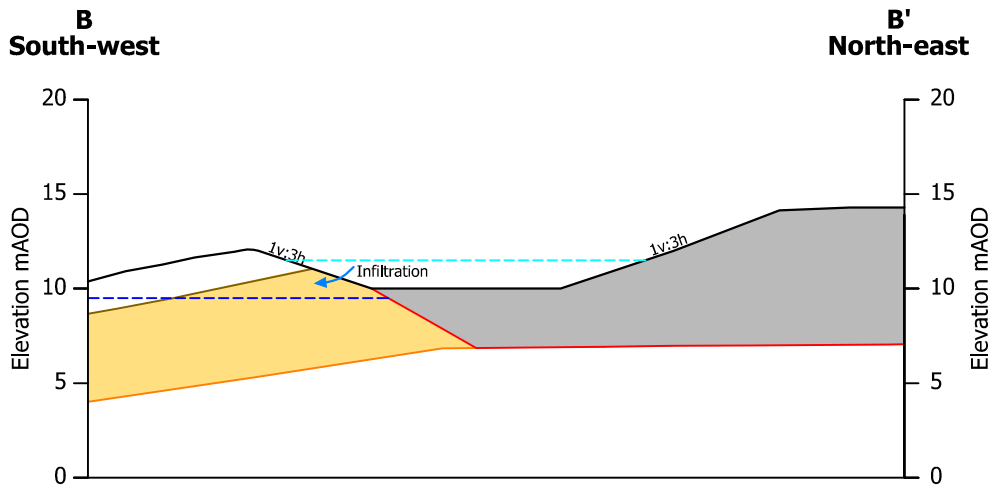
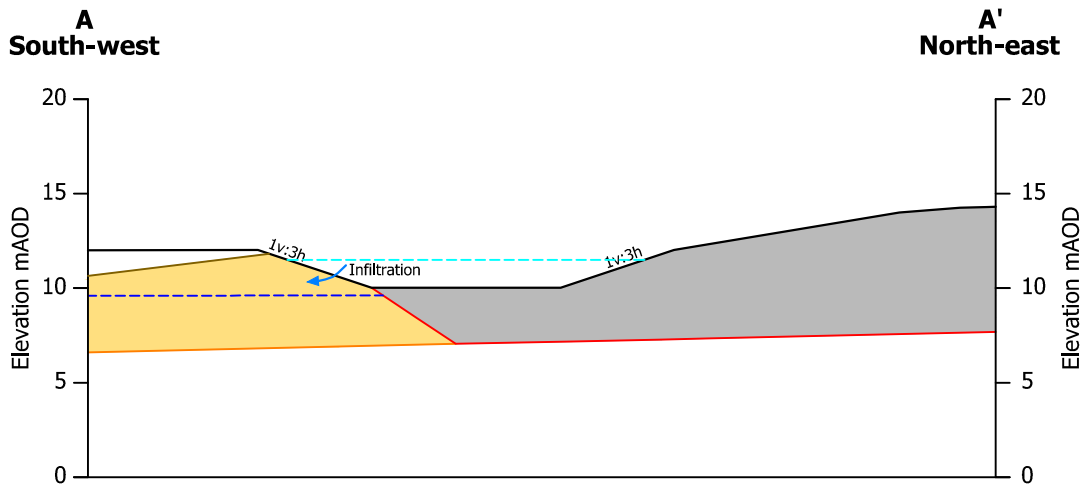
PROPOSED RESTORATION

Scale	Sheet Size	Date	
1:5,000	A2	DEC 2021	
Client Ref.	Drawing Ref.	Drawing No.	Status
-	2636-4-4-2-1	DR-0007	S4-P9



APPENDIX 2

GWP Drawing No. BOWFHIA1907-18



LEGEND

	Proposed restoration ground surface		Terrace sand and gravel		Representative high groundwater level
	Inferred base of overburden		Proposed excavation		Peak water level
	Inferred base of terrace gravel		Low-permeability fill		

Version	Revision and compilation notes	Date	Client
A	Issued	15.08.2019	Moreton C Cullimore Group
B	Issued	27.08.2019	Project
			Bow Farm: Water EIA

GWP consultants
 Upton House | tel +44 (0)1608 810374
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 Oxfordshire OX7 3PJ | e-mail info@gwp.uk.com
 United Kingdom | web www.gwp.uk.com

earth & water resources

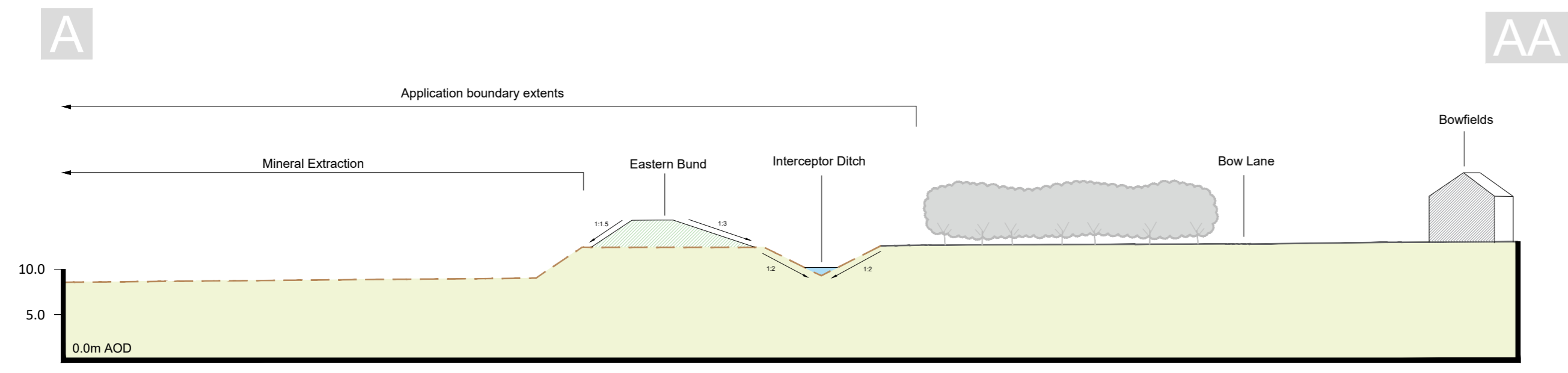
GWP Consultants LLP, Registered No. OC326162.
 Registered Office: Upton House, Market Street, Charlbury, Oxfordshire OX7 3PJ, UK

Cross sections A-A' and B-B'			
Date	Drawn	Checked	Scale
27.08.2019	MGM/EMB	CC	1:400 at A4
Drawing Ref		Drawing No	Version
BOWFHIA1907		18	B

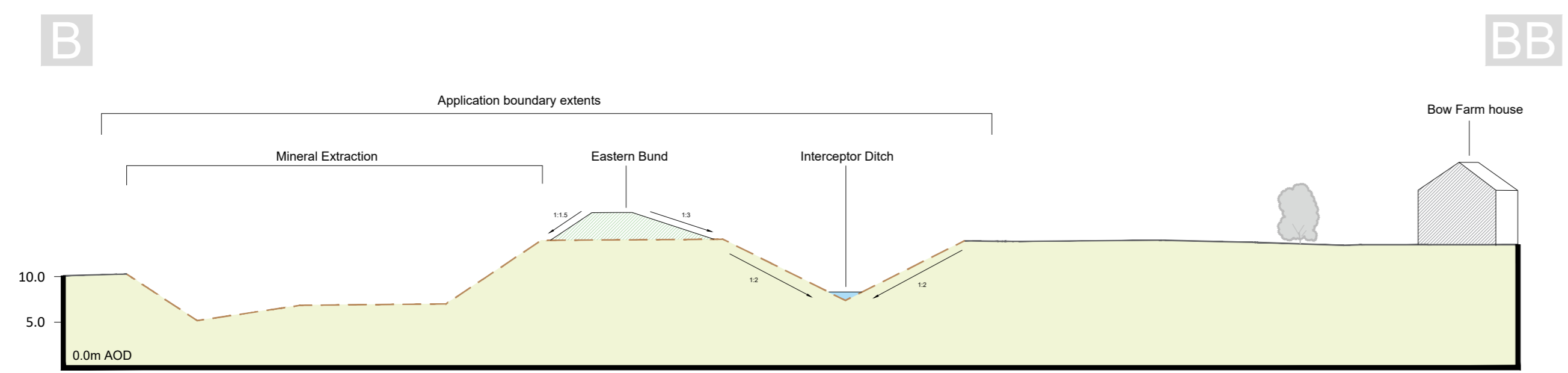
APPENDIX 3

DJA Drawing 2636-4-4-2-2-DR-0014 P3 Interceptor ditch cross sections

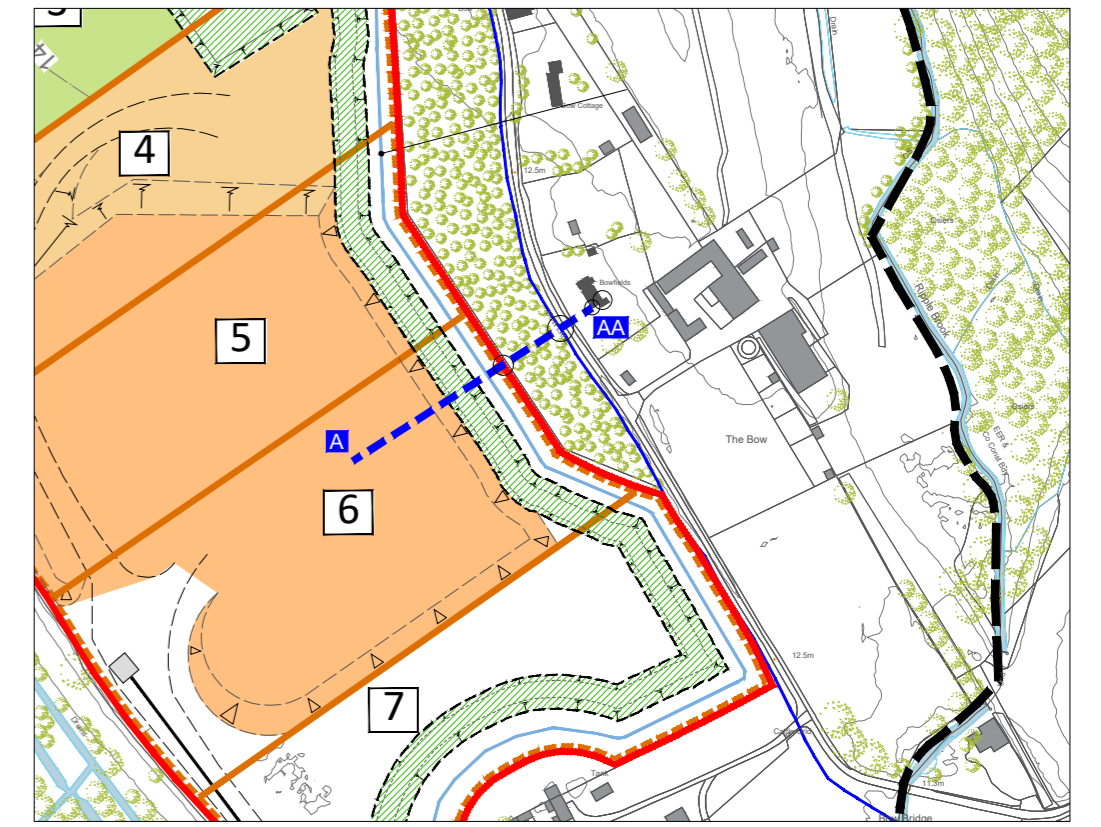
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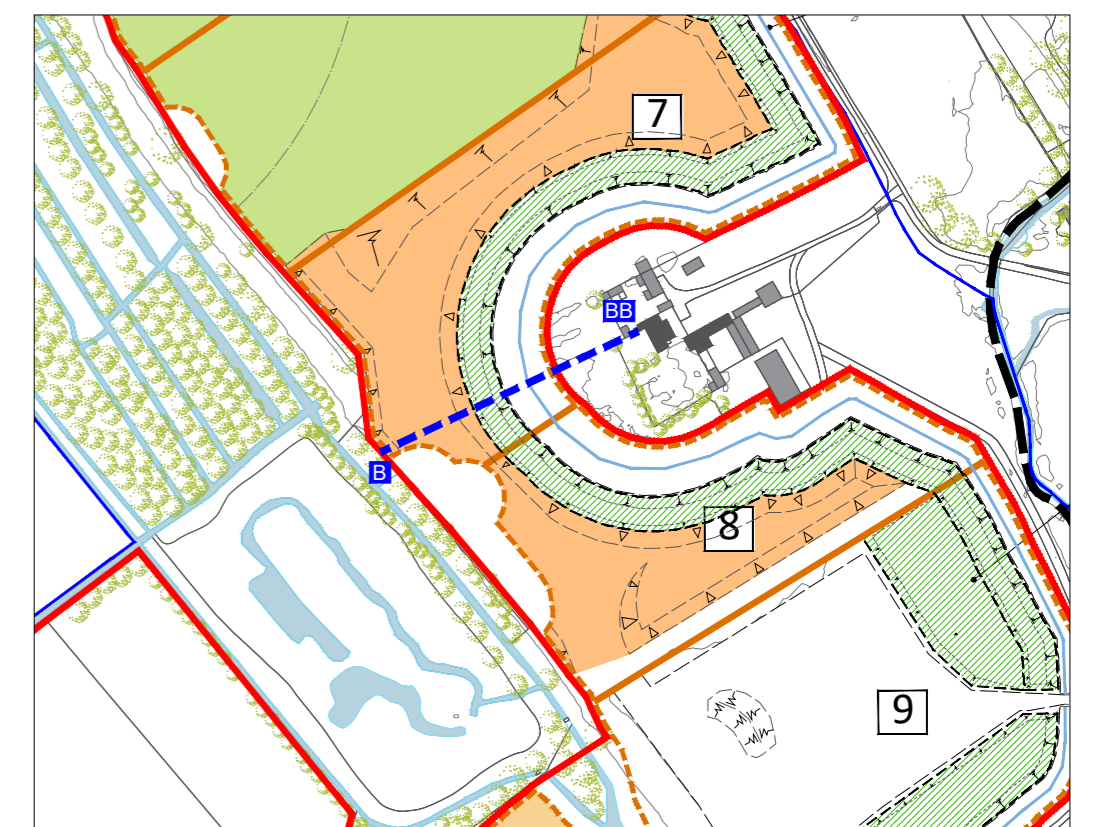
SECTION A - AA: Phase 5 and 6 Extraction
Scale 1:500



SECTION B - BB: Phase 7 and 8 Extraction
Scale 1:500



SECTION A - AA Plan View Scale 1:4,000



SECTION B - BB Plan View Scale 1:4,000

Notes
 Related Drawings: DIA Drawing based on 2636-4-4-2-1-DR-0004-54-P5 Phases 5 and 6 Extraction
 2636-4-4-2-1-DR-0005-54-P5 Phases 7, 8 and 8 Extraction
 LSS MODEL: 2636-5-1-8 BUND & DITCH W SURROUNDING TOPO
 Issue: Drawn by David Jarvis Associates Limited (CROWN COPYRIGHT. ALL RIGHTS RESERVED 2019 LICENCE NUMBER 0100031). This drawing is for Planning purposes only - Do not use this drawing for Construction. The information contained in the drawing should be used as a guide to the final forms and finishes of the landscape scheme. Any revisions to be approved by the Client and Local Authority

Drawing Revision				
Rev.	Date	Description	Drawn	Checked
P1	21/07/2020	First draft issued to client.	MP	AC
P2	27/01/2021	Extraction boundary	MP	AC
P3	08/12/2021	Extraction boundary	MP	AC

Status **FINAL ISSUE**

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Client
M.C. CULLIMORE (GRAVELS) LTD

Project
BOW FARM

Drawing Title
CROSS SECTIONS - INTERCEPTOR DITCH

Scale AS SHOWN	Sheet Size A2	Date 27/01/2021
Client Ref. -	Drawing Ref. 2636-4-4-2-2-DR-0014	Status P3

APPENDIX 4

Processing plant area attenuation pond Source Control outputs

Utton House, Market Street
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Date 19/11/2024 12:57
 File BOW FARM PROCESSING PLA...

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Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.060	0.060	7.8	0.0	7.8	332.8	O K
30 min Summer	0.077	0.077	8.0	0.0	8.0	426.5	O K
60 min Summer	0.095	0.095	8.3	0.0	8.3	523.8	O K
120 min Summer	0.123	0.123	8.7	0.0	8.7	682.4	O K
180 min Summer	0.140	0.140	8.9	0.0	8.9	775.4	O K
240 min Summer	0.151	0.151	9.0	0.0	9.0	837.3	O K
360 min Summer	0.164	0.164	9.2	0.0	9.2	909.9	O K
480 min Summer	0.170	0.170	9.3	0.0	9.3	946.2	O K
600 min Summer	0.173	0.173	9.3	0.0	9.3	962.4	O K
720 min Summer	0.174	0.174	9.3	0.0	9.3	965.7	O K
960 min Summer	0.171	0.171	9.3	0.0	9.3	953.0	O K
1440 min Summer	0.164	0.164	9.2	0.0	9.2	910.1	O K
2160 min Summer	0.155	0.155	9.1	0.0	9.1	860.9	O K
2880 min Summer	0.148	0.148	9.0	0.0	9.0	822.5	O K
4320 min Summer	0.137	0.137	8.9	0.0	8.9	760.5	O K
5760 min Summer	0.128	0.128	8.7	0.0	8.7	709.5	O K
7200 min Summer	0.121	0.121	8.6	0.0	8.6	669.8	O K
8640 min Summer	0.115	0.115	8.6	0.0	8.6	637.1	O K
10080 min Summer	0.110	0.110	8.5	0.0	8.5	610.0	O K
15 min Winter	0.068	0.068	7.9	0.0	7.9	373.8	O K
30 min Winter	0.087	0.087	8.2	0.0	8.2	479.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	46.939	0.0	340.1	0.0	23
30 min Summer	30.355	0.0	440.2	0.0	37
60 min Summer	18.986	0.0	551.6	0.0	66
120 min Summer	12.693	0.0	738.3	0.0	126
180 min Summer	9.856	0.0	860.4	0.0	186
240 min Summer	8.172	0.0	952.0	0.0	244
360 min Summer	6.199	0.0	1083.5	0.0	364
480 min Summer	5.057	0.0	1178.4	0.0	482
600 min Summer	4.302	0.0	1254.0	0.0	602
720 min Summer	3.762	0.0	1315.2	0.0	720
960 min Summer	3.033	0.0	1400.5	0.0	856
1440 min Summer	2.223	0.0	1399.2	0.0	1108
2160 min Summer	1.631	0.0	1712.1	0.0	1500
2880 min Summer	1.316	0.0	1842.6	0.0	1912
4320 min Summer	0.985	0.0	2068.4	0.0	2732
5760 min Summer	0.811	0.0	2270.9	0.0	3568
7200 min Summer	0.706	0.0	2471.0	0.0	4392
8640 min Summer	0.635	0.0	2668.2	0.0	5184
10080 min Summer	0.584	0.0	2860.1	0.0	5952
15 min Winter	46.939	0.0	380.7	0.0	22
30 min Winter	30.355	0.0	493.7	0.0	37

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Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	0.107	0.107	8.5	0.0	8.5	590.9	O K
120 min Winter	0.139	0.139	8.9	0.0	8.9	772.0	O K
180 min Winter	0.158	0.158	9.1	0.0	9.1	879.9	O K
240 min Winter	0.171	0.171	9.3	0.0	9.3	952.8	O K
360 min Winter	0.187	0.187	9.5	0.0	9.5	1041.4	O K
480 min Winter	0.196	0.196	9.6	0.0	9.6	1089.6	O K
600 min Winter	0.200	0.200	9.6	0.0	9.6	1115.3	O K
720 min Winter	0.202	0.202	9.7	0.0	9.7	1127.1	O K
960 min Winter	0.202	0.202	9.6	0.0	9.6	1125.3	O K
1440 min Winter	0.193	0.193	9.5	0.0	9.5	1076.5	O K
2160 min Winter	0.180	0.180	9.4	0.0	9.4	1003.0	O K
2880 min Winter	0.170	0.170	9.3	0.0	9.3	944.9	O K
4320 min Winter	0.151	0.151	9.0	0.0	9.0	840.3	O K
5760 min Winter	0.135	0.135	8.8	0.0	8.8	749.9	O K
7200 min Winter	0.122	0.122	8.7	0.0	8.7	676.8	O K
8640 min Winter	0.111	0.111	8.5	0.0	8.5	614.4	O K
10080 min Winter	0.101	0.101	8.4	0.0	8.4	561.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	18.986	0.0	618.2	0.0	66
120 min Winter	12.693	0.0	827.9	0.0	124
180 min Winter	9.856	0.0	964.4	0.0	182
240 min Winter	8.172	0.0	1066.1	0.0	240
360 min Winter	6.199	0.0	1213.8	0.0	356
480 min Winter	5.057	0.0	1320.7	0.0	472
600 min Winter	4.302	0.0	1404.8	0.0	586
720 min Winter	3.762	0.0	1433.8	0.0	698
960 min Winter	3.033	0.0	1447.0	0.0	914
1440 min Winter	2.223	0.0	1444.3	0.0	1160
2160 min Winter	1.631	0.0	1918.0	0.0	1624
2880 min Winter	1.316	0.0	2063.8	0.0	2080
4320 min Winter	0.985	0.0	2317.3	0.0	2984
5760 min Winter	0.811	0.0	2545.1	0.0	3856
7200 min Winter	0.706	0.0	2767.6	0.0	4680
8640 min Winter	0.635	0.0	2987.6	0.0	5528
10080 min Winter	0.584	0.0	3204.6	0.0	6344

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 387421 236740 SO 87421 36740
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.894

Time (mins) Area
From: To: (ha)

0 8 3.894

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Model Details

Storage is Online Cover Level (m) 1.150

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	5500.0	1.150	6351.0

Orifice Outflow Control

Diameter (m) 0.085 Discharge Coefficient 0.600 Invert Level (m) -0.250

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 0.950

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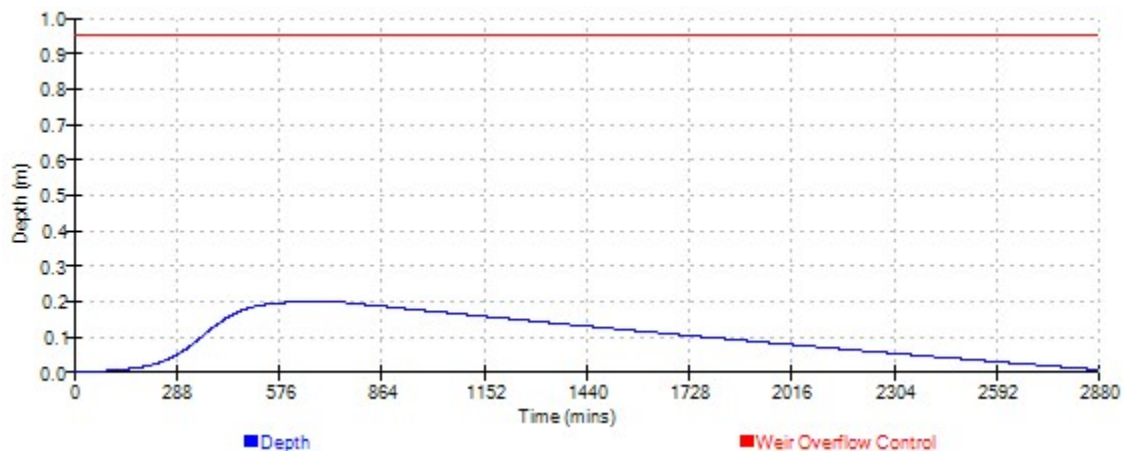
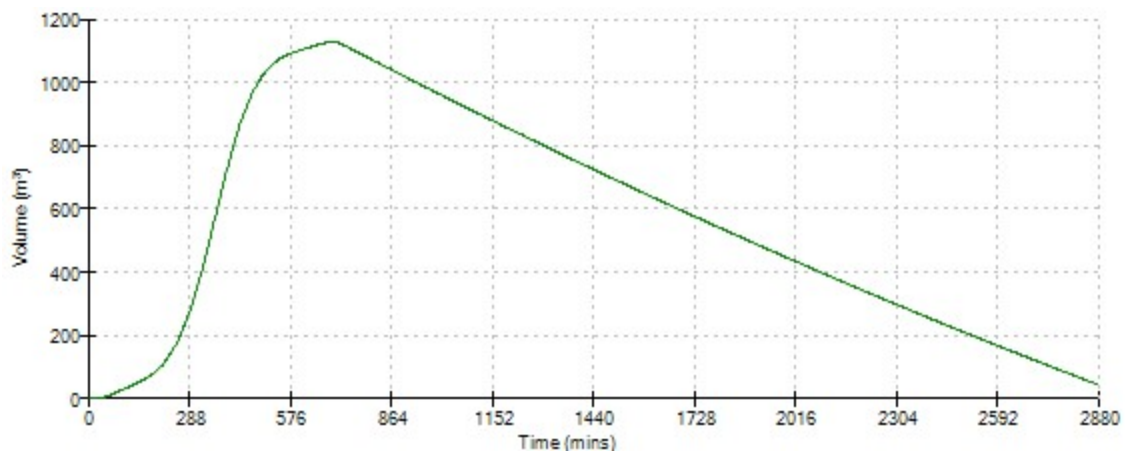
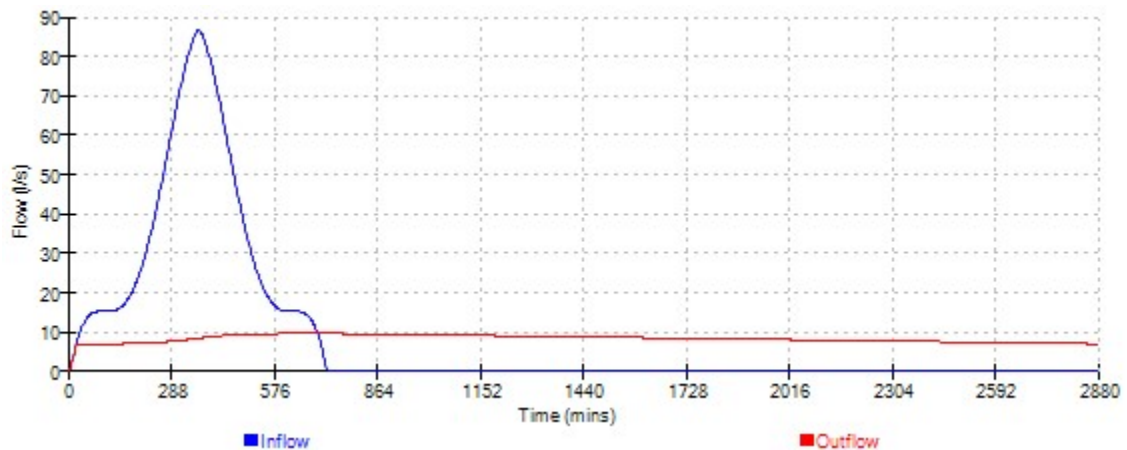
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Source Control 2020.1

Event: 720 min Winter



Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.143	0.143	8.9	0.0	8.9	791.8	O K
30 min Summer	0.187	0.187	9.5	0.0	9.5	1039.0	O K
60 min Summer	0.232	0.232	10.0	0.0	10.0	1292.9	O K
120 min Summer	0.275	0.275	10.5	0.0	10.5	1539.4	O K
180 min Summer	0.300	0.300	10.7	0.0	10.7	1683.5	O K
240 min Summer	0.317	0.317	10.9	0.0	10.9	1780.6	O K
360 min Summer	0.338	0.338	11.1	0.0	11.1	1899.4	O K
480 min Summer	0.349	0.349	11.3	0.0	11.3	1963.5	O K
600 min Summer	0.355	0.355	11.3	0.0	11.3	1997.8	O K
720 min Summer	0.358	0.358	11.3	0.0	11.3	2013.2	O K
960 min Summer	0.357	0.357	11.3	0.0	11.3	2009.6	O K
1440 min Summer	0.344	0.344	11.2	0.0	11.2	1936.3	O K
2160 min Summer	0.324	0.324	11.0	0.0	11.0	1819.0	O K
2880 min Summer	0.307	0.307	10.8	0.0	10.8	1724.3	O K
4320 min Summer	0.288	0.288	10.6	0.0	10.6	1611.3	O K
5760 min Summer	0.275	0.275	10.5	0.0	10.5	1538.9	O K
7200 min Summer	0.267	0.267	10.4	0.0	10.4	1493.9	O K
8640 min Summer	0.261	0.261	10.3	0.0	10.3	1461.7	O K
10080 min Summer	0.258	0.258	10.3	0.0	10.3	1440.6	O K
15 min Winter	0.160	0.160	9.1	0.0	9.1	887.9	O K
30 min Winter	0.209	0.209	9.7	0.0	9.7	1165.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	109.912	0.0	695.9	0.0	23
30 min Summer	72.422	0.0	743.4	0.0	38
60 min Summer	45.444	0.0	1324.5	0.0	68
120 min Summer	27.497	0.0	1521.5	0.0	126
180 min Summer	20.356	0.0	1573.4	0.0	186
240 min Summer	16.383	0.0	1608.5	0.0	246
360 min Summer	11.983	0.0	1652.5	0.0	366
480 min Summer	9.549	0.0	1677.8	0.0	484
600 min Summer	7.987	0.0	1692.8	0.0	604
720 min Summer	6.892	0.0	1701.3	0.0	722
960 min Summer	5.446	0.0	1706.1	0.0	962
1440 min Summer	3.894	0.0	1687.6	0.0	1344
2160 min Summer	2.786	0.0	2927.4	0.0	1688
2880 min Summer	2.208	0.0	3045.0	0.0	2076
4320 min Summer	1.614	0.0	2931.2	0.0	2900
5760 min Summer	1.310	0.0	3670.4	0.0	3744
7200 min Summer	1.127	0.0	3948.0	0.0	4544
8640 min Summer	1.006	0.0	4228.6	0.0	5368
10080 min Summer	0.920	0.0	4511.5	0.0	6160
15 min Winter	109.912	0.0	714.5	0.0	23
30 min Winter	72.422	0.0	766.2	0.0	37

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Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	0.260	0.260	10.3	0.0	10.3	1451.9	O K
120 min Winter	0.309	0.309	10.8	0.0	10.8	1731.8	O K
180 min Winter	0.338	0.338	11.1	0.0	11.1	1897.4	O K
240 min Winter	0.357	0.357	11.3	0.0	11.3	2009.9	O K
360 min Winter	0.381	0.381	11.6	0.0	11.6	2150.3	O K
480 min Winter	0.395	0.395	11.7	0.0	11.7	2229.5	O K
600 min Winter	0.403	0.403	11.8	0.0	11.8	2275.4	O K
720 min Winter	0.407	0.407	11.8	0.0	11.8	2300.6	O K
960 min Winter	0.409	0.409	11.8	0.0	11.8	2312.5	O K
1440 min Winter	0.401	0.401	11.8	0.0	11.8	2261.9	O K
2160 min Winter	0.378	0.378	11.5	0.0	11.5	2129.0	O K
2880 min Winter	0.360	0.360	11.4	0.0	11.4	2024.8	O K
4320 min Winter	0.329	0.329	11.0	0.0	11.0	1851.2	O K
5760 min Winter	0.309	0.309	10.8	0.0	10.8	1734.2	O K
7200 min Winter	0.294	0.294	10.7	0.0	10.7	1646.6	O K
8640 min Winter	0.281	0.281	10.5	0.0	10.5	1576.6	O K
10080 min Winter	0.272	0.272	10.4	0.0	10.4	1520.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	45.444	0.0	1483.6	0.0	66
120 min Winter	27.497	0.0	1582.9	0.0	124
180 min Winter	20.356	0.0	1638.6	0.0	184
240 min Winter	16.383	0.0	1676.1	0.0	242
360 min Winter	11.983	0.0	1722.8	0.0	360
480 min Winter	9.549	0.0	1749.3	0.0	476
600 min Winter	7.987	0.0	1764.7	0.0	592
720 min Winter	6.892	0.0	1773.3	0.0	708
960 min Winter	5.446	0.0	1776.8	0.0	936
1440 min Winter	3.894	0.0	1753.6	0.0	1374
2160 min Winter	2.786	0.0	3208.8	0.0	1776
2880 min Winter	2.208	0.0	3198.3	0.0	2216
4320 min Winter	1.614	0.0	3096.8	0.0	3120
5760 min Winter	1.310	0.0	4108.3	0.0	4040
7200 min Winter	1.127	0.0	4422.4	0.0	4904
8640 min Winter	1.006	0.0	4735.8	0.0	5792
10080 min Winter	0.920	0.0	5054.8	0.0	6656

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 387421 236740 SO 87421 36740
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.894

Time (mins)	Area
From:	To: (ha)
0	8 3.894

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Model Details

Storage is Online Cover Level (m) 1.150

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	5500.0	1.150	6351.0

Orifice Outflow Control

Diameter (m) 0.085 Discharge Coefficient 0.600 Invert Level (m) -0.250

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 0.950

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File BOW FARM PROCESSING PLA...

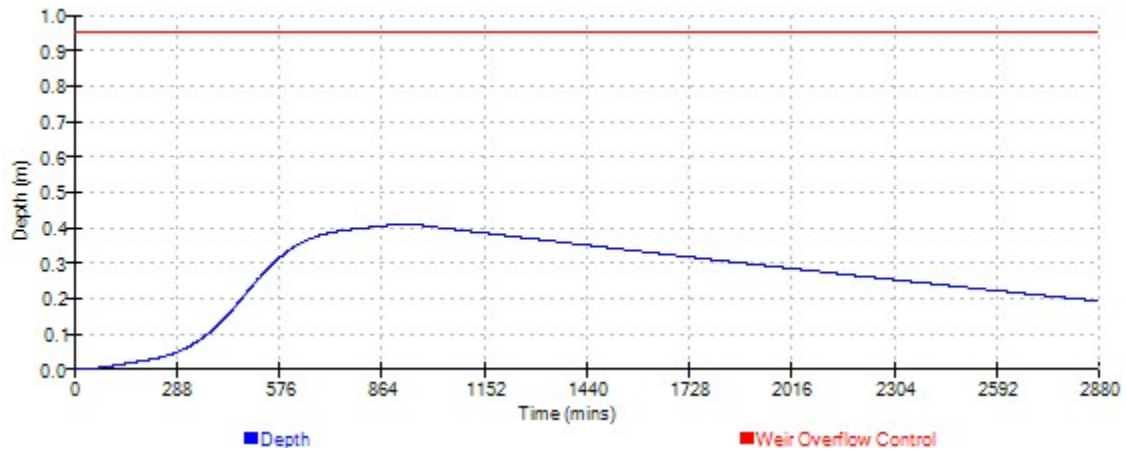
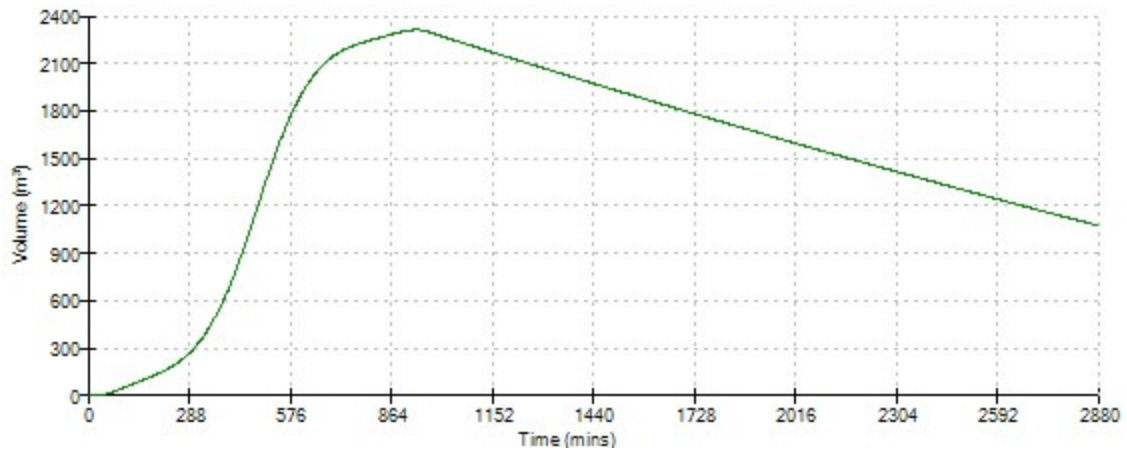
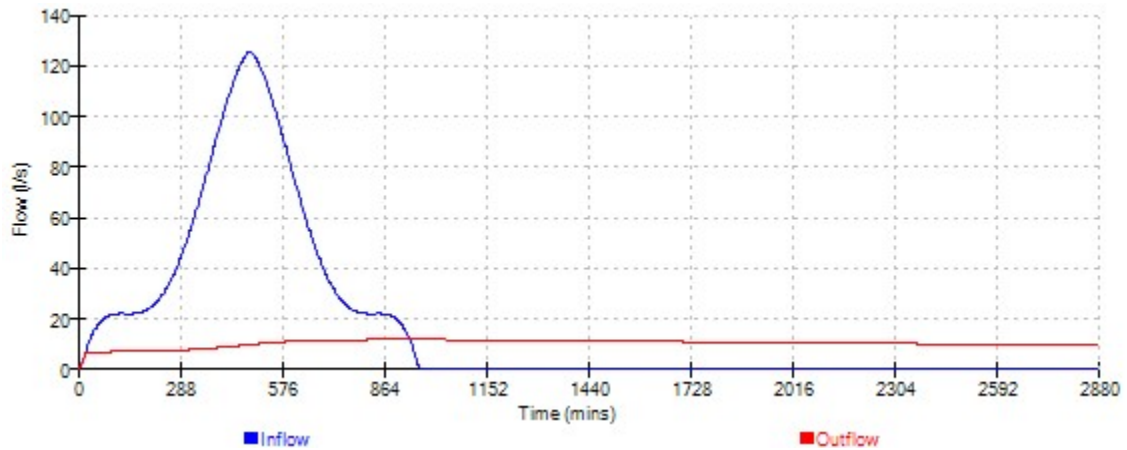
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Innovyze

Source Control 2020.1

Event: 960 min Winter



Utton House, Market Street
 Charlbury
 Oxfordshire, OX7 3PJ



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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.192	0.192	9.5	0.0	9.5	1070.9	O K
30 min Summer	0.253	0.253	10.2	0.0	10.2	1413.1	O K
60 min Summer	0.318	0.318	10.9	0.0	10.9	1782.8	O K
120 min Summer	0.373	0.373	11.5	0.0	11.5	2102.2	O K
180 min Summer	0.405	0.405	11.8	0.0	11.8	2284.8	O K
240 min Summer	0.425	0.425	12.0	0.0	12.0	2404.8	O K
360 min Summer	0.450	0.450	12.2	0.0	12.2	2546.9	O K
480 min Summer	0.463	0.463	12.3	0.0	12.3	2621.1	O K
600 min Summer	0.469	0.469	12.4	0.0	12.4	2659.6	O K
720 min Summer	0.472	0.472	12.4	0.0	12.4	2676.0	O K
960 min Summer	0.471	0.471	12.4	0.0	12.4	2668.8	O K
1440 min Summer	0.455	0.455	12.3	0.0	12.3	2576.1	O K
2160 min Summer	0.426	0.426	12.0	0.0	12.0	2406.8	O K
2880 min Summer	0.402	0.402	11.8	0.0	11.8	2269.8	O K
4320 min Summer	0.370	0.370	11.5	0.0	11.5	2086.3	O K
5760 min Summer	0.351	0.351	11.3	0.0	11.3	1975.7	O K
7200 min Summer	0.340	0.340	11.2	0.0	11.2	1913.4	O K
8640 min Summer	0.334	0.334	11.1	0.0	11.1	1874.6	O K
10080 min Summer	0.330	0.330	11.1	0.0	11.1	1852.5	O K
15 min Winter	0.215	0.215	9.8	0.0	9.8	1200.5	O K
30 min Winter	0.283	0.283	10.6	0.0	10.6	1584.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	148.200	0.0	748.8	0.0	23
30 min Summer	98.102	0.0	809.1	0.0	38
60 min Summer	62.287	0.0	1594.3	0.0	68
120 min Summer	37.208	0.0	1696.8	0.0	128
180 min Summer	27.291	0.0	1753.5	0.0	186
240 min Summer	21.800	0.0	1790.1	0.0	246
360 min Summer	15.755	0.0	1833.2	0.0	366
480 min Summer	12.442	0.0	1855.6	0.0	484
600 min Summer	10.330	0.0	1867.1	0.0	604
720 min Summer	8.859	0.0	1871.8	0.0	724
960 min Summer	6.933	0.0	1868.4	0.0	962
1440 min Summer	4.886	0.0	1834.0	0.0	1440
2160 min Summer	3.443	0.0	3364.5	0.0	1792
2880 min Summer	2.697	0.0	3337.4	0.0	2160
4320 min Summer	1.938	0.0	3197.9	0.0	2944
5760 min Summer	1.553	0.0	4352.1	0.0	3800
7200 min Summer	1.327	0.0	4647.4	0.0	4616
8640 min Summer	1.178	0.0	4952.3	0.0	5448
10080 min Summer	1.074	0.0	5264.2	0.0	6256
15 min Winter	148.200	0.0	772.2	0.0	23
30 min Winter	98.102	0.0	837.5	0.0	37

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	0.355	0.355	11.3	0.0	11.3	2000.4	O K
120 min Winter	0.418	0.418	11.9	0.0	11.9	2362.3	O K
180 min Winter	0.454	0.454	12.3	0.0	12.3	2570.9	O K
240 min Winter	0.478	0.478	12.5	0.0	12.5	2708.8	O K
360 min Winter	0.506	0.506	12.7	0.0	12.7	2876.0	O K
480 min Winter	0.522	0.522	12.9	0.0	12.9	2966.8	O K
600 min Winter	0.530	0.530	13.0	0.0	13.0	3017.5	O K
720 min Winter	0.535	0.535	13.0	0.0	13.0	3043.6	O K
960 min Winter	0.536	0.536	13.0	0.0	13.0	3051.7	O K
1440 min Winter	0.524	0.524	12.9	0.0	12.9	2982.3	O K
2160 min Winter	0.495	0.495	12.6	0.0	12.6	2808.5	O K
2880 min Winter	0.468	0.468	12.4	0.0	12.4	2654.1	O K
4320 min Winter	0.428	0.428	12.0	0.0	12.0	2422.2	O K
5760 min Winter	0.398	0.398	11.7	0.0	11.7	2248.6	O K
7200 min Winter	0.380	0.380	11.6	0.0	11.6	2140.0	O K
8640 min Winter	0.366	0.366	11.4	0.0	11.4	2059.3	O K
10080 min Winter	0.355	0.355	11.3	0.0	11.3	1999.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	62.287	0.0	1661.8	0.0	66
120 min Winter	37.208	0.0	1771.8	0.0	126
180 min Winter	27.291	0.0	1832.2	0.0	184
240 min Winter	21.800	0.0	1871.2	0.0	242
360 min Winter	15.755	0.0	1916.7	0.0	360
480 min Winter	12.442	0.0	1939.9	0.0	478
600 min Winter	10.330	0.0	1951.5	0.0	594
720 min Winter	8.859	0.0	1955.9	0.0	710
960 min Winter	6.933	0.0	1950.8	0.0	940
1440 min Winter	4.886	0.0	1910.8	0.0	1388
2160 min Winter	3.443	0.0	3542.5	0.0	2012
2880 min Winter	2.697	0.0	3505.8	0.0	2276
4320 min Winter	1.938	0.0	3364.8	0.0	3200
5760 min Winter	1.553	0.0	4874.9	0.0	4096
7200 min Winter	1.327	0.0	5204.8	0.0	4976
8640 min Winter	1.178	0.0	5545.3	0.0	5880
10080 min Winter	1.074	0.0	5700.7	0.0	6760

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 387421 236740 SO 87421 36740
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.894

Time (mins)		Area
From:	To:	(ha)
0	8	3.894

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Model Details

Storage is Online Cover Level (m) 1.150

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	5500.0	1.150	6351.0

Orifice Outflow Control

Diameter (m) 0.085 Discharge Coefficient 0.600 Invert Level (m) -0.250

Weir Overflow Control

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 0.950

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