PROJECT BASELINE
MIDLAND POOLS

Project report for the British Sub-Aqua Jubilee Trust

# Project Baseline Midland Pools

10th November 2021

British Sub-Aqua Jubilee Trust

MARLIN SUB-AQUA CLUB
NUNEATON, WARKS

**Project Baseline Midland Pools**


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Finally, this work would not be possible without the divers and surface support team listed on page I who volunteered their time and expertise, for which we are most grateful.

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| Revision | Date | Description |
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| 0 | 2021-11-08 | First issue |
| 1 | 2021-11-10 | Added map showing site locations |

# EXECUTIVE SUMMARY

Project Baseline's mission is to 'mobilise citizen-divers to record change in the world's underwater environments and to engage with scientific, conservation and government entities to advance the restoration and protection of our natural and cultural treasures'. The *Project Baseline Midland Pools* team is recording, monitoring and helping to preserve water-filled quarries within Leicestershire and Warwickshire, specifically:

- Ensor's Pool, Nuneaton, Warwickshire
- Newbold Quarry, Newbold on Avon, Warwickshire
- Blue Pool, Bishop's Itchington, Warwickshire
- Great Pit, Swithland Wood, Leicestershire
- Hill Hole Quarry, Markfield, Leicestershire

Stoney Cove, Stoney Stanton, Leicestershire was included in the project at a later stage to address limitations in access at other sites during the Covid-19 pandemic.

The project sought to answer the following questions:

1. What is in the quarry pools?
2. Is the aquatic environment favourable or unfavourable?
3. Is the aquatic environment improving, declining or remaining the same?

A secondary aim was to provide opportunities for scientific diving to the local diving community and to develop divers with the necessary skills to go on to contribute to other citizen science projects.

A team was recruited from the local diving community, and over sixteen project days they dived the quarry pools and recorded what was there (wildlife and cultural heritage), collected water samples for chemical analysis, installed a monitoring station including a temperature logger, and made visibility measurements.

A notable result was the confirmation that native white-clawed crayfish are present in Ensor's Pool (these had assumed to have been lost in 2014), Newbold Quarry, Hill Hole Quarry and Stoney Cove. This makes these sites important for the conservation of this endangered species.

Unfortunately, non-native signal crayfish were observed in November 2021 at Newbold Quarry, possibly having entered the pool from the Oxford canal, which is only fifty metres away. Signal crayfish are a significant risk to white-clawed crayfish and their continued survival at Newbold Quarry is therefore in doubt.

Water quality was determined to be good at all the sites with the mineral ions present correlating most with the underlying geology of the pools. There was no evidence of significant fertilizer or sewage runoff polluting the water.

The remains of quarrying equipment were located at several sites, with the most extensive remaining in Ensor's Pool.

Litter was removed at all sites from below the water and around the lake margins.

It was concluded that the quarry pools are favourable wildlife habitats although there were threats to the ongoing favourability of some sites.

# 1 INTRODUCTION

## 1.1 Project Baseline

Project Baseline's mission is to 'mobilise citizen-divers to record change in the world's underwater environments and to engage with scientific, conservation and government entities to advance the restoration and protection of our natural and cultural treasures'. [1]

Whilst divers may recall changes to the environment in their memories it is photographs that provide a means of demonstrating change to the public and policy makers. Figure 1 shows an example of a photographic record from the Florida diving community where Project Baseline began. In addition to photographs, Project Baseline maintains a database of temperature and visibility readings as well as any *ad hoc* data that teams collect. [2]


Figure 1 Images can inform the public and inspire action when change in the aquatic environment occurs – in this case the eutrophication of freshwater springs caused by agricultural runoff. (Photograph: © John Moran/Spring Eternal project, used with permission of Project Baseline.)

## 1.2 Project Baseline Midland Pools

Several Project Baseline teams are active in the UK. [3] A new team was registered as Project Baseline Midland Pools to record, monitor and help preserve water-filled quarries within Leicestershire and Warwickshire. The project seeks to answer the following questions:

1. What is in the quarry pools?
2. Is the aquatic environment favourable or unfavourable?
3. Is the aquatic environment improving, declining or remaining the same?

A secondary aim is to provide opportunities for scientific diving to the local diving community and to develop divers with the necessary skills to go on to contribute to other citizen science projects.

The project objectives are to:

- Identify divers who are interested in participating in diving projects and provide them with opportunities to build capacity safely
- Carry out historical research on the sites and compare this with submerged evidence
- Map the quarry pools by various methods
- Setup a visibility and temperature monitoring station at each site
- Survey the wildlife present
- Sample the water for chemical analysis
- Remove litter.

## 1.3 Site locations

Six flooded quarries have been selected for study (see Figure 2 and Table 1). Of these only one, Stoney Cove, is open to divers without special permission. Sites were selected that exhibit different habitat types, ranging from a slate pit within an ancient woodland environment to clay pits on both established and newly created nature reserves. It was expected that all sites would contain wildlife, and some may also contain traces of cultural heritage from their former lives as working quarries. Some are also significant due to the geological formations they reveal.

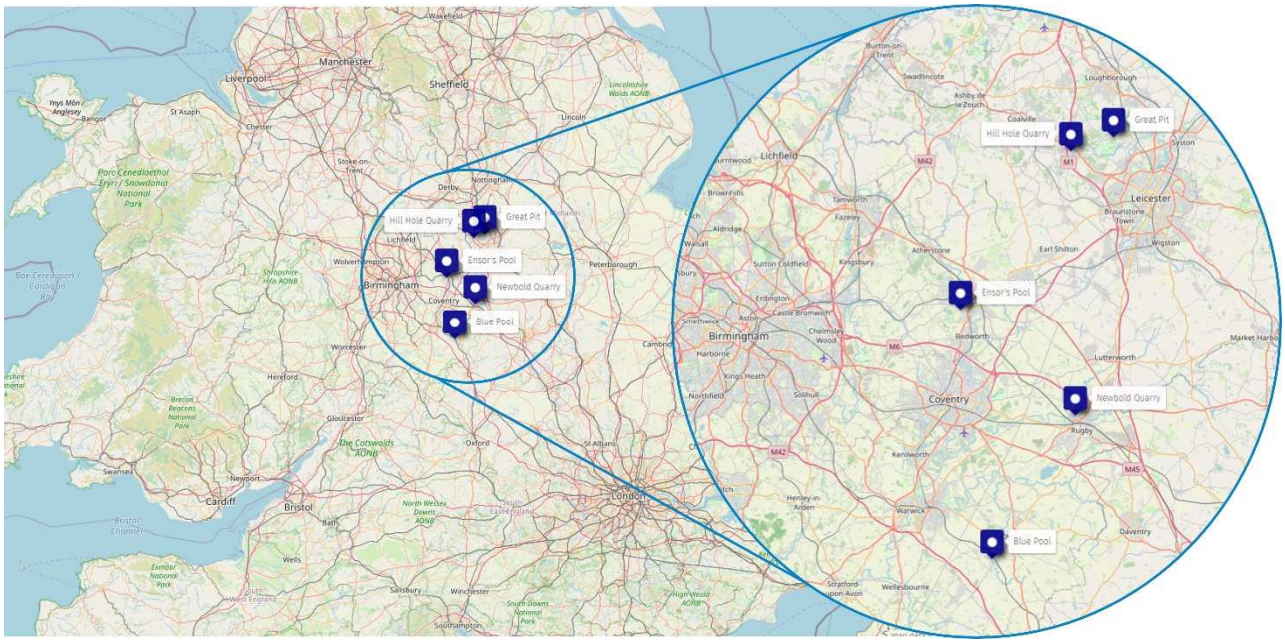



Figure 2 Map showing the study site locations.

Table 1 Summary of site characteristics prior to this project.

| Site | Extracted material | Depth, metres | Area of water, hectares[1] | Nature reserve | White-clawed crayfish recorded | Geological site |
|---|---|---|---|---|---|---|
| Ensor's Pool | Etruria marl | 10 | 1.8 | Yes | Yes | No |
| Newbold Quarry | Blue lias | 15 | 2.75 | Yes | Yes | Yes |
| Blue Pool | Blue lias | 10 | 0.73 | Yes[2] | No | No |
| Great Pit | Slate | 50 | 0.35 | Yes | No | No |
| Hill Hole Quarry | Granite | 7 | 0.85 | Yes | Yes | Yes |
| Stoney Cove | Granite | 36 | 5.76 | No | Yes | No |

[1] Measured using tools from UK Grid Reference Finder, gridreferencefinder.com

[2] Recently established

### 1.3.1 Ensor's Pool, Warwickshire

Ensor's Pool is a former clay pit in the south-west of Nuneaton in Warwickshire. The extracted etruria marl was used for brick making. It is a Site of Special Scientific Interest (SSSI) for the nationally important population of white-clawed crayfish, estimated at 50,000 individuals. Although crayfish plague outbreaks have occurred in the Midlands, this waterbody is isolated from river systems and is a good example of a refuge site in an important part of the species' former range. However there has been doubts that the population still exists. [4] It was reported that crayfish plague may have caused complete mortality between October 2013 and July 2014. The site is a nature reserve owned by Nuneaton and Bedworth Borough Council.

### 1.3.2 Newbold Quarry, Warwickshire

Newbold Quarry is a former blue lias quarry in the village of Newbold-on-Avon north-west of Rugby in Warwickshire. Lime was made at the site from 1850, but flooding stopped operations in 1923 and it closed in 1927. The quarry was used as a canal reservoir until the 1980s and was taken over by Rugby Borough Council in 1991. The site is a Local Nature Reserve (LNR) and contains a population of white-clawed crayfish. It is a Local Geological Site (LoGS) with two areas identified: an inaccessible 4 m vertical section in the alternating mudstones and fine-grained limestones of the Rugby Limestone Member of the blue lias formation, and an accessible area of spoil with frequent *Gryphaea sp* (oysters) and crinoid ossicles (types of echinoderms). The site is managed by Rugby Borough Council and Warwickshire Wildlife Trust.

### 1.3.3 Blue Pool, Warwickshire

Blue Pool is a former blue lias quarry north of the village of Bishops Itchington in Warwickshire. It is on the site of the former Harbury Cement Works that is made up of several blue lias limestone quarries. The rock is a sequence of limestones and shales laid down in the Jurassic period and rich in fossils. The site was opened in 1855 by Richard Greaves and continued to produce lias lime products in addition to cement until 1939. Three rotary cement kilns remained in service until manufacturing ceased in December 1970 and the site became a depot. In 1994 the remaining buildings were demolished and the site cleared. The site has been

owned by Folletts Land Holdings since 2001 but has been managed as part of Bishop's Hill Nature Reserve by Warwickshire Wildlife Trust since 2019.

### 1.3.4 Great Pit, Leicestershire

Great Pit is a former slate quarry within Swithland Wood south of the village of Woodhouse Eaves in Leicestershire. It is a biological Site of Special Scientific Interest (SSSI) and Nature Conservation Review site (NCR). It is Leicestershire's most important ancient woodland and quarries within the wood have been used as a source of slate for local buildings since Roman times. There are twenty-four slate pits in the wood although only two, Old Pit and Great Pit, were ever of industrial scale. Slate has been extracted to a depth of 55 m at Great Pit although since production ceased in 1887 it has filled with water. The wood has been a public woodland since 1925, upon its acquisition by the Leicester Rotary Club, and has been owned and run by Bradgate Park Trust since 1931.

### 1.3.5 Hill Hole Quarry, Leicestershire

Hill Hole Quarry is a former granite quarry in Markfield in Leicestershire. The quarry opened in 1852. Today it is a Regionally Important Geological Site (RIGS) for the exposed markfieldite granite. The site includes a meadow to the north that is designated a Site of Importance for Nature Conservation (SINC). The exposed rock faces and heath grassland are priority habitats, the subject of Biodiversity Action Plans. The quarry pool contains a population of white-clawed crayfish. In 2001 Hinckley & Bosworth Borough Council purchased the site and it is now a nature area within the National Forest.

### 1.3.6 Stoney Cove, Leicestershire

Stoney Cove is a former granite quarry in the village of Stoney Stanton in Leicestershire. Stone quarrying first began at the beginning of the nineteenth century but when quarrying ceased in 1958 spring water was allowed to flood the workings. Five years later the flooded quarry had become popular with local pioneers of scuba diving. Today it is an established inland diving site with water going to a maximum depth of 36 m. It is home to perch, roach and pike, as well as a healthy population of white-clawed crayfish.

## 1.4 Crayfish

The UK has one species of native crayfish, the white-clawed or Atlantic stream crayfish, *Austropotamobius pallipes*. There are six non-native species in the wild and one kept in aquaria. [5] Of the introduced species the North American signal crayfish (*Pacifastacus leniusculus*) is the most widely distributed having reached Scotland and Wales from England. Table 2 summarises the main features of the white-clawed and signal crayfish species that are shown in Figure 3.

White-clawed crayfish are largely nocturnal while signal crayfish may be active during the day. Both are least active during the winter where they may spend time torpid in burrows in the banks. They are most active during the summer. Mating takes place in autumn or early winter with the females carrying the developing eggs attached to the underside of the tail. Release of young usually happens in May and June.

Since the 1970s the white-clawed crayfish has declined in English rivers. They have fallen victim to competition from non-native species and the lethal disease, crayfish plague, carried by them. Crayfish plague is caused by the water mould *Aphanomyces astaci* that has a swimming spore that can transmit from infected or recently dead crayfish. The fungus attaches to thin areas of cuticle and grows through the tissue and is fatal within about two weeks of infection. In the absence of crayfish *A. astaci* is cleared from the water within a few weeks.

White-clawed crayfish are also infected by the microsporidian parasite *Thelohania contejeani* that causes thelohaniasis or porcelain disease.

Table 2 Description of selected crayfish species. (Reproduced from ref. [6].)

| Species and origin, introduced into UK | Body length | Rostrum | Body | Appendages |
|---|---|---|---|---|
| White-clawed crayfish (*Austropotamobius pallipes*) Native | <12 cm | Narrows to either a small triangular or a long sharp tip. | Brown to olive with a pitted appearance, but may be black, whitish-grey or beige. Row of spines on the shoulder of their carapace behind the cervical groove. | Topside of claws are weakly granular with the underside usually a dirty-white colour (sometimes light pink or green, but never red). |
| North American signal crayfish (*Pacifastacus leniusculus*) North America 1970s | Up to 16 cm | More or less parallel ending in a very pointed tip with prominent spiniform shoulders. | Smooth, bluish-brown to reddish-brown colour or light to dark brown. | Smooth claws with a white-turquoise patch on top of junction of fixed and moveable finger. Underside of claws are red. |

White-clawed crayfish are susceptible to pollution with biocides or silage effluent. They are preyed upon by pike, perch, chub, trout and eel, mink, rat and otter, heron and crow. Juveniles are predated by dragonfly larvae and larger crayfish. [9]

White-clawed crayfish are currently listed as *endangered* on the IUCN Red List of Threatened Species. [10] In the UK they are protected by legislation. The Wildlife and Countryside Act 1981 makes it illegal to take or sell them. For water bodies notified as Sites of Special Scientific Interest the Countryside and Rights of Way Act 2000 requires consent from Natural England to carry out any 'operations likely to damage the special interest'. White-clawed crayfish were not handled or trapped and so additional licenses were deemed not to be required for this project following discussions with the Environment Agency.

It is illegal to release non-native crayfish into the wild and this includes re-releasing trapped or captured animals. Use of crayfish for angling bait was made illegal in the UK in 2005. [5]

Red-claw crayfish (*Cherax quadricarinatus*) is the only species permitted to be imported for aquariums. It is a tropical species and require temperatures of 23 ˚C to breed and so it has been assumed they would not survive in the wild in the UK. [5] However Karplus *et al* found that they survived winter temperatures 7–10 ˚C for ten days [11], and Semple *et al* reported survive for a few days at 3 ˚C. [12] Climate change may make their viability in British waters more likely.

Figure 3 Photographs of white-clawed crayfish (top) [7] and signal crayfish (bottom). [8] Photos reproduced under the Creative Commons licence.

# 2 BACKGROUND RESEARCH

## 2.1 Historical maps

### 2.1.1 Ensor's Pool

Maps (Figure 4 to Figure 7) show the evolution of the clay pit from its creation to partial flooding in the 1937–1961 map, to complete flooding in the 1949–1969 one. The blue circles are scaled and centred on the same point. A tramway can be seen going into the pit during its working life for extracted material. The L&NWR Griff Branch railway line and a mineral line ran close to the pit to the east.

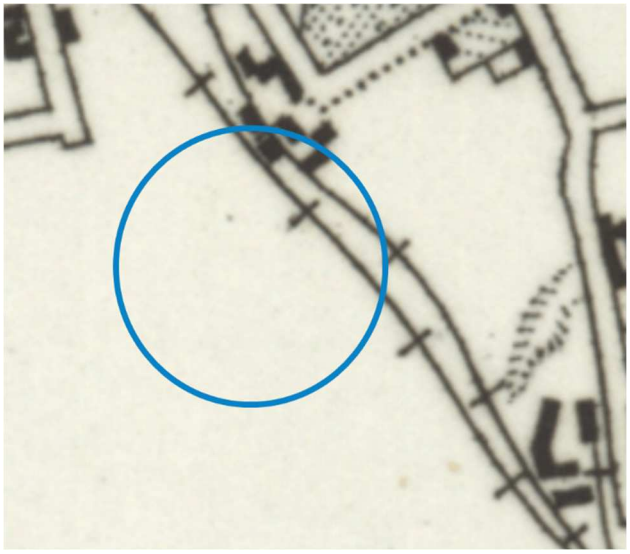


Figure 4 OS 1885–1900.


Figure 5 OS 1888–1913.

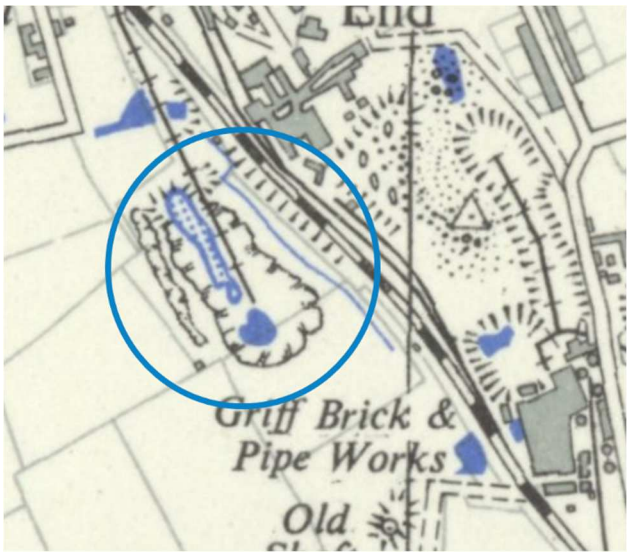



Figure 6 OS 1937–1961.


Figure 7 OS 1949–1969.

## 2.1.2 Newbold Quarry

Maps (Figure 8 to Figure 10) show extensive excavation and backfilling of the quarry during its lifetime to its current flooded state. The blue circles are scaled and centred on the same point. Various tramways were in use at different locations during the quarry's working life that would have taken extracted material away to the Rugby Portland Cement Works for processing. A track runs to the north east of the quarry.

Figure 8 OS 1885–1900.


Figure 9 OS 1888–1913.

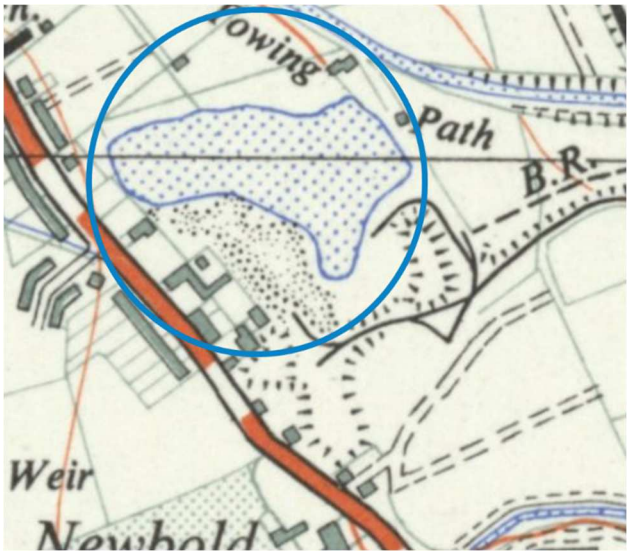



Figure 10 OS 1888–1913.

## 2.1.3 Blue Pool

Extensive quarrying to the south of Greaves's Works can be seen in the early maps (Figure 11 to Figure 14), but it is not until the 1937–1961that Blue Pool is seen. The blue circles are scaled and centred on the same point. A tramway was marked to the south of Blue Pool leading back to the works. Blue Pool and Mitre Pool (to the west of the road) are flooded and identified as reservoirs in the 1949–1969 map.

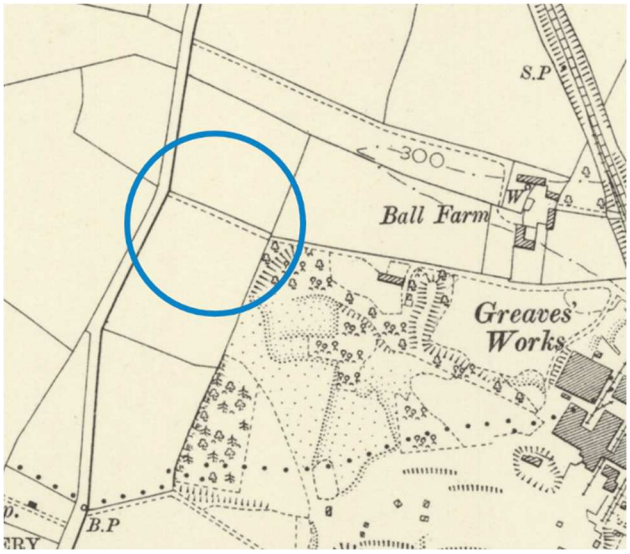



Figure 11 OS 1888–1913.

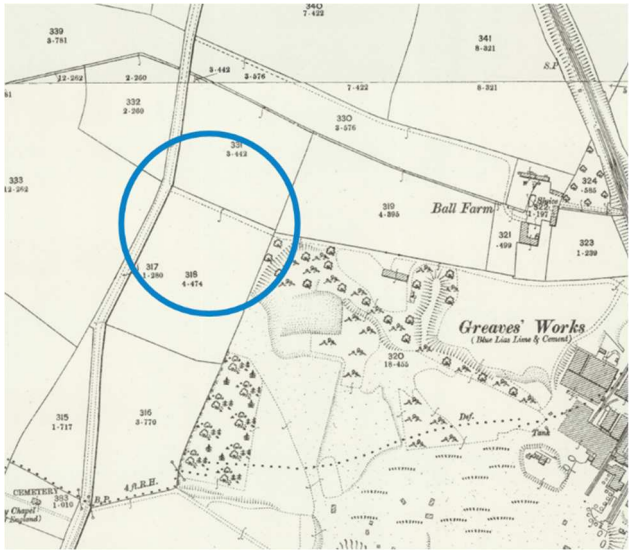



Figure 12 OS 1892–1914.

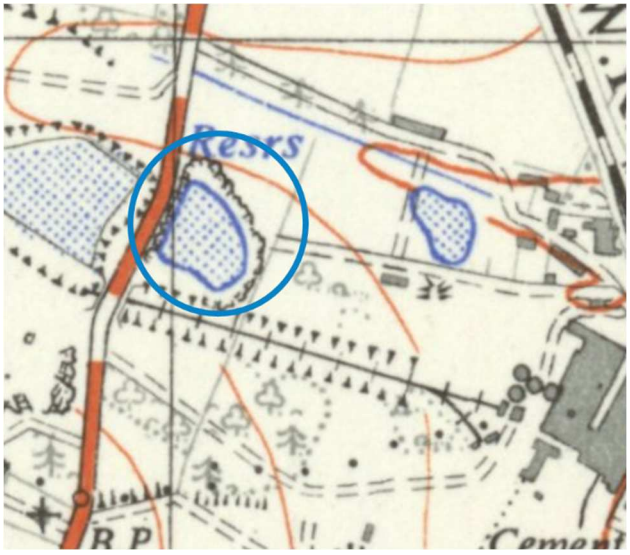


Figure 13 OS 1937–1961.


Figure 14 OS 1949–1969.

## 2.1.4 Great Pit

Swithland Wood has changed little over the years (Figure 15 to Figure 16) as expected for an ancient woodland site. The blue circles are scaled and centred on the same point. Buildings around Swithland Wood Farm to the north west of the quarry were constructed between the dates of the two maps shown.

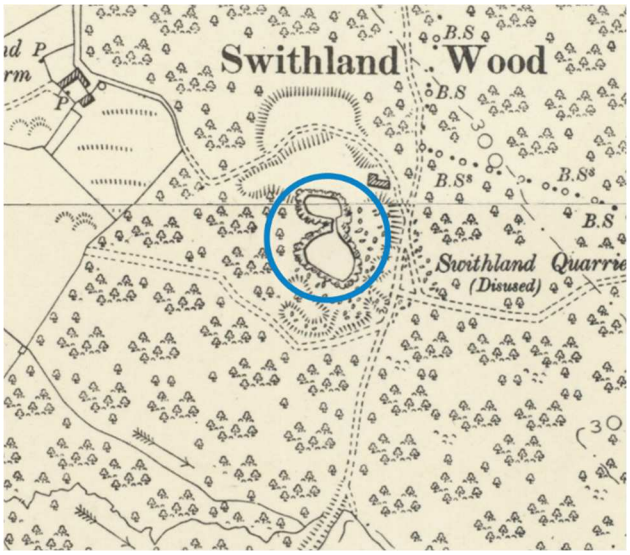



Figure 15 OS 1888–1913.

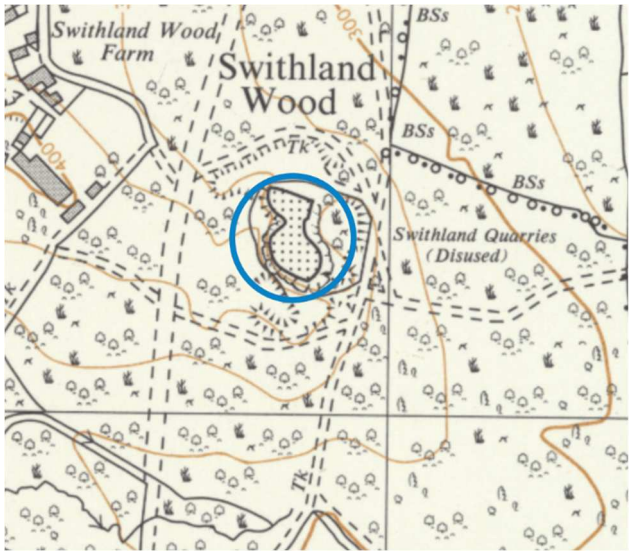



Figure 16 OS 1949–1969.

## 2.1.5 Hill Hole Quarry

The earliest map from 1885–1900 (Figure 17) shows a wooded area where the quarry is today. In subsequent maps (Figure 18 to Figure 20) the quarry is apparent with a crane being marked to the north of the site in the 1892–1914 map (Figure 19). The 1937–1961 map shows the quarry to be flooded (Figure 20). The blue circles are scaled and centred on the same point.


Figure 17 OS 1885–1900.

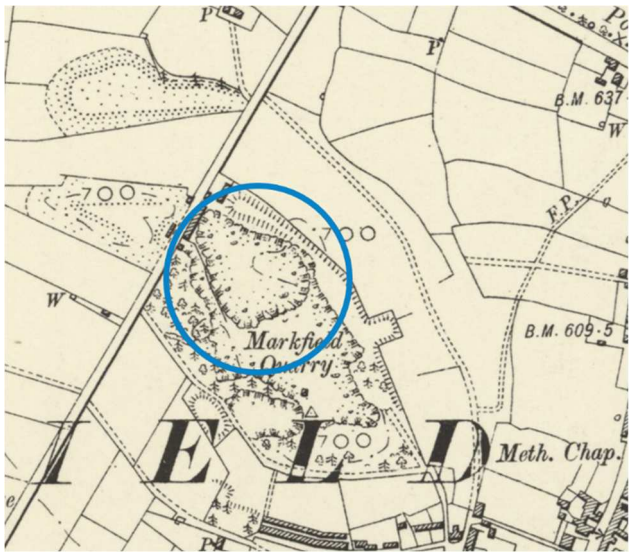



Figure 18 OS 1888–1913.

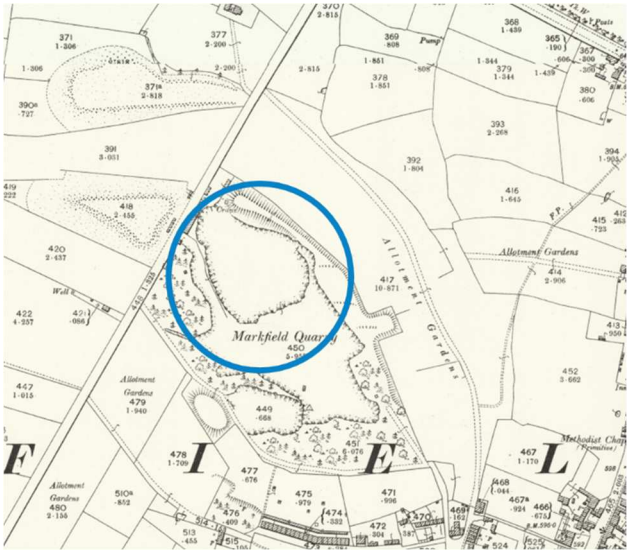



Figure 19 OS 1892–1914.

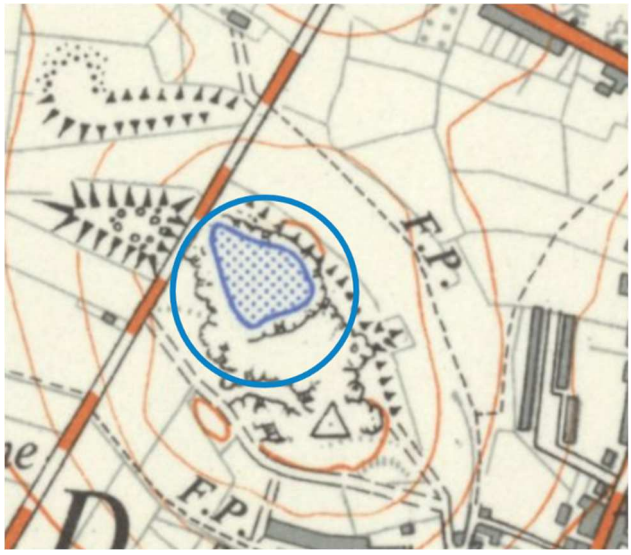



Figure 20 OS 1937–1961.

## 2.1.6 Stoney Cove

Stoney Cove began life as Top Quarry and Lane's Hill Quarry that remain separate in the 1888–1914 maps (Figure 21 and Figure 22) before merging and expanding to its current size in the 1937–1961 map (Figure 23). The blue circles are scaled and centred on the same point. The site is flooded and named Stoney Cove on the map of 1949–1969 (Figure 24). Tramway rails are visible running under the road to the north-east of the site and down what is now the access road and into to the Lane's Hill Quarry at the north of the site.

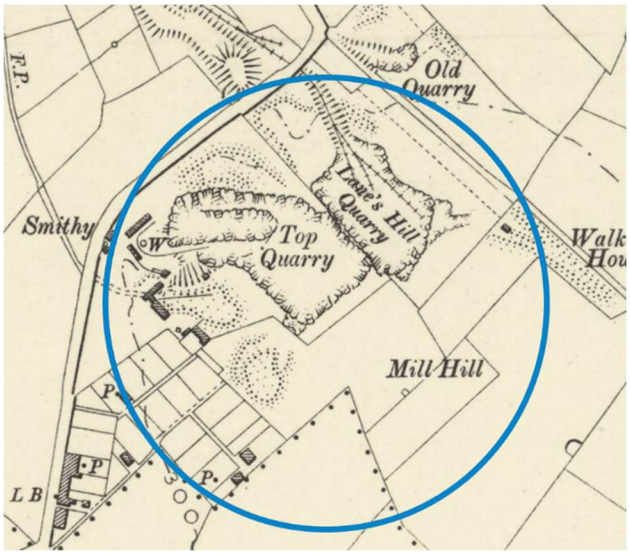



Figure 21 OS 1888–1913.


Figure 22 OS 1892–1914.

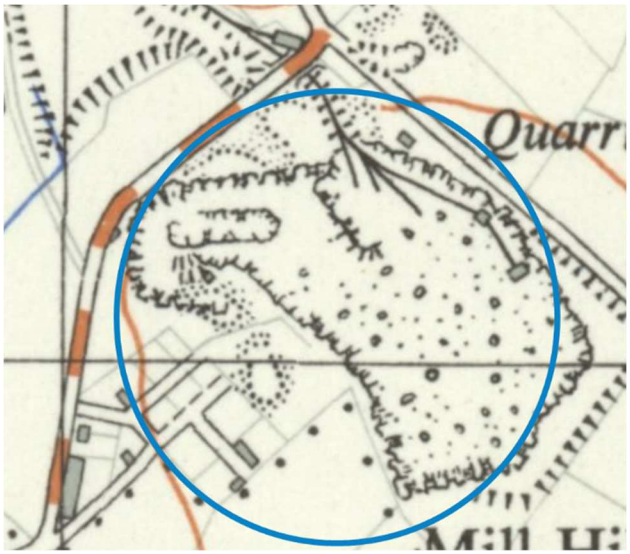



Figure 23 OS 1937–1961.

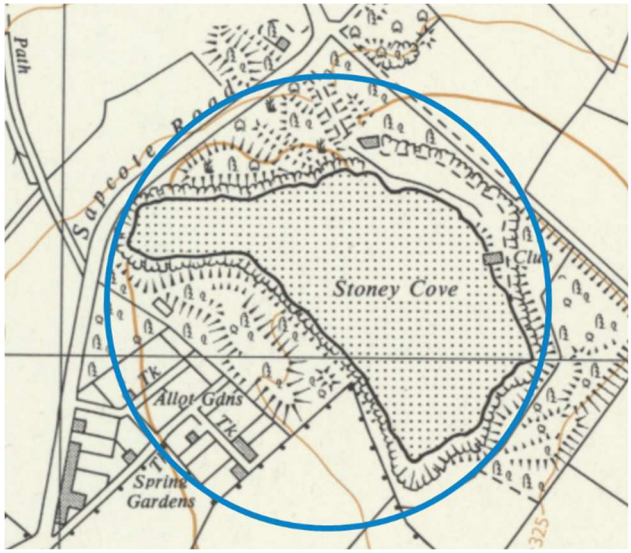



Figure 24 OS 1949–1969.

## 2.2 Archive photographs

The Britain from Above [13] photograph archive contains pictures of:

- Ensor's Pool (Figure 25) showing the trackway entering the pit.
- Blue Pool (Figure 26) prior to it becoming a reservoir.

An internet search produced photographs from Newbold Quarry (Figure 27 and Figure 28) looking north-east. Figure 28 was dated to 1976, which was a very hot summer and the quarry contains little water. At this time the quarry was being used as a canal balancing reservoir and it is thought the photographs show a barge containing a pump and associated pipework that transferred water to the nearby Oxford canal.


Figure 25 Stanley Brothers Brick and Tile Works showing the clay pit that would become Ensor's Pool, 1926.


Figure 26 Greaves' Cement Works showing the quarry that would become Blue Pool, 1927.

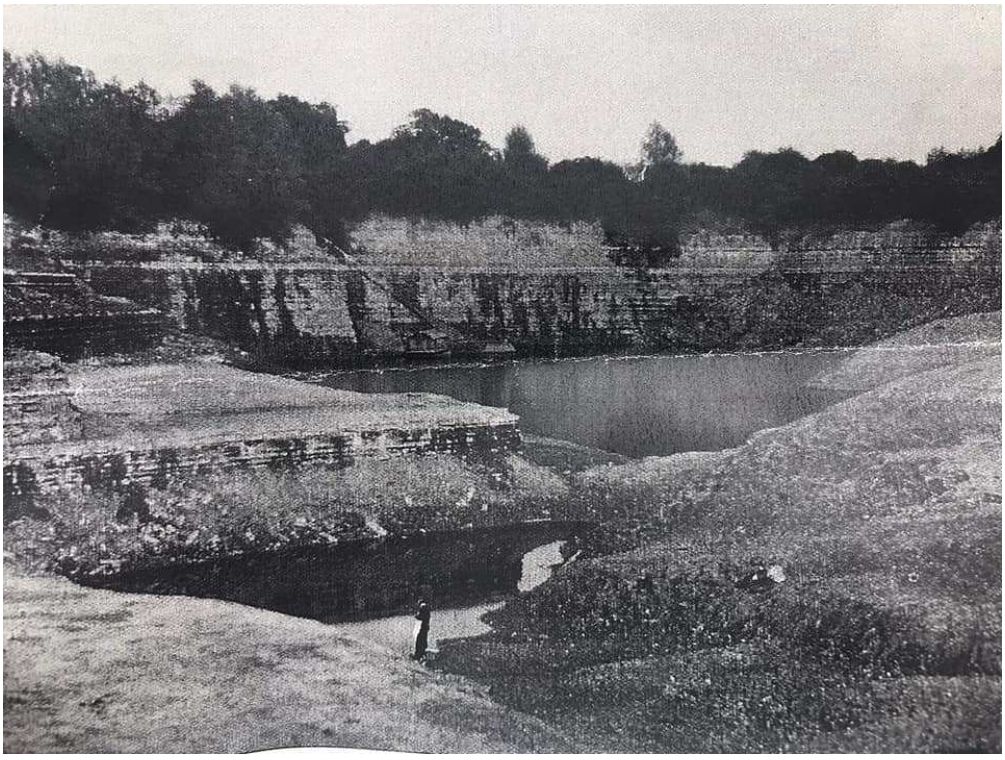


Figure 27 Newbold Quarry looking north-east showing a partially drained quarry pool, 1976?.

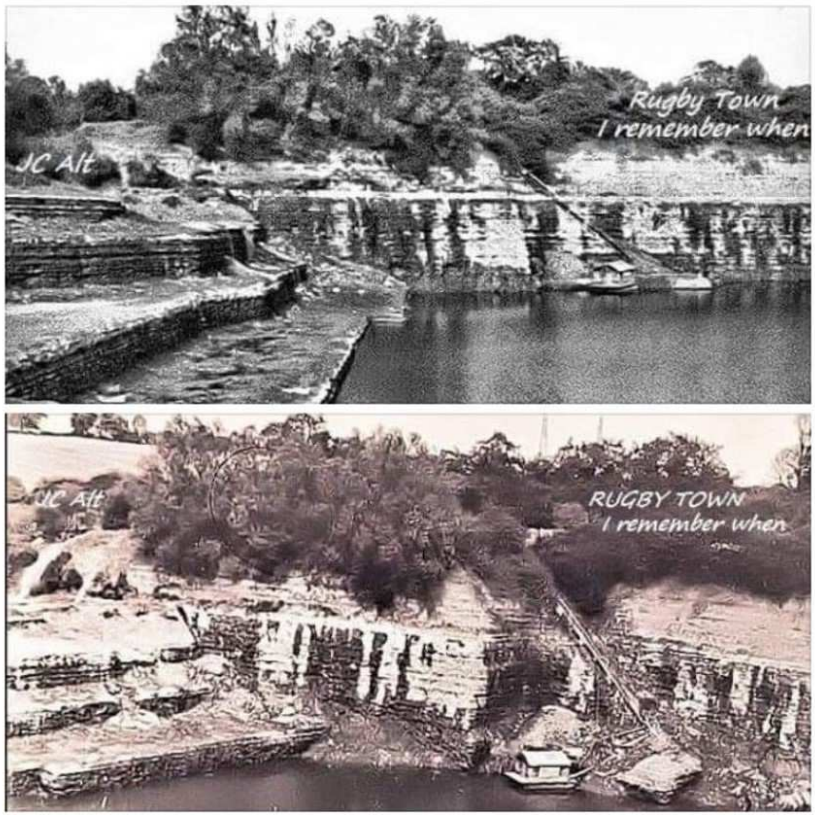



Figure 28 Newbold Quarry looking north-east showing a partially drained quarry pool, 1976. [14]

## 2.3 Satellite images

Satellite images [15] taken from approximately 700 m altitude show:

- Ensor's Pool (Figure 29) is surrounded by trees and adjoined by agricultural land to the west and suburban housing and light industrial units to the east and south. The water is 250 m by 70 m with a perimeter of 630 m and area of 1.8 ha.
- Newbold Quarry (Figure 30) is surrounded by a margin of trees and grassland with suburban developments further away. The water is 270 m by 180 m with a perimeter of 840 m and area of 2.75 ha.
- Blue Pool (Figure 31) is close to a trunk road to the west and grass and wooded areas to the east and south. A new housing development is being constructed on former grass and arable land to the north side of the pool. The water is 100 m by 75 m with a perimeter of 390 m and area of 0.73 ha.
- Great Pit (Figure 32) is surrounded by ancient woodland. It is within a fenced enclosure. The water is 95 m by 45 m with a perimeter of 300 m and area of 0.35 ha.
- Hill Hole Quarry (Figure 33) is surrounded by scrub and grass and wooded area to the south-west. A small road runs close to the north corner. It is within a fenced enclosure. The water is 150 m by 75 m with a perimeter of 400 m and area of 0.85 ha.
- Stoney Cove (Figure 34) is surrounded by grass and lightly wooded areas with a trunk road running close to the north-east. As a commercial dive centre is has a carpark and shop, bar and changing

facilities close to the north side of the water. The water is 300 m by 180 m with a perimeter of 1160 m and area of 5.76 ha.

Figure 29 Ensor's Pool.

Figure 30 Newbold Quarry.

Figure 31 Blue Pool.

Figure 32 Great Pit.

Figure 33 Hill Hole Quarry.

Figure 34 Stoney Cove.

## 2.4 Wildlife records

Wildlife records for white-clawed crayfish received from Leicestershire and Rutland Environment Records Centre, Warwickshire Biological Records Centre and data from ref. [4] are combined in Table 3. These show white-clawed crayfish to be present historically on all sites except Great Pit and Blue Pool. Past records are no guarantee of continued presence. A survey carried out between 22nd and 24th September 2014 with 160 traps did not find any crayfish at Ensor's Pool and it was concluded that the population had been lost at some point between October 2013 and July 2014. [4]

Table 3 White-clawed crayfish records.

| Site | Date | Abundance | Male | Female | Traps | Thelohaniasis |
|---|---|---|---|---|---|---|
| Ensor's Pool | Unknown | 58 | 29* | 29* | 39 | 0* |
| | Unknown | 63 | | | 39 | 0* |
| | 14 Jun 1905 [sic] | Present | | | | |
| | 1 Aug 1991 | Present | | | | |
| | 1 Mar 1992 | 168 | 133* | 35* | 40 | 0* |
| | 1 Apr 1992 | 127 | 106* | 21* | 40 | 1* |
| | 1 Sep 2000 | 45 | 25* | 20* | 40 | 1* |
| | 1 Sep 2000 | 112 | 56* | 56* | 40 | 4* |
| | 1 Aug 2005 | 172 | 100* | 72* | 72 | 3* |
| | 1 Sep 2005 | 73 | 36* | 37* | 80 | 1* |
| | 1 Aug 2008 | 194 | 92* | 102* | 160 | 4* |
| | Sep 2012 | 262* | 119 | 143* | 160* | 6* |
| | 24 Sep 2014 | 0* | 0* | 0* | 160* | -* |
| Newbold Quarry | Unknown | Present | | | | |
| | 20 Jun 1905 [sic] | Present | | | | |
| | 1 Apr 1993 | Present | | | | |
| | 15 Aug 2004 | Present | | | | |
| Hill Hole Quarry | 2000 | Present | | | | |
| | 2000 | Present | | | | |
| | 11 Sep 2010 | 25 | 15 | 10 | | |

| Site | Date | Abundance | Male | Female | Traps | Thelohaniasis |
|---|---|---|---|---|---|---|
| Stoney Cove | 1996 | Present | | | | |
| | 1996 | Present | | | | |
| | 14/11/1996 | Present | | | | |
| | 15/12/1996 | Present | | | | |
| | 2000 | Present | | | | |
| | 2000 | Present | | | | |
| | 07/05/2012 | 1 | | | | |
| | 24/09/2008 | 150 | | | | |
| | 21/02/2018 | 1 | | | | |
| | 24/12/2018 | 1 | | | | |

* Data from ref. [4]

Common toads (*Bufo bufo*) and common frogs (*Rana temporaria*) were recorded in Blue Pool, Ensor's Pool and Newbold Quarry. Smooth newts (*Lissotriton vulgaris*) were recorded in Ensor's Pool and Newbold Quarry. Pike (*Esox lucius*) and perch (*Perca fluviatilis*) were recorded at Stoney Cove.

Non-native zebra mussels (*Dreissena polymorpha*) were recorded in Ensor's Pool. Several records of Canadian waterweed (*Elodea canadensis*), a non-native species, were recorded from 1977 but a record in 1992 suggests theses are in fact curly waterweed (*Lagarosiphon major*), a native species.

A record of one signal crayfish (*Pacifastacus leniusculus*) was recorded along with zebra mussels in a pond close to Blue Pool in July 2014. The pond is approximately 270 m from Blue Pool and appears now to have been converted to a balancing pond for the Bishop's Hill housing development.

# 3 MATERIALS AND METHODS

## 3.1 Team recruitment and management

The Project Baseline team was formed by the project managers, Martin Maple and Robert Corby, in March 2020 under the auspices of Marlin Sub-Aqua Club (BSAC Branch 2260). A Facebook group [16] was created to facilitate the recruitment of volunteers. The group was publicised through established diver Facebook groups (e.g. BSAC regions) and through word of mouth. Qualified divers were accepted for membership of the group regardless of experience or training agency. As of July 2020 the group contained forty-six members and by September 2021 this had reached eighty-one.

An introductory webinar was held for team members in July 2020 at which the project was explained and the method statement and risk assessment summarised. [17] These documents were made available on the team Facebook group and were kept up to date during the project. A recording of the webinar was also made for volunteers' future reference.

A Google Form was used to collect membership data in accordance with the Project Baseline privacy policy. [18] This ensured that divers had certification details, an up-to-date Sport Diver Medical Declaration, photography release, next of kin contact details etc on file. Details of specialist training and prior project diving experience was also requested.

The team Facebook group was used to organise all dives where site access had to be agreed with landowners. An 'event' was created on Facebook and volunteers recruited from the wider team on a first-come-first-served basis.

For the Stoney Cove site data were collected from the general diving public *ad hoc*. An explanatory video was created to explain what data to record and how to do it. This was publicised through Facebook via the project page [19] and various Stoney Cove 'buddies' groups.

## 3.2 Diving operations

Diving was carried out in accordance with the project risk assessment and method statement (Figure 35). [17] This was agreed with the landowners and other stakeholders. A written dive plan was developed for each day of diving and shared with the project team. For Sites of Special Scientific Interest (SSSIs) consent was obtained from Natural England through the site owners prior to diving.

Diving was managed by the project managers, a BSAC Advanced Diver (MM) and Dive Leader (RC) who is working towards Advanced Diver. Assistant dive managers of Sports Diver grade and above assisted in collating dive management and scientific data on the surface.

Divers were arranged into teams of two or more depending upon skills, experience and task requirements. Teams of three or more can be extremely effective on project dives where multiple activities need to be completed. However they can lead to additional task loading especially for divers with insufficient capacity to complete tasks underwater while maintaining situational awareness. To minimise this, realistic and sufficiently limited objectives were agreed with each team before each dive to ensure they could be completed safely.

Standardised gases were used in diving teams to ensure that the same ascent profile could be applied. Decompression obligation was minimised with the use of nitrox. Nitrogen narcosis and carbon dioxide retention were minimised by maintaining an equivalent air depth of thirty metres or less using trimix where required.

Use of lifting bags for depositing and recovering items from the water was done in accordance with the project method statement. [17] Divers' breathing gas was not used to inflate lifting bags. A separate


Figure 35 Photographs illustrating the diving activities.

aluminium stage cylinder was used for inflation gas that was equipped with a whip but no second stage regulator.

Covid-19 security was maintained through controls described in a specific risk assessment, which was kept up-to-date as recommendations evolved during the pandemic. [20]

Site biosecurity was maintained by rigorously applying *check, clean, dry* procedures. [17]

## 3.3 Training

The project was used for Advanced Diver training in dive management for one member. All participants had the opportunity to experience diving in a team, in reduced visibility conditions, using ropes for entry/egress, the safe use of lifting bags, wildlife recording and water sampling. Search and recovery methods were used when diving to recover the temperature loggers.

## 3.4 Site mapping

Historical maps available online through the National Library of Scotland were consulted. [21] These showed the development of the quarries across their working lives and infrastructure such as quarry railway lines (see section 2.1).

Historical aerial photographs (see section 2.2) available online at the Britain from Above project [13] and satellite images (see section 2.3) from Google Earth [15] were also reviewed.

Aerial photographs were taken with a radio-controlled drone (DJI Mavic Pro) equipped with a camera. On clear-water days these allowed some shallow underwater features to be identified in the resultant photographs.

A preliminary sketch was made on site showing the profile of the quarry pool using depths measured with divers' dive computers (various models). The presence of submerged infrastructure (e.g. rails) and rubbish was also noted.

Experiments profiling the quarry pools with a Deeper PRO+ Smart Sonar mounted on a kayak were carried out (Figure 36). Narrow band and wideband sonar scans were recorded. The speed at which the kayak was paddled and the recording pattern was varied. Surface water temperature was also measured by the device. Depth data were referenced using global positioning system (GPS) either within the Deeper Pro+ or the mobile phone controller depending upon mode of operation. Fish Deeper v1.6.4.303 control software was used for data capture, and Lakebook web application for processing and plotting.

## 3.5 Wildlife surveying

Species records for the key sites were requested from the Leicestershire and Rutland Environment Records Centre [22] and Warwickshire Biological Records Centre. [23] For SSSIs the designation document was consulted. [24]

A Pond Habitat Survey [25] was completed for each site using a standardised form available from the Freshwater Habitats Trust. This included five classes of non-native plant species.

Crayfish specific surveying methods were reviewed by Wilson. [26] He identified methods that depend upon crayfish being active at night (trapping and night-viewing), those that involve finding crayfish that are hidden in refuges (manual searching), and surrogate methods (e.g. deceased remains). For 'deep water' (>0.4–0.5 m) only trapping or diver surveys are practicable. Scuba surveys were considered most effective since traps are size-selective and avoided by berried females.

Licencing requirements precluded the use of systematic manual surveys specifically targeting crayfish during this project. Instead, crayfish were recorded opportunistically if they were seen out in the open.


Figure 36 Blue Pool bathymetry data showing the route of the kayak across the water (blue line overlaying the map) and a depth profile (insert below).

Transect surveys were undertaken by divers equipped with scuba equipment. A depth profile and linear path were taken with divers recording in wetnotes or on slates the species seen while underwater. Photographs were taken where practicable. Species were identified using internet resources. [27] Results were transferred to a spreadsheet.

## 3.6 Monitoring station

A monitoring station was setup underwater at each site that comprised a secchi disk and information about the project printed on waterproof paper. The secchi disk was either mounted on existing infrastructure underwater, attached to a surface line, or a station was constructed from a plastic tube set in a concrete base. A preliminary dive was made to establish the optimum location, which was marked with a delayed surface marker buoy. Shallow locations that would be easy to find again on subsequent dives were preferred.

The monitoring station was installed by divers. For the concrete-base stations two lifting bags (Halcyon, 36.4 kg capacity) were used to float the station into position. Station location was determined from the surface either by obtaining a GPS fix on the surface marker buoy or by estimating the location from a map with reference to an aerial photograph obtained with a drone.

The secchi disk was a 20 cm diameter circle with black and white quadrants (Figure 37) printed on waterproof paper and laminated. It allowed visibility (water clarity) to be measured more consistently than an estimate. The method is usually used to measure water clarity from the surface by dropping the disk over the side of a boat and recording the average of the depth at which the disk disappears on lowering and reappears on recovery. Ambient light affects the measured depth and so sunny days are preferred.

Divers have adapted the method to measuring the visibility horizontal through the water at a recorded depth of water. In this work the distance from the observer's eye to the secchi disk was measured to the point just before it completely disappeared under ambient light conditions. A measuring tape was used at all sites except Stoney Cove where a rope, knotted at one metre intervals, was left in place. Date, time and water depth were also recorded for each observation.

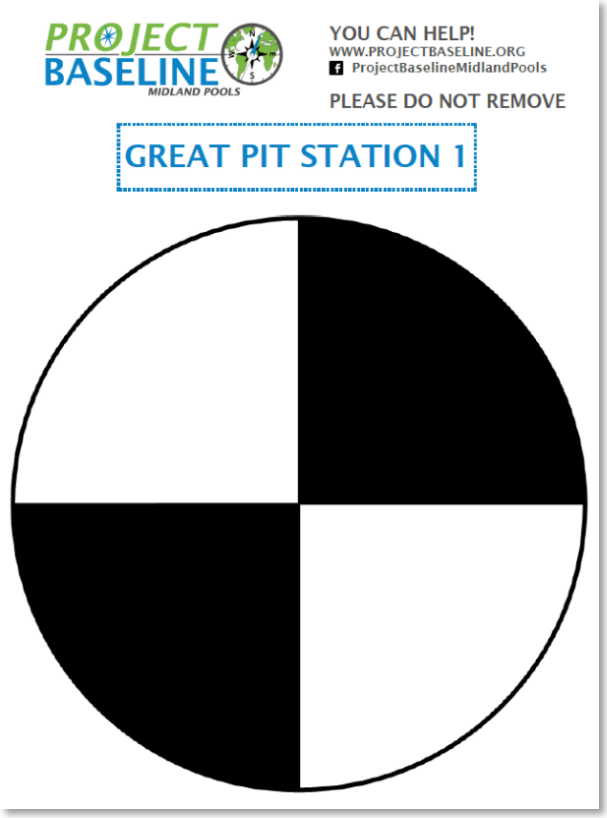



Figure 37 The secchi disk design used in this work.

A photograph of the base station was taken in ambient light at the time of the visibility measurement in most cases. The cameras used varied depending on availability and included conventional still cameras in underwater housings to action video cameras.

Water temperature was recorded at the monitoring station using the diver's wrist mounted dive computer (various models). An Onset TidbiT v2 temperature logger was also installed at each monitoring station (except Stoney Cove). The loggers were configured to record water temperature every hour from launch. The manufacturer's product specification stated that the accuracy of the logger is ± 0.2 ˚C over 0 to 50 ˚C with a resolution of 0.02 ˚C at 25 ˚C. The response time in water is five minutes and the stability (drift) is 0.1 ˚C per year. The loggers were periodically recovered from the water and data downloaded to a personal computer using an Onset HOBO Base Station. Data were processed using Onset HOBOware version 3.7.21 software and Microsoft Excel.

## 3.7 Water chemistry

Water samples were obtained by divers in two litre bottles. Location within the quarry pool and depth was recorded – these were at the base station location. The sample was divided into two portions, the first for

dissolved oxygen analysis and the second for all other analytes. Dissolved oxygen samples were stabilised with 2 ml of manganous chloride followed by 2 ml of alkaline iodide-azide solution and the container filled to the brim to exclude atmospheric air. Samples were delivered to the analytical lab the same day. Water was analysed by ALS Environmental at their Coventry laboratory. The majority of tests were by methods accredited by UKAS to ISO 17025. Not all the tests were completed within the timescales required by the relevant method.

Table 4 shows the list of water chemistry parameters measured. These were selected with reference to the literature review by Haddaway [28] that proposed ideal and tolerable ranges of for white-clawed crayfish.

Table 4 Water chemistry parameters.

| | Method description | Reporting limit | Units | UKAS/ISO 17025 accredited |
|---|---|---|---|---|
| Ammonium as $NH_4$ (Calc) | WAS036 Anions by colorimetry | 0.53 | mg/l | N/A |
| Chloride as Cl | WAS036 Anions by colorimetry | 3.7 | mg/l | Yes |
| Nitrate as N | WAS036 Anions by colorimetry | 0.7 | mg/l | Yes |
| Sulfate as $SO_4$ | WAS036 Anions by colorimetry | 4.4 | mg/l | Yes |
| Conductivity - Electrical 20C | WAS039 pH/EC in water by electrode | 30 | µS/cm | Yes |
| pH | WAS039 pH/EC in water by electrode | 1 | pH units | Yes |
| Phosphates , Total as P | WAS049 Metals in water by ICP-OES | 0.12 | mg/l | Yes |
| Dissolved Oxygen, Fixed | WAS052 Dissolved oxygen in water by titration | 0.5 | mg/l | No |
| Calcium, total as Ca | WAS076 ICPMS metals | 0.325 | mg/l | Yes |
| Magnesium, total as Mg | WAS076 ICPMS metals | 0.08 | mg/l | Yes |
| Potassium, total as K | WAS076 ICPMS metals | 0.37 | mg/l | Yes |
| Sodium, total as Na | WAS076 ICPMS metals | 0.46 | mg/l | Yes |
| Ammoniacal Nitrogen as N | WAS036 Anions by colorimetry | 0.41 | mg/l | Yes |

## 3.8 Litter removal

Litter was surveyed prior to recovery to ensure it met the criteria for removal. [1716] Floating litter was removed from the margins of the pool by hand collection into bags. Small items of submerged litter were collected into net bags. For larger items lifting bags were used. All waste was disposed of through pre-arranged collections by the local councils' waste departments.

## 3.9 Dissemination of results

### 3.9.1 Data

All data generated during this project have been deposited with Project Baseline. [2] Temperature, visibility and photographic data are available online on an open access basis and other data is available on request.

Species observations were supplied either to Leicestershire and Rutland Environment Records Centre [22] or Warwickshire Biological Records Centre [23] depending on site location.

This report records all the results and has been distributed to the project stakeholders and will be published on the project website at projectbaselineuk.org/midlandpools. [30]

### 3.9.2 Public outreach

A public Facebook page [19] was maintained throughout the project that was used to disseminate results on an on-going basis. Posts were shared to local community and diver-orientated Facebook groups to maximise the audience. These included:

- Friends of Ensor's Pool
- Friends of Newbold Quarry
- Bishops Itchington Community (Blue Pool)
- Stoney Cove Buddies.

Facebook posts were shared by third parties including Warwickshire Wildlife Trust and Rugby Police (as part of a water safety campaign).

A webinar was presented to the public on 13th November 2020 to explain the project and preliminary results. This was arranged by Project Baseline UK as part of a lockdown series and was streamed live on their Facebook page. A recording was made available for later viewing. The livestream was attended by eighteen people and a further fifty-six subsequently watched[1] the video.

An article suitable for publication in a diving magazine is planned.

[1] Data from Facebook for views of at least one minute (data for longer viewing times are not available).

# 4 RESULTS

The most comprehensive surveys were carried out at Ensor's Pool, Newbold Quarry and Blue Pool. For other sites a visit was made to install the secchi disk and logger, but these were later in the year than planned due to the Covid-19 pandemic. The project diary is summarised in Appendix 1.

## 4.1 Site maps

### 4.1.1 Photography

Photographs were obtained from a drone at:

- Ensor's Pool (Figure 38)
- Newbold Quarry (Figure 41)
- Blue Pool (Figure 44).

Selected underwater photographs are also shown below.

Figure 38 Ensor's Pool (north-west at top of image) showing its location next to agricultural land, grassland and a housing estate to the east. The location of two submerged standing telegraph poles was temporarily marked by orange buoys (main image, white arrows and insert). The top 1–2 m of water is silty having been stirred up by swimmers over several days prior to the fieldwork.

Figure 39 Diver examines artifacts in Ensor's Pool including a pickaxe head and tub rail. Rails may be stamped with a date of manufacture but this was not observed on the rails examined.

Figure 40 Telegraph pole, building blocks and pipework in Ensor's Pool.

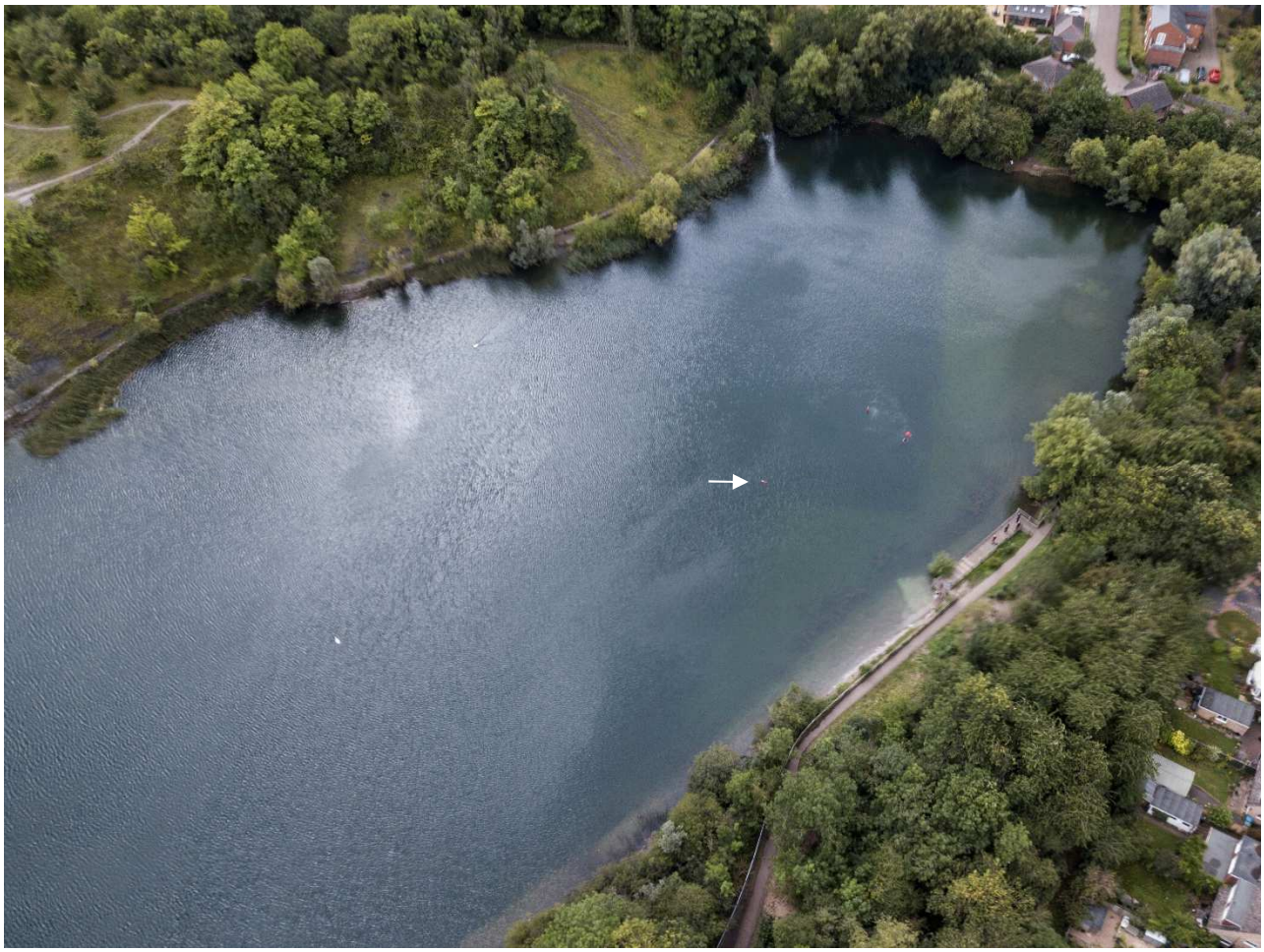


Figure 41 Newbold Quarry (west at top of image) showing its location in grassland and housing. The location of the monitoring station is marked by an orange buoy (white arrow). The sharp edges of the submerged shelves can be seen clearly.

Figure 42 Diver examines the remains of one of a pair of rails at Newbold Quarry with layers of blue lias in the background.

Figure 43 Remains of a car at Newbold Quarry.

Figure 44 Blue Pool (north at top of image) showing its location next to a trunk road to the west and a new housing estate to the north. The location of the monitoring station is marked by an orange buoy (white arrow).

### 4.1.2 Bathymetry

Bathymetry results for Blue Pool are plotted in Figure 45 and Figure 46 following approximately two hours of data collection. The sonar data were extracted into a spreadsheet, which showed the maximum depth of water recorded was 10.431 m at the north side of the pool on a track between 52.22639847°, -1.429833055° and 52.22641754°, -1.429829001°.

An attempt to measure the profile of Great Pit failed, possibly due to the sonar being reflected off a shallow layer of leaf debris. Further attempts to record bathymetry data at other sites were not made due to the need to reduce volunteer numbers on site during the pandemic, although this work is planned for the future.

The maximum depth measured at each site by diver survey is as follows:

- Ensor's Pool, 10.8 m
- Newbold Quarry, 17.0 m
- Blue Pool, 10.1 m
- Great Pit, 49.2 m
- Hill Hole Quarry, 8.0 m.

The result at Blue Pool aligns well with that recorded by the sonar.

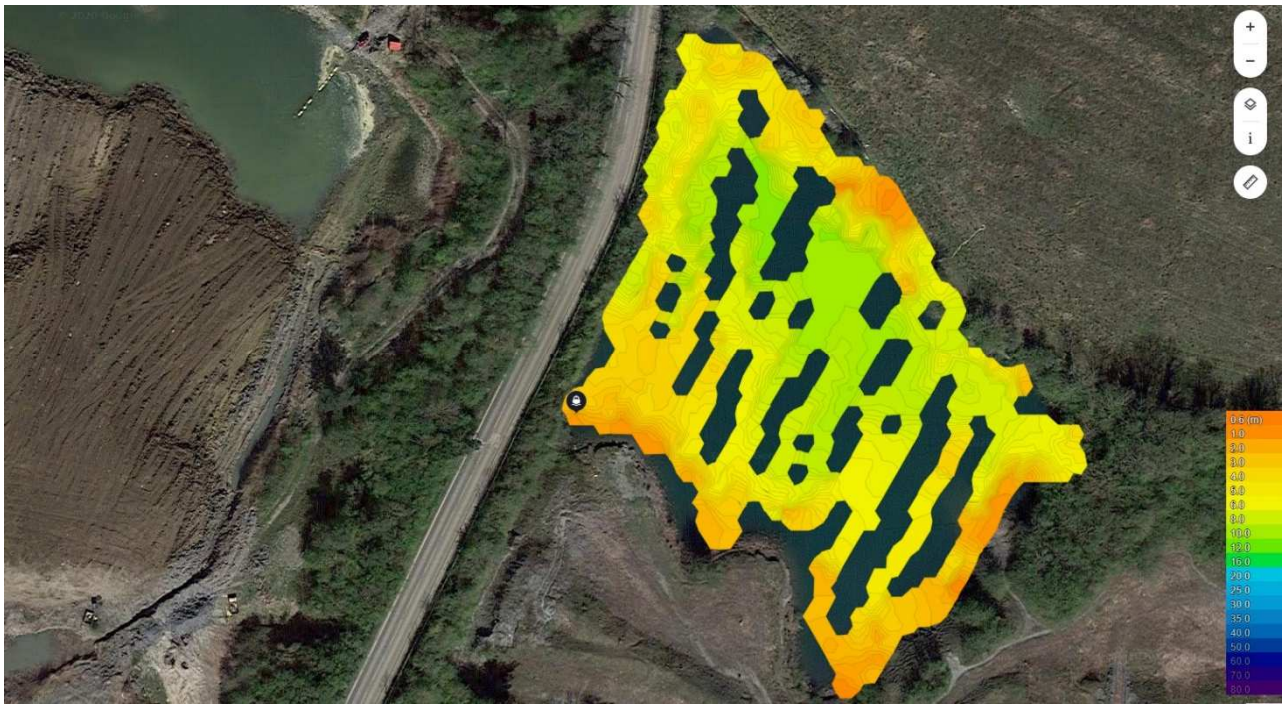


Figure 45 Blue Pool bathymetry data processed at high resolution, overlaid over a satellite map (Google) and colour coded to show shallow depths in orange and deeper areas in green. Gaps in the dataset are apparent.

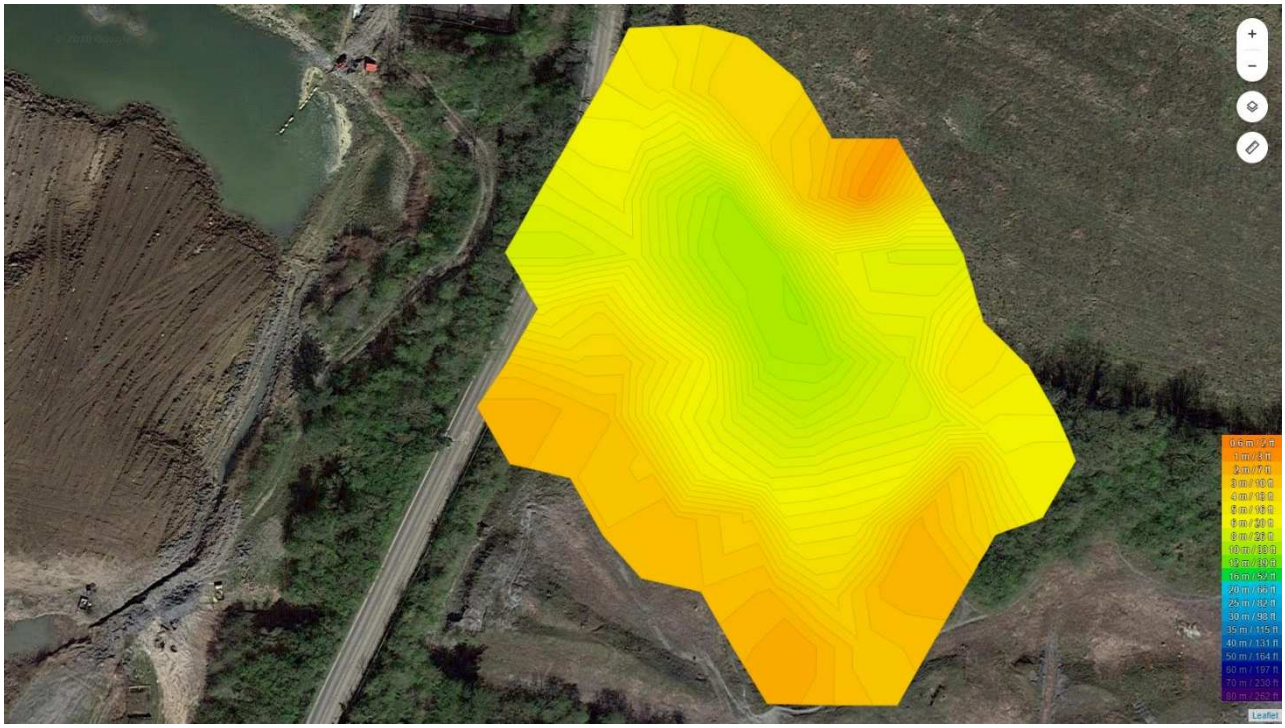


Figure 46 Blue Pool bathymetry data processed at low resolution, overlaid over a satellite map (Google) and colour coded to show shallow depths in orange and deeper areas in green. Low resolution processing fills in the gaps but at the expense of spatial precision.

### 4.1.3 Mapping

Combining a historical map, satellite and drone photographs revealed the likely location of a trackway, which was subsequently confirmed on the lakebed (Figure 47).

Sketch maps were also prepared from diver observations at Ensor's Pool (Figure 48), Newbold Quarry (Figure 49), Blue Pool (Figure 50), Great Pit (Figure 51) and Hill Hole Quarry (Figure 52).


Figure 47 Combining the map of Ensor's Pool from Figure 6, the drone image from Figure 38, and a modern satellite image helps identify the trackway (blue line) that remains within the water close to the two telegraph poles.


Figure 48 Sketch map of Ensor's Pool based on diver observations showing cars, and the remains of telegraph poles (blue circles), a building, and two tubs and rails. The location of the monitoring station is marked by a red star. [31]

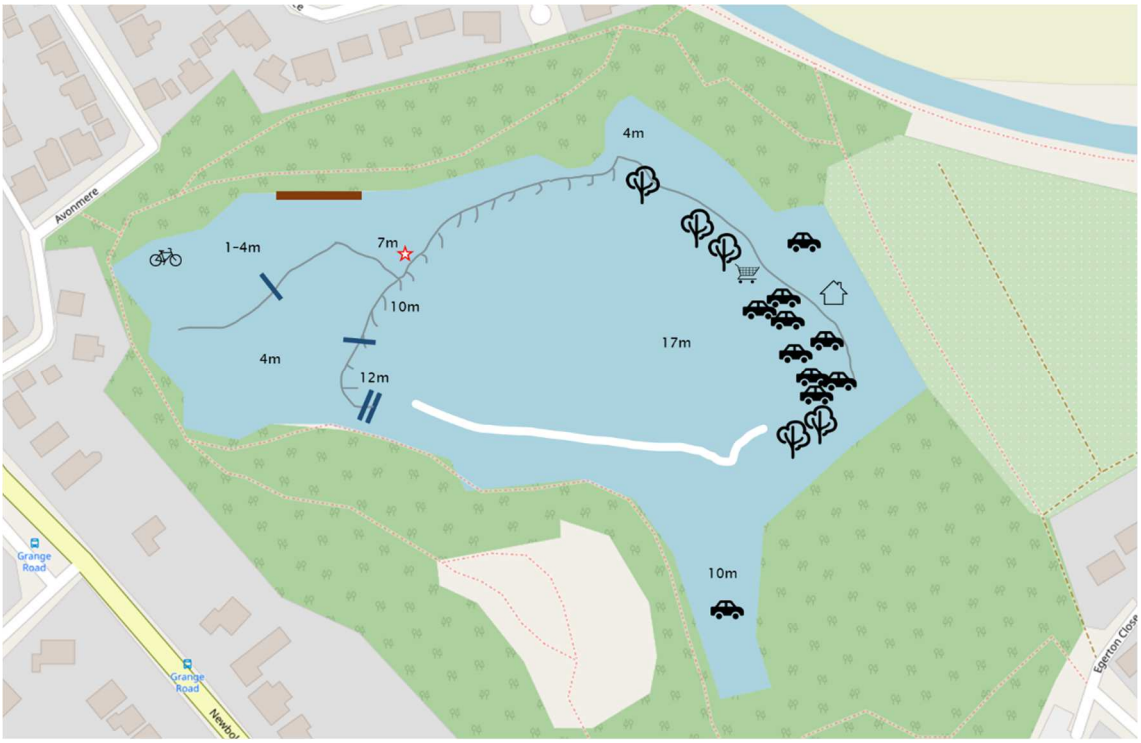



Figure 49 Sketch map of Newbold Quarry based on diver observations showing ten cars, fallen trees and the remains of iron rails (blue lines). The location of the monitoring station is marked by a red star. [31]


Figure 50 Sketch map of Blue Pool based on diver observations and bathymetry showing the remains of iron rails (blue lines). The location of the monitoring station is marked by a red star. [31]

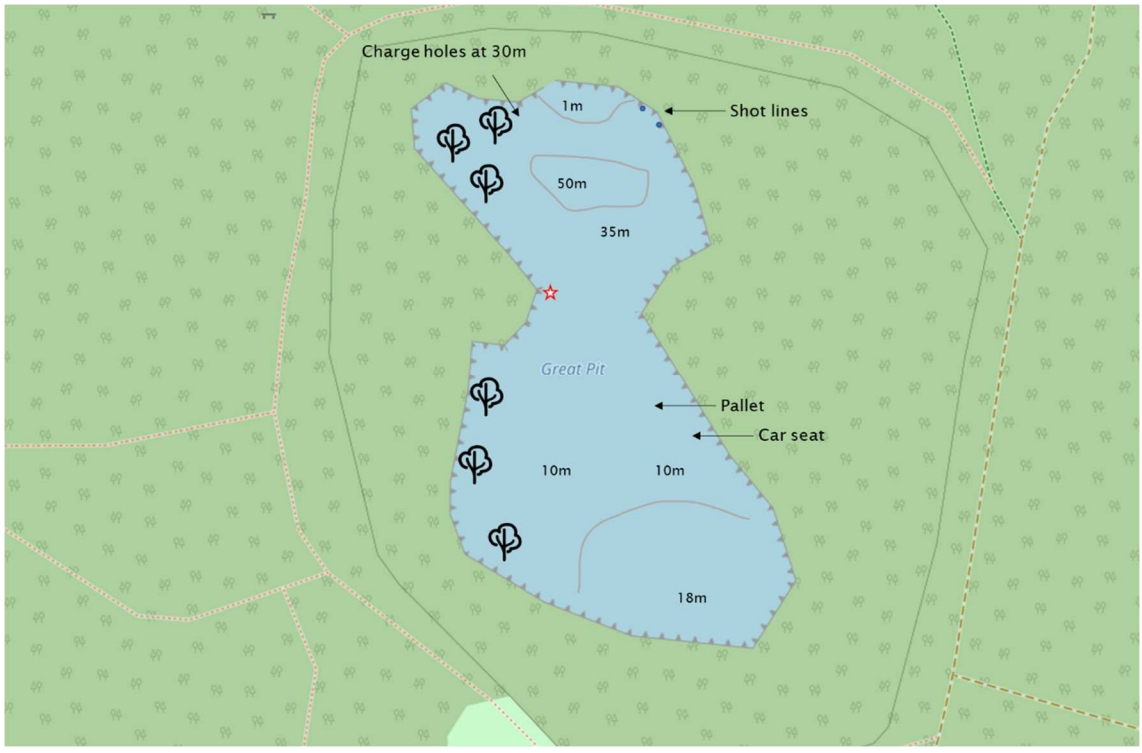



Figure 51 Sketch map of Great Pit based on diver observations showing fallen trees. The location of the monitoring station is marked by a red star. [31]

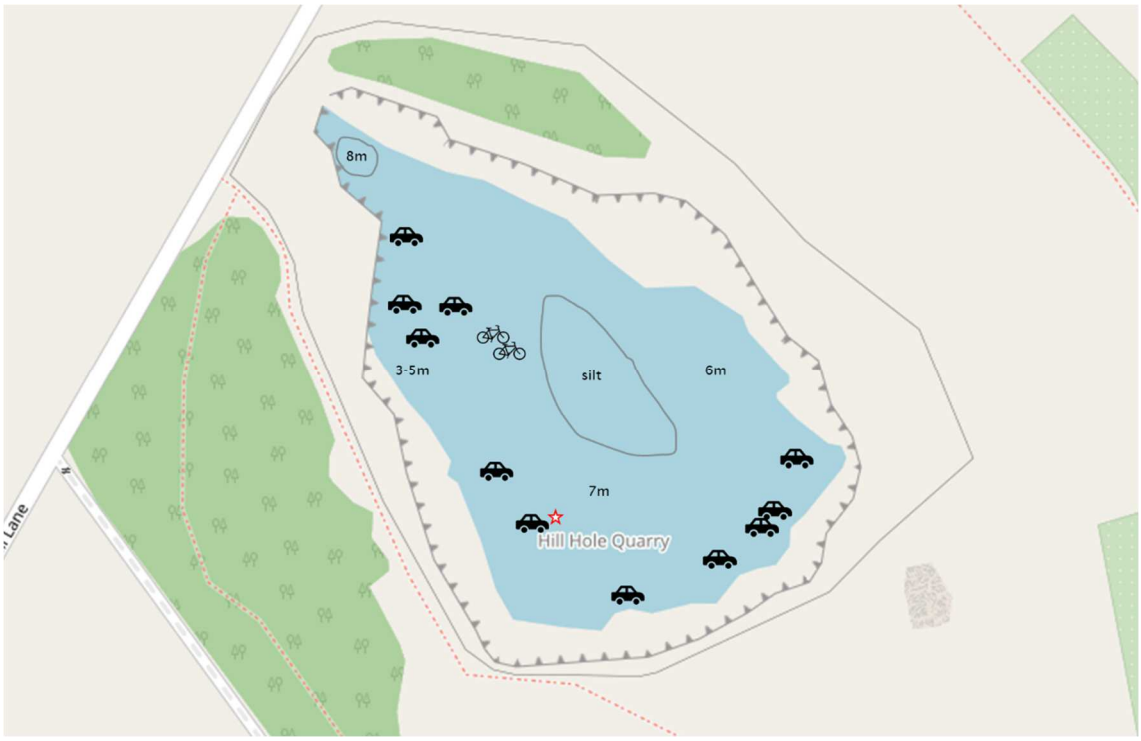



Figure 52 Sketch map of Hill Hole Quarry based on diver observations showing cars (number approximate). The location of the monitoring station is marked by a red star. [31]

## 4.2 Wildlife surveys

Divers carried out surveys of each pool, typically by making a transect by circumnavigation at a single depth. Table 5 shows the list of species confidently identified. Appendix 2 shows the standardised pond habitats surveys for each site.

White-clawed crayfish were recorded at Ensor's Pool, Newbold Quarry, Hill Hole Quarry and Stoney Cove. This was the first time that white-clawed crayfish had been recorded at Ensor's Pool since 2014 when they were presumed to have been wiped out by crayfish plague. It is significant to find that the population has at least partially recovered at this site.

In October 2020 a dead signal crayfish was found on the bank at Blue Pool, however this species was not seen alive in the water. In November 2021 three signal crayfish were seen in Newbold Quarry for the first time. They were noticeably larger than the white-clawed crayfish that were also recoded on the same dive. Two signal crayfish were caught and so a positive identification was made (Figure 56). This is extremely bad news for the native crayfish population as these are never found living alongside signal crayfish for long. Further monitoring will be carried out to determine if the population survives. Although Newbold Quarry is close to the Oxford canal and signal crayfish are known to be able to migrate across land, [29] they have not previously been recorded in the canal.

A sulfide layer (indicated by an eggy smell) was found in Newbold Quarry in November 2021. Bacterial mats were seen in most quarries, however the most notable was in Newbold Quarry near the hydrogen sulfide layer which was bright white in colour. This is likely to be *Beggiatoa sp* that oxidises hydrogen sulfide as energy source, forming intracellular sulfur droplets; oxygen is the terminal electron acceptor and $CO_2$ is used as carbon source. These phenomena could indicate stratification is occurring in the lake. Further research and monitoring are required in this area.

Table 5 Species observed in the water. * Indicates a grid reference at the centre of the water body.

| Site name | Species common name | Species scientific name | Number/ Abundance | Grid reference (OS format) | Date of record |
|---|---|---|---|---|---|
| Ensor's Pool | White-clawed crayfish (Figure 53) | *Austropotamobius pallipes* | 2 | SP 34797 90318 | 7 Jun 2020 |
| | White-clawed crayfish | *Austropotamobius pallipes* | 8 | SP 34797 90318 | 26 Oct 2020 |
| | Perch | *Perca fluviatilis* | Common | SP 34766 90400 | 26 Oct 2020 |
| | White-clawed crayfish | *Austropotamobius pallipes* | 2 | SP 34797 90318 | 27 Feb 2021 |
| | Perch | *Perca fluviatilis* | Occasional | SP 34832 90327 * | 6 Nov 2021 |
| Newbold Quarry | White-clawed crayfish (Figure 54) | *Austropotamobius pallipes* | 2 | SP 49369 77016 | 22 Aug 2020 |
| | White-clawed crayfish | *Austropotamobius pallipes* | 1 (dead) | SP 49338 77032 | 22 Aug 2020 |
| | Zebra mussel (Figure 55) | *Dreissena polymorpha* | Occasional | SP 49369 77016 * | 22 Aug 2020 |
| | Freshwater sponge (Figure 55) | | Occasional | SP 49369 77016 * | 22 Aug 2020 |
| | Pike | *Esox Lucius* | Rare | SP 49369 77016 * | 22 Aug 2020 |
| | Perch | *Perca fluviatilis* | Common | SP 49369 77016 * | 22 Aug 2020 |
| | Bullhead | *Cottus gobio* | Rare | SP 49369 77016 * | 22 Aug 2020 |
| | Pike | *Esox Lucius* | 1 | SP 49369 77016 * | 26 Oct 2020 |
| | Carp | *Cyprinus carpio* | 1 | SP 49369 77016 * | 26 Oct 2020 |
| | Roach | *Rutilus rutilus* | Common | SP 49369 77016 * | 26 Oct 2020 |
| | White-clawed crayfish | *Austropotamobius pallipes* | 1 | SP 49369 77016 * | 22 Mar 2021 |

| Site name | Species common name | Species scientific name | Number/ Abundance | Grid reference (OS format) | Date of record |
|---|---|---|---|---|---|
| | White-clawed crayfish | *Austropotamobius pallipes* | 5 | SP 49369 77016 * | 6 Nov 2021 |
| | Signal crayfish (Figure 56) | *Pacifastacus leniusculus* | 3 | SP 49369 77016 * | 6 Nov 2021 |
| | Pike | *Esox Lucius* | 1 | SP 49369 77016 * | 6 Nov 2021 |
| | Perch | *Perca fluviatilis* | Common | SP 49369 77016 * | 6 Nov 2021 |
| | Roach | *Rutilus rutilus* | Common | SP 49369 77016 * | 6 Nov 2021 |
| | Bacterial film | *Beggiatoa sp* | 2 $m^2$ patch | SP 49369 77016 * | 6 Nov 2021 |
| Blue Pool | Signal crayfish (Figure 57) | *Pacifastacus leniusculus* | 1 (dead) | SP 39002 58783 | 11 Oct 2020 |
| | Zebra mussel | *Dreissena polymorpha* | Rare | SP 39041 58808 * | 11 Oct 2020 |
| | Perch | *Perca fluviatilis* | Occasional | SP 39041 58808 * | 6 Nov 2021 |
| Hill Hole Quarry | White-clawed crayfish | *Austropotamobius pallipes* | 24 | SK 48533 10297 | 11 Aug 2021 |
| | Peach blosson jellyfish | *Craspedacusta sowerbii* | 1 | SK 48533 10297 | 11 Aug 2021 |
| Stoney Cove | White-clawed crayfish | *Austropotamobius pallipes* | 8 | SP 49427 94106 | 23 Oct 2020 |
| | White-clawed crayfish | *Austropotamobius pallipes* | 6 | SP 49427 94106 | 22 May 2021 |

Figure 53 White-clawed crayfish at Ensor's Pool (7th June 2020).

Figure 54 White-clawed crayfish at Newbold Quarry (22nd August 2020).

Figure 55 Fresh water sponge and zebra mussels at Newbold Quarry (22nd August 2020).

Figure 56 Signal crayfish (berried female, top, and male, bottom) from the water at Newbold Quarry (6th November 2021). The female's missing leg and adjacent white patch may indicate crayfish plague infection.

Figure 57 Remains of a signal crayfish on the bank of Blue Pool (11th October 2020).

## 4.3 Water chemistry, visibility and temperature

### 4.3.1 Monitoring stations

The quarry pools were surveyed for suitable locations to place the monitoring stations, which comprised a secchi disk and temperature logger. Sites away from public access, in locations that had a background that would show changes over time, and that could easily be found again with pilotage were chosen.

Monitoring stations at Newbold Quarry and Blue Pool were constructed from 2" white plastic tubing set in concrete. They were floated to their final locations using lift bags and dropped into position by releasing air slowly from the lifting bags. Control was found to be hard to maintain as the bags collapsed under pressure and it was impossible to add additional gas to slow the descent. The stations remained upright during descent and required only minimal rotation once on the bottom to reach their final position.

The monitoring stations at Ensor's Pool, Hill Hole Quarry and Stoney Cove were affixed to infrastructure already in the water. In the case of Ensor's Pool this was one of two telegraph poles that remained standing. At Hill Hole Quarry this was a submerged abandoned car. At Stoney Cove an apparently original winch gear was used on the 7 m shelf and the Wessex helicopter attraction on the 22 m shelf.

At Great Pit the secchi disk and temperature logger were attached to a length of #24 line tied to the rock face and a weighted with a sinker.

Monitoring stations were installed at the locations and depths shown in Table 6. It should be noted that at some sites water level does not remain static and so variation in depth was observed. Visibility, temperature and a photograph (where possible) were recorded by divers at each visit to the monitoring station.

Table 6 Location of monitoring stations.

| Site | Station | Depth at installation, m | Grid reference[1] | Latitude, Longitude (degs, mins, secs)[2] | Latitude, Longitude (decimal)[2] |
|---|---|---|---|---|---|
| Ensor's Pool | Station 1 | 8.2 | SP 34809 90381 | 52°30'37" N, 001°29'19" W | 52.510218, -1.4885481 |
| Newbold Quarry | Station 1 | 5.8 | SP 49376 77044 | 52°23'21" N, 001°16'33" W | 52.3892, -1.2759 |
| Blue Pool | Station 1 | 5.7 | SP 39012 58836 | 52°13'35" N, 001°25'49" W | 52.2263500, -1.4302817 |
| Great Pit | Station 1 | 7.0 | SK 53908 12196 | 52°42'17" N, 001°12'13" W | 52.704761, -1.203612 |
| Hill Hole Quarry | Station 1 | 4.2 | SK 48533 10297 | 52°41'17" N, 001°17'00" W | 52.688191, -1.283432 |
| Stoney Cove | Station 1 | 4.0 | SP 49412 93930 | 52°32'28" N, 001°16'22" W | 52.540994, -1.2728664 |
| | Station 2 | 18.7 | SP 49410 94070 | 52°32'32" N, 001°16'22" W | 52.542251, -1.2728796 |

[1] Ordnance Survey Great Britain.

[2] WGS84 coordinates.

### 4.3.2 Water temperature and visibility

Table 7shows the results of temperature and visibility measurements made by divers. Photographs are shown in Figure 58 to Figure 62. Temperature and visibility vary through-out the year, with temperature declining in the early part of the year, and visibility becoming poorer as the water warms up. There are however too few data points to draw firm conclusions.

The temperature data from the loggers is much more informative since it is collected continuously at one-hour intervals. Figure 63 and Table 8 show the results obtained at Ensor's Pool, Newbold Quarry and Blue Pool. In summary:

- Ensor's Pool: minimum temperature, 3.8 °C (Feb 2021), maximum temperature, 10.7 °C (Nov 2020)
- Newbold Quarry: minimum temperature, 3.9 °C (Feb 2021), maximum temperature, 15.7 °C (Oct 2021)
- Blue Pool: minimum temperature, 3.8 °C (Jan 2021), maximum temperature, 16.1 °C (Oct 2021).

Table 7 Temperature and visibility measurements by divers. Visibility is measured with reference to a secchi disk except where noted and measured with a tape measure or knotted rope (Stoney Cove only).

| Project Site | Station | Depth, m | Temperature, °C | Visibility, m | Observation date | Observation time |
|---|---|---|---|---|---|---|
| Ensor's Pool | Station 1 | 8.2 | 11 | 2.3 | 26 Oct 2020 | 07:57:00 |
| | | 9.0 | 6.1 | 2.0 | 27 Feb 2021 | 08:42:00 |
| | | 8.0 | 12 | 0.1 | 26 Oct 2021 | 19:50:00 |
| Newbold Quarry | Station 1 | ~7 | 10.3 | 6[1] | 22 Aug 2020 | Not recorded |
| | | 5.8 | 11 | 6.4 | 26 Oct 2020 | 11:00:00 |
| | | 6.8 | 7.1 | 3.7 | 22 Mar 2021 | 09:06:00 |
| | | 5.8 | 11.0 | 5.0 | 6 Nov 2021 | 11:53:00 |
| Blue Pool | Station 1 | 5.7 | 13.4 | 1.4 | 11 Oct 2020 | 12:30:00 |
| | | 5.7 | 11.0 | 1.0 | 6 Nov 2021 | 15:50:00 |
| Great Pit | Station 1 | ~7.0 | 12.0 | 6.0 | 11 Jul 2021 | 14:00:00 |
| Hill Hole Quarry | Station 1 | 4.2 | 18.9 | 2.7 | 11 Aug 2021 | 20:50:00 |
| Stoney Cove | Station 1 | 4.0 | 12 | 7 | 23 Oct 2020 | 13:36:00 |
| | | 20.0 | 11.0 | 9.2 | 20 Dec 2020 | 09:30:00 |
| | | 4.0 | 8.0 | 2.8 | 04 Apr 2021 | 10:45:00 |
| | | 4.0 | 11.0 | 2.5 | 22 May 2021 | 11:15:00 |
| | | 4.0 | 15.0 | 10.4 | 05 Oct 2021 | 11:49:00 |
| | Station 2 | 18.7 | 11 | 6 | 23 Oct 2020 | 10:19:00 |
| | | 5.5 | 8.0 | 12.0 | 20 Dec 2020 | 13:30:00 |
| | | 19.0 | 6.5 | 3.5 | 04 Apr 2021 | 13:30:00 |
| | | 19.0 | 8.0 | 6.5 | 22 May 2021 | 09:00:00 |
| | | 20.0 | 8.0 | 4.0 | 28 May 2021 | 10:00:00 |

[1] Estimate by eye.

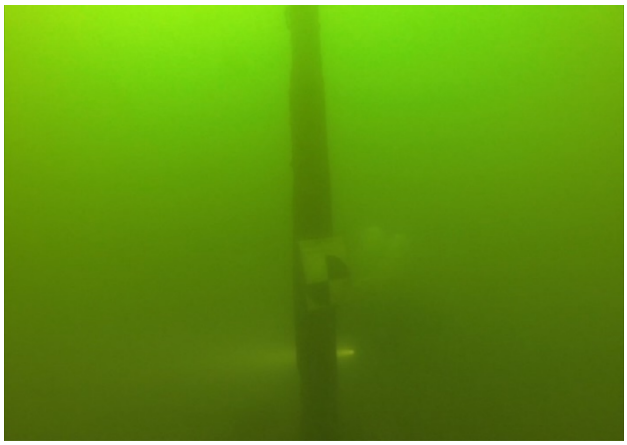


Figure 58 Ensor's Pool.

Figure 59 Newbold Quarry.

Figure 60 Blue Pool.

Figure 61 Stoney Cove (station 1, winch).

Figure 62 Stoney Cove (station 2, Wessex).

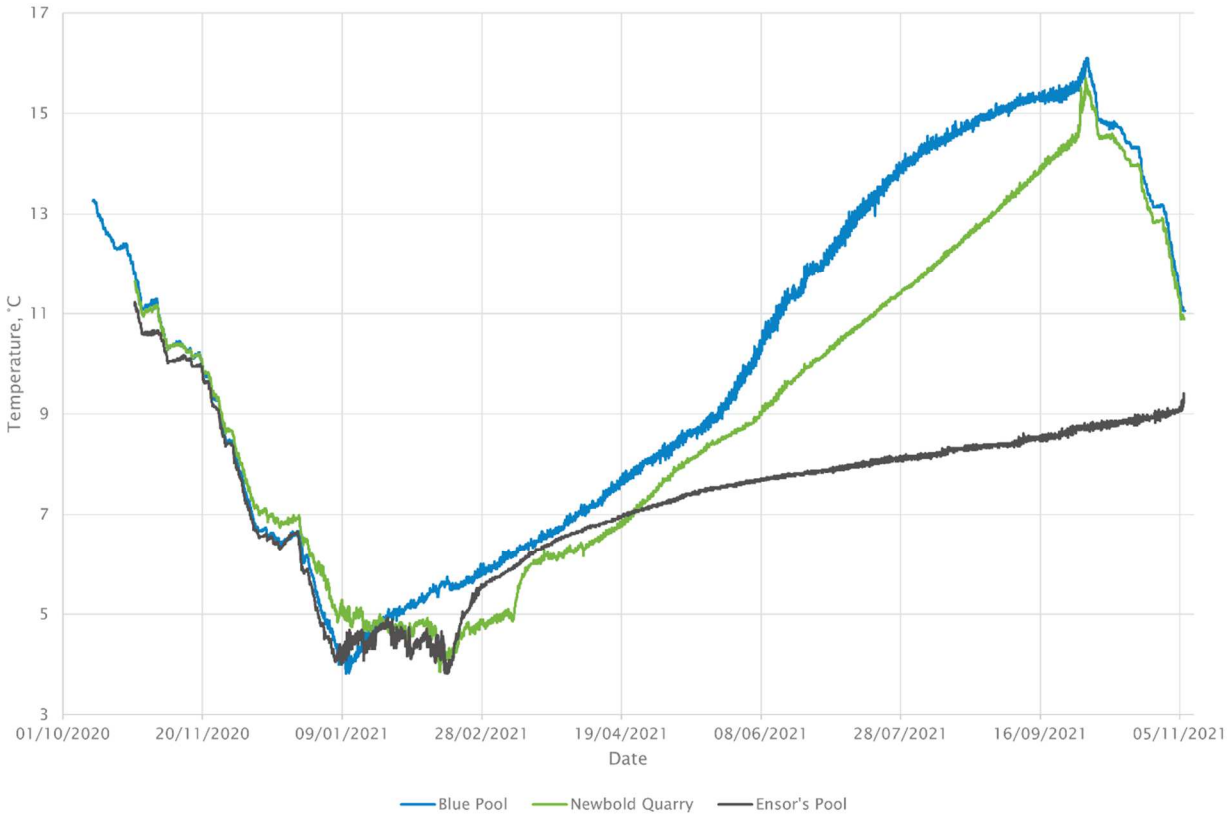



Figure 63 Plot of water temperature versus time over a twelve-month period at Ensor's Pool, Newbold Quarry, and Blue Pool. The logger at Ensor's Pool is ~2 m deeper than the other sites, which may explain the difference in maximum temperature given the size and volume of this quarry lies between the other two.

Table 8 Summary of temperature measurements from the loggers in Ensor's Pool (depth ~8.4 m), Newbold Quarry (depth ~6.3 m) and Blue Pool (depth ~5.7 m).

| | Ensor's Pool | | | Newbold Quarry | | | Blue Pool | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min temp, ˚C | Max temp, ˚C | Average temp, ˚C | Min temp, ˚C | Max temp, ˚C | Average temp, ˚C | Min temp, ˚C | Max temp, ˚C | Average temp, ˚C |
| Nov 2020 | 8.3 | 10.7 | 9.8 | 8.6 | 11.2 | 10.0 | 8.4 | 11.3 | 10.0 |
| Dec 2020 | 4.9 | 8.3 | 6.5 | 5.8 | 8.6 | 7.0 | 5.2 | 8.4 | 6.7 |
| Jan 2021 | 4.0 | 4.9 | 4.5 | 4.5 | 6.0 | 5.0 | 3.8 | 5.2 | 4.6 |
| Feb 2021 | 3.8 | 5.6 | 4.6 | 3.9 | 4.9 | 4.6 | 5.1 | 6.0 | 5.5 |
| Mar 2021 | 5.6 | 6.6 | 6.1 | 4.7 | 6.4 | 5.6 | 5.8 | 7.0 | 6.4 |
| Apr 2021 | 6.6 | 7.2 | 6.9 | 6.2 | 7.5 | 6.7 | 6.9 | 8.2 | 7.5 |
| May 2021 | 7.2 | 7.6 | 7.4 | 7.4 | 8.7 | 8.2 | 8.0 | 9.8 | 8.7 |
| Jun 2021 | 7.6 | 7.9 | 7.8 | 8.7 | 10.2 | 9.5 | 9.6 | 12.2 | 11.0 |
| Jul 2021 | 7.8 | 8.2 | 8.0 | 10.2 | 11.6 | 10.9 | 12.0 | 14.2 | 13.2 |
| Aug 2021 | 8.1 | 8.4 | 8.3 | 11.5 | 13.1 | 12.3 | 14.0 | 15.2 | 14.6 |
| Sep 2021 | 8.3 | 8.8 | 8.5 | 13.1 | 15.5 | 13.9 | 15.0 | 15.9 | 15.3 |
| Oct 2021 | 8.7 | 9.1 | 8.9 | 12.4 | 15.7 | 14.0 | 12.7 | 16.1 | 14.4 |

### 4.3.3 Water chemistry

A water sample was collected from one location at each quarry pool by divers and analysed for a selection of species. The results are shown in Table 9. Comparing the results with the ranges given in ref. [28], which are reproduced in Table 10, reveal where each measurement falls with the range that white-clawed crayfish have been found before.

Each result is interpreted as follows:

- **Ammonium:** Ammonium is toxic to many aquatic species, but the concentrations measured are low, although the method used could not identify concentrations below 0.53 mg/l. Rotting leaf litter can be associated with high ammonium concentrations but this was not found at our sites, even at Great Pit which contains a layer of leaf litter.
- **Chloride:** Haddaway found no populations of white-clawed crayfish in water with more than 60 mg/l of chloride. All the sites are lower than that.
- **Nitrate:** Nitrate levels were low in all the sites. Haddaway noted no evidence for an association with low nitrate levels.
- **Sulfate:** Most of the sites had low concentrations of sulfate. The exceptions were Blue Pool and Newbold Quarry, the latter had concentrations similar to the worst polluted site studied by Haddaway. He suggested white-clawed crayfish prefer lower concentrations of sulfate but may be tolerant of higher concentrations. It is possible that the concentration at Blue Pool would be too high for them though. Evidence of precipitated sulfate, typically the result of decomposing organic matter, was observed by divers on the lakebed at Newbold Quarry although it was not confirmed by chemical analysis.
- **Conductivity:** Conductivity correlates with the concentration of cations and anions in the water. Water with a conductivity above 700 µS/cm is typically polluted or brackish/saline and Haddaway suggests this as the maximum tolerated by white-clawed crayfish. Blue Pool was the only site with a conductivity above 700 µS/cm and this is likely to be associated with the geology at that site.
- **pH:** White-clawed crayfish have been found across a pH range of 6.0 to 9.2. At the sites with crayfish a slightly alkaline pH around 8 was found.
- **Phosphate:** An association between crayfish and low phosphate concentrations was found by Haddaway and that is in line with the results found in this work.
- **Dissolved oxygen:** Haddaway suggests a minimum concentration of oxygen of 5 mg/l which excludes Great Pit in the present sites.
- **Calcium:** Crustacean exoskeletons are composed of chitin encrusted with calcium carbonate. The majority of crayfish populations have been found in water with a calcium concentration above 5 mg/l and the sites we have studied all follow this trend.
- **Magnesium:** Is essential for crustacean moulting. Haddaway suggests that the wide range of concentrations suggest little association with Mg concentration, but that most of his sites were below 12 mgl/l. We found 30 mg/L at Newbold Quarry, and 108 mg/l at Blue Pool. This is likely to be associated with the geology at these sites.
- **Potassium:** No association with potassium concentration has been identified previously. The sites here are all at the higher end of the concentrations Haddaway found but he suggests that there is no intolerance of higher potassium concentrations.

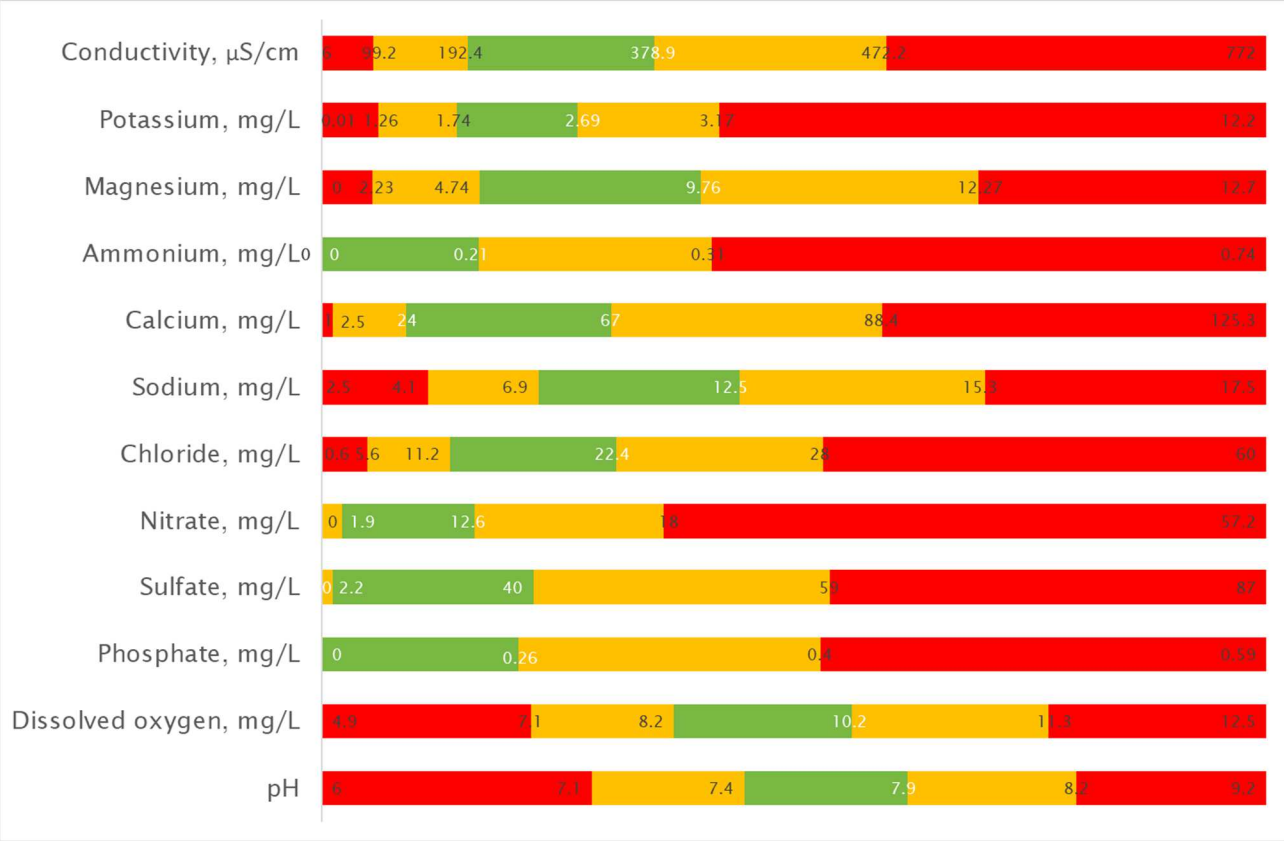
- **Sodium:** There may be a lower tolerance to sodium by white-clawed crayfish according to Haddaway. Great Pit and Hill Hole Quarry had low concentrations of sodium, while the other sites had high levels. Given that Ensor's Pool and Newbold Quarry both contain white-clawed crayfish they may be relatively tolerant of sodium.

For the sites with white-clawed crayfish the water is ostensibly within the ranges reported by Haddaway. Great Pit would seem unfavourable due to its low dissolved oxygen concentration, and Blue Pool due to its very high conductivity, resulting from high ion concentrations. The apparent blue colour is associated with Ca and Mg carbonates precipitating as temperature changes and so this is perhaps unsurprising.

Table 9 Results of chemical analysis. Colour coding relates to the ranges of water suitability for white-clawed crayfish given in ref. [28], see also Table 10.

| | Units | Ensor's Pool | Newbold Quarry | Blue Pool | Great Pit | Hill Hole Quarry |
|---|---|---|---|---|---|---|
| Date of sampling | | 26 October 2020 | 26 October 2020 | 11 October 2020 | 11 July 2021 | 11 August 2021 |
| Depth of sample, metres | | 6 | 6 | 3 | 6 | 5 |
| Ammonium as $NH_4$ (Calc) | mg/l | <0.53 | <0.53 | <0.53 | <0.53 | <0.53 |
| Chloride as Cl | mg/l | 21.2 | 40.2 | 41.2 | 8.2 | <3.7 |
| Nitrate as N | mg/l | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 |
| Sulfate as $SO_4$ | mg/l | 31.3 | 119 | 698 | <4.4 | <4.4 |
| Conductivity 20 ˚C | µS/cm | 311 | 538 | 1350 | 142 | 166 |
| pH | pH units | 8.1 | 8.2 | 8.0 | 7.2 | 8.0 |
| Phosphates , Total as P | mg/l | <0.120 | <0.120 | <0.120 | <0.120 | <0.120 |
| Dissolved Oxygen, Fixed | mg/l | 8.5 | 6.9 | 9.1 | 2.6 | 9.2 |
| Calcium, total as Ca | mg/l | 37.9 | 62.2 | 200 | 16.4 | 28.0 |
| Magnesium, total as Mg | mg/l | 12 | 30 | 108 | 7.7 | 6.3 |
| Potassium, total as K | mg/l | 8.9 | 4.1 | 18 | 3.1 | 1.1 |
| Sodium, total as Na | mg/l | 16 | 20 | 19 | 4.7 | 3.6 |
| Ammoniacal Nitrogen as N | mg/l | <0.41 | <0.41 | <0.41 | <0.41 | <0.41 |

Table 10 The recommended water quality guidelines for white-clawed crayfish reproduced from ref. [28].




Within 2.5 standard errors of means reported in the literature, from ref. [28]

Within 5 standard errors of means reported in the literature, from ref. [28]

Total range

Out of range for the purposes of Table 9

# 5 DISCUSSION

## 5.1 Organisation

Team recruitment via Facebook was successful in establishing a group of more than eighty divers from the region who were interested in participating in the project. The number who attended diving days was however a minority of these although the project was well supported by the core team that self-established. It was certainly beneficial to extend the diving opportunity to people outside the Branch as additional experience and expertise was accessed in this way.

Diving operations were managed using a scheduled plan for the day with objectives defined in advance. Timekeeping was a challenge, but the activities were generally completed each day. No incidents or high potential near misses occurred during the project.

Training proved to be effective with knowledge and experience being readily shared and more formal activities, such as the safe use of lifting bags, being included as part of the brief. Teams were managed to include a diver experienced in any techniques that were unfamiliar to the others.

The installation of two monitoring stations at the Stoney Cove inland diving centre, and the production of a video explaining how to record photographs, visibility, depth and temperature measurements was hoped to provide ready access to a site and engage the wider diving community in monitoring projects. However without the organisation of project days few measurements were submitted *ad hoc*.

## 5.2 Survey and monitoring

Diver surveys were effective in creating basic maps of the underwater sites. The lakebed composition and the presence of infrastructure within the water was identified. Combined with bathymetry data relatively accurate topological maps are possible. The location of submerged objects could be identified from a delayed surface marker buoys and GPS or drone photographs. Future dives should build upon and refine the maps produced this year, improving their accuracy.

The loggers were effective for monitoring the temperature of the water. Data points could be obtained at one hour intervals with sufficient memory and battery power in the logger to last five years.

Visibility measurements varied through the year, largely dependent on the presence of algal blooms and sediment stirred up after rain. The secchi disks provide a reasonable means of measurement underwater visibility, however the precision was found to be very dependent upon ambient light level and so an uncertainty of at least one metre is likely.

Ensor's Pool contained the remains of a tub railway, two standing telegraphs poles and a quarry building. Vehicles were also present and some angling and food packaging litter. Future work using photogrammetry would be useful for recording the infrastructure present. The site was improved during the project by the independent formation of a 'friends' group of local residents who carried out regular litter-picks and monitored activity on the site.

Newbold Quarry contained the remains of a pumping barge and a small quarry building now mostly buried in silt. The quarry had high terraces providing variable depths. There was little litter but several vehicles that had presumably been pushed into the quarry from the path, formerly a road, above the east side of the quarry. The site was much improved during the project by the local residents' efforts with frequent litter-picks and the borough council's replacement of fencing. Hydraulic connections to other water bodies were apparent due to flooding over the winter months.

Blue Pool is a smal bowl-shaped quarry. It contained a great deal of surface litter resulting from its semi-derelict state prior to Warwickshire Wildlife Trust taking over the management of the site. Litter reappeared

over the project duration including inflatables and polystyrene insulation board from the adjoining building site. The polystyrene broke down and contaminated the bank with polystyrene beads that will be hard to clean-up.

Evidence of blasting or prising holes was found in Great Pit at thirty metres of water. Great Pit is thought to contain one car, but this was not located. Two downlines were found, and a jackstay, from its previous use by scuba divers. This site contains an area of fifty metre deep water that proved accessible using trimix and staged decompression but was completely dark due to the black colour of the slate walls and the overhanging shape of the quarry. Little was identified at the bottom of the quarry except boulders and tree branches.

Hill Hole Quarry contained a great number of vehicles and also litter from unauthorised recreational use, notably food containers, barbecues, inflatables and objects thrown in from the surrounding area such as signs, fencing and rubbish bins. The site is fenced and a repair to this was made by the borough council that remained intact during the project although litter accumulation in the water continued.

The relative level of pollution from litter varied from site to site, with all locations containing abandoned cars from the 1970s and 1980s. Divers proved to be a great resource for safely accessing the water margins and lakebed and removing rubbish, mainly by hand collection of small items, which was disposed of via the landowners.

## 5.3 Habitat

White-clawed crayfish have been recorded at four sites, Ensor's Pool, Newbold Quarry, Hill Hole Quarry and Stoney Cove. Confirmation of their continuing presence is a positive result, especially at Ensor's Pool, which is a SSSI for the crayfish population, but which had been assumed to have been lost since 2014. There were few natural refuges apparent in the quarries except Newbold Quarry where erosion of the cliff faces provided small holes within the layers that could be inhabited by crayfish.

Ensor's Pool suffered from continuous anti-social behaviour by local youths during the project as reported on social media. Anglers, open water swimmers, and unauthorised camping, fires, destruction of signs and fences was prevalent. This is a threat to the wildlife particularly the white-clawed crayfish. Swimming causes turbidity to increase, albeit mainly in the top few metres of water, and anglers inevitably lead to lost fishing line and hooks, and the risk of introducing crayfish plague from other sites.

White-clawed crayfish are relatively tolerant of different water chemistries, but are thought to prefer low conductivity, low ammonium, low sodium, low sulfate, low nitrate, low phosphate and high dissolved oxygen. [28] The two sites where white-clawed crayfish were not found have either low dissolved oxygen or high conductivity and so are unlikely to be suitable as ark sites.

Conductivity correlates with the contrition of dissolved ions in the water and is indicative of nutrient load, geology, and the presence of pollution. Blue lias is composed of limestone ($CaCO_3$) and mudstone (clay) and so will contribute to the ion load in the water.

Ammonium, nitrate and phosphate are indicative of agricultural pollution (fertilizer and sewage run off). Assessing the quality of the water requires knowledge of the background levels that should be expected at the site that was beyond the scope of this project. The Freshwater Habitats Trust applied limits of 0.1 mg/l for phosphate and 1 mg/l for nitrate to indicate polluted water. [32] The limits of detection in this work of 0.12 mg/l and 0.7 mg/l for phosphate and nitrate, respectively, do not allow a precise assessment but indicate that none of the quarry pools is heavily polluted with phosphate or nitrate. For reference, UK drinking water has a nitrate limit of 50 mg/l. [33]

Blue Pool was one site with very high concentrations of several ions. Although this may be due to the underlying geology, the same concentrations were not measured at the other blue lias quarry at Newbold and so the local geology may vary slightly or there may be some other source. A runoff from the adjoining trunk road may contribute to the higher concentrations, but there was no clear correlation with, for example, sodium and chloride concentrations, which can result from road salt pollution or agricultural run-off. It was concluded that the water chemistry, reflected in the name Blue Pool, is a result of the geology. The water is not blue in colour but a blue appearance indicates the presence of carbonate precipitates that form on an annual cycle as the water warms up in spring. However discussion with a local resident suggests that the colour has been more green than blue in recent years.

Non-native zebra mussels were seen at Ensor's Pool, Newbold Quarry, Blue Pool and Stoney Cove. A non-native freshwater jellyfish was recorded for the first time at Hill Hole Quarry. A signal crayfish was found on the bank of Blue Pool. Most worryingly in November 2021 three signal crayfish were found in the water at Newbold Quarry. Two were caught, one male and a berried female. It is not known where the signal crayfish had come from but the Oxford canal is within fifty metres of the quarry and signal crayfish are known to be able to walk between water bodies several hundred metres apart. [29]

Temperature and visibility measurements varied over the year as would be expected. The logged temperature data showed the minimum temperature at each site was consistent at about 4 ˚C. The maximum water temperature was about 16 ˚C at Newbold Quarry and Blue Pool but only 11 ˚C at Ensor's Pool. The reason for this may be that the logger at Ensor's Pool ~2 m deeper in the water column. Data collection over the next few years may show variation of maximum and minimum water temperature from year to year and for different durations during the year. This may affect the wildlife present although only time will tell.

# 6 CONCLUSIONS

## 6.1 What is in the quarry pools?

The pools at all the former quarry sites have become populated by aquatic plants and animals including fish. In four cases they are 'ark sites' for white-clawed crayfish.

White-clawed crayfish were confirmed at Ensor's Pool, Newbold Quarry, Hill Hole Quarry and Stoney Cove. The records from Ensor's Pool are especially significant because the population was assumed to have been lost in 2014. Recording white-clawed crayfish at Ensor's Pool confirms that this site remains significant on a UK and European level.

The discovery of breeding signal crayfish in Newbold Quarry is disappointing as this threatens the viability of the white-clawed crayfish population at this site.

Diver surveys were effective in providing data for the local environmental records centres and landowners. Photographs of hazards identified underwater (trees, cars etc) were used by landowners and the local police in their water safety campaigns during the summer. In future years systematic recording will be attempted.

The depth and lakebed were characterised by diver observation. Attempts to use towed sonar were partially successful and will continue in future years.

Cultural heritage was identified at several sites. Ensor's Pool provides the most extensive collection of infrastructure associated with quarrying, including a two clay tubs and trackway, the remains of a building and two telegraph poles. Even the remains of a pickaxe were seen underwater. Recording of these artefacts with photogrammetry will be attempted in future years.

The remains of a barge at Newbold Quarry were found. At Great Pit evidence of tool marks from the slate extraction process was observed.

## 6.2 Is the aquatic environment favourable or unfavourable?

This question is more complicated to answer than expected at the start of the project and depends upon the baseline parameters and assumptions from which the assessment is made.

The water at all sites is free of high concentrations of ammonium, nitrates and phosphates that leads to eutrophication. Pollution from road run-off (salt) did not appear to be present. From these simple measures, and that, for example, white-clawed crayfish have re-established themselves at Ensor's Pool, and remain at Newbold Quarry, Hill Hole Quarry and Stoney Cove, indicates that the aquatic environment is favourable at least to this species at these locations.

The presence of non-native species is of concern, albeit (for example) the zebra mussels observed are extremely common and do not appear to be causing harm. The presence of a signal crayfish near Blue Pool is more concerning, but since this water body is not home to native crayfish, and is unlikely to be suitable for them, it is not an immediate threat. Breeding signal crayfish in Newbold Quarry does pose an immediate threat to the survival of the native crayfish population.

Litter is also a threat to wildlife. While anglers can inadvertently spread water borne diseases the more immediate threat to wildlife comes from the snagging and loss of hooks and line. During this project the Friends of Ensor's Pool group reported a signet having fishing line caught in its throat, and despite the efforts of the group and a local animal sanctuary the bird died. While public awareness of so called 'ghost fishing gear' in the sea is increasing its presence in freshwater lakes goes largely unobserved.

The effect of climate change on the quarry pools is also uncertain. Sites such as Hill Hole Quarry, being very shallow and rain-fed, increase in temperature more rapidly during the summer than deeper sites such as Great Pit. It may be Hill Hole Quarry becomes too warm for white-clawed crayfish to survive in the future.

## 6.3 Is the aquatic environment improving, declining or remaining the same?

It is too soon to answer this question with empirical evidence. However during this project, we have seen the local communities at Newbold Quarry and Ensor's Pool form 'friends' groups and carry out numerous litter picks and other activities. Blue Pool is now under the management of a conservation organisation. For our small part the baselining the sites and the underwater litter picks we have completed have improved the site locations.

# 7 FURTHER WORK

Further work will include:

- Continued monitoring of the sites for changes over time, especially in temperature, dissolved oxygen concentration and the presence of key species such as crayfish
- More detailed wildlife surveys will be carried out especially concentrating on the plant life
- Bathymetry surveys at the remaining sites
- Use of photogrammetry to record the infrastructure under the water
- Continued removal of litter from the water.

# 8 REFERENCES


1. About Project Baseline, https://projectbaseline.org/about/.
2. Project Baseline database, http://db.projectbaseline.org/?c=GBR&p=4P.
3. Project Baseline UK teams, https://projectbaselineuk.org/teams/.
4. White-clawed crayfish survey for Ensor's Pool SSSI/SAC (Warwickshire), Natural England, October 2015.
5. S. Peay, D.M. Holdich and J. Brickland, *Freshwater Crayfish*, 2010, 17, 109–122.
6. Crayfish Identification, Distribution and Legislation, Buglife, https://cdn.buglife.org.uk/2019/07/Final-Crayfish-ID-distribution-and-Legislation-23-06-15_JG.pdf.
7. White-clawed crayfish by David Gerke, Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3274551.
8. Signal crayfish by David Perez, Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=7628718.
9. J.D. Reynolds, W. O'Connor, C. O'Keeffe and D. Lynn, *A technical manual for monitoring white-clawed crayfish Austropotamobius pallipes in Irish lakes*, Irish Wildlife Manuals, No. 45, National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, 2010.
10. L. Füreder, F. Gherardi, D. Holdich, J. Reynolds, P. Sibley and C. Souty-Grosset, Austropotamobius pallipes, The IUCN Red List of Threatened Species, 2010. https://dx.doi.org/10.2305/IUCN.UK.2010-3.RLTS.T2430A9438817.en.
11. I. Karplus, M. Zoran, A. Milstein, S. Harpaz, Y. Eran, D Joseph and A. Sagi, 1998, *Aquaculture*, **166**, 259–267.
12. G.P. Semple, D.B. Rouse and K.R. McLain, *Freshwater Crayfish*, 1995, **8**, 495–503. [cited in ref. 5]
13. Britain from Above, http://www.britainfromabove.org.uk/.
14. Ken Blackwell and Paul Gamble, 'Rugby Town…I remember when', Facebook group.
15. Map data: © Google.
16. Project Baseline Midland Pools Facebook group, https://www.facebook.com/groups/ProjectBaselineMidlandPools.
17. Surveying and litter removal method statement and risk assessment, Project Baseline Midland Pools, version 2.1, July 2020.
18. Project Baseline privacy policy, https://projectbaseline.org/privacy-policy/.
19. Project Baseline Midland Pools Facebook page, https://www.facebook.com/ProjectBaselineMidlandPools.
20. Diving activities during Covid-19 pandemic, Project Baseline Midland Pools, July 2020.
21. Reproduced with the permission of the National Library of Scotland, https://maps.nls.uk/.
22. Leicestershire and Rutland Environment Records Centre, https://www.leicestershire.gov.uk/environment-and-planning/planning/leicestershire-and-rutland-environment-records-centre-lrerc.
23. Warwickshire Biological Records Centre, https://www.warwickshire.gov.uk/environment-ecology/warwickshire-biological-records-centre.
24. SSSI designations, https://designatedsites.naturalengland.org.uk/.

25. Pond habitat survey recording form, PondNet, Freshwater Habitats Trust.

26. S Wilson, A cost-led evaluation of survey methods and monitoring for white-clawed crayfish, *Bull. Fr. Pêche Piscic.*, 2004, **372-373**, 335–352.

27. Freshwater Habitats Trust, https://freshwaterhabitats.org.uk/pond-clinic/identifying-creatures-pond/.

28. N.A. Haddaway, Conservation of British White-clawed Crayfish (Austropotamobius pallipes) using Ark Sites, PhD Thesis, University of Leeds, 2010.

29. D. Aldridge, Signal Crayfish, GB Non-native Species Secretariat, 2019, http://www.nonnativespecies.org/factsheet/downloadFactsheet.cfm?speciesId=2498.

30. Project Baseline Midland Pools, https://projectbaselineuk.org/midlandpools/.

31. Underlying mapping © OpenStreetMap contributors. Reproduced under CC BY-SA.

32. Clean Water for Wildlife Technical Manual, Freshwater Habitats Trust, 2017, https://freshwaterhabitats.org.uk/wp-content/uploads/2015/10/CWfWTechnicalDocumentPRFinal18Sept2017FINAL.pdf.

33. Observatory monitoring framework – indicator data sheet, Environmental impact: Water Indicator DA3: Nitrate and phosphate levels in river, 2012, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/162164/defra-stats-observatory-indicators-da3-120224.pdf.

## APPENDIX 1 PROJECT DIARY

| Date | Site | Number of volunteers | Number of dives | Description of tasks completed |
|---|---|---|---|---|
| 22 Aug 2020 | Newbold Quarry | 7 | 14 | 1. Survey and install monitoring station, secchi disk and temperature logger<br>2. Measure visibility and temperature<br>3. Wildlife survey |
| 11 Oct 2020 | Blue Pool | 15 | 26 | 1. Survey and install monitoring station, secchi disk and temperature logger<br>2. Measure visibility and temperature<br>3. Wildlife survey<br>4. Sample water |
| 23 Oct 2020 | Stoney Cove | 3 | 2 | 1. Survey and install monitoring stations and secchi disks<br>2. Measure visibility and temperature<br>3. Wildlife survey |
| 26 Oct 2020 | Ensor's Pool | 2 | 1 | 1. Measure visibility and temperature<br>2. Sample water |
| 26 Oct 2020 | Newbold Quarry | 3 | 1 | 1. Measure visibility and temperature<br>2. Sample water |
| 20 Dec 2020 | Stoney Cove | 3 | 2 | 1. Measure visibility and temperature at both stations |
| 27 Feb 2021 | Ensor's Pool | 2 | 2 | 1. Recovered the temperature logger, downloaded the data and replaced it<br>2. Measure visibility and temperature<br>3. Wildlife survey – crayfish recorded |
| 22 Mar 2021 | Newbold | 2 | 2 | 1. Recovered the temperature logger, downloaded the data and replaced it<br>2. Measure visibility and temperature<br>3. Wildlife survey – crayfish recorded and quarry building. Misty layer observed – query oil or $H_2S$ |
| 4 April 2021 | Stoney Cove | 3 | 2 | 1. Measure visibility and temperature at both stations |
| 22 May 2021 | Stoney Cove | 2 | 2 | 1. Measure visibility and temperature at both stations |
| 28 May 2021 | Stoney Cove | 2 | 1 | 1. Measure visibility and temperature at station 2 |

| Date | Site | Number of volunteers | Number of dives | Description of tasks completed |
|---|---|---|---|---|
| 11 Jul 2021 | Great Pit | 6 | 8 | 1. Survey and install monitoring station, secchi disk and temperature logger<br>2. Deep team explored the 50 m section<br>3. Measure visibility and temperature |
| 11 Aug 2021 | Hill Hole | 2 | 1 | 1. Survey and install monitoring station, secchi disk and temperature logger<br>2. Measure visibility and temperature<br>3. Wildlife survey – 24 crayfish recorded |
| 6 Oct 2021 | Stoney Cove | 2 | 1 | 1. Measure visibility and temperature |
| 26 Oct 2021 | Ensor's Pool | 2 | 1 | 1. Recover the temperature logger (visibility was too poor to locate it)<br>2. Measure visibility and temperature. |
| 6 Nov 2021 | Newbold Quarry | 2 | 2 | 1. Recover the temperature logger, download the data and replace it<br>2. Wildlife survey – 5 white-clawed crayfish and 2 signal crayfish recorded<br>3. Misty layer observed – sulfate? |
| 6 Nov 2021 | Blue Pool | 2 | 2 | 1. Recover the temperature logger, download the data and replace it<br>2. Measure visibility and temperature |
| 6 Nov 2021 | Ensor's Pool | 2 | 2 | 1. Recover the temperature logger, download the data and replace it<br>2. Measure visibility and temperature |

# APPENDIX 2 POND HABITAT SURVEYS

Freshwater Habitats Trust pond habitat surveys were completed for:

- Ensor's Pool
- Newbold Quarry
- Blue Pool
- Great Pit
- Hill Hole Quarry.

| Pond name | Ensor's Pool | Newbold Quarry | Blue Pool | Great Pit | Hill Hole Quarry |
|---|---|---|---|---|---|
| **8 figure grid ref** | SP 34832 90325 | SP 49450 77004 | SP 39039 58812 | SK 53912 12180 | SK 48548 10322 |
| **Is the pond new?** | No | No | No | No | No |
| **Pond altitude, m** | 102 | 82 | 97 | 108 | 197 |
| **Area, $m^2$** | 18,000 | 27,500 | 7,300 | 3,500 | 8,500 |
| **Pond dries?** | Never | Never | Never | Never | Never |
| **% pond overhung by trees/shrubs** | 10 | 10 | 10 | 10 | 10 |
| **% pond margin overhung to at least 1 m** | 10 | 10 | 10 | 10 | 10 |
| **Waterfowl impact** | None | None | None | None | None |
| **Fish presence** | Major | Major | Minor | Minor | Minor |
| **Disturbance by dogs** | Minor | Minor | Minor | None | None |
| **% of whole pond occupied by emergent vegetation** | 10 | 20 | 10 | 5 | 0 |
| **% of pond water surface area covered by all vegetation** | 10 | 20 | 10 | 10 | 0 |
| **% of water are in pond relative to maximum** | 100 | 100 | 90 | 100 | 100 |

| Pond name | Ensor's Pool | Newbold Quarry | Blue Pool | Great Pit | Hill Hole Quarry |
|---|---|---|---|---|---|
| **Drawdown, cm** | 0 | 75 | 25 | 50 | 0 |
| **Grazing** | No | No | No | No | No |
| **Pond management** | None | Platform removed<br>Fenced | None | None | None |
| **Turbidity** | Turbid | Clear | Turbid | Clear | Clear |
| **Inflow present** | No | No | Yes | No | No |
| **Outflow present** | No | No | No | No | No |
| **pH** | 8.1 | 8.2 | 8.0 | 7.2 | 8.0 |
| **Conductivity, µS/cm** | 311 | 538 | 1350 | 142 | 166 |
| **Nitrate, ppm** | <0.7 | <0.7 | <0.7 | <0.7 | <0.7 |
| **Phosphate, ppm** | <0.120 | <0.120 | <0.120 | <0.120 | <0.120 |
| **Pond base** | Silt/clay | Hard rock | Silt/clay | Hard rock | Hard rock |
| **Surrounding land use** | Trees/woodland/scrub<br>Unimproved grassland<br>Arable<br>Urban building & gardens<br>Roads, tracks & paths | Trees/woodland/scrub<br>Unimproved grassland<br>Urban building & gardens<br>Roads, tracks<br>Rock, stone & gravel & paths | Trees/woodland/scrub<br>Unimproved grassland<br>Urban building & gardens<br>Roads, tracks<br>Ponds & lakes | Trees/woodland/scrub<br>Unimproved grassland<br>Rock, stone & gravel | Trees/woodland/scrub<br>Unimproved grassland<br>Improved grassland<br>Urban building & gardens<br>Roads, tracks & paths<br>Rock, stone & gravel |

| Pond name | Ensor's Pool | Newbold Quarry | Blue Pool | Great Pit | Hill Hole Quarry |
|---|---|---|---|---|---|
| **Is the pond in a protected area?** | Yes, SSSI | Yes, LNR | Yes, LNR | Yes, SSSI | Yes, LNR |
| **Location score for grate crested newts** | A | A | A | A | A |
| **Number of ponds** | 0 | 0 | 2 | 1 | 0 |
| **Habitat quality for amphibians** | Good | Good | Good | Good | Good |
| **Water quality for amphibians** | Good | Good | Good | Good | Good |
| **Extent of modified bank** | 2 (1-25 %) | 1 (0 %) | 4 (51-75 %) | 5 (75-100 %) | 5 (75-100 %) |
| **Modified hydrology?** | Natural | Natural | Natural<br>Drain into the pond | Natural | Natural |
| **How much pond perimeter can be surveyed? %** | 25 | 75 | 50 | 10 | 10 |

PROJECT BASELINE

Mobilising citizen-divers to record change in the world's underwater environments and to engage with scientific, conservation, and government entities to advance the restoration and protection of our natural and cultural treasures through grassroots engagement and collaborative scientific missions.