Site Investigation into the Design of an Amusement Park in Riverside Park, Newcastle

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21/03/2024

Abstract: This site investigation report comprises a review of all available and accessible data by means of a desk study, a summary of findings from a walkover survey of the site, and a discussion of ground investigation recommendations and ground hazards that should be addressed. Through the findings, it is importantly noted that flooding, subsidence and contamination risks are all prevalent in the site, due to the topography and historical use of the land for industrial means.

NOTE: Every figure is NORTH orientated: N and reference WGS84 datum is used for latitudes and longitudes.

I. Introduction

This report addresses the site investigation of the redevelopment of a section of Walker Riverside Park (see Figure 1), in Newcastle upon Tyne, into an amusement park. The park is specified to include a ferris wheel and two low rise buildings. This site investigation comprehensively covers all available material relevant to determining the suitability of the site, and specific areas within the site, for such a purpose. A desk study and site walkover are covered within this report along with recommendations for further investigations using procedures such as drilling boreholes or trial pits throughout the site.

Figure 1: Satellite Image of Designated Site Area (credit: Google Maps)

II. Desk Study

A. Topography

Figure 2 shows the topographic nature of Riverside Park and the surrounding areas. Topographic features of relevance to the site are listed as follows:

- Contour lines within the site show multiple wooded slopes
- Three intersecting paths pass through the site
- Roads are accessible from the car park at the bottom-right of the site and above the riverbank on the bottom-left site side
- Non-coniferous trees and scrubs cover the natural areas, with multiple presumed fields in between the woodland
- The coastal water body is the River Weir
- A man-made promenade runs along the riverbank below the site
- There is a residential area above the site, including a football pitch and sewage pumping station

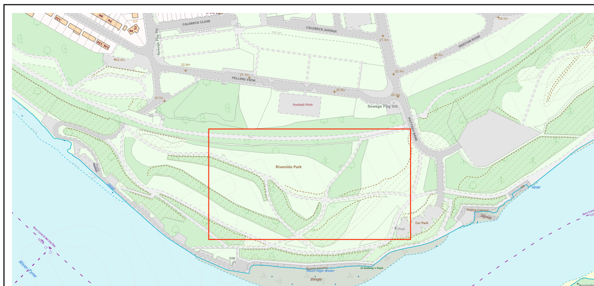

Figure 2: Topology of Riverside Park (credit: Digimap)

B. Geology (solid and drift)

Figure 3 shows the approximated geological formation of the land, via the BGS: British Geology Survey, with the site largely comprised of Pennine Middle Coal Measures Formation. According to the

BGS [1], this is a formation of mudstone, siltstone, sandstone and coal seams.

Figure 3: Geology of site using a coloured legend (credit: British Geology Survey)

C. Historic data

It is important to study the historical data of the site to gauge what activity may have taken place on in or around the area of the site. Figure 4 shows the outlay of the Riverside Park area in the 1860s; a copper works directly in the middle of the site as well as residential buildings (*Kings Head Inn*) around the site.

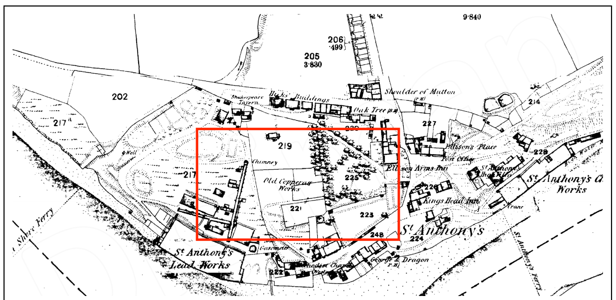

Figure 4: Historical map of the site in the 1860s (credit: Digimaps)

Figure 5 shows the area in the 1890s; the copper site has appeared to have been developed into a lead works and there are mentions of *cranes* alluding to the heavy industrial nature of the area at the time; notably there is a railway running above the site.

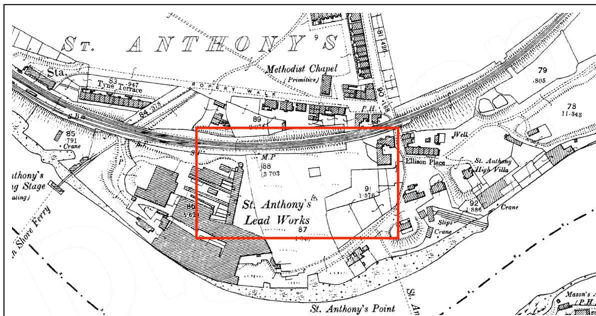

Figure 5: Historical map of the site in the 1890s (credit: Digimaps)

Figure 6 is of the area in the 1940s; the industrial developments of previous decades have appeared to disappear altogether from the site but there still seems to be some industrial buildings to the right of the site; the railway remains; more residential housing has been built above the site.

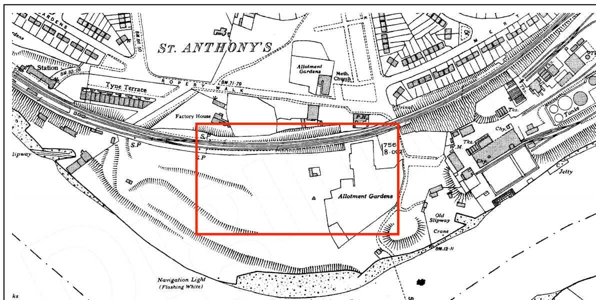

Figure 6: Historical map of the site in the 1940s (credit: Digimaps))

Figure 7 is the most recent *historical* map of the area; there is little change in the outlay or man-made development in or around the site from the 1940s map.

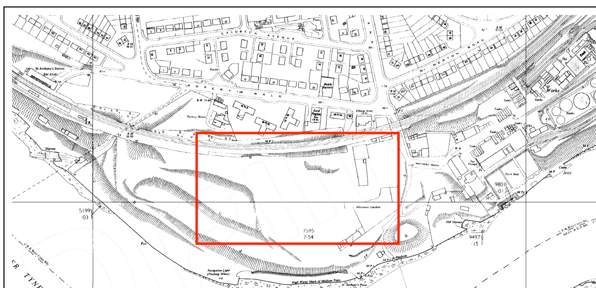

Figure 7: Historical map of the site in the 1960s (credit: Digimaps)

D. Mining

There are three recorded mining entry points in the site (see Figure 8). They are deemed Development High Risk Areas [2].

Figure 8: Recorded mining entry points - shown as red *Xs* (credit: The Coal Authority via the British Geological Survey; records from 2014))

E. Risk of Flooding

According to *Flood map for planning service* [2] provide by the British Government the site is within *flood zone 1* and has a low probability of flooding from rivers and the sea. The service states that most developments that are less than 1 hectare (ha) in flood zone 1 do not need a flood risk assessment (FRA) as part of the planning application. However the site in this report is approximately 3.9 hectares.

F. Contamination issues

Possible contamination found within the site is inferred from historical data from section II-C as follows:

- Metal contaminants from Copper and Lead works in the late nineteenth century - i.e. Cu and Pb contamination may be found in the ground of the site.
- The industrial buildings to the right of the site seen in the 1940s and 1960s maps were infact tar works [3]. This might insinuate contamination in the soil and groundwater of chemicals such as Polycyclic aromatic hydrocarbons (PAH) released by tar processing. A study [3] on the former tar works site shows the highest PAH concentration on the where the tarworks was seen in Figure 7 and some PAH contamination found in the river bed parallel with it.

G. Borehole records

Figure 9 show the locations, relative to the site, where there are readily available borehole records [4]&[5]. The boreholes below the site may prove as an accurate representation of the ground in the lower parts of the site especially. The site or area concerning these boreholes has not appeared to have had any major redevelopment since the 1940s when looking at section II-C.

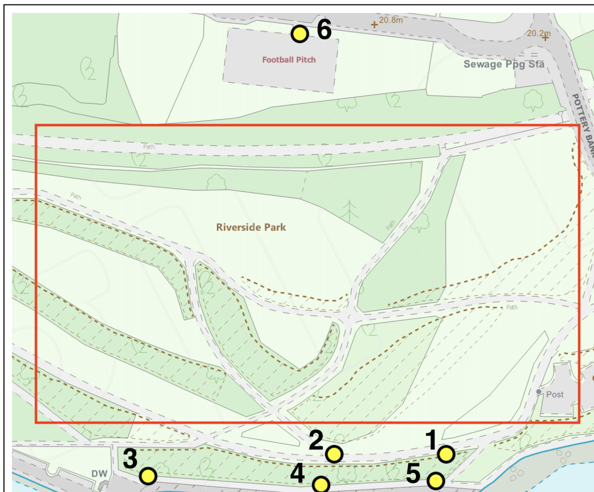

Figure 9: Recorded (accessible) boreholes - shown as yellow circles (credit: British Geological Survey; records from 1966-70)

Borehole No.	Year	Latitude	Longitude	Length (m)
1	1966	54.960170	-1.551861	12.19
2	1966	54.960192	-1.552922	9.94
3	1966	54.960069	-1.553767	3.04
4	1966	54.960022	-1.553034	6.10
5	1966	54.960045	-1.551925	6.09
6	1970	54.961801	-1.552998	8.53

Table I: Data for boreholes seen in Figure 9

Figure 14 shows the findings for these boreholes and Figure 13 shows a graphical representation of boreholes 1 to 5 with adjusted ground levels using approximations for the borehole coordinates using *topographic-map.com* [6]

Depth (m)	Description of Strata	SPT Value
Borehole 1		
0.0 - 1.2192	FILL; soft brown and grey sandy silty clay; some gravel	N/A
1.2192 - 5.4864	FILL; dirty brown sand; gravel; ash; brick rubble	14-27
5.4864 - 12.192	STIFF brown silty clay; some mixed GRAVEL	N/A
Borehole 2		
0.0 - 1.9812	FILL; clay; ash; brick rubble	5
1.9812 - 2.4384	FIRM brown and green slightly mottled sandy silty CLAY; little mixed GRAVEL; Blue streaks	N/A
2.4384 - 9.906	STIFF brown/grey sandy silty CLAY; some mixed GRAVEL; Occasional blue streaks especially at top; coal gravel traces	N/A
Borehole 3		
0.0 - 3.048	STIFF brown sandy silty CLAY; little mixed gravel	N/A
Borehole 4		
0.0 - 1.0668	Mixed brown SAND and mixed GRAVEL	N/A
1.0668 - 6.096	STIFF brown sandy silty CLAY; some mixed GRAVEL	N/A
Borehole 5		
0.0 - 1.8288	Mixed brown SAND and mixed GRAVEL	20
1.8288 - 2.5908	SOFT brown silty CLAY	N/A
2.5908 - 6.096	STIFF brown silty sandy CLAY; some mixed GRAVEL	N/A
Borehole 6		
0.0 - 1.524	FILL	4
1.524 - 4.4196	Firm mottled blue-grey and brown-yellow sandy silty CLAY with fine to coarse gravel and sandstone and coal fragments	4-11
4.4196 - 6.858	Loose to medium dense brown very silty fine to coarse SAND with weathered sandstone fragments	8
6.858 - 8.5344	Weathered sandstone	16

Figure 10: Records of boreholes 1 through 6 - from Figure 9 (credit: British Geological Survey; records from 1966-70)

III. Walkover Survey

The site was investigated during a walkover survey to compare the established desk study data with the existing site. Figure 11 shows six areas of interest observed during the walkover survey. Image 1 shows a water source on the edge of one of the paths; image 2 shows cracks on the concrete path and evidence of creeping of the ground above the path; image 3 shows a track which clearly has been previously used by vehicles to move between the upper and lower fields on the right hand side of the site; images 4,5 and 6 shows large grassy field areas, with evidence of water-logging and initially muddied ground.

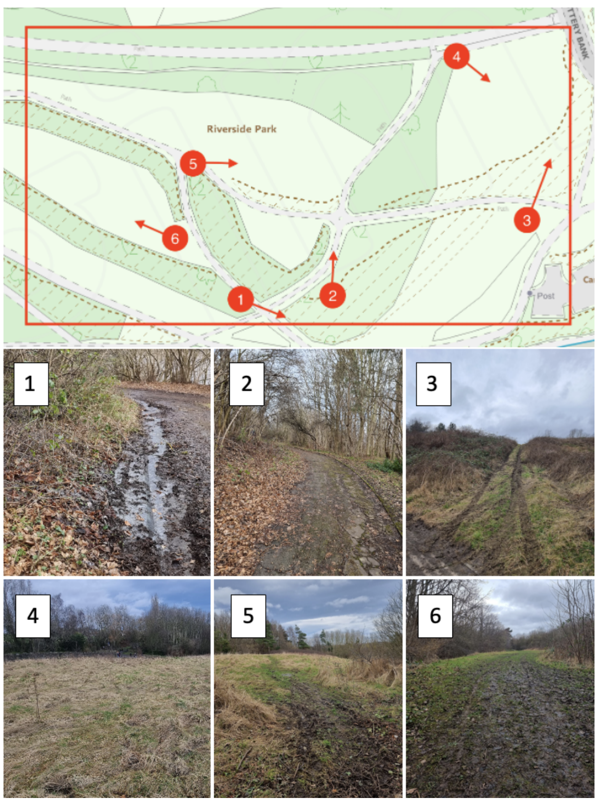

Figure 11: Images of interest within the site from the walkover survey, numbered and correspondingly located on the topographical map

IV. Proposed Ground Investigations

Looking at the array of gathered desk study data in section II and additional observations from the walkover survey in section III, the following conclusions of significance have been made:

- The Glaciofluvial deposits from the Devensian period indicate past glacial influence with sediments typically well-drained and sorted (see Figure 3. Also noted is Till from the same period, which is usually unsorted glacial debris. Glaciofluvial deposits largely consist of coarsely-grained sediments [7].
- Significant findings highlight the land's evolution from industrial use to potential recreational development. Past industrial activities raise concerns about soil and groundwater contamination, chiefly with heavy metals and PAHs from historical copper, lead, and tar works in section II-C.
- The presence of old mine shafts underscores the risk of subsidence in the locations established in Figure 8. The geological data in Figure 3 indicates a presence of Pennine Middle Coal Measures Formation, which further suggests historical coal mining activities in the area.
- The borehole records from 1966-70 indicate that the ground is comprised of made ground/fill until it becomes very stiff silty clay and gravel at 5.5m to 7m below ground level [5]&[4]. No groundwater was encountered in any of the boreholes, which were drilled to depths of 10-12m. Looking at Figure 9, this may give an impression of the ground south of the site, but may also represent the site more generally. It should be acknowledged that these boreholes may not accurately represent the ground, despite no obvious redevelopments since before the 1960s.

Figure 12 shows the proposed building locations for the ferris wheel and low rise buildings based on relatively flat, spacious and exposed ground.

Figure 12: Suitable identified areas for building on (*orange areas*), subject to ground investigations

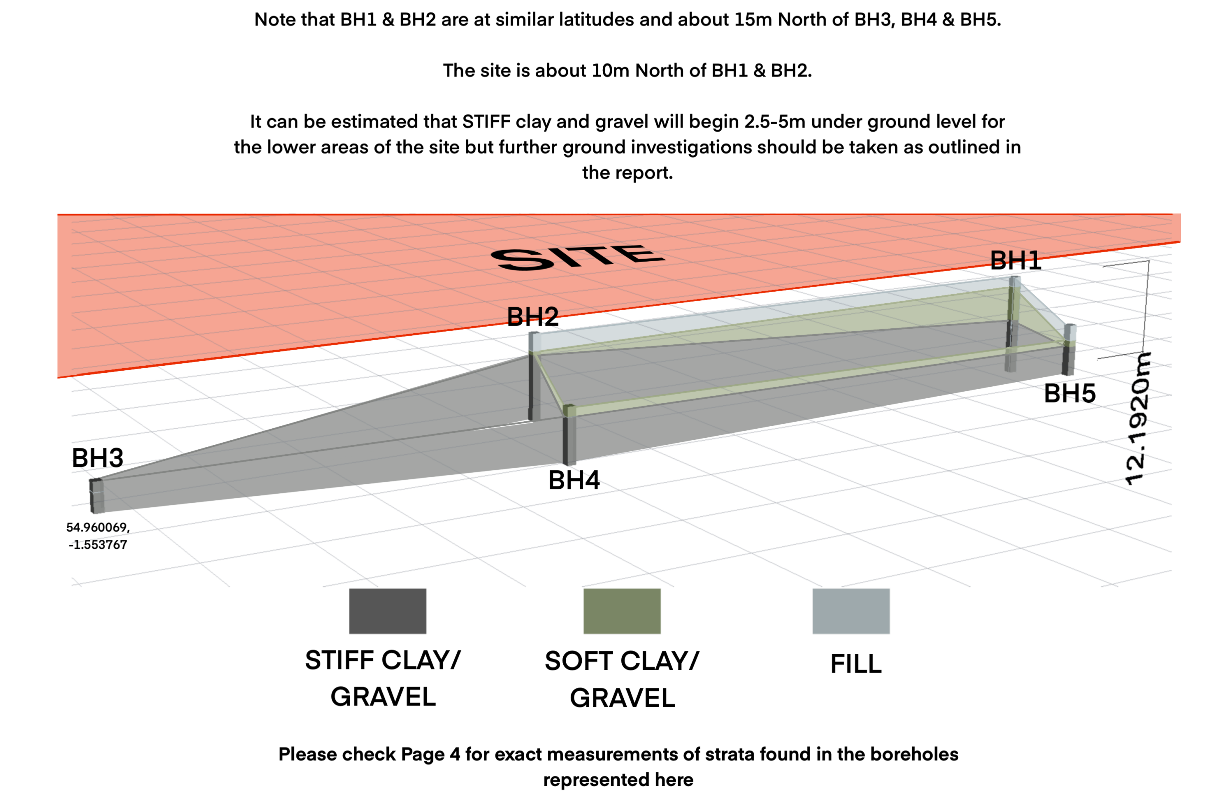

Figure 13: Graphically represented 3D **ground model** of the available borehole records (1 to 5) due south of the site - from Figure 9 (credit: British Geological Survey; records from 1966-70)

There are a number of proposed ground investigation that should be carried out to assess the conditions of the ground for building the aforementioned amusement park:

- Boreholes should be placed where historical maps indicate former industrial activity - i.e. the old copper and lead works and tar processing areas - to assess soil and groundwater contamination. Boreholes should also be located near the recorded mining entry points to evaluate subsidence risk. Figure 14 shows the proposed borehole locations. Two of them have been determined to assess the ground water and ground conditions in the proposed construction locations for the low rise buildings and ferris wheel. These boreholes should be drilled to depths of at least the proposed foundations to check for groundwater and bedrock. Depending on the size and design of the ferris wheel, this may be to a depth exceeding 10m (see proposed foundations by Wu on a large scale ferris wheel [8]). Previous borehole records from the bottom of the site area indicate that harder ground is located at depths of 5.5m-7m. This indicates boreholes may not need to exceed depths greater than this if this is also the case for the proposed borehole location. Another borehole should be taken on the water source at the bottom of the site and a borehole should be taken by the old tar works to check for chemical contamination - see section II-F.
- Trial pits are recommended in areas showing evidence of water-logging and ground movement to assess near-surface soil conditions and potential for shallow contamination.
- Geotechnical monitoring instruments, such as piezometers for groundwater levels and inclinometers for slope stability, should be installed in identified areas where there is uneven or soft ground.
- Piles might be necessary for the ferris wheel to bypass contaminated or unstable soil layers.

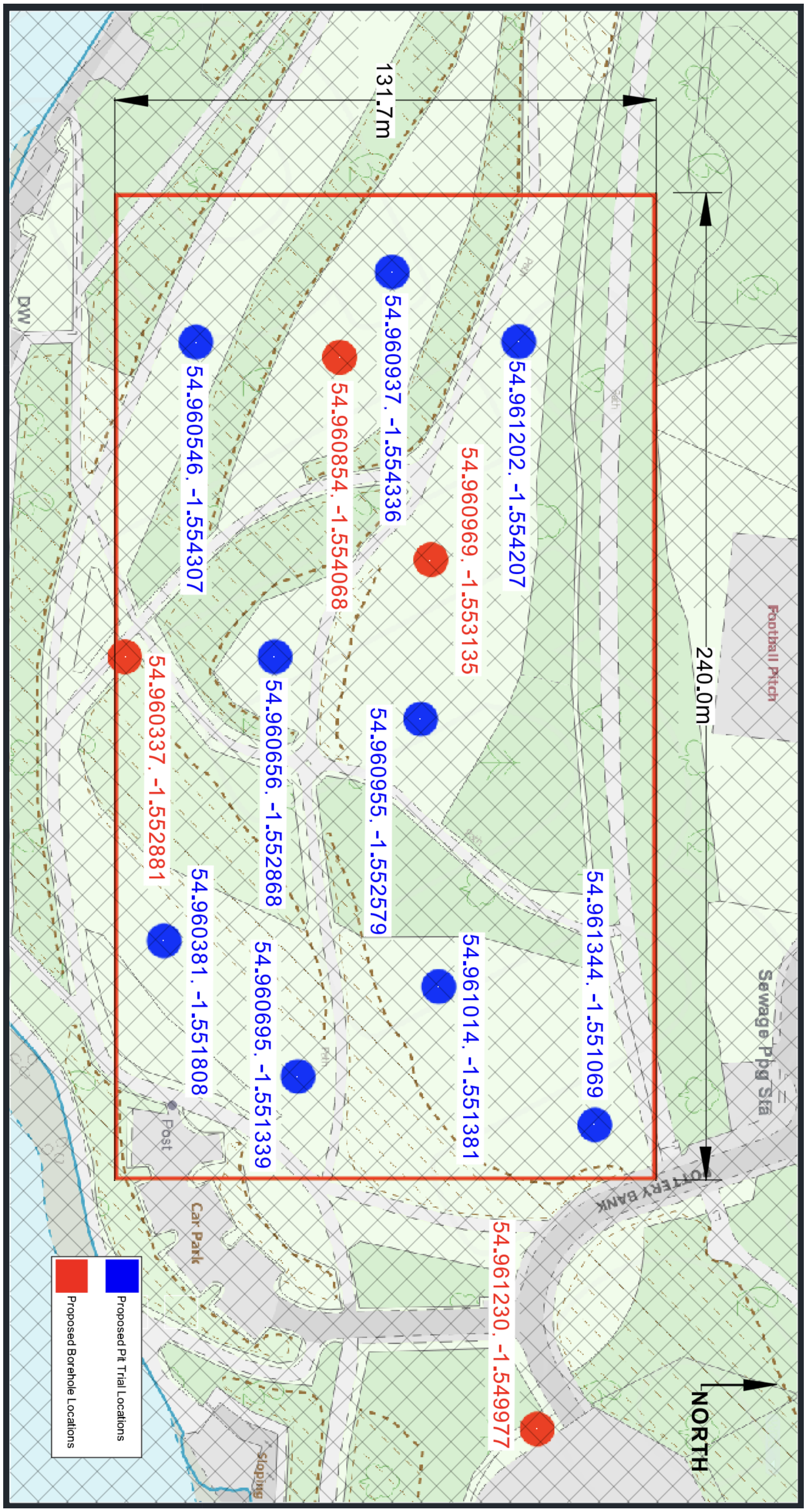

Figure 14: Longitudes & latitudes of proposed boreholes (*red circles*) and pit trials (*blue circles*).

- For the low-rise buildings, raft foundations with a vapor barrier might be appropriate if shallow soil contamination is confirmed by the ground investigation.

- For soil compacting paths that appear to be creeping (see Figure 11, image 2), triaxial compression tests on collected soil samples should be taken to assess the soil's strength and stability to see if the paths should be reinforced or rerouted them to provide stable access for the construction of the ferris wheel and buildings. **The use of deep foundations for the ferris wheel, such as piles, is recommended**. Piles can bypass unstable or contaminated soil layers, providing stable support in deeper, more stable strata. **For the low-rise buildings, raft foundations could be a suitable choice**, especially if shallow soil contamination is confirmed. Raft foundations distribute the load over a large area and are suitable for soils with lower bearing capacities.

V. Hazards

The hazards that have been referred to in section IV are listed as follows:

- Industrial Contamination: Historical industrial use, notably tar, copper, and lead works, raises significant concerns about soil contamination. The presence of such industries often leads to residues of hazardous substances like Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals (Cu, Pb) in the soil. This contamination poses a risk to construction workers and to future park users and local ecosystems. It necessitates thorough soil testing and potentially extensive remediation measures.

- Mining Subsidence Risk: The site's history includes coal mining activities, evidenced by recorded mining entry points. This historical mining legacy introduces the risk of ground subsidence, which could undermine structural stability. Addressing this requires detailed subsurface investigations to locate voids or weak spots that might collapse under the weight of new structures.

- Soil Instability and Creep: Observations of cracking and creeping along paths point towards unstable soil conditions. This instability could be due to various factors, such as poor compaction, changes in moisture content, or the decomposition of organic material in the soil. Such instability can have significant implications for foundation design and the longevity of structures.

- Flooding Risks: The site's location within a designated flood zone emphasizes the need for a comprehensive flood risk assessment. Flooding can affect foundation choices, necessitate the implementation of drainage solutions, and influence the overall layout and design of the amusement park.

- Ground Composition Challenges: The geological context, characterized by Devensian till and Glaciofluvial deposits, suggests a complex subsurface with variable soil conditions. These deposits can present challenges in terms of bearing capacity, drainage properties, and potential for differential settlement.

- Vegetation Impacts: Existing wooded areas can affect soil stability and moisture content. The roots of trees and shrubs can create voids or areas of uneven soil density, while the removal of such vegetation might change the soil's water retention characteristics.

References

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[8] X. Wu and D. Zhang, "Research for the influence of ferris wheel deep foundation pit excavation on adjacent existing tunnel," in *Journal of Physics: Conference Series*, vol. 2424, p. 012032, IOP Publishing, 2023.