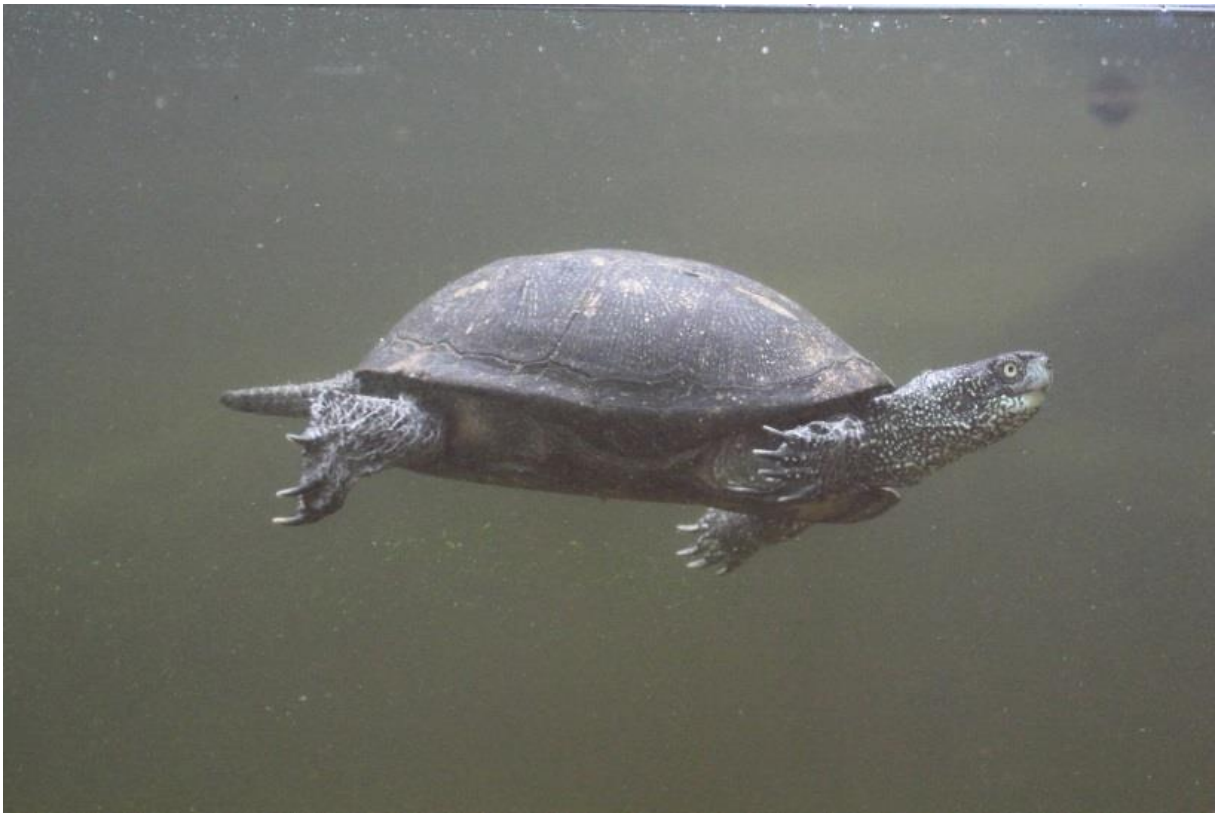
RETURN OF THE POND TURTLE TO THE CZECH REPUBLIC: A POTENTIAL OF THE HULÍN SAND PIT FOR BIODIVERSITY



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ABSTRACT

The aim of our project was to assess a potential of postindustrial habitats in returning(reintrodution) of genetically oringinal populations of the European pond turtle (*Emys orbicularis)* to the Czech Republic.We chose the Hulín sand pit (central Moravia, Czech Republic) as a model site. The critically endangered pond turtle (*Emys orbicularis*) has nearly dissapeared from the Czech Republic due to significant changes in landscape in the past (wetlands drainage, intensive management of fish ponds, destruction of natural nesting habitats) as well as due to being hunt for food. Mining activity in sand pits often creates mosaics of specialand rare biotopes, from bare, nutrient poor, sandy substrates to diverse wetlends, which represent a suitable habitat for the pond turtle.

At selected sites, we measured environmental variables which can affect nesting and survival of the pond turtle (these variables were, e.g. pH, substrate temperature, presence of specific microhabitats in sand pit and its surroundings). As a part of the study, we also made an inventory survey of selected groups of organisms to assess if the site also hosts some other endangered organisms.

After measurements of pH and substrate temperatures, we found that the most suitable place for a special acclimatization device for turtles can be found on the newly formed disposal of fine sandy sludge. In future, after simple management measures (directed sand sludge disposal together with creation of pools separated from a main lake), the site could provide optimal habitats with suitable pools and nesting sites for the pond turtle.

Moreover, habitats with bare sand, potential substrate for laying eggs by females of the turtle, host specific arthropod fauna which cannot be found in modern landscape. This is best illustrated by presence of aculeate bees and wasps associated with open sandy biotopes, almost a third of all captured species are red-listed species. Besides, moist habitats with bare sands host endangered ground beetles and earwigs.

The results of our project show, that the pond turtle can serve as an „umbrella species“. By protecting populations of the turtle, we can easily protect also other endangered and rare organisms. In current situation, the reintroduction of the pond turtle to the Hulín sand pit can be made in several successive steps.

The acclimatization device can be placed in the eastern part of the sand pit, at the newly formed fine sand sludge disposal. Subsequently, by further but directed disposal of sand sludge, modulation and spontaneous succession, new wetlands will form in the proximity of the disposal. These wetlands will be colonized by turtles from the acclimatizoation device.

We propose management measures that will enable successful reintroduction of the pond turtle together with the preservation of other specialized and endangered organisms living in the Hulín sand pit. Similar management measures and further monitoring of the sites and biotopes, the reintriduction of the pond turtle could be possible even in other sand or gravel pits.

INTRODUCTION

A unique potential of sand pits for biodiversity conservation has already been described in scientific literature (Tropek & Řehounek 2011, Řehounek et al. 2015). Mining aktivity often creates mosaics of special and rare biotopes, from bare, nutrient poor, sandy substrates to diverse wetlends, grasslands and forests. The mining activity thus partially substitutes a natural function of unregulated rivers which form alluvial sandy silts, creeks, pools, etc. In modern, intensively managed landscape, these features together with their associated organisms are rarely found. The critically endangered European pond turtle (*Emys orbicularis*), is one of the species that has suffered from the modern changes in the landscape. Transformation of pools into intensive fish ponds, and wetlands into fields, together with hunting for food were the main reasons behind the extinction of original populations of the turtle in the Czech Republic. A persistence of some native population is very doubtful; currently, only a few populations are know in the Czech Republic, and all of them originate from geographically different genetic lineages or their origin is not known.

Our project aims at using the unique potential of the sand pitsfor the return (reintroduction) of genetically original populations of the pond turtle to the Czech Republic. We chose the Hulín sand pit (central Moravia, Czech Republic) as a model site

Reintroductions (also repatriations) of locally extinct species are often controversial and they demand a very cautious approach. It is important to carefully assess the effect of the reintroduction on the future populations of the introduced species as well as the other organisms inhabiting particular sites. The target of this project is not to introduce the pond turtle to the Hulín sand pit at any cost. The project aims at providing a management plan evaluating benefits and costs of a potential reintroduction. The present project has these aims:

- To perform an analysis of the habitats in the Hulín sand pit in terms of their suitability for the reintroduction of the pond turtle, to define advantages/disadvantages of the site,
- To perform an inventory survey of the site for several groups of organisms: plants, aquatic invertebrates, ground beetles, aculeate bees and wasps, butterflies, amphibians and reptiles,
- To develop a reintroduction plan based on the acquired data; to propose management strategies for preservation of a viable population of the pond turtletogether with preservation or improvement of the potential of the site for biodiversity conservation.

The pond turtle

The European pond turtle *Emysorbicularis* (Linnaeus, 1758) is one of the most endangered species in the Czech Republic. It has disappeared from most of its original area due to extensive draining and conversion of wetlands and pools into fields or forests, and also due to hunting for meat in the past. Currently, only non-indigenous populations, mostly from southern countries, are known in the Czech Republic. A successful release of the turtles has been carried out at Betlém, a location in South Moravia, where a viable population survives until today (Šebela 2012). This population, however, originates from different geographic region.

The turtle prefers habitats with stagnant or slowly flowing water, such as overgrown parts of rivers, oxbows, or small water pools with muddy bed in lowlands (Arnold et Ovenden 2002). A suitable site should have overgrown deep pools prefered by adults, as well as shallow waters for young turtles. Banks of rivers or ponds should be overgrown with vegetation but with free and accessible places for heating during the day (Balová 2015). A presence of suitable places for laying eggs is of great importance, the turtles use only sunny places with sparse vegetation and trampled sandy-loam soil (Kminiak 1992).

Feasibility of the project is based on the fact that we have legal opportunity to obtain individuals from geographically original lineages (Fritz 2003, Fritz et al. 2007, Sommer et al. 2009). The project is a part of the initiative "Želva bahenní v ČR" coordinated by HERPETA organization. The Zoo Hluboká nad Vltavou is responsible for keeping records of breeding individuals.

METHODS

Short characteristic of sand pit Hulin

The research was carried out nearby the town Hulín GPS: 49.3006814N, 17.4720731E.
Area: 93,5 ha,
Altitude: 187mn.m.
Locality is large lake surrounded by fields and deciduous forest.

People responsible for research

Michal Plátek: management and coordination of the fieldworks, sampling of arthropod material, identification of ground invertebrates and butterflies, sorting of the material, writing of the final report.
Martin Šandera: measurement and analysis of water conditions, substrate temperatures, herpetological survey, writing of the final report.
Šárka Cimalová: botanical survey, writing of the final report.
Daniel Benda: identification of bees and wasps.

Research site

Field surveys were performed from 1st April 2016 to 8th September 2016 (13 visits).
Biodiversity survey was only restricted to areas where females of the pond turtles could potentially lay eggs and to small water bodies separated from the main lake, which could act as feeding sites.
The inventory survey of the selected groups of organisms was performed in five habitats (Chart 1):(i). moist sands; (ii) dry open sands; (iii) dry sands covered with trees; (iv) reeds; (v) pool separated from the main water body. Ad (i) bare sun-lit sands adjoining water, forming shallow littoral in the water, outside the water the sand substrate is moist, covered with sparse vegetation with flowering plants at the edges; ad (ii) dry sun-lit sand,at the edges covered with reeds; ad (iii) dry sands covered with trees, mostly early-sucessional colonists, e.g. birch; ad (iv) dense reeds flooded by water in spring and slowly drying in summer and autumn; ad (v) a pool separated from the main lake, surrounded by moist sands. The polls was formed recently, due to sludge disposal.
Except for these habitats, an informative inventory survey of invertebrates, amphibians and reptiles was also performed in other places in the sand pit.

Substrate temperature measurements

Substrate temperature measurements at the site were important to assessif the site provides suitable conditions the turtle's eggs incubation. We used CometSystem S0121 data-loggers with Pt 1000 temperature probes. The loggers,put in protective plastic cover,were buried in the soil, the probes were installed 10 cm deep in the soil corresponding to the depth in which the turtles lay eggs.

Each data-logger had two probes, thus enabling installing the sensors to places with different sun exposure or plant cover. The temperatures were recorded every 60 min.

On 25thApril,two data-loggers were installed in former waste pond in the eastern part of the sand pit. The former waste pond is a large, old deposit of fine sand covered with sparse herb vegetation, with low birch trees at the edges. The open areas of the former waste pond are well sunlit from south and south-west.

First data-logger (12930713) was installed at GPS: 49.30031N 17.47345E, probe 1 in totally bare sand substrate, probe 2 in sand substrate with sparse grasses.Second data-logger (12930716) was installed at GPS: 49.30038N 17.47373E, itstwo probes in totally bare sand substrate with admixture of clay.

During May, some part of the former waste pond was extracted together with the data-loggers. The first data-loggerwas later found on the heap of extracted substrate, but the probes were destroyed. Last record of temperature was from 16th May at 8:00am. The second logger was not found at all.

A third data-logger (10931015) was thus installed on 8th June (01:20 pm) at the edge of open substrate of former waste pond, at GPS: 49.30024N, 17.47363E, both probes in bare sunlit sand substrate, probe 2 close to a small birch tree. We thus managed to cover the whole season of potential egg laying at least with one data-logger.The tird data-logger was removed on 8th September (03:10pm).

Water conditions measurements

Information on basic water conditions can help evaluate a potential of the water to host diverse organisms. Measurements of water conditions in diverse water bodies that can be found in the Hulín sand pitand in adjacend technically reclaimed site south of the sand pit were carried out on 25th April and on 8th September using HI 98130 instrument (HANNA Instruments). The water bodies were of a diverse nature and size, from small, sometimes temporary ponds and pools to the main, large lake. Some of the small pools dried out during summer, thus in these the measurements were only made in spring. On the other hand, one of the pools (in eastern part of the sand pit) have been created during the season, thus measured only in autumn.

Besides acidity (pH) and temperature (°C), we also measured salinity, or conductivity (mS).

The distribution of the water bodies measured for water conditions is shown in Mapa XX. There were five bodies measured: (i)northeastern (SV) waste pond: periodical shallow water pond in the lower part of the waste pond; (ii) meadow pond: shallow water body in technically reclaimed part south of the central pond; (iii) central pond: large deep pond in the central part; (iv) separated pool: a pool of ca 35 x 10 m created during the seasonby disposal of the sand sludge separating it from central pond, max. depth more than 1 m; (v) reed pond: a pond with dense reed vegetation.

Inventory survey focused on:

Vascular plants: 1 botanical survey in during a vegetation season (autumn).

Terrestrial invertebrates: (ground beetles, day-flying butterflies, aculeate bees and wasps, and other captured insects). For the sampling, several methods were used: (i) pitfall traps for ground beetles (10 traps per habitat), (ii) sweeping by sweeping net (50 standardized sweeps per each habitat), (iii) yellow pan traps for bees and wasps (10 traps per habitat), (iv) individual sampling and collection, e.g. records of butterflies.

Aquatic invertebrates: Sampled using adjusted pot trapsand a strainer.

Amphibians and reptiles: Records of egg clutches, adults and sounds.

RESULTS

Substrate temperature measurements

On 16th May, the data-loggers were accidentally removed from the habitat together with extracted substrate, and data recording was thus interrupted (see Methods above). Data from one of the loggers show temperatures in the period preceding normal period of laying eggs by turtles. In some days, daily temperatures of the substrate exceeded 20°C (maximum 24.3°C on 9th April at 05:00pm). Differences in temperatures between two probes were rather insignificant (only in one decimal placeof °C). However, in some days temperatures during daytime in the probe 1 were more than 1 degree greater

than those measured by the probe 2, whereas nighttime temperatures were lower in the probe 1 than in the probe 2 for few tenths of a degree of centigrade.
The third data-logger was installed on 8th June and removed on 8th September. We thus managed to cover the whole season of potential egg laying with this logger.
Differences in temperatures recorded by probe 1 and probe 2 were rather low, in tenths of degree.In some days, daytime temperatures measured by probe 2 were more than 3°C greater than those of probe 1, mostly in hot days. In some days, nighttime temperatures measured by probe 2 were lower for few tenths of degree than those measured by probe 1.
Average temperature of the substrate was 21.4°C and 22.1°C for probe 1 and probe 2, respectively.
For a successful development of turtle emryos, it is mostly temperatures in the first month what is important. In the first month, the average temperature was 22.2°Cand 23.2°C, for probe 1 and probe 2, respectively.In the period from mid June to mid July, the average temperature was 22.8°C and 23.7°C, for probe 1 and probe 2, respectively. In some days the temperatures exceeded 30°C, although always only for few hours. Maximal temperaturemeasured were 33.8°C for probe 1, and 36.4°C for probe 2.

Water conditions measurements
On 25th April, the measurements were performedin the afternoon (02:00pm-05:45pm), during air temperatures ranging from 11 to 15°C, and relative humidityof 24%. Dne 8th Septemberthe measurements were conducted in the afternoon (01:30pm-03:30pm), air temperature 27 to 28°C, relative humidity lower than 24%.
We found extreme pH and conductivity values in north-eastern part of former waste pond and in reed pond. These values indicate unsuitable conditions for most of the aquatic animals.

Biodiversity
In selected habitats of the Hulín sand pit, we carried out an inventory survey of biodiversity in the periodfrom 1st April to 8th September 2016. In total, we found 132 animal species and 92 plant species. 22 species are specific inhabitants of open sandy habitats. 23 of them are endangered species. Number of species for particular studied group (ground beetles, butterflies, bees and wasps and other insects, amphibians and reptiles), their red-list category according to Czech national red-listsor in and degree of association with open sandy habitats (or similar substrates) are displayedin Chart 2.

Vascular plants: In the area of the sand pit, we found 92 taxonsof vascular plants in total, 5 species are red-listed.

Bees and wals: In total, we captured 56 species of ground beetles. 11 of them are red-listed species, 3 species are listed in Decree for implementation, No. 395/1992 Sb. - Threatened species (Czech code) (Vyhláška 395/1992 Sb).
Aquatic insects: In total, we captured 4 species of aquatic insects.
Butterflies: In total, werecorded 23 species of butterflies, 1 of them is red-listed species.
Ground Beatles: In total, we captured 38 species of ground beetles. 1 of them is red-listed species,5 species are listed in Decree for implementation, No. 395/1992 Sb. - Threatened species (Czech code) (Vyhláška 395/1992 Sb).
Other insects :We also captured 4 species of orthopteroid species (e.g. grasshoppers, locusts), and 1 species of earwigs. One earwig speciesis red-listed and 1 species of mantis.
Amphibians and reptiles: We found 3 species of amphibians and 2 species of reptiles

Management measures supporting local biodiversity, and persistence and viability of potential pond turtle populationare proposed and described in Table 1. Chart 3 shows potential ways how the pond turtle population could spread to surroundings of the acclimatizationdevice installed in the Hulín sand pit.

Discussion

The importance of the return of the pond turtle to the Czech Republic
Habitat fragmentation represents a serious threat for many endangered organisms with low dispersal abilities (Hanski et Gilpin 1997; Hanski 2005).Reintroductions are one of the means how to mitigate the effects of habitat fragmentation and preserve locally extinct or endangered species (Hayward 2011).

The reintroductions often lead to improvement of biodiversity or sometimes even to transformation of the whole ecosystems to the original state, for instance by the activity of keystone species (Gibbs et al. 2008).Some keystone species positively affecting their ecoszstems can be found among large herbivors, for instance wild horeses, aurochs, or European bison (Vera 2000) are slowly reintroduced also to the Czech nature in recent years (Jirků et Dostál 2015).
But why reintroducing the pond turtle to the Czech nature, and why to sand pits, in particular?
The pond turtle is an umbrella species. By protecting populations of the turtle, we can easily protect also other endangered and rare organisms associated with the same habitat but not attractive for public or conservation promotion. According to recent studies (Ptáčková et Dušková 2016) the public generally considers post-industrial sites as something negative, as „scars" in the green countryside caused by man.
The pond turtle is also a flagship species, because it is a nice and interesting species positively perceived by public. As such the pond turtle can bring attention of the public to the importance of post-industrial sites in supporting biodiversity.
In contrast to reintroduction of large predators, presence of the pond turtle does not pose any societal problems, like potential disputes between different interest groups,e.g. foresters, hunters, farmers, ecologists, nature conservationists. The reintroduction can also be relaitevely cheap and cost-efficient if some management measures supporting habitat quality and biodiversity are kept. Still, the reintroductions must be made cautiously. It is important to keep in mind the habitat preferences of the target species. Unsuitable conditions of reintriduction can easily lead to low viability of the released population and in the end lead to a failure (Rantanene et al. 2010)
In the Czech Republic, there is an on-going programme for reintroduction of a non-native lineage of the pond turtlein Betlém u Věstonické nádrže (Šebela 2012), and we thus have enough information needed for assessing benefits and risks associated with reintroduction to sand pits and other similar habitats.

Substrate temperature
Substrate temperature measurements were carried out from the end of April. Despite the problem with accidentally removed data-loggers, we menaged to measure temperatures through most of the season (including the period of potential egg laying by turtles) with an additional logger. In Central Europe, the female pond turtles lay eggs mostly in the first half of June, sometimes a bit later (Rogner 2009). Information on temperatures of sand substrate exist from several Central European sites occupied by populations of the pond turtle. In Brandenburg, average temperaturesin nesting places were found to be 21.2 – 24.4°C from the mid June to end of August (Rogner 2009). In Austria, the nesting places had average temperature of 22.6°C, maixmum of 32.2°C (Rössler 1999). In 2013, a measurement of the substrate temperatures of nesting places was carried out in PP Betlém. Here, average temperatures for a period of one month from 8th June were found to be 21.6°C and 23.6°C (two probes were used, similarly to our study); from mid June to mid July the temperatures were 22.3°C and 25°C; maximum 34°C (Šandera – unpublished data). In the Hulín sand pit, the temperatures wer similar to those mentioned above.
Average temperature of the substrate was 21.4°C and 22.1°C for probe 1 and probe 2, respectively. In the first month, the average temperature was 22.2°Cand 23.2°C, for probe 1 and probe 2, respectively.In the period from mid June to mid July, the average temperature was 22.8°C and 23.7°C, for probe 1 and probe 2, respectively. In some days the temperatures exceeded 30°C, although always only for few hours. Maximal temperaturemeasured were 33.8°C for probe 1, and 36.4°C for probe 2.
Based on this information, we can conclude that the sand pit provides suitable conditions egg incubation of potential pond turtle population.
Differences between measurements of probes show that the cover of the substrate affects temperature conditions. Bare substrate was warmer during daytime, and slightly colder during nighttime. The differences reflect diverse habitat conditions at the site. The site thus provides a spectrum of possibilitites, where the turtles could chose to lay eggs.

Propositions for the acclimatization device placement
The results of the substrate measurements show that the Hulín sand pit offers a suitable habitat for potential reintroduction of the pond turtle and for successful preservation of its viable population. In order to facilitite the reintroduction, creation of a special acclimatization device is needed (description in Appendix 1) For the reintriduction, three spots at the site could be used:

1. The most realistic and economically easiest way is to create the device in newly formed fine sand sludge disposal (Chart 2, nuber 1), where there is both suitable subtrate of nesting and

suitable water pool with neutral pH separated from the main lake. The area of the sludge is about to increase in future, thus in collaboration with the administration of the sand pit the process to the sludge disposal could be targeted to particular in order to create suitable habitats (for the turtle and associated biodiversity) for minimal costs. The pipe for sludge disposal could be manipulated in a way to form small pools together with heaps of bare fine sand. A similar process can already be seen at the place of sludge disposal (Image 1).

2. Less effective and more expensive option is to create a device at the spot (Chart 2, nuber 1). Here, the wetlands covered withh reeds could be connected with former waste pond. This option is less appropriate because it requires deepening pools in the wetland, cutting of the reeds and interconnection with sandy habitats. Acid water conditions also represent a problem. These conditions are most probably caused by decomposing biomass of reeds in autumn.
3. Third option is to create small pools on a watersoaked meadow (Chart 2, nuber) in the sand pit. Here, a main problem is that the sand substrate for nesting of the turtles would have to be transported from the sand sludge disposal areas. However, a creation of complex of pools would be beneficial for the biodiversity associated with sandy habitats of post-industrial sites. In spring, we found populations of frog *Bombina bombina* here. In summer, these meadows are dry and attractive for endangered butterfly (*Lycaena dispar*) or endangered grand beetle (*Brachinus crepitans*). These meadows could be managed by mowing in a special way so that a mosaic of cut grass but also untouched higher grass is left at the place (note: we did not carry out the inventory in this habitat).

The first option seems to be the most realistic.In this case, the reintroduction could be made in near future. It is, however, important to create small water pools separated from the main water body (the central lake). Only a single pool was created this year. In future it is desirable to monitor the sludge disposal in the main lake and to create a plan of pool creation, thus to consult in advance the possibilities of targeted creation of suitable habitats.Such a management of the site is desirable not only for sucessful pond turtle reintrodution but also for preservation od biodiversity at the site (see below).Last possibility is to find another sand pit with similar conditions, where the measurements of site conditions and biodiversity would be carried out in a similar way.

A possibility of dispersal to the nearest surroundings of the site is an important condition in a sucessful reintroduction of the pond turtle.In the close surroundings of the sand pit, there are some large water bodies, ponds.The largest one, Záhlinické rybníky, seems unsuitable for the pond turtle because it is an intensive fish pond. Another close water body, EVL Skalky, a complex of small pools formed by former sand mining activity and later established as a reserve, seems more promising for the turtle as it offers diverse pools in different stages of succession. Several inventories focused on amphibians, reptiles, dragonflies,were made here (Šálek 2002a, Šálek 2002b). This site represent a possible habitat for colonization by the turtle. The only problem of EVL Skalky is the spontaneous succession and tree encroachement which have caused shading of the site.There is also a possibility that the pond turtle could disperse to new habitats throught eh Morava river stream. The creation of the acclimatization device would help to establish a viable population of the turtle in the Hulín sand pit. The Hulín sand pit would later act as a source population, with young individuals spreading to the surroundings and establishing new populations.

Biodiversity evaluation

For the biodiversity inventory in the Hulín sand pit, we focused on places selected as potentially suitable for breeding and nesting of the turtle, thus places with a potential to support a viable population of the turtle.

The inventory survey was performed in the seasonof 2016 and focused on several target groups. We focused on the most common and well known taxa for which enough information exist.We did not aim to assess overall biodiversity of the ecosystem which would not be cost-effective.

Aculeate hymenoptera (bees and wasps) represent a group with many species specialized on sandy substrates and thus this group tends to be particularly rich in sand pits (Macek et al 2012, Tropek et Řehounek. 2011; Řehounek et al. 2015). In the Hulín sand pit, we found 56 druhů in total. A large proportion of them are specialists (22 species) associated with open sandy biotopes (sunlit warm and loose sands). In the Czech Republic, such substrates canonly be found in isolated remnants in southern Moravia or in Polabí. 11 species are listed as threatened species in Czech red-lists. We found critically endangered *Mimumesa littoralis*, probably a glacial relict species that can rarely be found in original sand dune areas. In the Czech Republic, only two locations of this species were

known (Macek et al. 2012). Further, we also found other rare species, like *Andrena barbilabris, Epeolus variegatus*, *Cerceris quadrifasciata*,*Crossoceru swesmaeli, Tachysphex grandii*, *Epiyron rufipes*,*Pompilus cinereus*,*Nysson maculosus*, *Crabro scutellatus*, or *Lasioglossum quadrinotatum*. We also found other endangered species, like *Bombus hortorum, Bombus terrestris*a *Bombus lapidarius*, which are not associated with sandy habitats, andcan be found more often even in other biotopes.
Bare sandy habitats at the water/shore boundary are important places for ground beetles associated with moist sandy or gravel river silts and shores, for instance *Nebria livida,Cylindera arenaria*, or *Omophron limbatum*. Farther from the water, we also found the endangered tiger beetle *Cylindera germanica*, and also more common *Cicindela campestris*or *Cicindela hybrida*. Moist sandy areas are also important sites for the largest and most endangered Czech earwing, *Labidura riparia*.
The Hulín sand pit with its mosaic of diverse habitats, open, sunlit habitats but also places covered by sparse and dense vegetation, offers suitable conditions also for the sand lizard (*Lacerta agilis*) which find enough prey and hiding places here.

Botanical survey has shown that the Hulín sand pit is rich especially in ruderal species, including also invasive species (*Acer negundo*, *Reynoutria sachalinensis*, *Solidago canadensis*) and expansing ones (*Cirsium arvense*, *Calamagrostis epigejos*).
However, even in these assemblages, we found common early-successional terophytes rare in the Czech Republic, e.g. *Atriplex prostrata* subsp. *latifolia,* or *Verbascum densiflorum*.
We found interesting plant species in littoral zone of the ponds and at the edges of the reeds or in the temporarily flooded and watersoaked habitats. In the littoral zone we found endangered *Cyperus fuscus*), a typical species of moist sand shores and uncovered pond beds.We also found a small population of *Senecio sarracenicus* at the edge of awatersoaked depression, and laso at the edge of reeds, similar to another plant species *Bolboschoenus planiculmis*. Both species can be found even at the close site Záhlinické louky (Podešva et Šálek 2004, Herman 2012), which is probably a source of colomization of the plants to the sand pit. The above mentioned species are sun-loving, nitrofilous species tolerating some degree of salinity, some of them are even competition tolerant (*Senecio sarracenicus*). The persistence of their populations is mostly threatened by changes in water regime, succession, and destruction of biotopes. The results of the botanical survey show that the sand pit represents a unique and specific habitat, that host common but also rare species of vascular plants. The presence of endangered species increases the conservation value of the site which represents a biotope with rare early-successional stages.

In order to support populations of endangered and specialized species of sandy habitats it is important to management abide by several management guidelines. It is necessary to maintain the mosaic of open sandy substrates, and to prevent overgrowing by vegetation (reeds and birch). At some places, it is appropriate to create vertical or steep sandy slopes oriented to south-east (in May, a part of fine sandy area was extracted leading to diversification of the site, allowing substrates for some bees and wasps). It is important to keep the areas with fine sand open, not surrounded by forests which could calm down the substrate and isolate the habitats (Macek et al. 2012). Moist sandy areas should regularly be disturbed by machinery or trempling of visitors.

We also sampled aquatic organisms in the water bodies separated from the main lake (Chart 1).
At first, the pond with dense reeds seemed to be rich in animals.In May the pond was filled with water at least 0.5 m deep, we found frog *Bombina bombina* here and we also captured several common species of water bugs (*Corixa* sp.). After a detailed analysis we found that the water in the pond was to acid (see above) and thus unsuitable for most of the organisms (Hruška et al. 2013).

Moreover, in summer, the water body dried out. After that, the newly created pool seems to be the most important habitat for biodiversity. pH of its water was neutral. We used several methods for sampling aquatic invertebrates (Jeřábková et Boukal 2015) but we found only common species of dragonflies within the pool. In future, we can, however, expect colonization of this pool by larger species of water beetles, dragonflies, or amphibians because the close EVL Skalky host particularly rich water fauna (Šálek 2002a). The dynamics of small pools and its associated fauna could therefore be similar to that of EVL Skalky. It is, however, necessary to prevent overgrowing by reeds and target sand sludge disposal in a way to enable creation of new pools together with smooth transition to open sandy terrestrial habitats.

CONCLUSION

The present study is a first study analysing possibility of the return of the pond turtle to the Czech Republic by reintrodution of the species into the area of the Hulín sand pit. It shows that post-industrial sites can serve as important habitats for the reintroduction of locally extinct species.

Based on a survey of the Hulín sand pit we can conclude.

- The habitats that provide suitable substrate conditions for nesting of the pond turtle also host a range of organisms specialized in open sandy habitats with many endangered species that cannot be found in common landscape. The pond turtle thus may serve as a umbrella species. It can also serve as a flagship species in promoting post-industrial sites and wetlands as places with high conservation value.
- We propose management measures, mostly a targeted succession measures, which will help in supporting endangered species associated with sandy habitats, wetlands and small water bodies.
- The Analyses of temperatures showed that the substrate is suitable for breeding of pond turtle.
- Water pond overgrown by reeds because of spontaneous succession has been found to be unsuitable for most of the organisms present in the Hulín sand pit. Overgrowing by reeds leads to shading of the substrate and water, and later to acidification of the water.
- Thanks to the mining activity (fine sand sludge disposal), new pools separated from the main lake are created. These have also suitable pH conditionsare craeted. In future, number of such pools can be increased if the disposal of sludge is consulted with the administration of the sand pit, and targeted to particular places. It can thus increase the number of habitats suitable for the potential population of the pond turtle.
- The surroundings of the sand pit offer several water bodies which could be colonized by the turtle in future from the source population in the sand pit (namely to the Skalky reserve or Morava river stream by corridors, such as channels or small ponds).

APPENDIX

Table 1: management arrangements (in Czech)

Managementová opatření a zásahy	**Popis zásahu**	**Místo zásahu (červeně vymezené plochy v Mapě 1)**
1. Rekultivace	Nerekultivovat klasickými metodami (např. nezavážet ornicí, nezatravňovat, nesázet stromy atd.).	Celé území pískovny
2. Zalesňování	Nezalesňovat ani nevysazovat dřeviny. Místa bez ochranářského významu (ruderály, haldy nevyužitého podorničí) je možno ponechat spontánní sukcesi.	Celé území pískovny
3. Sečení rákosin a vyřezávání náletových dřevin	Na písčinách (suchých i vlhkých) je vhodné vysekat zapojené porosty, jako jsou rákosiny, porosty ruderálních rostlin a náletových dřevin. Žádoucí je vytvoření mozaiky holých písčin s řídkou vegetací. Posečený a pořezaný biologický materiál nesmí zůstat ležet na místě, ale musí být odvezen mimo pískovnu nebo spálen.	i, ii, iii, iv
4. Tvorba tůní	V místech ukládání výpěrků vytvořit soustavu mělkých i hlubších tůní plynule přecházející v souš (viz bod 6). Část tůní by měla být tak mělká, aby docházelo při kolísání hladiny k vysychání. Nakládání s materiálem z vyhloubených tůní viz bod 5. Do budoucna aplikovat zásahy popsané v bodech 3 a 7. Do tůní se nesmí vysazovat žádné druhy ryb. Vhodné je ponechání několika kusů větví nebo kmenů ve vodě.	i, ii
5. Tvorba písečných dun	Jemný písek z vyhloubených tůní může být použit k tvorbě „dun“. Jiný materiál bude odvezen mimo tato místa. Do budoucna aplikovat zásahy popsané v bodech 3 a 7.	i, ii
6. Výpěrky po těžbě	Místa současného i minulého ukládání výpěrků se nesmí zavážet nevyužitým materiálem nebo ornicí. Mělo by docházet k samovolnému vytváření pobřeží s jemnou pískovou frakcí. Pokud dojde k zarůstání rákosem, náletovými dřevinami či jinou vegetací, je tato místa nutné posekat a biologický materiál odvézt mimo tato místa (bod 3. a 7.). Náplav je možné nechat přirozeně sedimentovat do jezera – těžbou se tak vytváří stále nová a obnažená písčitá stanoviště. Vhodnější by bylo usměrněné ukládání kalů tak, aby vznikaly různě hluboké tůně oddělené od hlavního jezera plynule navazující na odhalený písčitý substrát. Starší úložiště výpěrků by neměla být izolována vzrostlým zapojeným lesem.	i, ii, iii, iv
7. Pohyb mechanizace, terénních aut,	Na vybraných místech je nutný pravidelný a náhodný pohyb těžké mechanizace (bagr, nákladní auta, terénní auta atd.) narušující vegetaci na písčitých substrátech. K narušování	i, ii, iii,

turistů, koní apod.	podkladu můžou přispět jiní činitelé (kontrolovaný pohyb turistů, koní). Narušování technikou by se mělo provádět pouze v období podzimu a zimy, kdy je vegetační klid. Narušování by nemělo probíhat najednou na celé ploše. Je nutné ponechat mozaiku sukcesně různě starých, ale stále osluněných substrátů.	
8. Prosvětlení lesních porostů	Porosty spontánně vzniklých porostů dřevin rostoucích na písčinách je potřeba razantně prosvětlit. Podrost keřů a bylin je nutné také posekat a pořezat. Porost nechat výškově různorodý. Ponechat doupné a mohutné stromy. Dřevo a biologický materiál odvézt mimo štěrkovnu, spálit nebo štěpkovat. Část biologického materiálu může zůstat na lokalitě na vybraných místech na hromadě, aby sloužil jako místo pro rozmnožování a úkryt plazů a hmyzu.	Celé území pískovny, kde jsou biologicky hodnotné písčiny
9. Management vlhkých luk	Na vlhkých loukách mimo písčiny je nutné zavést management na podporu ohrožených druhů motýlů a hmyzu. Je nutné nesekat lokalitu najednou. Vhodná je tzv. mozaikovitá seč, kdy se část louky nechá v daném roce neposečená. Biologický materiál nesmí zůstávat na místě. Zcela vyloučené je mulčování. Vhodné je vytvoření tůní nebo terénních depresí (vyjeté koleje s loužemi) za pomocí techniky. Důležitý je průzkum hmyzu (hlavně motýlů a florikolních brouků), aby bylo možno navrhnout účinný a cílený management.	vi
10. Nepůvodní rostliny a porosty třtiny rákosovité	Dojde – li k přemnožení nepůvodních druhů rostlin na štěrkovně (trnovník akát, pajasan žláznatý, křídlatka, netýkavka atd.), je potřeba jejich porosty pravidelně likvidovat sečením, pravidelným narušováním technikou. Nepoužívat herbicidy. Biomasu odvážet mimo štěrkovnu nebo spálit.	Celé území štěrkovny
11. Úklid odpadků	Uklízet odpadky.	Celé území pískovny
12. Eutrofizace jezera	Do vodních ploch nenavážet biologický odpad, hnojiva, chlévskou mrvu atd.	Celé území současných i budoucích vodních ploch
13. Detailní monitoring bezobratlých	Na lokalitě byl proveden monitoring vybraných skupin organismů. Do budoucna je žádoucí pokračovat v monitoringu vývoje populací již studovaných skupin organismů a doplnit jej o další skupiny ohrožených organismů vázaných na holé písčiny. Důležitý je průzkum pavouků, kovaříkovitých brouků a křísů. Na nově vznikajících vodních plochách je důležitý průzkum vodního hmyzu (brouci, ploštice, jepice, chrostíci).	Celé území pískovny
14. Odstranění ornice a ponechání	V místech budoucí těžby, by bylo vhodné strhnout na co největší ploše ornici a podorničí ponechat holé, dokud se na místě nebude těžit. Vytvoří se tak přechodné stanoviště chudé	Místa budoucí těžby

surového substrátu před samostatnou těžbou*[3]	na živiny, kde najdou útočiště konkurenčně slabé druhy organismů. Tato místa mohou být výškově různorodá, mohou vznikat malé vodní plochy.	
15. Ukládání podorničí a tvorba mělké litorální zóny	Podorničí chudé na živiny, které nebude využito, by mělo být ukládáno na vybraná místa v jezeře a tím vytvářet mělké litorální zóny.	Vybraná místa v jezeře u pobřeží
16. Vytváření členitého pobřeží rovnou při těžbě	Při samostatné těžbě je žádoucí postupovat tak, aby se vytvářelo různorodé a členité pobřeží s různou výškou břehů. Těžbou můžou vznikat kolmé stěny, které mohou být využity jako hnízdiště pro ohrožené břehule a pro blanokřídlý hmyz. V průběhu těžby je žádoucí vznik zátok, ostrůvků, poloostrovů, které mohou sloužit přechodně jako útočiště pro řadu druhů organismů. Je žádoucí aplikovat opatření z bodu 14.	Místa budoucí těžby

Table 2: list of species.

Species	Specialization	RL	§	Dry sand	Moist sand	Pond	Reed weatland	Other habitats
Carabidae								
Agonum marginatum								*
Amara bifrons				*				
Amara fulva				*	*			
Anisodactylus binotatus								*
Bembidion biguttatum								*
Bembidion fumigatum								*
Bembidion lampros								*
Bembidion lunulatum								*
Brachinus crepitans			O					*
Calathus erratus				*				
Calathus fuscipes				*	*			
Calathus melanocephalus								*
Carabus granulatus								*
Carabus violaceus								*
Carabus scheidleri			O					*
Carabus ullrichi			O					*
Cylindera arenaria vienensis	*		O	*	*			
Cicindela campestris			O		*			
Cylindera germanica				*				
Cicindela hybrida				*	*			
Elaphrus riparius								*
Harpalus affinis				*	*			
Harpalus rufipes				*	*			*
Harpalus smaragdinus				*	*			

Chlaenius spoliatus							*
Chlaenius vestitus					*		*
Loricera pilicornis							*
Microlestes minutulus							*
Nebria livida		NT			*		
Omophron limbatum					*		
Poecilus cupreus							*
Poecilus lepidus							*
Poecilus versicolor							*
Pterostichus strenuus							*
Stenolophus teutonus					*		
Pterostichus melanarius				*			*
Abax parallelepipedus							*
Pterostichus oblongopunctatus							*
Dermaptera							
Labidura riparia	*	EN		*			
Hymenoptera - Apocrita							
Alysson spinosus	*				*		
Andrena barbilabris	*	VU		*	*		
Andrena flavipes				*	*		
Andrena minutula				*	*		
Andrena nigroaenea				*			
Andrena taraxaci				*			
Andrena vaga				*	*		
Andrena ventralis	*			*	*		
Anthophora plumipes				*			
Apis mellifera				*	*		*
Bombus hortorum			O	*			
Bombus lapidarius			O	*	*		
Bombus terrestris			O	*	*		
Cerceris quadrifasciata	*	VU		*			
Colletes cunicularius	*			*	*		
Crabro scutellatus		EN		*			
Crossocerus ovalis				*			
Crossocerus wesmaeli		VU		*	*		
Diodontus minutus	*			*	*		
Ectemnius continuus					*		
Elampus panzeri	*			*			
Epeolus variegatus		VU		*			
Episyron rufipes		VU		*	*		
Halictus maculatus				*			
Halictus subauratus				*			
Halictus tumulorum				*			
Lasioglossum laticeps				*			
Lasioglossum lativentre					*		
Lasioglossum malachurum				*			
Lasioglossum morio				*	*		
Lasioglossum pauxillum				*	*		

Lasioglossum politum				*	*			
Lasioglossum quadrinotatulum	*	EN		*				
Lasioglossum zonulum				*				
Methocha ichneumonides	*			*				
Mimumesa atratina				*				
Mimumesa littoralis	*	CR		*				
Mimumesa unicolor				*				
Nomada fabriciana				*	*			
Nomada fucata				*				
Nomada goodeniana				*				
Nomada ruficornis				*				
Nysson maculosus	*	VU		*				
Nysson trimaculatus	*			*				
Osmia bicornis				*				
Oxybelus bipunctatus	*			*	*			
Passaloecus singularis				*				
Pompilus cinereus	*	VU		*				
Pseudomalus pusillus	*			*	*			
Smicromyrme rufipes				*	*			
Sphecodes albilabris	*			*	*			
Tachysphex grandii	*	EN		*				
Xylocopa violacea				*	*			*
Vespa crabro				*	*			
Vespula vulgaris				*	*			*
Vespula germanica				*	*			*
Lepidoptera								
Aglais urticae				*				*
Anthocharis cardamines								*
Aphantopus hyperanthus								*
Araschnia levana								*
Coenonympha pamphilus								*
Erynnis tages								*
Gonepteryx rhamni								*
Heteropterus morpheus								*
Iphiclides podalirius		VO	O					*
Inachis io								*
Leptidea juvernica								*
Lycaena dispar								*
Maniola jurtina								*
Ochlodes sylvanus								*
Pieris brassicae								*
Pieris napi				*	*			*
Pieris rapae				*	*			*
Polygonia c-album				*				*
Polyommatus icarus								*
Thymelicus lineola								*
Thymelicus sylvestris								*
Vanessa atalanta				*				*

Vanessa cardui				*				*
Orthoptera								
Pteronemobius heydeni					*			
Tetrix subulata					*			
Tetrix tenuicornis								*
Eumodicogryllus bordigalensis					*			
Mantidae								
Mantis religiosa	VU	KO						*
Odonata								
Libelula depresa						*		
Ischnura elegans						*		
Heteroptera								
Gerris sp.						*		
Corixa sp.						*	*	
Amphibia								
Rana dalmatina								*
Bombina bombina								
Pelophylax ridibundus						*		*
Reptilia								
Lacerta agilis				*				*
Natrix natrix								*
Plantae								
Acer negundo								
Betula pendula								
Corylus avellana								
Populus alba								
Populus canadensis								
Populus tremula								
Populus xcanescens								
Pseudotsuga menziesii juv.								
Quercus robur								
Rosa canina								
Rubus sp.								
Salix alba								
Salix aurita								
Salix purpurea								
Sambucus nigra								
Achillea millefolium								
Agrostis stolonifera								
Amaranthus powellii								
Amaranthus retroflexus								
Arctium tomentosum								
Arrhenatherum elatius								
Artemisia vulgaris								
Atriplex prostrata subsp. latifolia		*C4a*						
Ballota nigra								
Betula pendula								
Bidens tripartitus								

Bolboschoenus planiculmis		*C4a*	
Calamagrostis epigejos			
Calystegia sepium			
Centaurea oxylepis			
Chenopodium album agg.			
Chenopodium polyspermum			
Cichorium intybus			
Cirsium arvense			
Cirsium vulgare			
Crepis biennis			
Cyperus fuscus		*C3*	
Dactylis glomerata			
Datura stramonium			
Daucus carota			
Digitaria sanguinalis subsp. sanguinalis			
Echinochloa crus-galli			
Echium vulgare			
Elytriga repens			
Epilobium tetragonum			
Equisetum arvense			
Erigeron annuus subsp. septentrionalis			
Fallopia dumetorum			
Galeopsis speciosa			
Heracleum sphondylium			
Hypericum perforatum			
Juncus bufonius			
Juncus effusus			
Lactuca serriola			
Lathyrus pratensis			
Linaria vulgaris			
Lolium perenne			
Lycopus europaeus			
Medicago lupulina			
Melilotus albus			
Melilotus officinalis			
Myosoton aquaticum			
Persicaria maculosa			
Persicaria mitis			
Petasites hybridus			
Phragmites australis			
Picris hieracioides			
Plantago major			
Poa annua			
Poa compressa			
Poa palustris			
Polygonum arenastrum			
Reynoutria sachalinensis			

Rumex crispus			
Rumex obtusifolius			
Senecio sarracenicus		C2b	*§2*
Senecio viscosus			
Setaria pumila			
Silene dioica			
Solidago canadensis			
Symphytum officinale			
Tanacetum vulgare			
Taraxacum sect. Taraxacum			
Trifolium dubium			
Trifolium hybridum			
Trifolium pratense			
Tripleurospermum inodorum			
Tussilago farfara			
Typha latifolia			
Urtica dioica			
Verbascum densiflorum		*C4a*	
Vicia cracca			

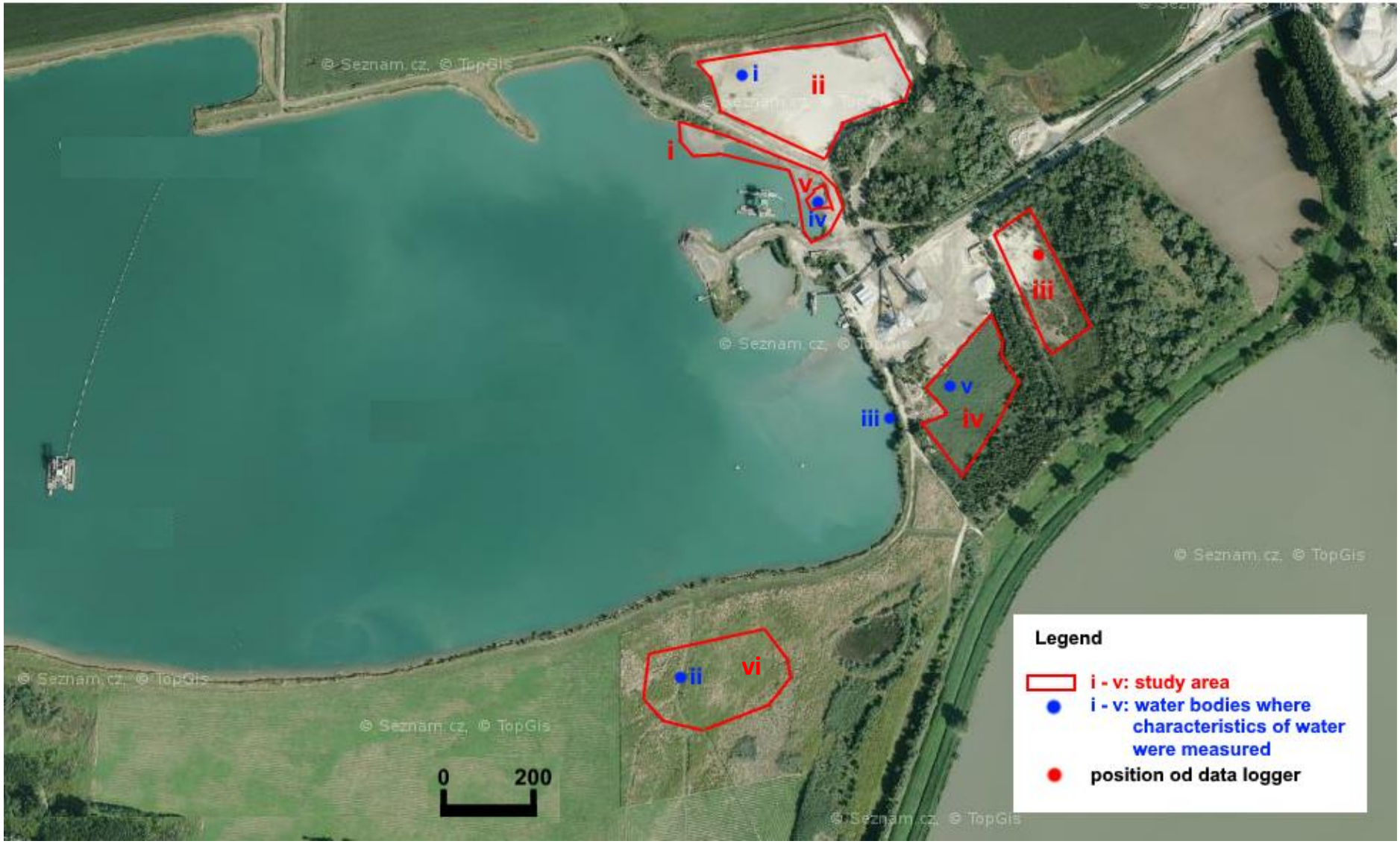

Chart 1: Study areas.

Chart 2: Areas for instaling of potential acclimatization device for pond turtle

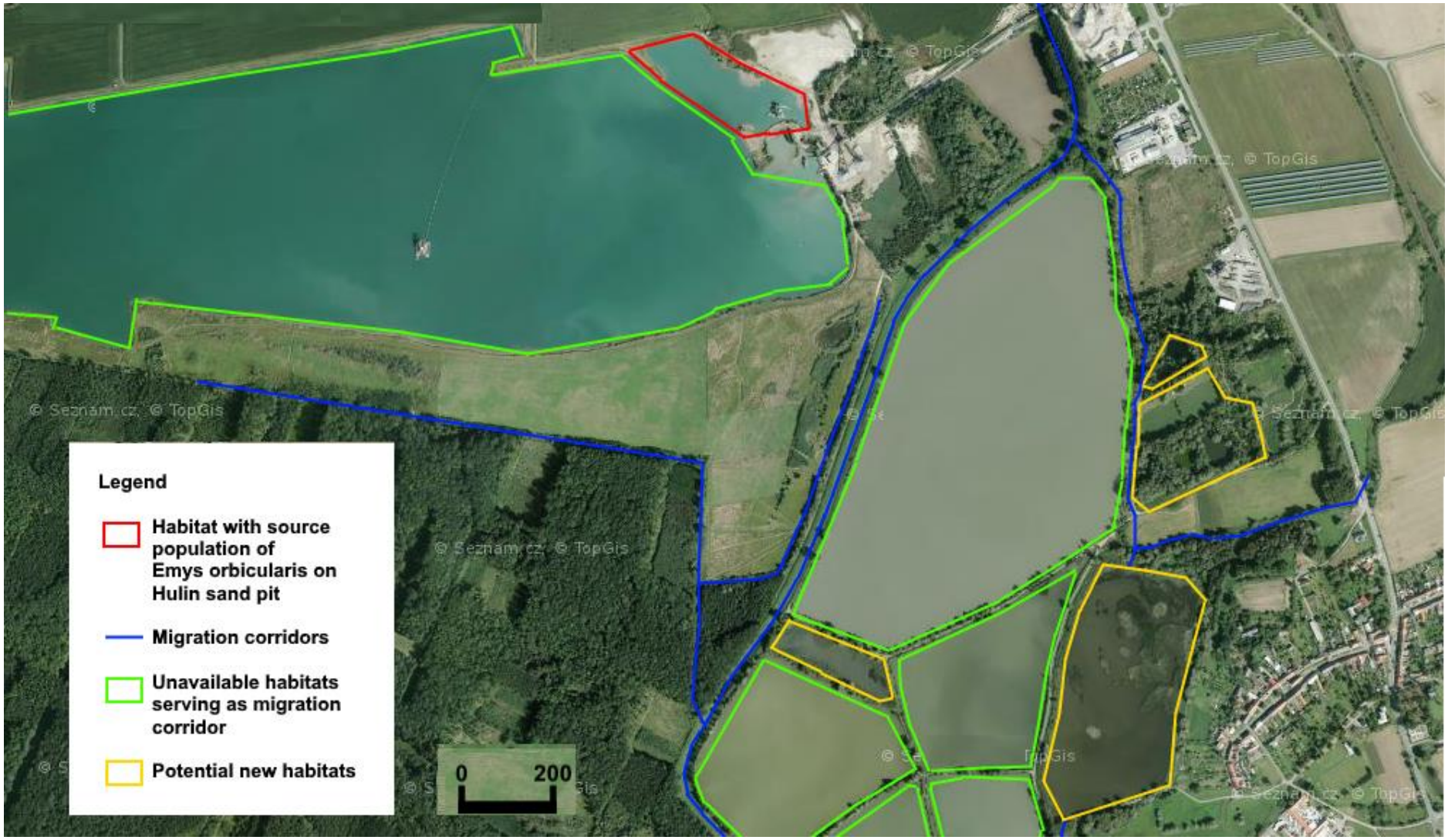

Chart 3: Surroundin with potential migration corridors.

Image 1: Potential habitats for pond turtle with pools and bare sands.

Image 2: Bare sand is potential breeding site for pond turtle.

Image 3: Reeds pool with extréme low pH of water.

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