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An Assessment of Historic Landfills for Continuing Environmental Impact

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Author's contribution

This whole work was carried out by the author AU.

Original Research Article

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ABSTRACT

Aims: To investigate any physical evidence of ongoing environmental impact of historic landfill sites by assessing the characteristics of vegetation on these sites.
Place and Duration of Study: Welwyn and St. Albans district in Hertfordshire were mapped for this environmental assessment between March 2011 and February 2012.
Methodology: Seventeen (17) landfill sampling points were mapped out on nine (9) sites based on availability of historical records and accessibility. A Phase 1 habitat survey was conducted on these sites. Plants species were identified and recorded on site.
Results: A total number of 42 woody, herbaceous and grass species were identified and recorded on all sites. Most of these species were perennial plants with a few biennial plants. Site surface appearance was generally uneven and elevated compared to adjacent undisturbed land. Two out of the 17 sites had sparsely vegetated areas. *Rumex* species were dominant on most of the sites. Soil conditions were neutral on all sample points with the maximum and minimum soil pH recorded being 7.0 and 6.4 while soil temperature recorded was 14.2ºC and 6.4ºC.
Conclusion: Field results show that there was no visible evidence of contamination arising from the degradation of waste materials based on the analyses of Phase 1 Habitat Survey and the environmental parameters that were measured. It is recommended that plants root analysis, surface water and groundwater quality studies should be embarked upon in future in order to be able to present a holistic environmental assessment status of the study area.

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Keywords: Historical landfill; vegetation; phase 1 habitat survey; environmental assessment.

1. INTRODUCTION

Over the years, landfilling has remained the most common option for waste disposal. In recent years, new regulations have been introduced to reduce the impact of landfills on human health and the environment [1,2,3]. Strict waste legislation was introduced in the early 1970s in order to manage environmental pollution [4,1]. Modern landfills are required by law to be properly engineered to manage pollution [5]. Municipal waste consists of different organic materials which decompose over time to form leachate and landfill gas [1,6].

Biodegradation of organic waste is the source of landfill gas. Landfill gases comprise of methane, carbon dioxide, and carbon monoxide, hydrogen, oxygen, nitrogen and hydrogen sulphide [7,8]. The main hazards of landfill gas include flammability, asphyxiation and depletion of oxygen in the root zone [9]. Leachate contains toxic heavy metals such as Zn, Hg, Pb, Cd and Fe [9,10]. The concentration of metals with the exception of iron is often lower in older, more stabilized landfills [9]. Some properties of soil influence the retention of heavy metals. Some of these soil properties include soil pH, organic matter, clay minerals, status of soil moisture and redox reaction [11]. The interface between the solid and solution stages of soil influences metal uptake by plants.

Some plant species are good indicators of soil pH conditions. Soil pH influences plant growth rate [12]. Soil temperature affects the breakdown of pesticides, microbiological activity and nutrient cycles. There are some factors that influence soil temperature such as tillage, precipitation, air temperature, vegetation, soil color and groundwater [13]. Surface pigmentation or deposit on soils could indicate possible land contamination [9]. There are plant species that can be used to immobilize heavy metals on contaminated sites. Some plant species are tolerant to metal contamination and are commonly used for Phytostabilisation [14] because they can absorb and accumulate metals in their roots minimizing movement of metals.

Some historical landfill sites located in Welwyn-Hatfield and St Albans districts of Hertfordshire, United Kingdom (UK) were mapped out for an environmental assessment in order to evaluate the likely impacts they might have on vegetation on the surrounding sites sequel to poorly engineered leachate and gas control systems. Historic landfills are sites that have received waste in the past which have either been closed or restored. These landfills were built in the past without much consideration of their associated environmental risk. These sites no longer have a permit [9,15].

2. MATERIALS AND METHODS

Trowels were used for digging up soil for pH measurements on site. Photographs provided supplementary information on site observations. Other materials used are listed as follows:

waterproof jacket; wellington boots; high resolution binoculars; plastic bags; gloves; Floral Identification guides; 1:10,000 Phase 1 habitat field maps; Handbook for Phase 1 habitat survey; Soilstik pH meter; distilled water; recording sheets; digital camera; Berol Verithin color pencils.

2.1 Study Area

The study area is presented in the topographical map below Fig.1 which delineates the sampling points appropriately.

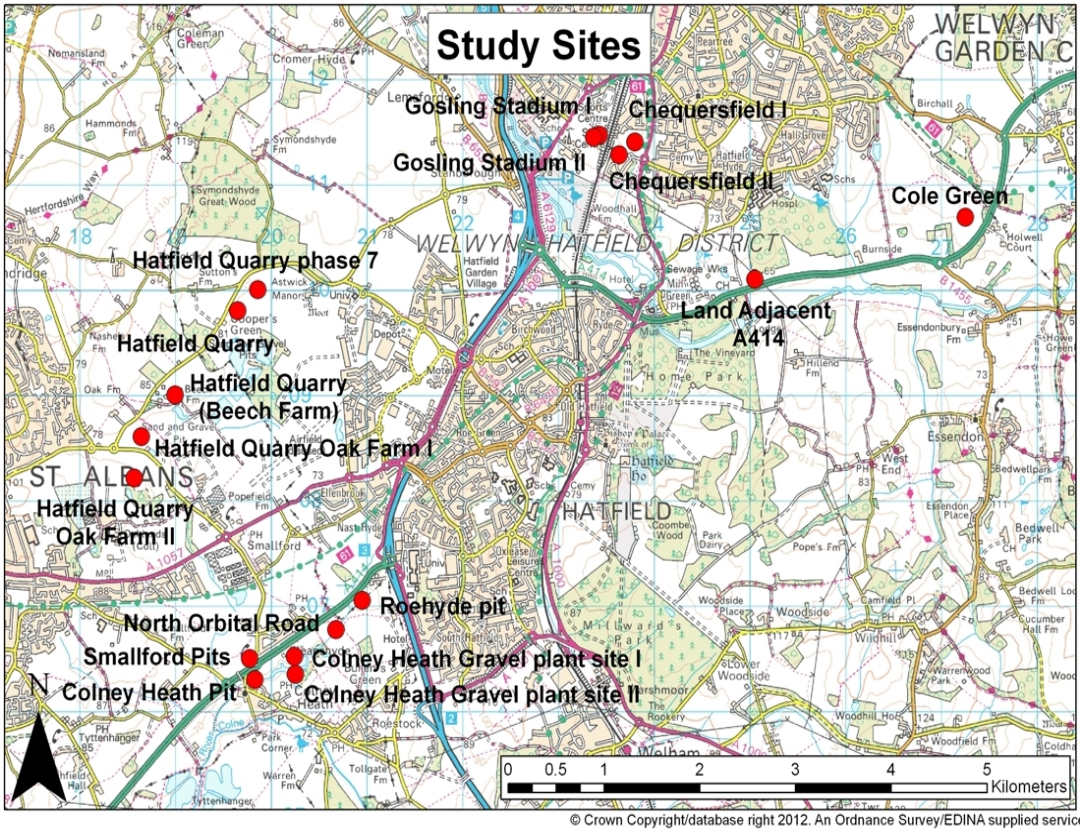


Fig. 1. Map of study area

2.2 Desk Review

A review of historical documents provided some background information on each of the studied site. Desk review of these sites was done at the Hertfordshire County Council. Documents reviewed include historical maps dated as far back as the 1940's, aerial photographs, planning application and planning permission documents. However there was little or insufficient historical information on some of the sites. Find below summary of findings from the desk review:

2.2.1 Gosling stadium

Historical records indicated these sites received inert waste from 1982 to 1986 after which they were closed and restored to amenity grassland. Gosling stadium is located in a built up area.

2.2.2 Chequers field

Chequers field was quarried for brick earth in the 1930's. Historical records show it first received waste in 1965 and was closed sometime in the 1990's. The waste types recorded include; domestic, commercial, industrial, inert and special waste. There is evidence of gas monitoring ongoing on these sites. The site is located in a built up area and is bordered on the north end by the East Coast mainline.

2.2.3 Roehyde pit

The former gravel pit first received waste in 1972 and was closed and restored in 1984 to rough grassland. It is surrounded by rough grassland and wedged between the A1 (M) and A414 (North Orbital Road) in Hatfield, Hertfordshire. The site shares boundary with the North Orbital road site and woodland.

2.2.4 North orbital road

The site received waste from 1947 to 1966. Records show it received commercial and industrial waste. It is also runs adjacent to the A1 (M) in Hatfield.

2.2.5 Colney heath

Originally gravel pits extracted for mineral which were filled with waste soil and rubble from 1984 – 1985. These sites were restored to pasture and arable land. They share boundaries with the village of Colney Heath and the A414 (North Orbital Road) in Hatfield.

2.2.6 Smallford pit

These sites were former gravel pits filled with commercial, household, and inert waste from 1945 to 1976. They were then closed and restored to agriculture and amenity lakes. It shares common boundary with farm land and Smallford village.

2.2.7 Hatfield quarry

These sites were former sand and gravel pits filled with commercial, household, and inert waste from 1935 to 1991. The sites were restored to agricultural use and amenity lakes as required by their planning permission document. Records show they were lined and capped with a gas monitoring system installed. It shares boundary with woodland.

2.2.8 Cole green sites

These site received commercial, industrial, liquid sludge and inert waste from 1923 – 1990. It was then closed and restored to agriculture use. In 1990, landfill gas emission was reported on one of the sites. Site is located along the A414 between Hatfield and Hertford.

2.2.9 Land adjacent A414

This site is located on the A414. It first received inert waste in 1992 however there is insufficient information to determine the date it was closed. However, the site was restored to amenity use.

2.3 Phase 1 Habitat Survey Method

The Phase 1 Habitat Survey was adopted for this study being a standard technique for an initial ecological survey for Environmental Impact Assessment (EIA) [16]. This method was adapted from the Handbook of Phase 1 habitat survey developed by the Joint Nature Conservation Committee (JNCC) for a detailed description of habitats and vegetation on sites [16,17]. Field investigation was carried out with the aid of GIS map on a scale of 1:10,000 because it contains more detailed information on surveyed habitat [18,19]. The habitat maps were produced with as much accuracy possible. However, it is important to note that there may be possible errors in measurements below 5%. There may also be 'observer error' during field observation. The different habitats identified were color coded on phase 1 maps with Berol Verithin color pencils which is the recommended set of pencils used for color coding habitat maps according to the habitat type. Habitats were characterized by broad vegetation categories as recognized by the JNCC handbook which points out the specific areas of interest on the site [17]. The aerial photographs of 1972 were also used to map the different habitat types on each site especially for sites with limited or restricted access. Changes in vegetation cover of the 17 sampling points under review were compared with the aid of the habitat maps, aerial photos and site photographs as recommended by the JNCC handbook [20]. Plants species were identified in the field with the aid of the British Flora identification guide by Francis Rose and an experienced botanist [21].

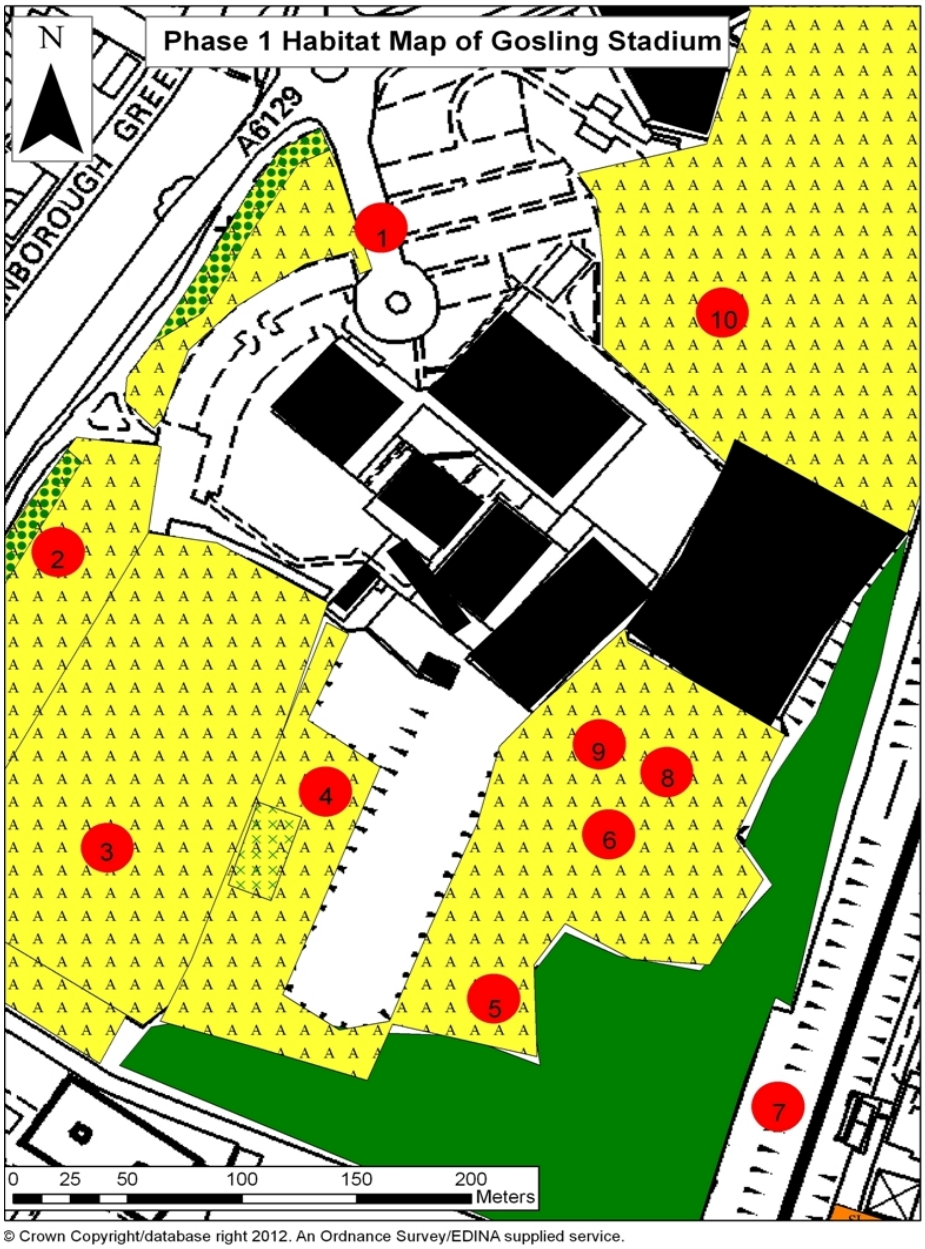
2.4 Soil pH and Temperature Analysis

Sampling points were determined with the aid of the site maps and GPS coordinates developed in the GIS lab. These points were also marked on the field maps. A Soilstik pH meter was used to obtain soil pH and temperature *In situ*. The pH meter was calibrated in distilled water prior to measuring the soil parameters. Loose soil sample was dug out at a depth of about 4 inches below the earth surface. Soil materials within the hole were pulverized and debris removed. The hole was filled up with distilled water and slurry was formed by mixing the soil with distilled water. This was left in an upright position for about five minutes before a Soilstik pH meter was then inserted and pH and temperature readings were recorded after 60 seconds when the meter stabilizes. Three readings were recorded at three different sample points for both parameters and average values were calculated accordingly.

3. RESULTS AND DISCUSSION

The characteristics of the plant species identified at the study sites indicated no significant difference in physical features such as color, size, and leaf appearance from similar species on adjacent fields, nearby farmlands and other undisturbed sites in the Welwyn-Hatfield area. Table 1 and Fig. 2 indicate findings from the Phase 1 Habitat mapping of Gosling stadium with target notes codes. The Phase 1 Habitat maps as well as photographs of the other studied sites are presented in the appendix. The findings obtained from desk study review and field visits of all 17 sampling points surveyed are presented in Table 2 while Table 3 is the summary of some plant species identified at these sites. On all 17 sampling points, land surfaces appeared undulated in most of the sites compared to adjacent land. This is one of the characteristics of old landfills.

A total of 42 perennial and biennial plant species were recorded. The most common woody plants were oak, ash, hornbeams, beech and hawthorns. The dominant grass species observed was the perennial ryegrass. Perennial weed such as common ragwort and sorrel were locally abundant on most of the sites. Wild teasel, a biennial weed was found on almost all the studied sites. *Rumex* species was observed to be growing in colonies on most of these sites. On the Chequers field site these plants species were found to cover between 8 – 10 per cent of the total site surface and mainly present along the southern boundary. There were dense low shrubs scattered across the Chequers field site. Roehyde Pit, Colney Heath and Smallford sites had rough overgrown grassland with a poor physical appearance.



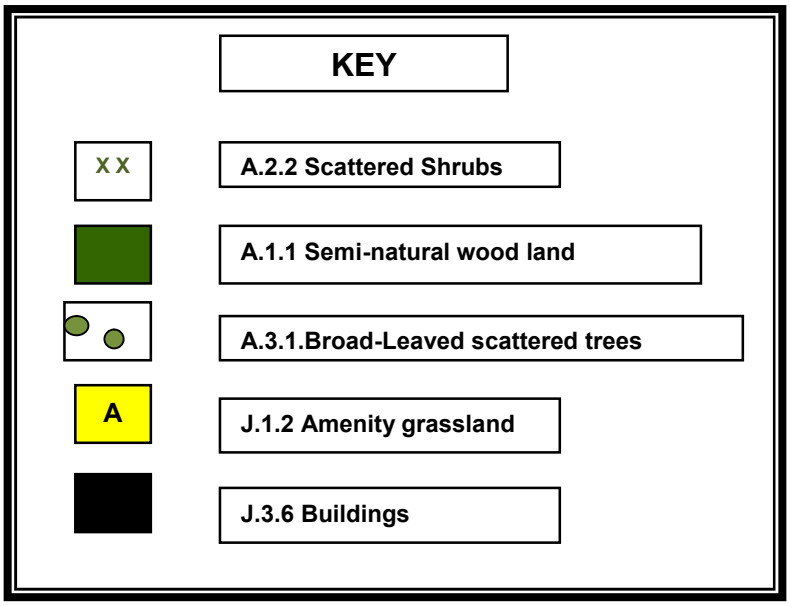


Fig. 2. Phase 1 habitat survey map of gosling stadium site

Table 1. Field target note for gosling stadium site

Survey title: Phase 1 Habitat survey	**Site name: Gosling Stadium**
Grid ref. TL523400 211400NE & TL523300 211400NE	
Surveyor. Adora Udechukwu	Survey date. 18/07/2011
County: Hertfordshire	L.A. district: Welwyn Hatfield
Habitat(s) included	**Name**
Dominant:	Amenity grassland
Other:	Broad-leaved woodland, scattered trees and shrubs

Target note. (TN)
1. Entrance from Stanborough lane
2. Scattered shrubs
3. Golf driving range
4. Ski slope covered with Perennial rye grass and scattered shrubs
5. Woodland Semi-natural woodland with mature oak, hawthorn, silver birch and ash trees.
6. Colonies of wild teasel
7. East-coast main railway line
8. Colonies of sheep sorrel
9. Colonies of Hogweed
10. Football pitch

Temperature and pH data of soils range from 18.6ºC to 22.8ºC and 6.4 to 7.0 respectively as shown in Table 4 which are depicted in Figs. 3 and 4 respectively. These pH ranges indicate neutral soil conditions. The site at Roehyde Pit has the highest temperature while North Orbital has the least. The site at Gosling Stadium has the highest pH value and Colney Heath has the least.

Table 2. A record of field observation on the study sites

Site name	Land Surface appearance	Evidence of past land use	Presence or absence of patches	surface deposits	Odor	Other
Gosling Stadium	Elevated surface	None	None	None	None	Evidence of rabbit grazing.
Chequers field	Uneven surface	None	Bare patches	None	None	Often used by dog-walkers. Gas control system evident.
Roehyde Pit	Uneven surface	Old tracks visible	Sparsely vegetated	None	None	Debris and Rubble. Gas control system evident.
North Orbital road	Slightly uneven surface	None	Sparsely vegetated areas	None	None	Horses grazing
Colney Heath Sites	Elevated surface	None	None	None	None	Amenity lakes on site
Smallford Pit	Uneven surface	None	None	None	None	None
Hatfield quarry	Elevated surface	None	None	None	None	Fly-tipped waste on site Gas controls system evident.
Cole Green Sites	Uneven and elevated surface	None	None	None	None	Horses grazing
Land Adjacent A414	Elevated surface, Rubble	None	None	None	None	None

Table 3. Summary of plant species observed on each study site during field visits

Site Name	Trees and Shrubs	Grass, Rushes and Sedge	Herbs/Forbs
Gosling Stadium I and II	*C. monogyna, C. betulus, Q. robur*, *F. excelsior*, *B. pendula*	*L. perenne, A. stolonifera,*	*P. major, L. vulgare, R. acetosa, D. fullonum, A. millefolium*, *S. jacobaea, V. speedwell*
Chequers field	*C. monogyna*, *C. betulus*, *Q. robur*, *F. excelsior*, *B. pendula*	*A. pratensis, D. glomerata, P. trivialis, L. perenne*	*R. acetosa, L. vulgare, P. vulgaris, C. nigra, S. jacobaea, H. sphondylium*, *P. reptans*, *A. millefolium, D. fullonum*
Roehyde Pit	*C. monogyna, P. spinosa, C. betulus*, *P. sylvestris*, *Q. robur*, *F. excelsior*	*A. stolonifera*, *C. cristatus, L. campestris*	*S. oleraceus, D. fullonum*, *P. lanceolata, S. jacobaea, R. acetosa*
North Orbital road	*Q. robur, F. excelsior, F. sylvatica, C. monogyna*	*L. perenne*	*P. lanceolata*, *R. acetosella*, *D. fullonum*, *S. jacobaea*, *T. repens*
Colney Heath Sites	*A. glutinosa*, *Salix*, *C. betulus*, *Q. robur*, *F. excelsior*, *B. pendula*, *F. sylvatica*, *C. avellana*, *C. monogyna*	*L. campestris* , *A. stolonifera*, *F. Pratensis*, *A. elatius* , *C. cristatus*, *A. pratensis*, *D. glomerata*	*R. acetosa, P. major*, *C. arvense*, *Centaurea nigra*, *S. jacobaea*, *H. sphondylium*, *A. millefolium*
Smallford Pit	*B. pendula, Q. robur*, *F. excelsior*, *C. monogyna*	*F. Pratensis*, *A. elatius, A. pratensis*, *L. ampestris*	*C. vulgare*, *R. acetosa, U. dioca*, *R. repens*, S. *media*, *S. jacobaea*, *P. major*, *C. nigra*
Hatfield quarry sites	*F. excelsior*, *A. campestre*, *B. pendula*, *P. avium*, *S. aucuparia* , *C. monogyna, P. spinosa*, *C. betulus*, *Q. robur*	*L. perenne*, *F. pratensis, P. trivialis*	*B. napus*, *A. millefolium*, *C. nigra*, *S. jacobaea*, *G. saxatile*
Cole Green Sites	*F. excelsior* , *B. pendula*, *Q. robur*, *P. sylvestris*, *C. monogyna*	*A. pratensis*, *P. trivialis*	*R. acetosa, P. lanceolata*, *D. fullonum*
Land Adjacent A414	*P. spinosa*, *C. monogyna*	*Lolium perenne*	*P. major*, *S. oleraceus*

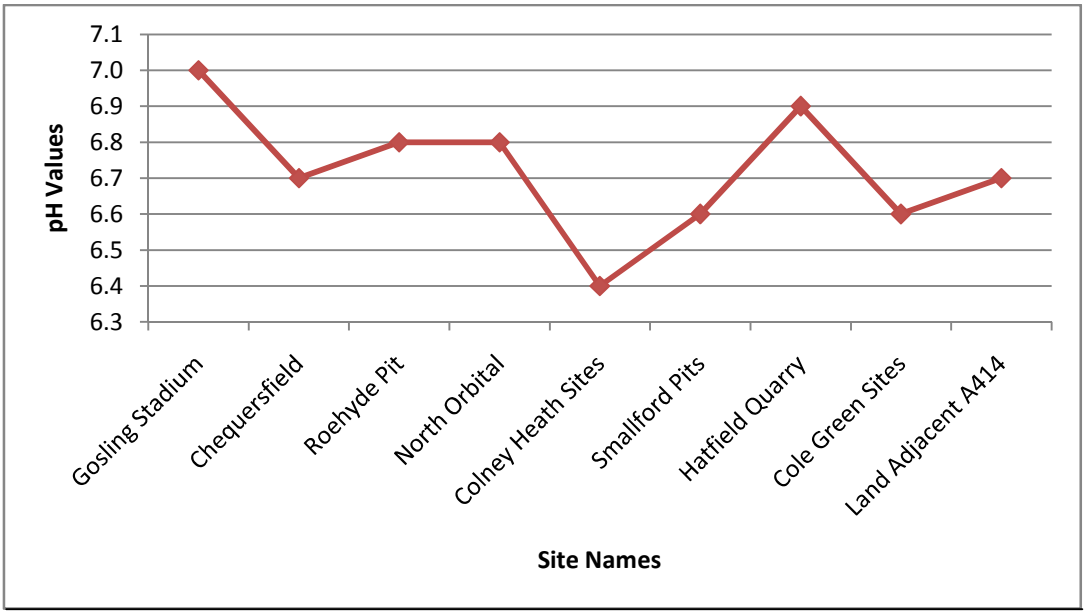


Fig. 3. The pH Values obtained at the study sites

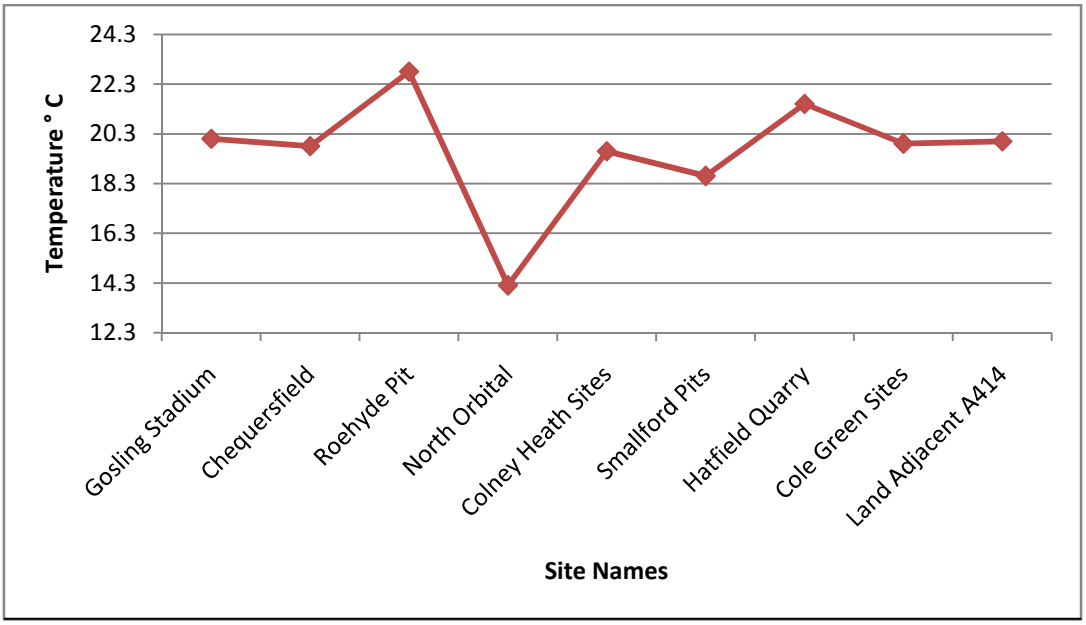


Fig. 4. Temperature data obtained at the study sites

3.1 Odor, Soil Color and Patches of Vegetated Land

No unusual odor was detected nor soil coloration. Patches of bare vegetation were recorded on the Chequers field, North Orbital Road sites. The most significant evidence of bare

vegetation was recorded on the Chequers field and North Orbital road sites where large patches of bare soil were observed.

Table 4. Soil pH and temperature data

Site Name	*pH*	*Temp (°C)*
Gosling Stadium	7.0	20.1
Chequers field	6.7	19.8
Roehyde Pit	6.8	22.8
North Orbital	6.8	14.2
Colney Heath Sites	6.4	19.6
Smallford Pit	6.6	18.6
Hatfield Quarry	6.9	21.5
Cole Green Sites	6.6	19.9
Land Adjacent A414	6.7	20.0

pH values were derived from average of 3 readings

4. DISCUSSION

In the past capping layers were often made of a thin layer of soil. The introduction of the Environment Protection Act 1990 (EPA), required landfills to have gas and leachate control systems installed [15]. At the time of operation of most of the studied sites, strict legislations were not in place. The Phase 1 Habitat map of the study area indicates the most frequently occurring land cover types observed were semi-improved neutral grasslands and arable farmlands. Historical records available had very little information on how some of these sites where closed and restored.

The entire perimeters of these sites were not covered due to limitations of the study method; there may be possible ongoing gas emission especially on sites such as the Cole Green sites where previous incidence have occurred. Soil pH is a useful tool in determining suitable soil types for different plants. This may have been put into consideration during the restoration process of the studied sites [22,23]. The temperature and pH values obtained appear to favor the growth of trees, herbs and grass species more than shrubs and sedges [12].

Old landfills are often restored with layers of compacted soil. Extreme conditions in the landfill top soil such as gas releases, high temperatures, lack of nutrients and leachate contamination prevent the growth of vegetation on closed landfills unlike in modern landfills where technology has helped in controlling these effects for the establishment of valued habitats [2,5,23]. The characteristics of the vegetation identified at the study sites indicated no significant difference when compared against similar species growing on comparatively to undisturbed land in the Welwyn-Hatfield Area.

The soil conditions on these sites appear to be adequate to support plant growth however other factors may have influenced distribution patterns and percentage cover of certain species such as *R. acetosa, L. perenne and C. monogyna*. This is evident in the abundance of common weed such as *R. acetosa* and *S. jacobaea* species in the region of the landfill sites. Odor does not pose any concern with respect to aesthetic quality of the environment. The presence of sparsely vegetated areas on the North Orbital road can be largely attributed to heavy grazing by horses on this site. However the presence of bare patches surrounded

by colonies of oxeye daises on the Chequers field site is very significant and requires an intrusive investigation.

5. CONCLUSION

The findings of the research showed no evidence of ongoing contamination. Vegetation on many of the studied sites had a generally poor appearance and these sites would benefit from re-restoration to a more species-rich sward, amenity or agriculture use. This is an initial assessment and there are limitations to the survey methodology. It is therefore difficult to ascertain the likely causes of bare patches or plant distribution and dominance on some of these sites without an intrusive investigation such as a Phase 2 assessment. A root analysis of species such as *R. acetosa and L. perenne* may give a better indication of any landfill factors and would be appropriate for future research in order to be able to present a holistic environmental assessment of the study area.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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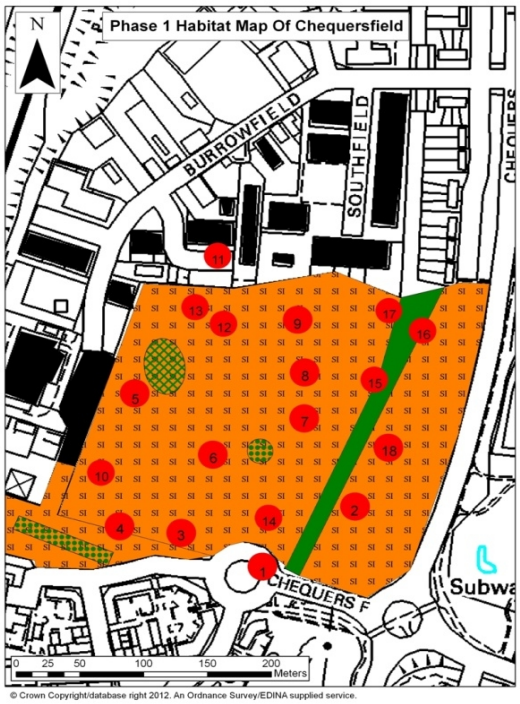
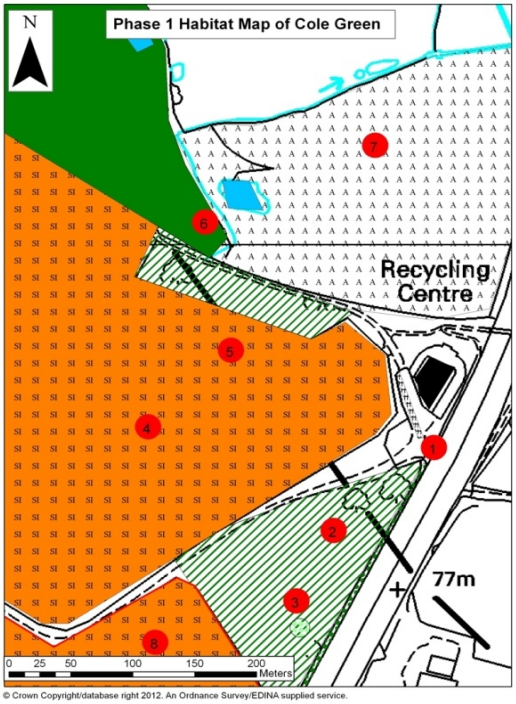
APPENDIX 1: Site Photos

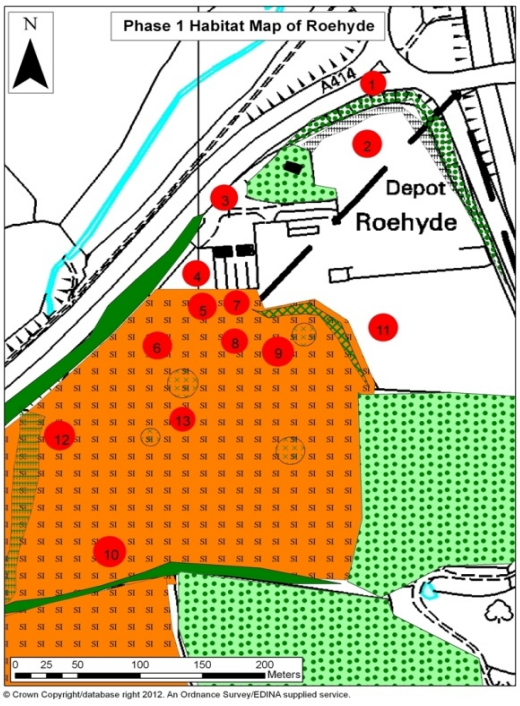
Colonies of oxeye daises surrounding bare patch on the Chequersfield site (Source: Author, 2011).

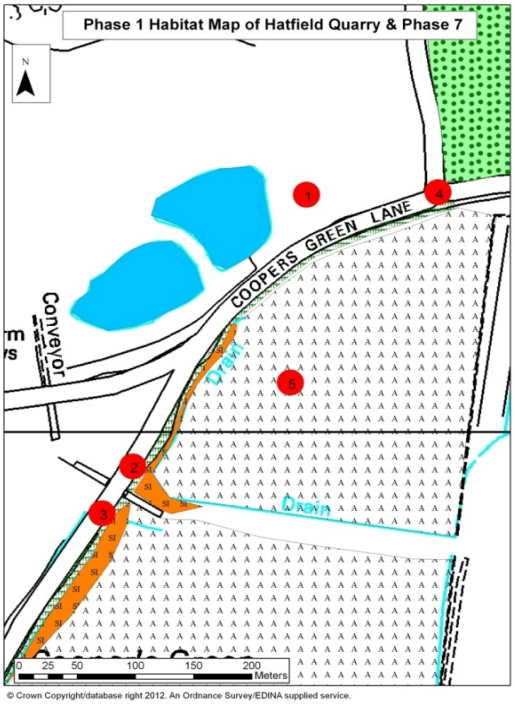
Gosling Stadium ski ramp (Source: Author, 2011).

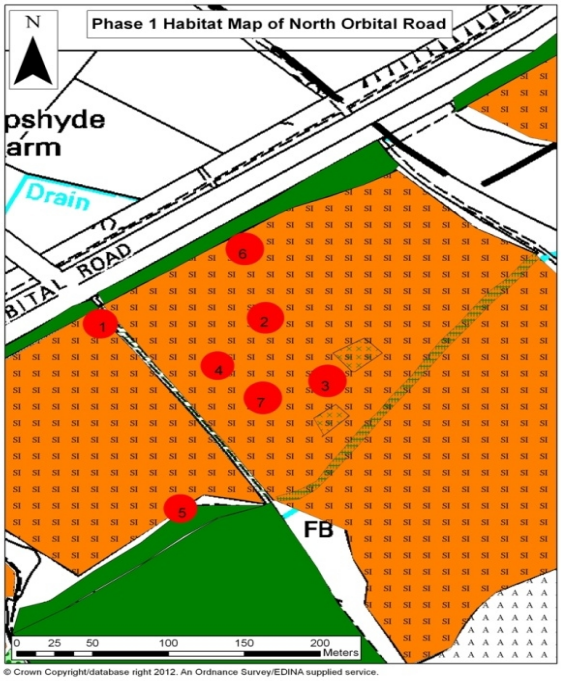
APPENDIX 2: Site Maps










Phase 1 Habitat Map of North Orbital Road
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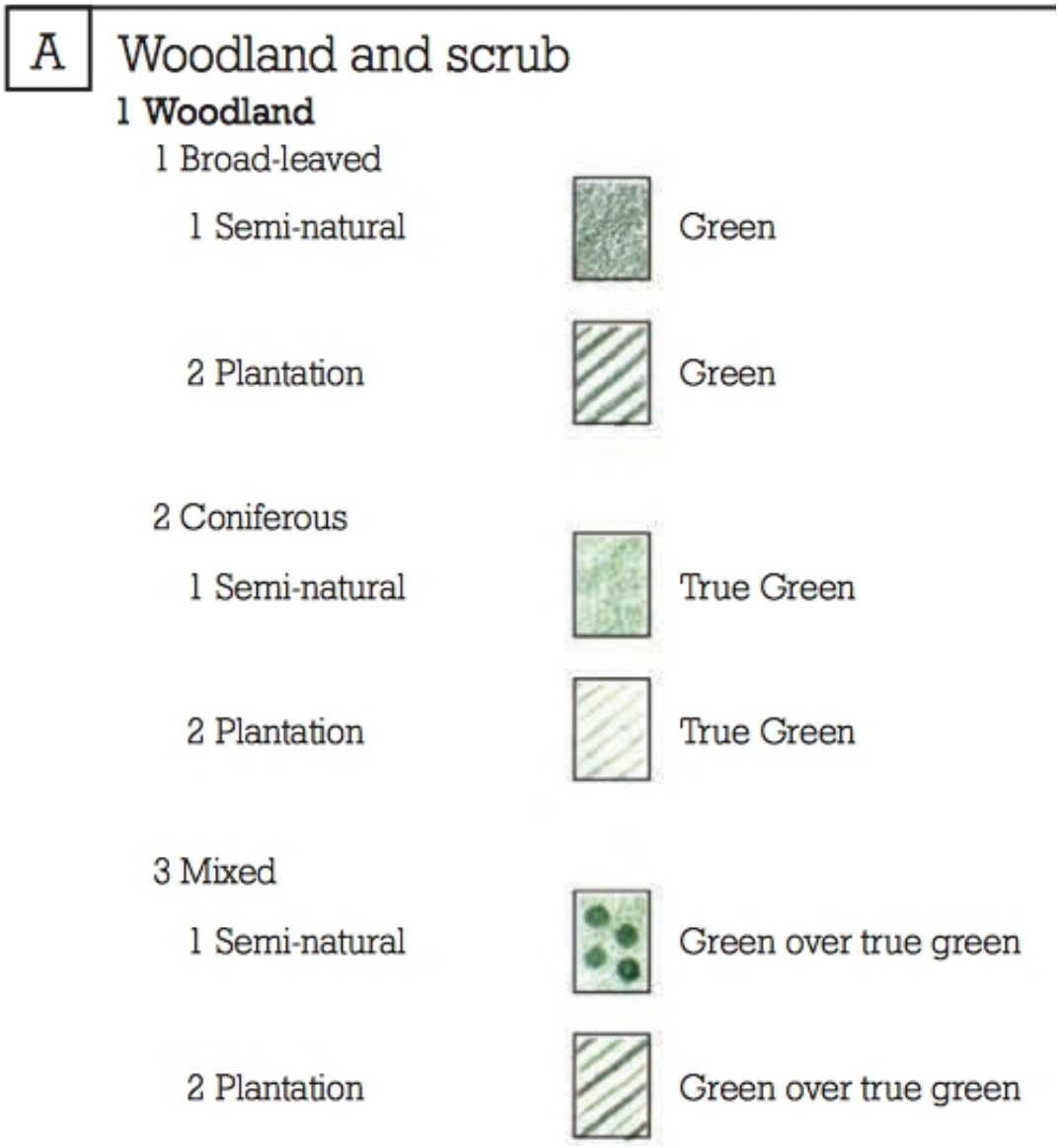
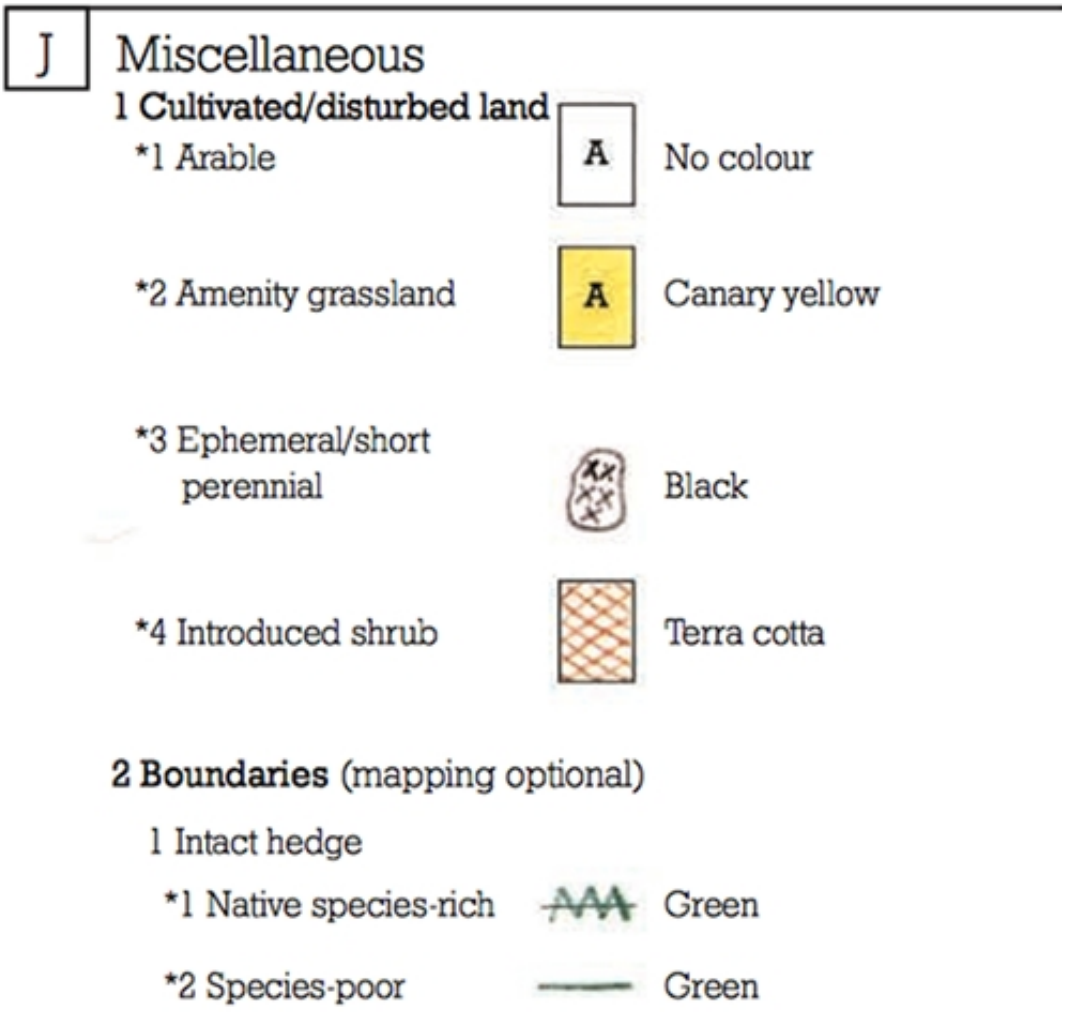
APPENDIX 3: Habitat Key





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