



Swarth Moor
Yorkshire Dales National Park
DRAGONFLY HABITAT ENHANCEMENT PLAN

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February 2024
Updated April 2025

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Introduction to this Report

This document is in five parts.

Part 1 summarises the site and give details on its location, designations, ownership & tenancy, recent management history, current management, agri-environment scheme details and key contacts.

Part 2 we aim to apply the habitat requirements from the literature review to assess a target site in Yorkshire for its suitability for white-faced darters. The target site is Swarth Moor, a lowland raised bog in North Yorkshire (see Figure 1.1).

We first carried out a series of habitat surveys to collect data on these factors: 1) vegetation structure, 2) peat depths, 3) pH, 4) electrical conductivity, 5) water depths, 6) water flow, and 7) nitrate and phosphate levels.

We then describe how we carried out an aquatic invertebrate survey to collect data on these factors: 1) aquatic invertebrate abundance and diversity as prey, and 2) presence of fish and amphibians as predators.

Part 3 is a detailed Dragonfly Habitat Enhancement Plan for Swarth Moor. The Habitat Enhancement Plan sets out in full the restoration works needed and a timetable for completing the works. It is intended that the Habitat Enhancement Plan will be used, without significant editing, as a detailed specification attached to contract documentation that will be used to seek tenders for carrying out the peatland restoration works described.

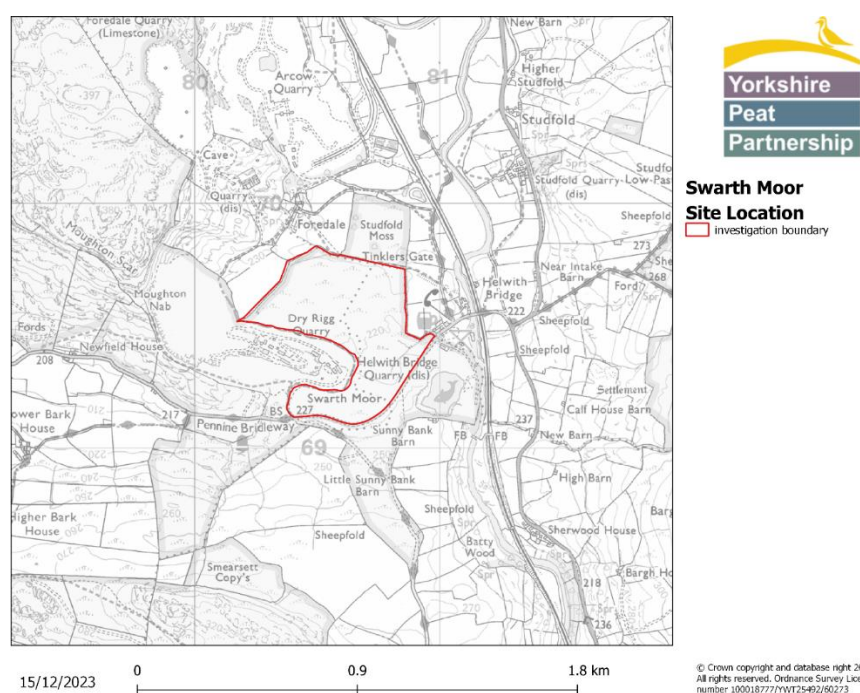


Figure 1.1 – Site Location of Swarth Moor

PART 1: BACKGROUND

1.1. GENERAL SITE LOCATION

Swarth Moor is situated within the parishes of Stainforth and Austwick in the west of the Yorkshire Dales National Park. It covers an area of approximately 29 hectares and the OS Grid Reference for the centre of the site is SD806695 (Figure 1.1).

Swarth Moor lies within Swarth Moor SSSI. The condition of the Raised Bog is designated by Natural England as being 'unfavourable - recovering', and the southern Fen area designated 'favourable'.

Swarth Moor is a lowland raised bog boarded by a large quarry, farmland and a road. It is much smaller now than its historical extent and has historically had drainage cut into it. There has been little management beyond grazing which has all but ceased.

In 2020, Swarth Moor benefited from a rewetting project. This involved cell-bunding in a grid pattern across the centre of the bog to slow the flow of water escaping the peat dome (see Figure 1.2). This is working well and seems to be increasing the cotton grasses coverage and decreasing the *Molinia* grass coverage. Three ponds were created as mitigation for the great crested newts on site, shown as three small ponds in the south of the site (Figure 1.2).

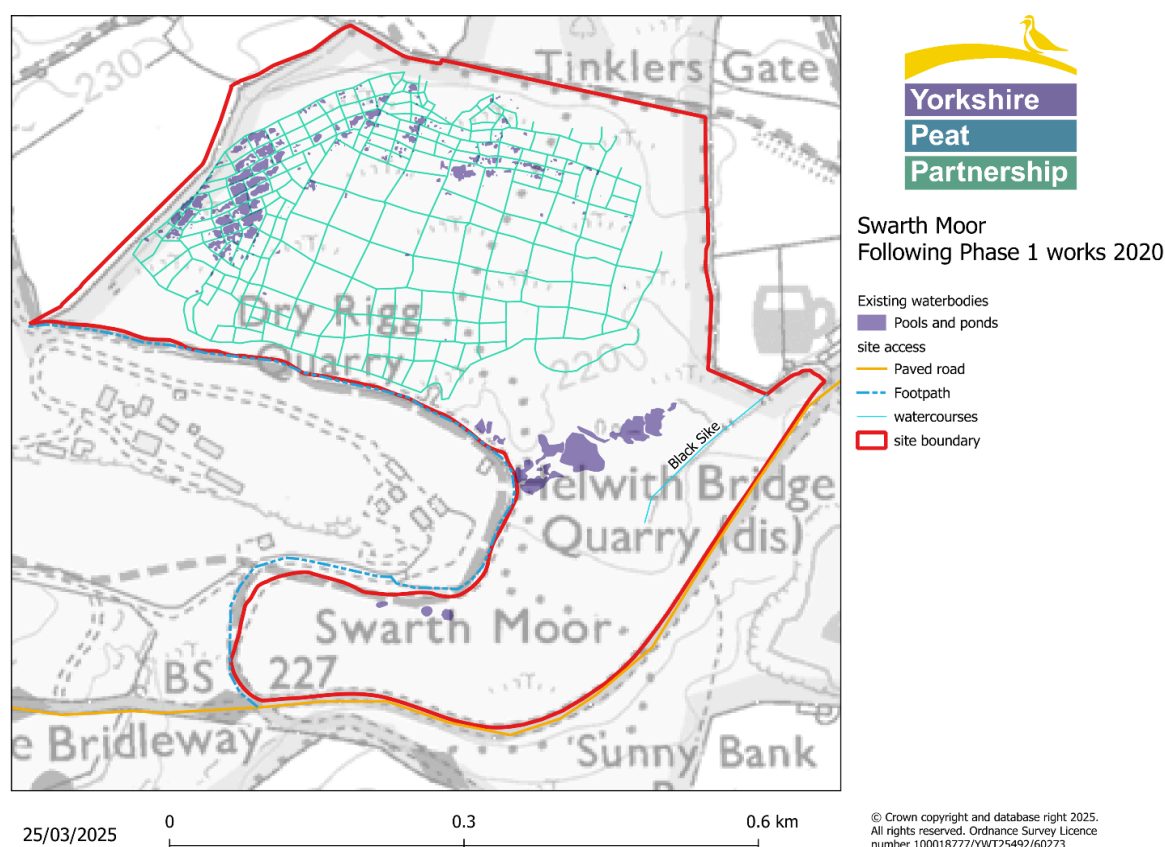


Figure 1.2: Swarth Moor cell-bunding and waterbodies, following the phase 1 restoration works in 2020.

1.2. DESIGNATIONS

1.2.1. National

1.2.1.1. *Sites of Special Scientific Interest (SSSI)*

Swarth Moor lies within Swarth Moor SSSI. The condition of the Raised Bog is designated by Natural England as being 'unfavourable - recovering', and the southern Fen area designated 'favourable'.

1.2.1.2. *National Park*

Swarth Moor lies within Yorkshire Dales National Park.

1.3. OWNERSHIP & TENANCY

Swarth Moor is split into a couple of land parcels: the dome and southern fen area are owned by Natural England, and managed by Ingleborough NNR, and central parcel is privately owned.

1.4. RECENT MANAGEMENT HISTORY

Swarth Moor is a lowland raised bog boarded by a large quarry, farmland and a road. It is much smaller now than its historical extent and has historically had drainage cut into it.

There has been little management beyond grazing which has all but ceased.

There are four known active grazing rights held for Swarth Moor. There is no livestock grazing on site but there are several roe deer frequently seen on site.

In 2023 the fen area was surveyed and a hydrological restoration plan written through funding by Natural England.

1.5. CURRENT MANAGEMENT

Swarth Moor has recently benefited from a rewetting project funded by the quarry owner, Tarmac, the Stories in Stone project and Natural England. This involved bunding across the centre of the bog to hold back water. This is working well and seems to be increasing the cotton grasses and decreasing the Molinia.

There is no livestock grazing on site but there are a number of roe deer frequently on site.

The site is managed by NE and their staff at the Ingleborough NNR who, with local volunteers, manage the scrub that is increasing on the site.

The work on the fen area was carried out in autumn 2024 also with funding from Natural England, overseen by Yorkshire Peat Partnership.

PART 2: SURVEY REPORT

Swarth Moor was surveyed by Yorkshire Peat Partnership between 5th September to 20th December 2023 in order to carry out an initial Habitat Suitability survey.

The survey which was broken down into 4 parts as follows:

2.1 UAV survey

The site was fully surveyed on the 05/09/2023 using a DJI Mavic 3 Enterprise equipped with a 4/3 CMOS 20MP RGB sensor at a resolution of 2.5cm/per pixel. An orthomosaic and digital surface model (DSM) were generated from the data using PIX4D Mapper photogrammetry software.

The resulting data was used to investigate the vegetation structure of the site, in particular to look at: proximity of waterbodies to 'tree roosts', and proximity of waterbodies to 'shrub shelter', pond surface vegetation, pond emergent vegetation, and the watershed i.e. water flow paths on the site.

2.2 Pre-survey

The Pre-Survey is the initial desk-based survey using aerial photographs and data from the UAV survey. Target areas for the habitat field survey were mapped out around existing waterbodies and scrub patches (Figure 2.1). The centre of the raised dome was generally avoided during survey activities because cell-bunding had already been successfully implemented here for restoration of the raised bog hydrology.

2.3 Habitat field survey

Information was recorded with the Mergin Maps software onto a smart tablet about the vegetation species coverage within the existing waterbodies and the cover within an 5m buffer of the waterbodies. Other data recorded were peat depth, water depth, waterbody size and the overall vegetation community. Previous data from the survey delivered by Yorkshire Peat Partnership in April 2023 was consolidated with the data from this survey to give full peat depth maps.

Additionally, measurements were taken in areas of standing water for: pH, electrical conductivity (EC), nitrate NO₃ levels, and phosphate PO₄ levels.

The data gathered is used in the final stage of the survey to determine the type of work required to enhance the dragonfly habitat on the site.

2.4 Post-survey

With the field survey data uploaded to QGIS, Voronoi polygon maps and proximity heat maps were created to show how the biotic (e.g. vegetation structure) and abiotic factors (e.g. acidity, water depth, watershed) changed across the site.

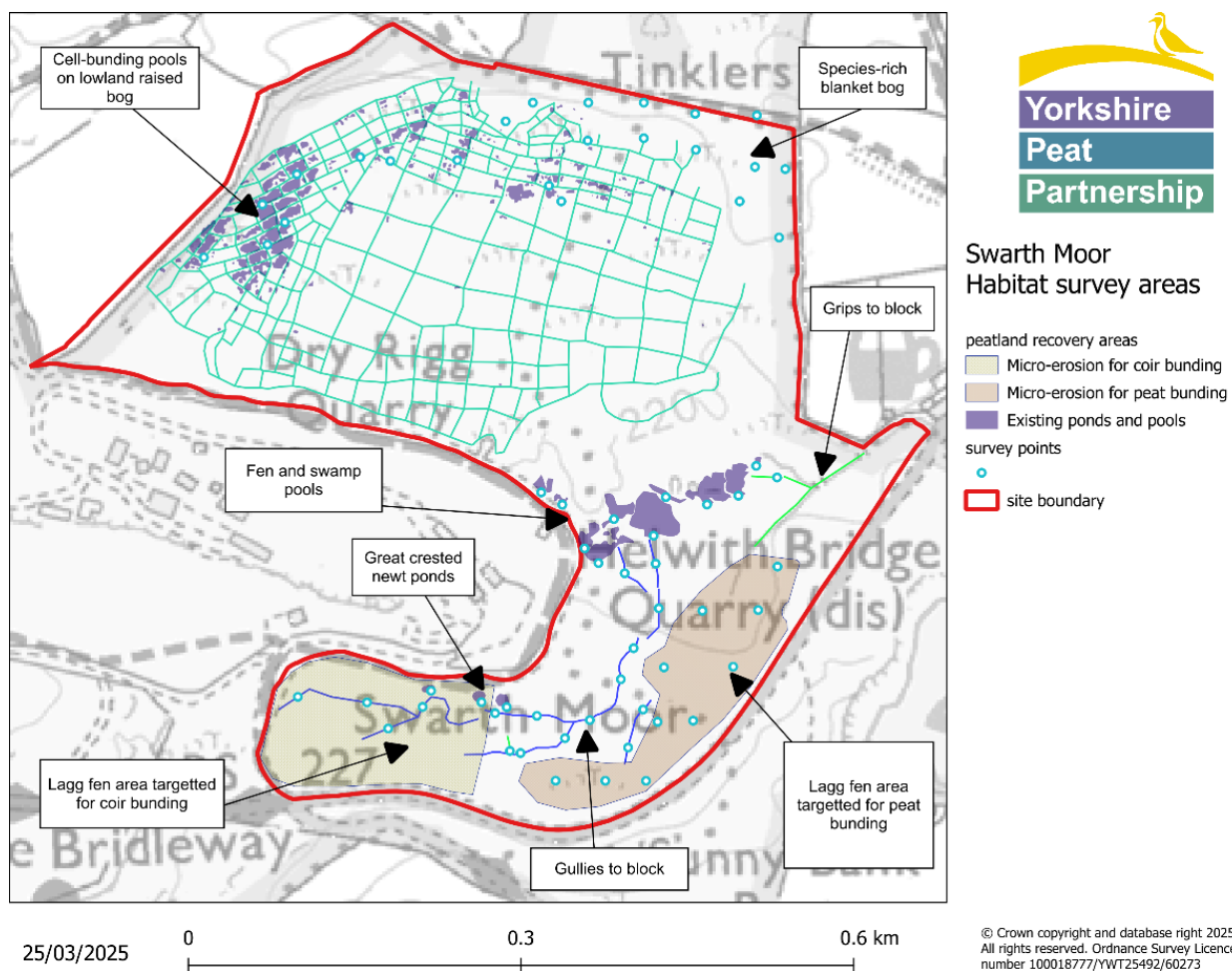


Figure 2.1 - Habitat suitability survey areas

2.5 RESULTS

2.5.1 Vegetation Structure

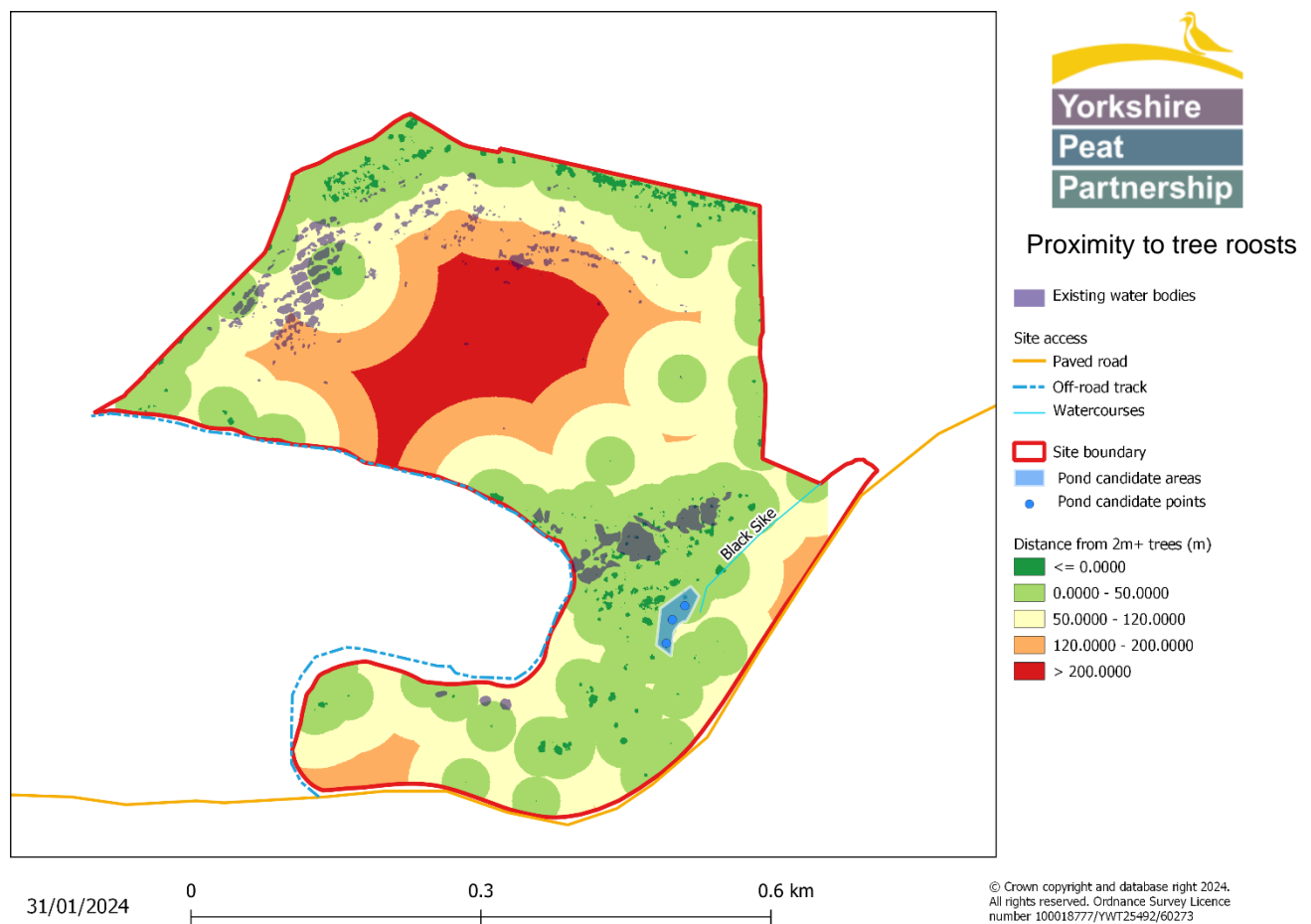


Figure 2.2 - Proximity to 'tree roosts' over 2m in height

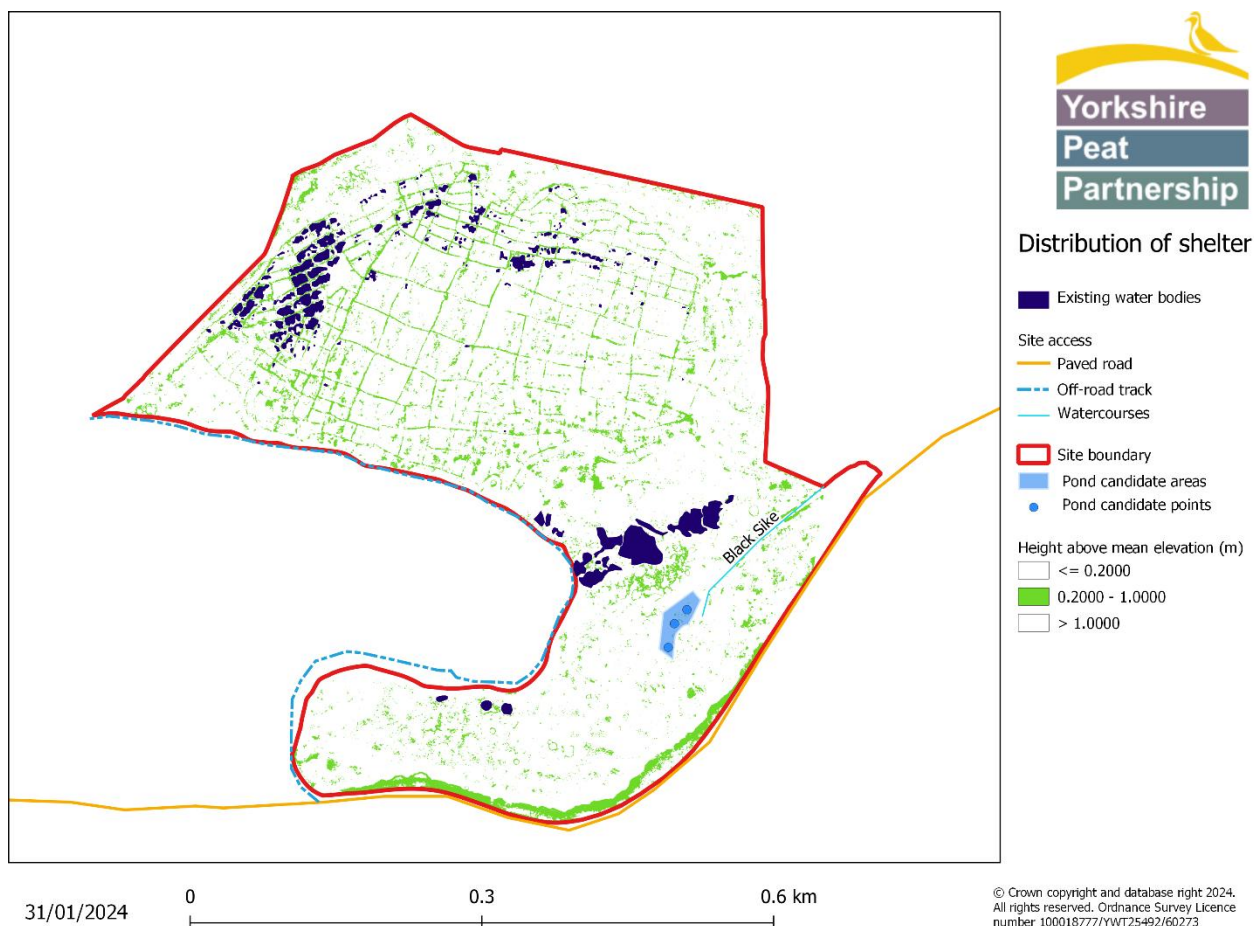


Figure 2.3 - Distribution of 'shrub shelter', vegetation 20-100cm in height

Figure 2.2 shows that all existing waterbodies have some 'tree roosts' (as defined as trees/scrub over 2m tall) surrounding and/or close to them.

Figure 2.3 indicates that 'shrub shelter' (defined as vegetation between 0.2-1.0m tall) is spread across the site with greater density in some specific areas, which are likely to be more suitable.

L. dubia prefers to breed in waterbodies within 50m of tree roosts, but they have been observed traveling up to 120m between water and roost areas. An emerging dragonfly's maiden flight to shrub shelter, on the other hand, can be a short distance away up to 2-3m. Newly emerged dragonflies 'tenerals' on their maiden flight need to fly towards shelter quickly, to prevent avian predators (e.g. Reed buntings) from catching tenerals on their first flight.

2.5.2 Peat Depths

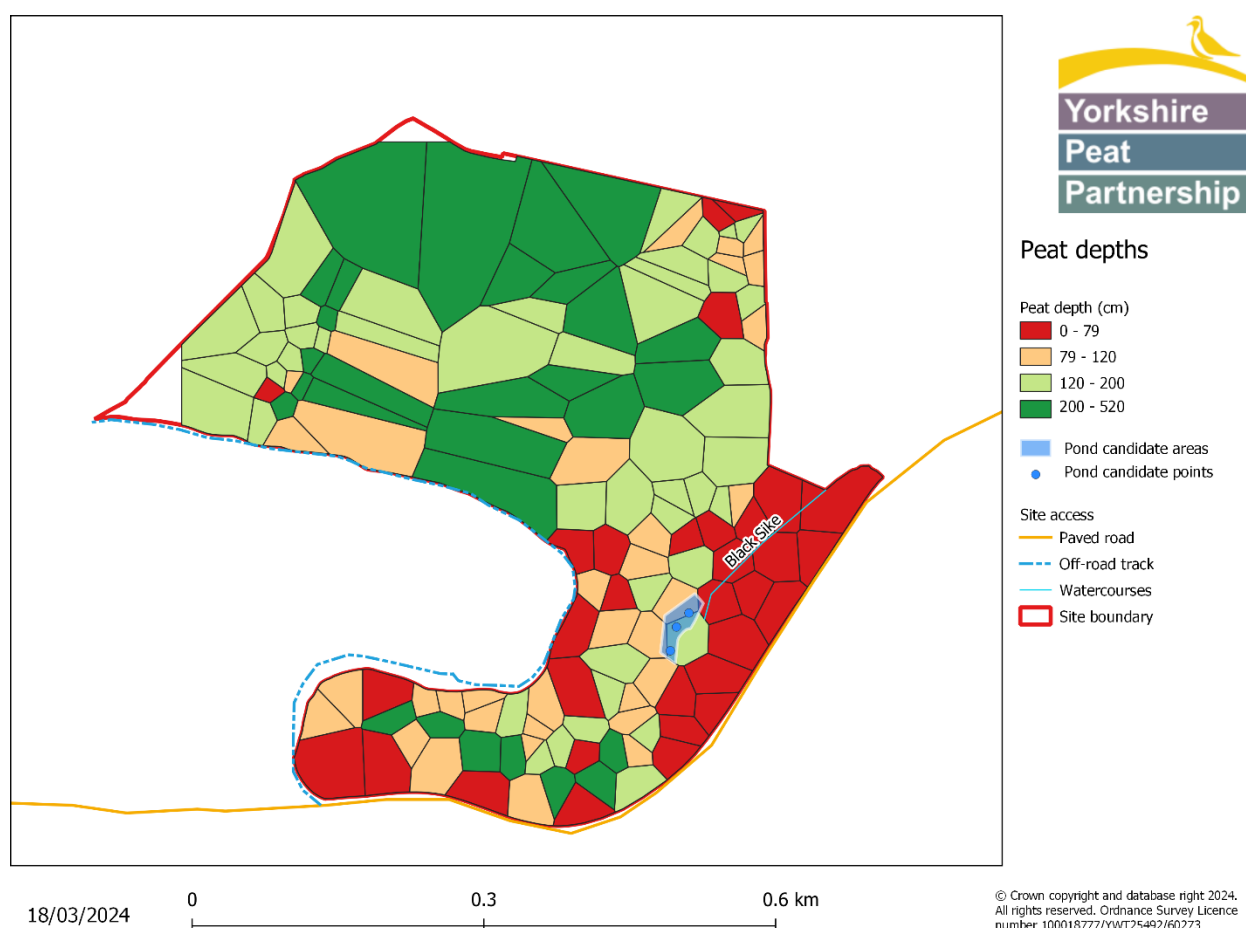


Figure 2.4 - Peat depths, extrapolated from field points using Voronoi polygons.

The greatest peat depth found on site was 5.2 meters in the top centre of the dome, with the average peat depth being higher on the northern half of the site. The British Dragonfly Society recommends providing ponds at least 1m deep for *L. dubia*, although they have successfully breed in pools and ditches of 47cm in depth in Chartley Moss in Staffordshire with 67cm being the most ideal in this paper (T. Beynon, 2001); more research is needed to accurately map the depths at which this species prefers to breed. Our research and the expert advice we were given led us to view that the ponds need to be at least 70cm deep with a peat substrate base. Therefore, the peat depth needs to be at least this deep to create suitable pools.

2.5.3 pH

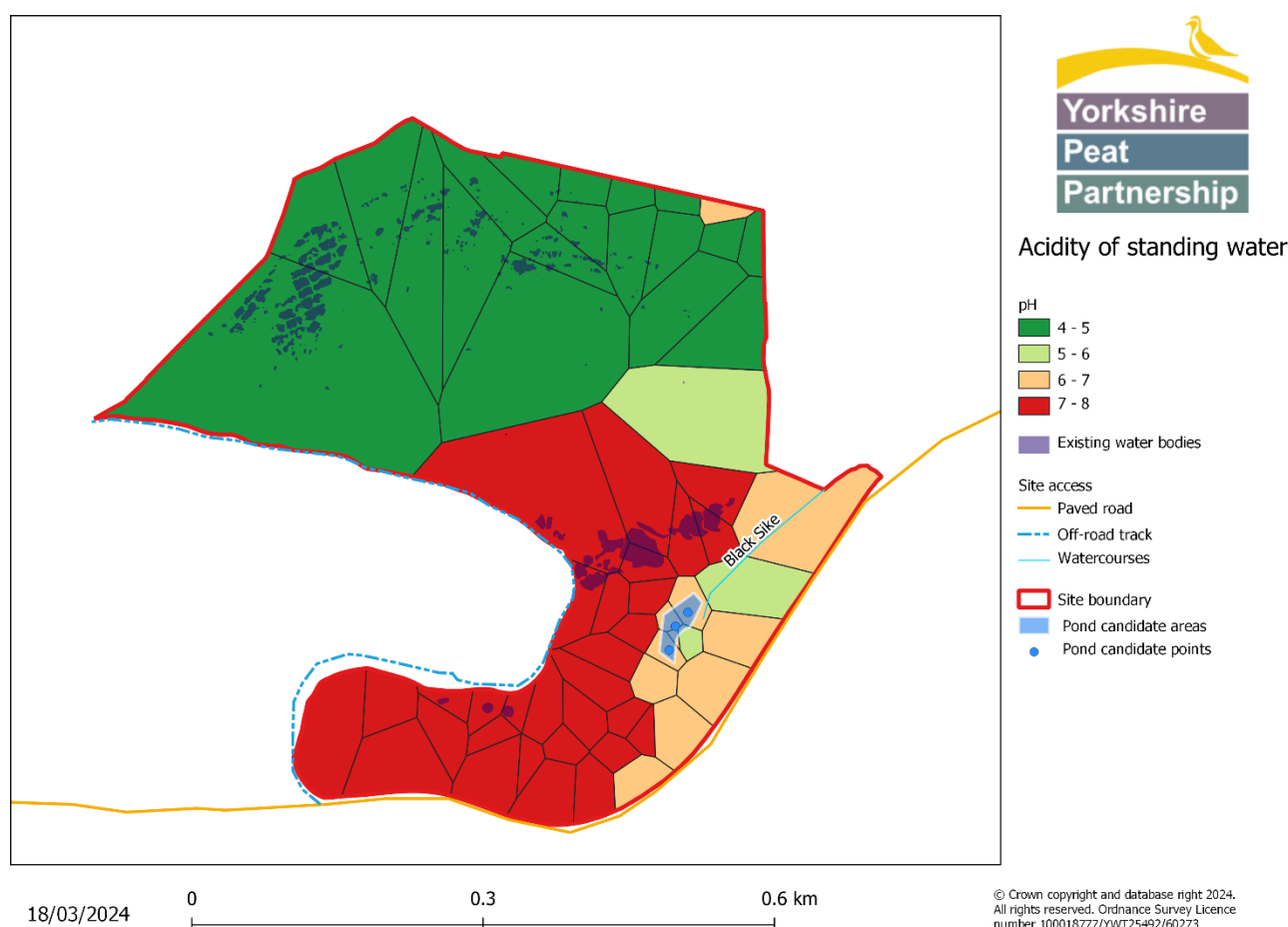


Figure 2.5 - pH of standing water, extrapolated from field points using Voronoi polygons.

As demonstrated in Figure 2.5 there's a significant difference in pH between the northern and southern half of the site. Acidity was greatest in the north at between 4.0-6.0 pH and lowest along the southwest edge at 6.0-8.0 pH. On a healthy raised bog, the pH is below 6.0. It is natural for an area of lagg fen to be more base-rich than the neighbouring bog but the extent of it across the southern half of the site is likely to be influenced by the neighbouring land use and the watercourse running south-west to north-east across the south of the site.

L. dubia can tolerate pH levels as low as 3, whereas most potential predator species (such as fish or newt efts) cannot survive and/or reproduce lower than 5. Additionally, great crested newts favour ponds above pH 6. *L. dubia* requires *Sphagnum cuspidatum* for oviposition, a species with the ability to lower the pH of the water around it by manipulating ions – any ponds created would benefit from *S. cuspidatum* inoculation.

The ideal pH for the pond area would be <6.0, but 6-7 is acceptable because fish have not been recorded on site and with *S. cuspidatum* inoculation any newt species should be deterred.

2.5.4 Electrical Conductivity

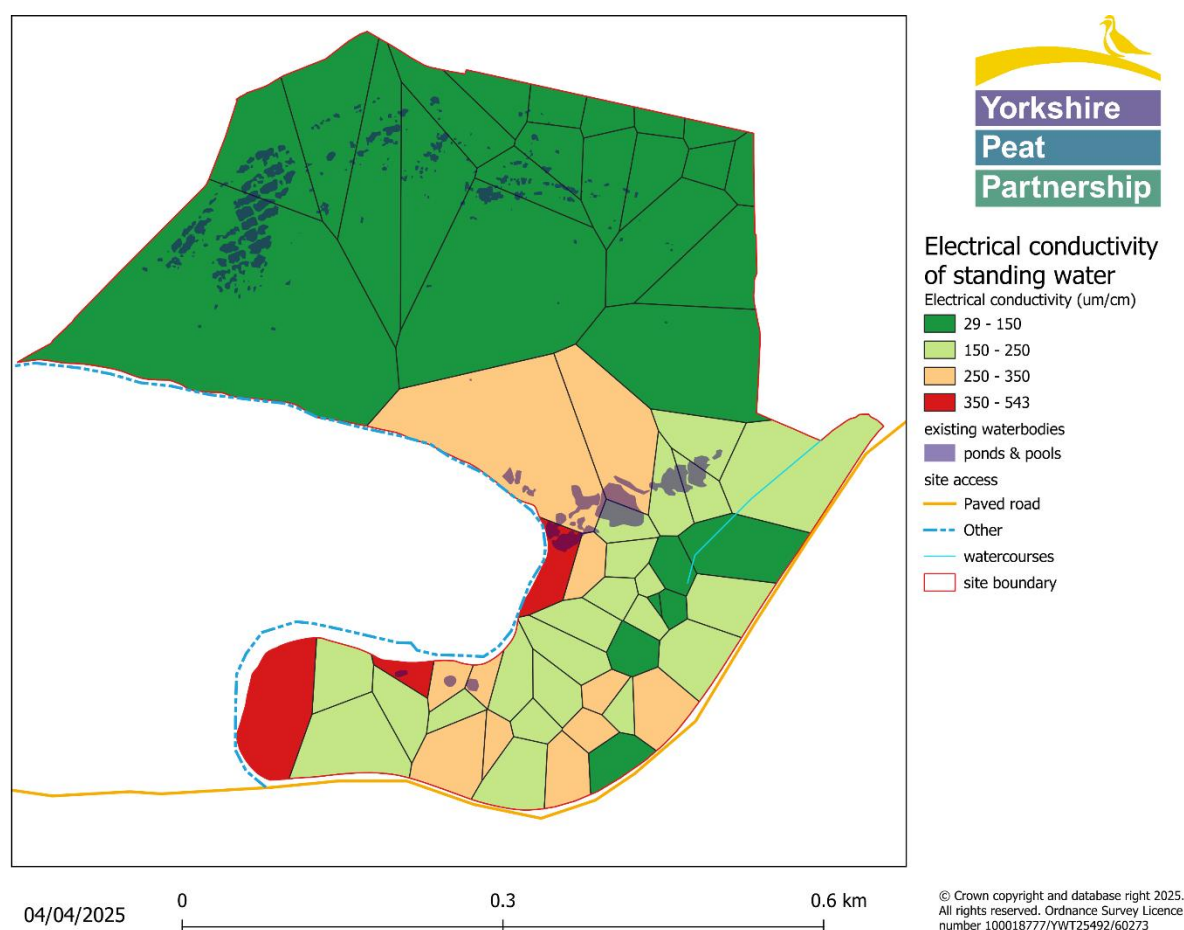


Figure 2.6 - Electrical conductivity of standing water, extrapolated from field points using Voronoi polygons.

Electrical conductivity (EC) is lowest around the mound of the raised bog, which is to be expected from an ombrotrophic bog, i.e. minerals and nutrients only enter the habitat through precipitation; likewise, the EC is relatively higher in the fen area because it is minerotrophic: i.e. nutrients are also brought in from ground water. All of the areas surveyed are within the range that *L. dubia* can be found successfully breeding; a conductivity below $250 \mu\text{S}/\text{cm}$ is a good target for ponds, above $600 \mu\text{S}/\text{cm}$ are not ideal for ponds. The highest EC recordings were measured closest to the edge of the quarry bank, so this could indicate that some polluting ionic compounds are reaching the site from the quarry, or mineral-rich groundwater naturally seeping into the fen.

By measuring the EC across the site, we have been able to use it as a proxy of measuring nutrient levels in the water. The vegetation *L. dubia* is closely associated with can be outcompeted by more vigorous species when nutrient levels are high, so for them, lower is better.

2.5.5 Water depth

Waterbody (as labelled in Figure 2.1)	Water depth (cm)	
	Range	Mean
<i>Cell-bunding pools on lowland raised bog</i>	10-40	28.3
<i>Fen and swamp pools</i>	10-65	36.25
<i>Great crested newt ponds</i>	40-60	50
<i>Lagg fen area for coir bunding</i>	8-20	13.25
<i>Lagg fen area for peat bunding</i>	0	0
<i>Gullies to block</i>	0-65	24.32
<i>Grips to block</i>	5-35	20
<i>Species-rich blanket bog</i>	0-10	5

Table 2.1 - Water depths of existing waterbodies

The waterbodies already in existence on the target site range from a minimum of 5cm of shallow water, up to 65cm deep in the fen pools.

N.B. Grips and gullies to be blocked were also included in the 'water depths' recorded, although at the time of the survey they had not been blocked and so would not be classed as permanent waterbodies, however the planned restoration would result in standing water as potentially permanent waterbodies.

As discussed in the literature review, the average pond depth in the literature for *L. dubia* presence is 1.0m, with a confidence interval ($\pm 1\sigma$) of 0.5-1.92m, and so a depth of above 0.5m would be acceptable, and above 1.0m would be ideal.

However, the existing waterbodies with depth 65cm did not have the correct abiotic conditions, therefore new ponds would need to be constructed to meet the pond depth and abiotic requirements.

2.5.6 Watershed

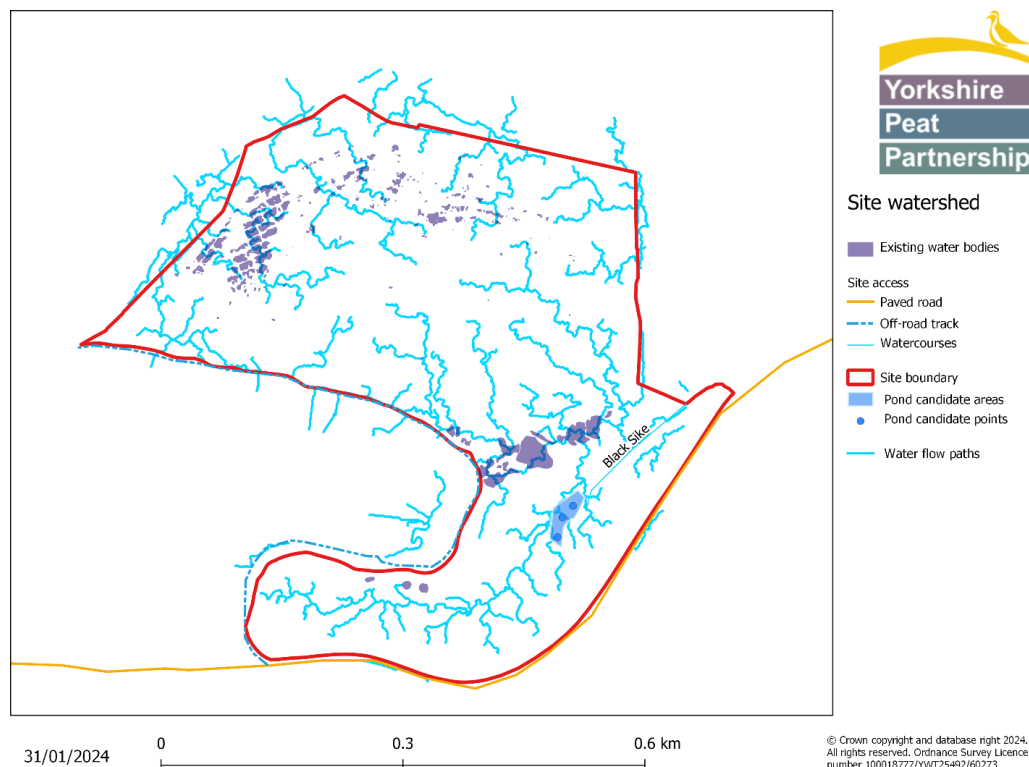


Figure 2.7 - Swarth Moor watershed

The flow paths mapped from UAV data show that the northernmost part of the site is hydrologically isolated from the rest of the site, which is to be expected with a raised dome. This separation offers an explanation to the significant contrasts in pH and EC figures between the areas. A bog receives all its water from precipitation (i.e. rainwater fed) and so is described as 'ombrotrophic'.

The rest of the site will be receiving rainwater, but it also receives groundwater which will be seeping out of the ground, enriching the southern 'lagg fen' and the central 'fen pools' with mineral deposits, creating the different vegetative communities. These fens are described as 'minerotrophic'.

Currently, most of the water on site flows into the drain named "Black Sike". This has resulted in the water table of the lagg fen and peat dome being lowered, and consequently purple moor grass *Molinia* has spread across the site as it prefers drier conditions.

The flow paths confirm that the grips and gullies are all draining into Black Sike and off-site. The peat restoration work planned will block the grips and gullies, including Black Sike, and thus will slow the flow of water and raise the water table. A higher water table is good for the health of the bog, fen, and lagg fen, and will also be good for maintaining permanent waterbodies on site for aquatic wildlife including dragonflies.

2.5.7 Nitrates and Phosphates

When deciding on a location for a wildlife pond, it is important to consider pollution levels which may hamper the success of invertebrate life establishing in the new ponds. Pollution which affects Swarth Moor could come from a number of sources such as: large numbers of wildfowl populations such as Canada geese, direct run-off from the nearby road, pesticide and fertilisers coming from nearby farmers' fields, and potentially dog and livestock waste.

Nitrate and phosphate are commonly used as measures of pollution. We used test kits for nitrate NO_3 and phosphate PO_4 which use a colour chart to qualitatively determine the concentration of the chemicals in parts per millions (ppm). According to Freshwater Habitats Trust which produce advice on installing and maintaining ponds, levels of nitrate at less than 0.5ppm and phosphate at less than 0.05ppm are considered to have no pollution from these chemicals, so these are the levels we would target for installing our ponds.

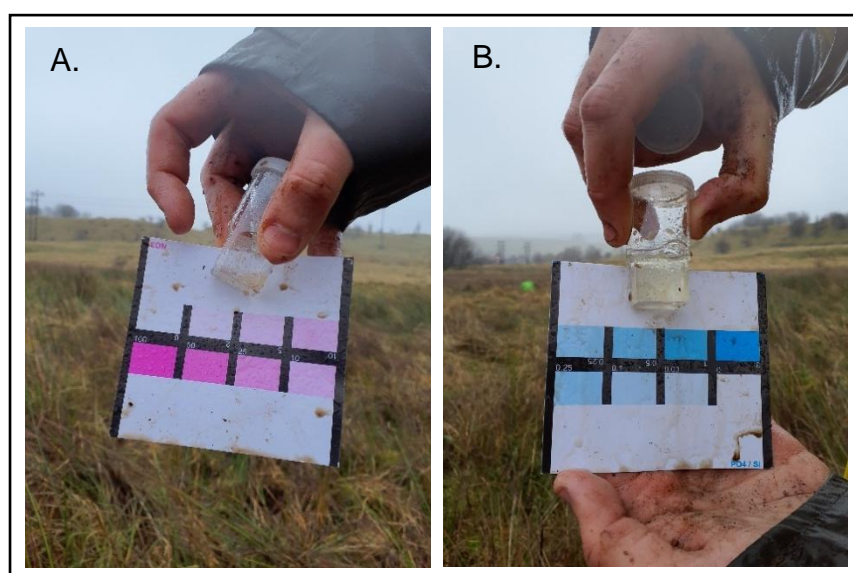


Figure 2.10: A. Nitrate test showing approx. 0-2ppm NO_3 , B. Phosphate test showing <0.03ppm PO_4 .

We sampled the groundwater at 6 places in total: three within the fen area in the 'pond candidate area' at 50-90cm deep peat, one close to a field and the road on the raised bog at 160cm deep peat, and two in an area of species-rich bog on 150-200cm deep peat.

For phosphate levels, all of the points sampled were between 0-0.03ppm PO_4 ; furthermore, the level of separation on the colour chart using the PO_4 kit we used was easy enough to distinguish with confidence that the water was below the 0.05ppm threshold. Therefore, we are confident that the points we sampled all were acceptable for phosphate pollution, or had no phosphate pollution at all.

For the species-rich bog samples and raised bog samples, the nitrate levels appeared to be around 0ppm for nitrate and so are all at acceptable levels of low or no nitrate pollution.

At the pond candidate areas in the lagg fen area, one sample came up at 0ppm, but the other two samples showed 1-2ppm. The degree of separation between 'no pollution' at <0.5ppm, 'some degree' of pollution at 0.5-1.0ppm, and high or very high levels of pollution at 1-2 or 2-10ppm were too close to be very confident of any results. Unfortunately, the test we used was not sensitive enough to distinguish between this range confidentiality. However, there is a chance that the areas in the fen on shallower peat and closer to the road may have some nitrate pollution.

2.6 AQUATIC INVERTEBRATE SURVEY APRIL 2024

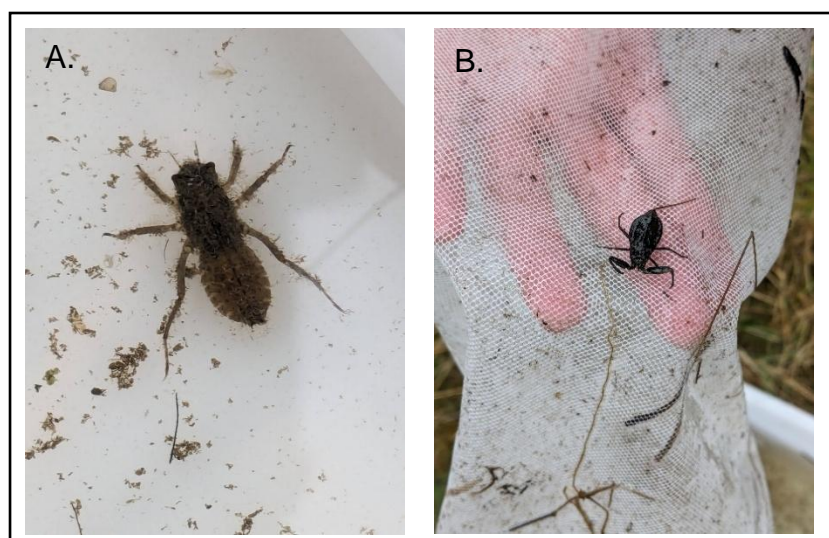


Figure 2.11 Photographs from aquatic invertebrate survey, showing A. a Four-spotted chaser nymph, and B. a Water Scorpion.

2.6.1 Survey background

The next thing to investigate was the abundance of aquatic invertebrates and the diversity of aquatic invertebrates as a baseline on the target site before any works took place.

The purpose of this survey was firstly to determine if there was enough prey for dragonfly nymphs present on site. Odonata nymphs spend most of their lives underwater, from a matter of weeks for the smaller emerald damselflies, to several years for the larger dragonflies; *L. dubia* generally take 2-3 years to develop. Dragonflies are voracious predators in their underwater phase, and they need to be able to catch and eat prey to grow and to undergo a series of moults, before the final phase where they emerge as an adult dragonfly. Therefore, this underwater ecosystem is essential for the development of the dragonfly, and it is necessary to look for an abundance and a range of aquatic prey as a food source.

The second purpose was to investigate the site for the abundance and diversity of predators; *L. dubia* are particularly susceptible to predation by fish, and they are typically not found in waterbodies containing fish in the United Kingdom. As described in the literature review *L. dubia* lack certain defensive features to protect against fish predation and so ponds with fish are seen as unsuitable for translocations. Other predators of *L. dubia* nymphs include larger dragonfly nymphs, tadpoles, and newt efts. So, part of the investigation was to identify any waterbodies containing fish which should be ruled out from future translocations, and to record the areas where other dragonfly predators exist.

We chose to survey 11 points across 5 habitat types across Swarth Moor: 1) the groundwater runnels in the lagg fen, as the pond candidate area, 2) grip and gully erosion features to be

blocked, 3) the existing man-made ponds which contain great crested newts, 4) the natural, shallow fen pools, and 5) the shallow pools which have formed behind the cell-bunding on lowland raised bog 'peat dome' itself. The survey was carried out in April under the supervision of a great-crested newt permit holder, to mitigate and minimise disruption to the known population on site. Waterbodies were sampled with a pond-dipping net for 180 seconds at each plot, broken up proportionally to sample the number of meso-habitats e.g. for 3 meso-habitats, each area would be sampled for 60 seconds. The number and type of taxonomic groups were recorded, and the total number of invertebrate individuals was estimated.

2.6.2 Results

Encouragingly, there were no fish recorded across any of the waterbodies sampled. Therefore, fish have either not made it across to the waterbodies on this site, or else the acidic conditions are too harsh for fish to maintain populations here.

Great crested newt (GCN) eggs were recorded on the man-made GCN ponds, which is a positive outcome for these mitigation ponds. These ponds were recorded previously as having a pH of 7-8, and so these are more suitable to newts and not highly suitable ponds for *L. dubia* nymphs. Frogspawn was recorded in the cell-bunding area, although not at any of the sampling locations. There clearly are large amphibian predators present on the site, although few adults were recorded, and not in all the waterbodies.

The lowest number of taxonomic groups or individuals recorded was at the drainage grip which had been installed historically to drain the site. Just 2 coleoptera (beetles) were recorded; this tells us that in its current eroding state this drainage channel is supporting almost no aquatic invertebrate biodiversity.

The natural shallow pools of the lagg fen and the fen areas recorded relatively moderate individual counts but some of the highest taxonomic diversity: around 20-40 individuals and 3-6 taxonomic groups for the lagg fen per sample, and 40-100 individuals and 5-6 taxonomic groups for the fen pools per sample. There were no Odonata larvae recorded in the lagg fen, which at the time of the survey had no ponds, but a number of beetles, bugs, and midge larvae were present in the waterlogged runnels in between the sedges and rushes. Unsurprisingly, the shallower waterbodies found in the fen did not support a wide range of aquatic invertebrate groups, but they do clearly support an ecosystem of shallow-water loving insects. In the fen pools we recorded the four-spotted chaser dragonfly nymph; the chaser nymphs have eyes which are adapted to stick up out of murky pond-debris, and ambush their prey and so they are adapted to hunting in shallow water. In conclusion, as established natural habitats they support a good diversity of taxonomic groups, but as they are shallow waterbodies there is a limit to the invertebrate abundance which they can contain.

The highest abundance of aquatic invertebrates was recorded at the man-made great-crested newt pools: up to 2000 individuals were recorded in one sample across a wide range of 6 taxonomic groups. Up to around 1000 individuals were recorded at the man-made cell-

bunding of the lowland raised bog dome, although only across 3-5 taxonomic groups. This would suggest that, if installed in the right place and at the right depth, man-made pools can support a high abundance and a wide taxonomic diversity of aquatic invertebrates on this lowland raised bog.

Odonata nymphs were only recorded at two locations: at the man-made great-crested newt ponds, and in the natural pools of the fen. The great-crested newt ponds yielded a variety of Odonata nymphs: these were hawkers (common hawker or migrant hawker or southern hawker), darters (Common darter or black darter), and damselflies (common blue, azure blue, or emerald). While this survey did not allow enough time to get each nymph down to species, this does demonstrate the variety of dragonflies and damselflies which breed in these man-made ponds. In addition, the shallower fen pools yielded a four-spotted chaser nymph. The hawker and chaser nymphs would be predators of any *L. dubia* nymphs, which are only slightly larger than the tiny black darters. While we can't, and arguably shouldn't, try to eliminate all predators of any chosen species, this highlights a solution where ponds should be designed to a variety of depths and sizes, so that a variety of habitats is created and provides opportunities for *L. dubia* to hide from larger natural predators.

2.7 DISCUSSION OF SUITABILITY FOR WFD BEFORE PONDS CREATED

The surveys completed in 2023 and 2024 collected the data we needed to determine the suitability of Swarth Moor for white-faced darter.

We have found peat on the peat dome and in the fen to suitable depths (>80cm). We have identified that most of the peat dome was less suitable in terms of vegetation structure as it lacks the shrub shelter, but the fen and lagg fen areas were in close proximity to both tree roosts and shrub shelter.

The abiotic metrics showed that the existing waterbodies on the site are low in ionic compounds and phosphate levels, but at this stage our tests are not sophisticated enough to rule out nitrate pollution. Testing the pH revealed that the peat dome is very acidic, but most of the lagg fen is too neutral/basic for white-faced darters, leaving one area of the lagg fen which is acidic enough with a $\text{pH} \leq 6.0$.

The aquatic invertebrate survey revealed that there are no fish on Swarth Moor, which are significant predators of white-faced darter. There are however a range of aquatic invertebrates, especially across the deeper waterbodies including the man-made newt ponds. The erosion channels of the grips and gullies supported very slow levels of aquatic prey.

The area these habitat suitability tests highlighted for further investigation is the acidic and peaty lagg fen. This area has no existing deep waterbodies, but it does have the right vegetation structure, aquatic invertebrate biodiversity, pH and other abiotic factors. Crucially, it has a peat depth of around 80-90cm which means it could be targeted for construction of new ponds which should provide the habitat requirements for white-faced darter.

These results allow us to assess Swarth Moor at this stage as having a potential habitat suitability for white-faced darter: it has all the essential factors as described above, and none of the deal-breakers (e.g. fish present, shallow peat etc); what it lacks currently is the waterbodies.

In Part 3 we lay out the Dragonfly Habitat Enhancement Plan, with particular focus on the white-faced darter habitat requirements gathered in the literature review.

PART 3: DRAGONFLY HABITAT ENHANCEMENT PLAN

This Plan is only concerned with the area identified from the survey as being suitable for creating dragonfly ponds for *Leucorrhinia dubia* with a central grid reference: SD 8077 6929.

3.1 RATIONAL

- *L. dubia* are red listed on the British Dragonfly Society Odonata red list 2008 and are extinct from Yorkshire.
- *L. dubia* are specialists of *Sphagnum cuspidatum* filled bog pools, and are found on lowland raised bogs.
- Swarth Moor is also home to other dragonflies such as Black Darter and Common Hawker, which are also in significant decline in the UK according to the British Dragonfly Society report.
- Lowland raised bogs, and the bog pools within them are an especially important habitat for many macroinvertebrates including Odonata
- Since the 19th century the extent of active lowland raised bog in the UK has declined from c95,000 ha to only c6000 ha, of which only 500 ha is in England.
- By creating acidic bog pools we will be promoting a heterogeneity of habitats on Swarth Moor SSSI, improving the habitat for the existing priority Odonata species, and providing the opportunity to create habitat which suits the requirements for the red-listed *L. dubia* for a potential future translocation
- The Habitat Assessment Survey in Section 2 identified two areas suitable for *L. dubia*: A) the Wet Bog area just below Studfold Moss next to the dome, and B) the fen area near to Black Sike
- The following Dragonfly Habitat Enhancement Plan is focused on area B.

3.2 OBJECTIVES

The restoration objectives for Swarth Moor are as follows:

- To construct **3** dragonfly ponds, at a total volume of **56m³ - 140m³** in volume
- To plug plant **700-1200** micro-propagated *Sphagnum* spp plugs into the ponds

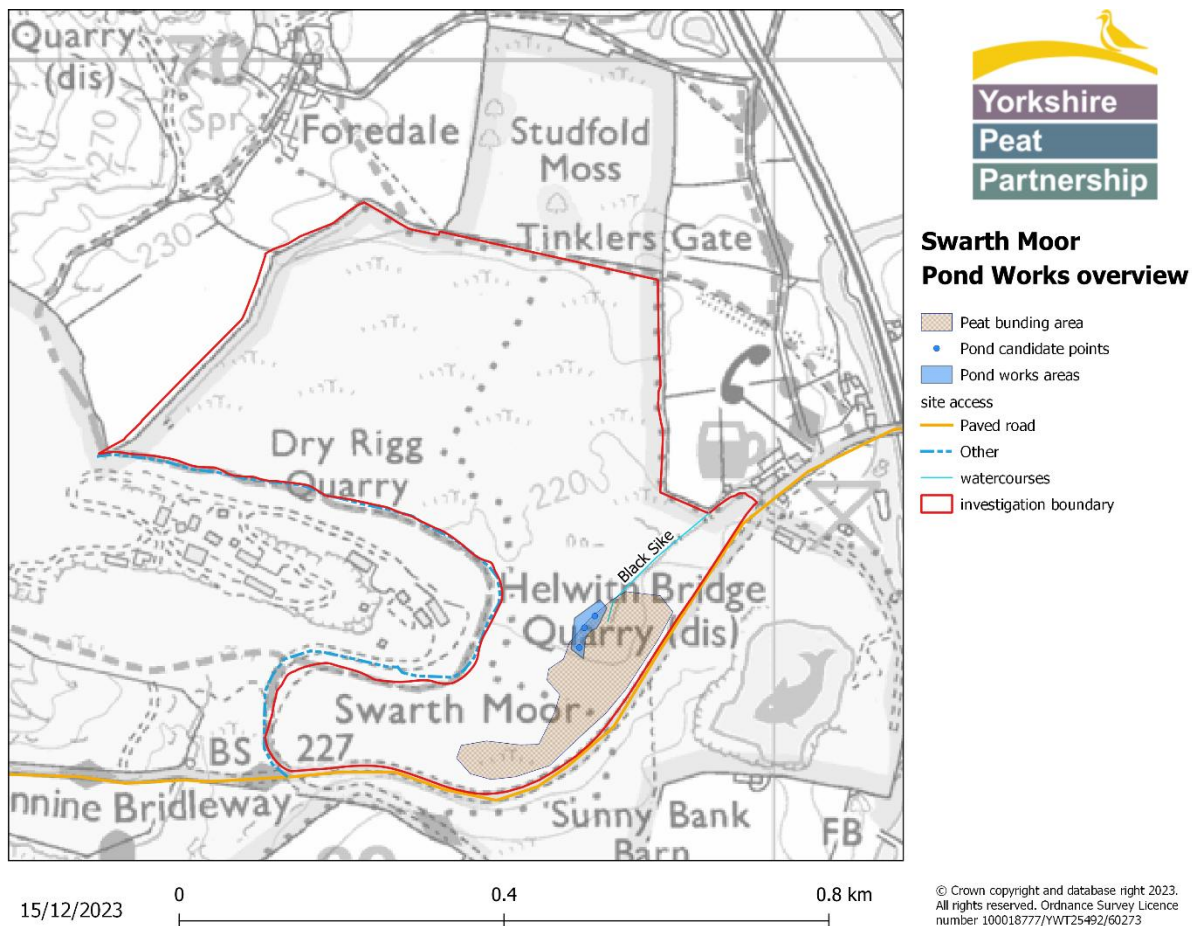


Figure 3.1 - Proposed pond installation area

The peat from the pond construction will be lost into the edge of the peat-based acidic grassland area, shown in Figure 3.1 as the 'Peat bunding area'.

3.3 POND CONSTRUCTION

Ponds will be constructed as habitat for peatbog dragonflies on Swarth Moor.

The ponds will have an area of between 40m² and 100m², and maximum depth of 0.7m. As there are 3 ponds to be constructed, the total volume of peat moved can be estimated to be between 56m³ and 140m³.

See **YPP Technical Specification Dragonfly Pond Creation** for full details.

3.4 SPHAGNUM ESTABLISHMENT

3.4.1 Sphagnum plugs

Sphagnum moss plays an important part of the habitat requirements of *L. dubia*; the female oviposits her eggs into floating mats of *Sphagnum cuspidatum* in acidic bog pools. One of the main objectives is to create bog pools which are suitable for *L. dubia* to breed on site, so it is necessary to plant up the edges of the newly constructed bog pools with *S. cuspidatum*. Additionally, whilst the proposed pond creation area is not within the optimum pH range to deter predators, inoculating Sphagnum will reduce the pH levels of the pond water over time as mentioned in 2.2.4 above.

The site survey did not find significant areas of Sphagnum on site, so Sphagnum will be supplied from a suitable supplier and transplanted into the circumference of the ponds, in accordance with section 2.3 of the **YPP Technical Specification 3**.

The below table gives the range of plugs plants which will be needed for the works. The number of plugs will depend upon the circumference of the ponds created on site and that will depend upon the shape of the pond created by the contractors working on the ground in consultation with YPP. Bog Pool mix plugs, containing *Sphagnum cuspidatum*, will be planted up to 2m from the edge of the newly created ponds: this will minimise trampling of the newly exposed bare peat, and will enable the Sphagnum to grow from the pond edges inwards.

	Total area of ponds to plant up (m ²)	BeadHumok™ - Bog pool mix @ 4/m ² (plugs)
Minimum area	175	700
Maximum area	300	1200

3.5 GPS RECORDING OF WORK

All contractor work must be recorded using accurate GPS technology and supplied to YPP. No invoices can be paid until evidence of the work completed has been supplied to YPP in the required format (see **Technical Specification 8**) and this has been verified by YPP in person.

3.6 ACCESS

Access to the site will be along Austwick Road (figure 3.2).

A full photographic survey of the access route is required and any damage caused by the contractor will be restored back to this condition.

Prior to restoration work, an on-site meeting will be held with the successful contractor, a YPP officer and a representative from the estate, graziers and other stakeholders to assess the results of the photographic survey and draw up an agreed Access Plan prior to the agreed start date.

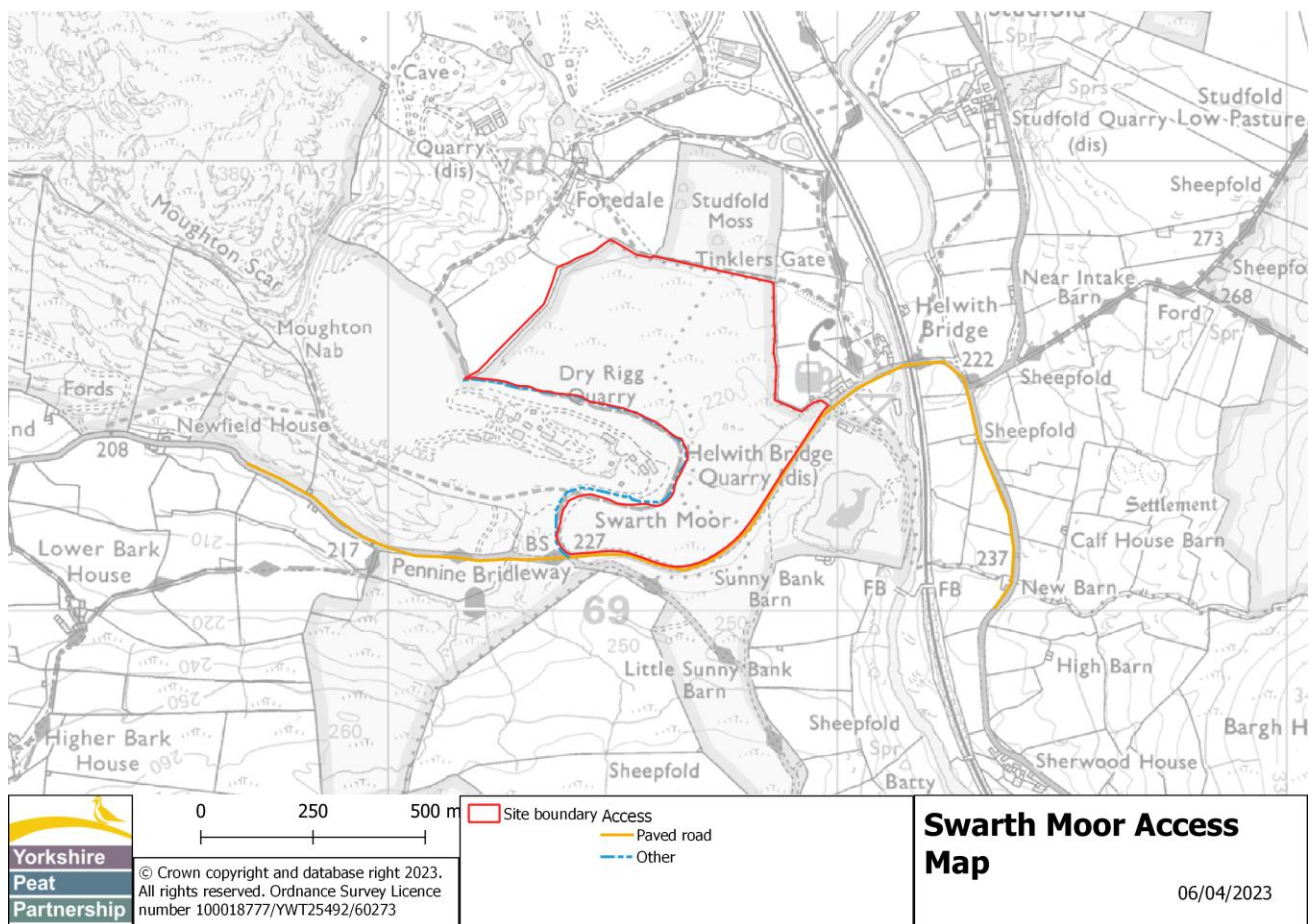


Figure 3.2 - Swarth Moor location and access

3.7 ARCHAEOLOGY

An archaeological walk-over survey was carried out in 2020 prior to the previous restoration work (Figure 3.3). This resulting report identifies the archaeological features found on the ground and what their susceptibility to restoration is through a traffic light system where red constraint areas are to be completely avoided, amber is where work is to be avoided and plant machinery must not track and lastly green areas are where there are no noted archaeological features of concern (Figure 3.4).

Any access restrictions will be incorporated into the final work plan.

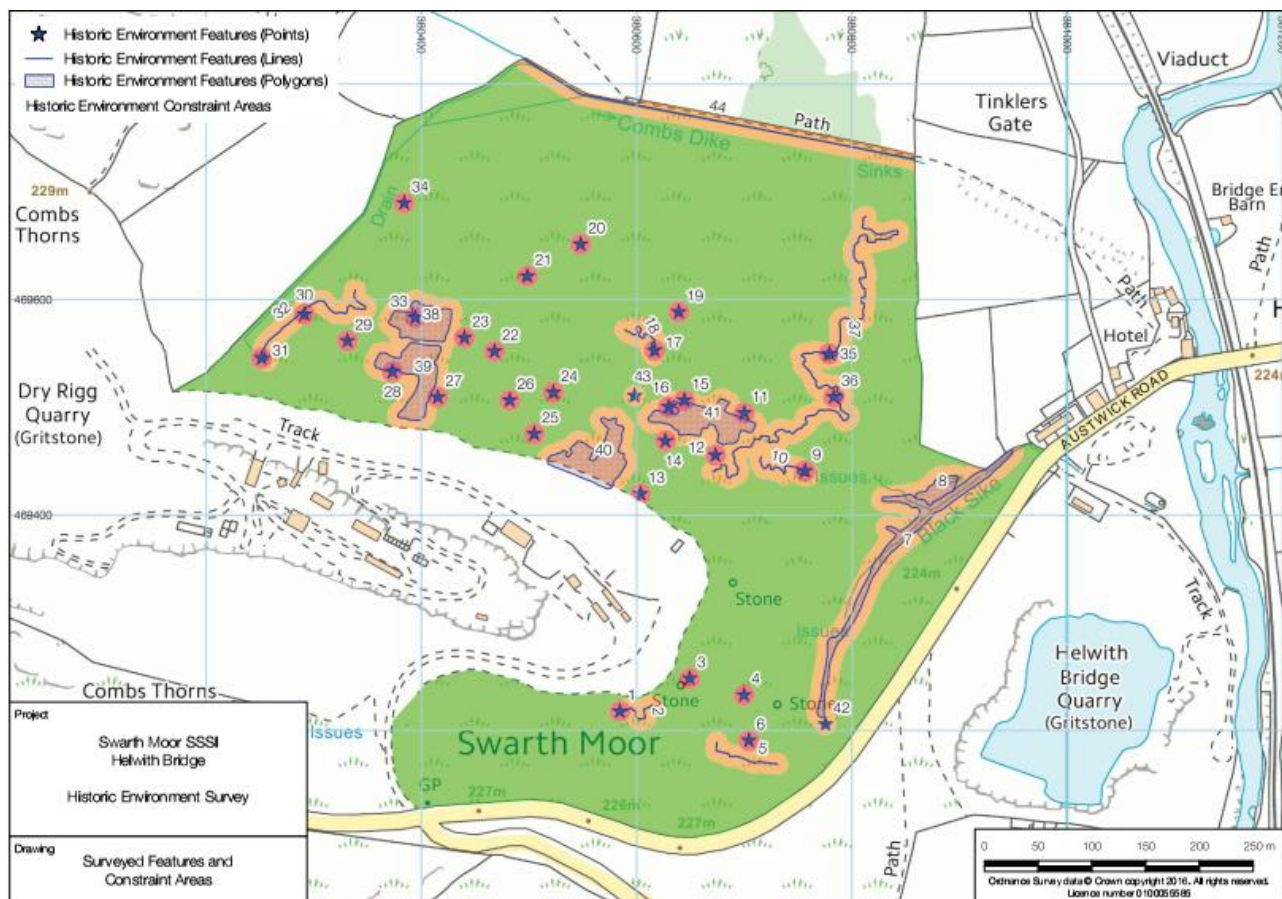


Figure 3.3 - Overview of the archaeological features, as provided in the archaeological report written by Jim Brightman for Andrew Hinde at Ingleborough National Nature Reserve, January 2020.

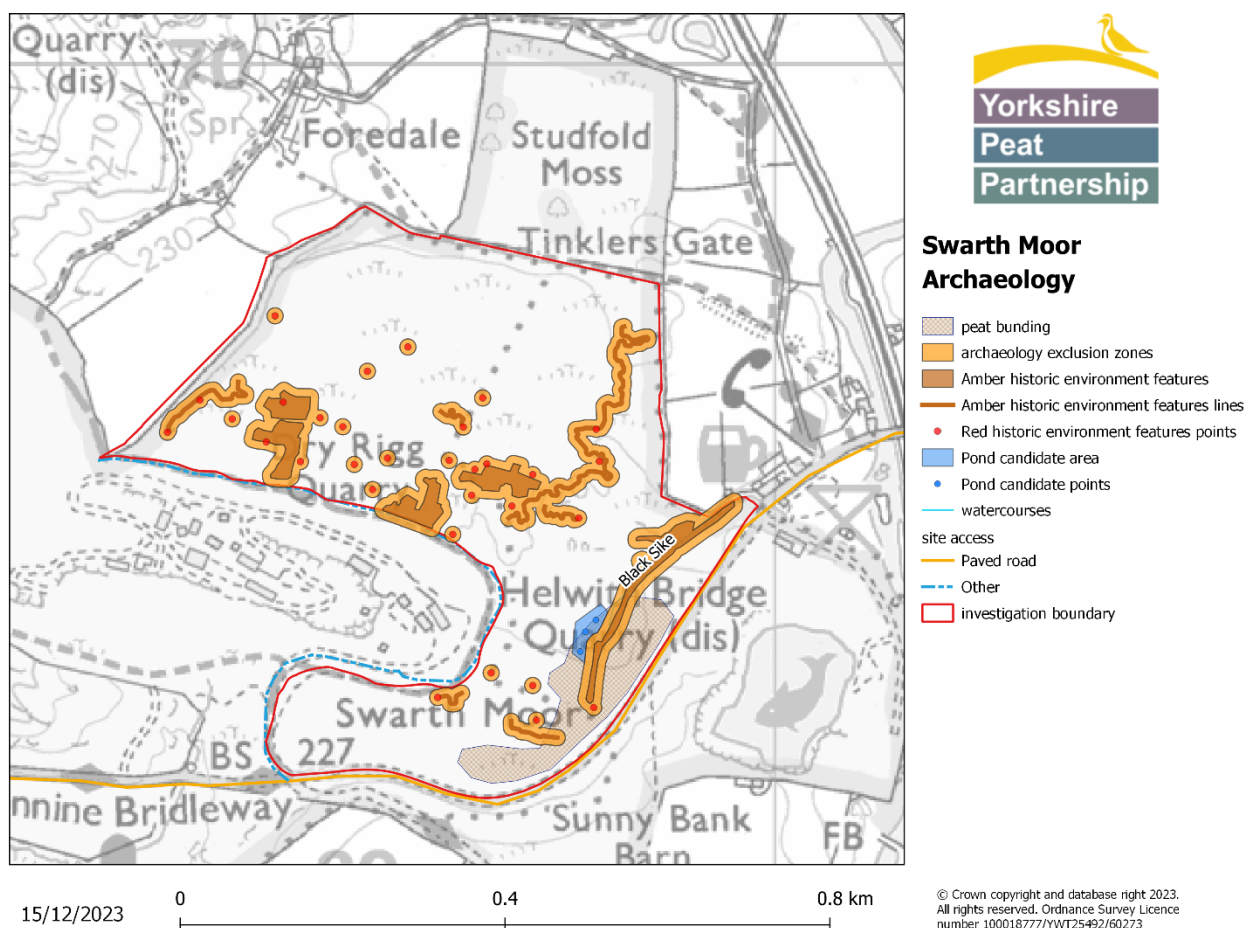


Figure 3.4 - Archaeology exclusion zones alongside the proposed pond creation area.

3.8 MONITORING

Restoration will be undertaken by experienced contractors and will be monitored by the YPP who over the past 11 years has managed the restoration of 31,526 ha of blanket bog habitat in Yorkshire.

The landowner agrees to allow reasonable access for this monitoring to take place and for photographic evidence to be collected and published from Yorkshire Peat Partnership & YWT media outlets.

3.9 TIMETABLE

After discussions with ecologists, it was agreed that the works should be carried out from August to October. As the site is so wet with small areas of standing water scattered everywhere, great crested newts could still be found anywhere during the breeding season, when they are usually expected to be confined to ponds.

August is after the breeding season but before hibernation begins and should therefore be the time when disturbance has the least impact on their life cycle.

Example payment schedule:

Activity	Final completion date
Pond construction	End of October 2024
Relocating peat spoil into peat bunding area	End of October 2024
Sphagnum inoculation	End of October 2024
Final Track repairs	End of October 2024

3.10 CONSENTS & UTILITIES

SSSI Consent will be needed from Natural England.

Checks for services and utilities will be carried out by Yorkshire Peat Partnership.

3.11 ENVIRONMENTAL IMPACT

3.11.1 Biodiversity Impact

1. This project will directly assist the colonisation of *L. dubia*, a priority species and currently extinct in Yorkshire. It is therefore highly valuable to return this species to Yorkshire, beginning to link up the other successfully reintroduced populations further north in Cumbria and further south-west in Cheshire. By expanding the range of this Red-Listed species, this project will improve the resilience of this dragonfly nationally in the face of climate change by expanding its range. This species has significantly declined in Great Britain and is now only found in a small number of sites in England, so it is unlikely to re-establish its populations without interventions now. It is therefore essential to make active efforts with capital works to increase their numbers in England.
2. By increasing the water table and increasing the number of permanent bog pools of this SSSI lowland raised bog, this will directly benefit many other Odonata species, including two other priority species *Sympetrum danae* (Black darter) and *Aeshna juncea* (Common hawket), and other bog pool invertebrates. This papers shows that peat restoration greatly improves Odonata species richness and abundance (Elo et al. BMC Ecology (2015) 15:11).
3. There are Great Crested Newts breeding on site too which will likely also benefit from the construction of additional pools.
4. The increase in aquatic life will also attract their predators, such as Common Lizards and protected bird species such as Curlews.
5. Providing still clean water is one sure way to attract wildlife, especially by improving the quality and heterogeneity of priority habitat on an important lowland raised bog, and in this way the project will directly improve many species.

3.12 SOCIAL IMPACT

3.12.1 Volunteers

1. We will be involving volunteers throughout the monitoring (and future potential translocation) processes of this project. This will build on and grow local volunteer groups, providing them with the opportunity to contribute to valuable conservation work. The volunteers will receive all the necessary training to support the survey transects, collect water monitoring data, and will learn much about Odonata species, lowland raised bog habitats and ecology.
2. In the past we have had several of our specialist monitoring volunteers apply for jobs in our work and successfully interview and become hired, which demonstrates the career opportunities that the training and knowledge gained from such volunteering can provide the individuals.

3.12.2 Local community groups and schools

1. Over the course of the project we will lead 1 community engagement day trip and 1 local school day trip.
2. There are many opportunities for positive community engagement with the introduction of a priority species, a session involving a dragonfly transect and pond dipping would make a great learning opportunity for a biology school trip.
3. At least two talks will be delivered in the final year of the project to local interest groups, which will increase awareness and knowledge of the importance of invertebrates, bog habitats, peat restoration, and the restoration of priority species.