FINAL REPORT

FIELD INVESTIGATION SUMMARY REPORT – BEDDINGTON LANE LANDFILL

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TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 General 1
1.2 Previous Investigations 1
1.3 Current Investigation 2
1.4 Report Organisation 2

2.0 SITE DESCRIPTION 3
2.1 Site Location 3
2.2 Surrounding Land Use 3
2.3 Operations and Current Activities 3
2.4 Structures, Facilities and Utilities 3
2.5 Historical Summary 4

3.0 PREVIOUS INVESTIGATIONS 5
3.1 General 5
3.2 Investigations by Mott MacDonald Environment 6
3.3 Investigations by RPS Consultants Ltd 7
3.4 Investigations by CRA 9

4.0 CURRENT FIELD INVESTIGATION 10
4.1 General 10
4.2 Trial Pits 10
4.3 Laboratory Analyses 10
4.4 Interior Boreholes 10
4.5 Perimeter Boreholes 10
4.6 Cone Penetrometer Testing 11
4.7 Geotechnical Testing 11
4.8 Landfill Gas and Groundwater Level Monitoring 11

FIGURES

Figure 2.1 Site Location Plan

APPENDICES

Appendix A Mott Macdonald: Report
Appendix B RPS Consultants: Report
Appendix C RPS Consultants: Report
Appendix D CRA: Borehole Log & Location Plan
Appendix E Geotechnical Developments: Report
Appendix F CRA: Trial Pit Logs
Appendix G Laboratory Results: Certificates & QA/QC Documentation
Appendix H CRA: Monitoring And Levelling Data

1.0 INTRODUCTION

1.1 General

Conestoga-Rovers & Associates (UK) Ltd (CRA) was retained by ProLogis Developments Ltd (ProLogis) to conduct a field investigation relating to geotechnical and environmental conditions of subsurface Site deposits at the Beddington Lane Landfill Site, Beddington, South London (the Site). The Site is currently undeveloped and operated in the past primarily as a sand and gravel quarry and then as a landfill for various types of wastes. Site background is discussed further in Section 2.0.

The purpose of this report is to provide factual information pertaining to the field investigation activities conducted to date. This report includes a discussion of previous investigations by others and current investigation activities by CRA, and has been prepared for the use of ProLogis. This report may not be relied upon by other parties without written concurrence from CRA and ProLogis.

1.2 Previous Investigations

Previous Site investigation reports that have been used to provide the factual information presented herein, are listed below:

- Beddington Lane Landfill Site, Investigation of Contaminated Land, **Draft Report**, Volume I of II, October 1991, Ref 20113/ESD/SI Rev. 1, by Mott MacDonald Environmental Consultants on behalf of London Borough of Sutton.

- Beddington Lane Landfill, Beddington Lane, Croydon, Environmental Review, **Draft Report**, May 1999, Ref KE2079/001R, by RPS Consultants Ltd on behalf of Quintain Estates & Development PLC.

- Beddington Lane Landfill Site, Beddington Lane, Croydon, Environmental Site Investigation Report (Interim), **Draft Report**, August 1999, Ref KE2079/016R, by RPS Consultants Ltd on behalf of Quintain Estates & Development PLC.

- Beddington Lane Landfill Site, Croydon, **Letter Report** (Confidential), 29th February 2000 (Ref MM/sa/14647) by Conestoga Rovers & Associates (UK) Ltd on behalf of ProLogis Developments Ltd.

- Field Investigation – Beddington Lane Landfill Site, Croydon, **Letter Report** (Confidential), 6th April 2000 (Ref JH/sa/14647) by Conestoga Rovers & Associates (UK) Ltd on behalf of ProLogis Developments Ltd.

The reports listed above are appended (unless noted as Confidential).

Other reports, which provide Site investigation data and which are referenced within the documents listed above, but are currently unavailable, are as follows:

- Polytechnic of East London Landfill Gas Well Installations Monitored between October 1989 and January 1991, Ref. 204.167/PO32-008, September 1989 for London Borough of Sutton. Reviewed in Mott MacDonald 20113/RSD/SI Rev. 1 and RPS KE2079/001R and KE2079/016R reports.

- Square Root Ltd; Beddington Landfill Quarterly Landfill Gas Monitoring; September 1998, January 1999 and March 1999, Job No. NL8C 7135 Ref WH002590 for London Borough of Sutton. Reviewed in RPS KE2079/016R report.

- Site Investigation Report of the Former Phillips Site, 138 Beddington Farm Road, Croydon, August 1996. Undertaken for Parlison Properties Ltd and Croydon Land & Estates Ltd by RPS Consultants Ltd, Ref KE1019. Reviewed in RPS KE2079/001R report.

Groundwater modelling studies are presented in the report entitled: Groundwater Fate and Transport Assessment, Beddington Lane Landfill, February 2000, Ref ER2074, by RPS Consultants Ltd on behalf of Quintain Estates & Development PLC. This report is not discussed further herein.

1.3 Current Investigation

The current investigation included the following activities:

- Investigative geotechnical boreholes (interior) to provide information on the geotechnical properties of the native material (predominantly London Clay) below the waste material.
- Investigative geotechnical boreholes (perimeter) to provide information on the stratigraphic conditions around the Site boundary.
- Cone penetrometer testing to provide information on the relative density of the waste material.
- Trial pits to provide information on waste material properties.
- Standpipe installation and monitoring to establish static water levels, facilitate collection of leachate samples and to allow measurement of landfill gas parameters.

The investigation was designed to focus on data collection needed to provide supplemental information for the design of the proposed Site development, which is presented in other documents.

1.4 Report Organisation

This report is organised as follows:

Section 1	Presents the introduction;
Section 2	Presents the Site description;
Section 3	Presents information from previous investigations; and
Section 4	Presents information from the current investigation.

2.0 SITE DESCRIPTION

2.1 Site Location

The Site is situated approximately 3km to the northwest of Croydon town centre, near Mitcham Common, South London as shown on Figure 2.1. Direct access to the Site is via padlocked fencing off Beddington Lane (A232).

The Site is roughly rectangular in general dimensions with boundary sides ranging in length from approximately 215m to 265m. The Site approximately covers an area of 5.75 ha.

The Site itself is centrally situated at National Grid Reference (NGR) $^{5}29800$ $^{1}66700$, within a predominantly undeveloped setting. Built environment density analysis reveals that 64% of land surrounding the Site for a distance of 1km is open land, with only 36% of land currently developed. However, the percentage of developed land increases rapidly with distance from the Site, with 70% of land being developed within 3km of the Site boundaries. The nearest watercourse is a tributary of the River Wandle, present approximately 1000m south of the Site. The River Wandle is present approximately 1600m to the west.

The topography of the Site is elevated with respect to local elevation, and comprises raised steep earth banks on all boundaries (approximately 4-8m above surrounding land level). The topography across the surface of the Site is undulating, with raised ridges and hummocks of land with the southern half of the Site noted to be higher in elevation than that of the northern half. The topography of the surrounding area is predominantly flat to slightly undulating approximately 30m (∓ 10m) Above Ordnance Datum (AOD).

2.2 Surrounding Land Use

North, Northwest and Northeast

Light industrial, including a scrap yard, landfill and commercial land use.

East and Southeast

Light industrial and commercial land use.

West and Southwest

Light Industrial, commercial and residential properties.

Southern

Light industrial and commercial land use including sewage works, with farmlands beyond.

2.3 Operations and Current Activities

The Site is currently undeveloped with no active operations on-Site. Horses are however present on-Site, belonging to a local resident.

2.4 Structures, Facilities and Utilities

There are currently no structures or facilities present on-Site with the exception of fencing. There are existing utilities and advertisement hoardings located around the Site perimeter.

2.5 Historical Summary

The Site has had a long history of usage, primarily as a gravel pit, and more recently as a landfill. It is estimated, based on historical map information that gravel extraction activities occurred over at least 37 years, from 1914 to 1951, and possibly longer. Landfilling of the pit areas is thought to have occurred from the 1950's through to the late 1960's, as newspaper evidence from Mott MacDonald Environment Site investigations (October 1991 Report 20113/ESD/SI Rev 1) recovered print dated 1956 at a depth of 4m bgl, and investigations by CRA (November 2000) recovered print dated as late as September 1967 from a depth of 0.70m bgl.

Previous reports (Mott MacDonald Environment 1991) indicate that the Site had been infilled and raised above the surrounding ground level by up to 6m by 1965, after which the Site was taken over by Greater London Council (GLC). However, landfilling operations must have continued after 1965, due to the presence of newspapers from 1966-1967 within the upper 3m of waste profile. Historical map extracts from 1968, suggest that the Site was probably still active as a landfill, particularly over the northwestern half of the Site, as evidence of sloped banks as seen on the 1976 map extract are not shown. As there are no records of landfill activity prior to 1965, and limited information thereafter, it is difficult to ascertain when landfilling activities ceased.

3.0 PREVIOUS INVESTIGATIONS

3.1 General

The following section provides a summary of previous investigations undertaken by Mott MacDonald Environment and RPS Consultants Ltd.

A number of previous and current Site reports have been used to provide the factual information presented. Those reports which have been used are listed below:

- Beddington Lane Landfill Site, Investigation of Contaminated Land, **Draft Report**, Volume I of II, October 1991, Ref 20113/ESD/SI Rev. 1, by Mott MacDonald Environmental Consultants on behalf of London Borough of Sutton.

  The investigation was undertaken to define the ground conditions, identify uses to which the Site may be put and to recommend strategies for development of the Site. Technical works comprised 15 trial pits to a depth of about 3m, with 10 boreholes, eight of which were drilled to a depth of 8-10m, and two to a depth of 20m. Standard Penetration Tests (SPT's) were undertaken together with a sampling programme for soil and groundwater contaminant identification. A landfill gas monitoring programme was also conducted utilising wells installed by Mott MacDonald Environment and those installed earlier by The Polytechnic of East London.

- Beddington Lane Landfill, Beddington Lane, Croydon, Environmental Review, **Draft Report**, May 1999, Ref KE2079/001R, by RPS Consultants Ltd on behalf of Quintain Estates & Development PLC.

  This report provided historical, environmental and regulatory information gathered over a period of 5 years prior to the report date. The information was presented in a risk assessment context.

- Beddington Lane Landfill Site, Beddington Lane, Croydon, Environmental Site Investigation Report (Interim), **Draft Report**, August 1999, Ref KE2079/016R, by RPS Consultants Ltd on behalf of Quintain Estates & Development PLC.

  The investigation comprised installation of nine monitoring wells; a programme of soil, groundwater and leachate sampling for contaminant identification; and included a programme of landfill gas monitoring.

- Beddington Lane Landfill Site, Croydon, **Letter Report** (Confidential), 29th February 2000 (Ref MM/sa/14647) by Conestoga Rovers & Associates (UK) Ltd on behalf of ProLogis Developments Ltd.

  The investigation consisted of monitoring nine existing RPS boreholes for groundwater elevation and levels of Methane, carbon dioxide, oxygen and barometric / atmospheric pressure.

- Field Investigation – Beddington Lane Landfill Site, Croydon, **Letter Report** (Confidential), 6th April 2000 (Ref JH/sa/14647) by Conestoga Rovers & Associates (UK) Ltd on behalf of ProLogis Developments Ltd.

  This letter report documented field investigation works which were carried out between the 6th and 8th of March 2000 in response to concerns about the presence of Chalk reported to be present in RPS BH1. A confirmatory borehole was drilled to ascertain actual ground conditions.

  The installation and monitoring of 12 shallow gas probes around the perimeter of the landfill was also carried out within the dates of investigation.

Other reports, which provide Site investigation data and which are referenced within the documents listed above, but are currently unavailable, are as follows:

- Polytechnic of East London Landfill Gas Well Installations Monitored between October 1989 and January 1991, Ref 204.167/PO32-008, September 1989 for London Borough of Sutton. Reviewed in Mott MacDonald 20113/RSD/SI Rev. 1 and RPS KE2079/001R and KE2079/016R reports.

  The Polytechnic of East London in 1989 advanced 16 boreholes and undertook a programme of gas monitoring within the monitoring wells and surrounding off-Site drains and service ducts. Monitoring was conducted regularly during 1990 and the early part of 1991. The results and report were not available for review by CRA.

- Square Root Ltd; Beddington Landfill Quarterly Landfill Gas Monitoring; September 1998, January 1999 and March 1999, Job No. NL8C 7135 Ref WH002590 for London Borough of Sutton. Reviewed in RPS KE2079/016R report.

  Square Root Ltd conducted a landfill gas monitoring programme from September 1998 to March 1999, utilising wells installed by The Polytechnic of East London. Assessments on hydrocarbon contamination of groundwater and leachate impact on the drainage ditch were also conducted. The results and report were not available for review by CRA.

- Site Investigation Report of the Former Phillips Site, 138 Beddington Farm Road, Croydon, August 1996. Undertaken for Parlison Properties Ltd and Croydon Land & Estates Ltd by RPS Consultants Ltd, Ref KE1019. Reviewed in RPS KE2079/001R report.

  The results and report were not available for review by CRA.

3.2 Investigations by Mott MacDonald Environment

The Mott MacDonald Environment report of October 1991 provides a review of Site history, environmental setting, and details the results of their Site investigation to determine the suitability of the Site for future development. A copy of the report and borehole logs are provided in Appendix A.

A brief reference to the intrusive study carried out by The Polytechnic of East London (Ref. 204.167/PO32-008, Sept 1989) has been made in the Mott MacDonald Environment report. The review of this study by Mott MacDonald Environment indicated the following:

- A grid comprising sixteen boreholes was used.
- Waste was located in boreholes to a maximum depth of 9m below ground level (bgl).
- Gas monitoring within the Site boundaries revealed "significant" concentrations of methane and carbon dioxide in a number of boreholes.
- "Leachate condensate" was reported to be present at the surface of two boreholes, with phenolic and oily odours recorded frequently.
- Regular gas monitoring was also undertaken during 1990 and the early part of 1991 in the drains and service ducts outwith the Site boundary. It was reported that landfill gas at these locations was not detected.

It should be noted that the above report was not available for review by CRA and therefore comments as above represent the views of Mott MacDonald Environment only.

The following points summarise information gained from the Mott MacDonald Site investigation:

- The Site investigation involved the excavation of 15 trial pits to depths of approximately 3m and the advancement of ten boreholes to depths of between 10m and 20m, on a 50m grid system.

- Groundwater (as water strikes during drilling) was encountered at depths between 3.20m and 8.25m below ground level.
- Fill materials were found to comprise up to 10.8m of brown /grey sandy gravelly clay with glass, metal, concrete, ash, terrace gravels, rubber, wood, plastic and some paper, cloth and bitumen.

- Standard Penetration Test results revealed a range of N values from 1 to 36 for the Made Ground, and N values of 36 at the top of the London Clay, increasing to approximately 55 at 17m below ground level.

- Sixty-nine soil samples were collected for chemical analysis.

    - For domestic gardens and allotments 19% to 51% of the samples analysed exceeded the ICRCL trigger concentrations for lead, mercury, cadmium, arsenic and sulphate.

    - For parks and open spaces 1% to 4% of the samples analysed exceeded the ICRCL trigger concentrations for lead, mercury, cadmium and arsenic.

    - For 'areas where plants are to be grown', 22% to 68% of the samples analysed exceeded the ICRCL trigger concentrations for zinc, copper, nickel and boron (water-soluble).

- Methane concentrations were found to range between <1% to 24%, with highest concentrations detected in the northwest of the Site and lowest concentrations in the southeast.

- Carbon dioxide concentrations were found to range between <1% to 26%, with highest concentrations detected in the northwest of the Site and lowest concentrations in the southeast.

- Oxygen concentrations were found to be below 1% by volume.

- Hydrogen gas concentrations were found to be effectively undetectable. Hydrogen Sulphide concentrations ranged from 0.0001% to 0.0006% by volume.

- Radioactivity levels, measured at ground level along parallel Site transects, were found to average between 1-2 counts per second (c/s) within the Site boundary and 1.5-4 c/s outside the Site boundaries.

3.3 Investigations by RPS Consultants Ltd

RPS's Environmental Review (Ref. KE2079/001R May 1999) provided information gathered during RPS's involvement with the Site 5 years previous to the report date, in a risk assessment context. A copy of the report is provided in Appendix B.

The assessment comprised a review of the historical land uses associated with the Site to assess the potential for ground contamination; a review of the environmental setting to assess the sensitivity of the surrounding environment to contamination / pollution and consultation with the regulatory authorities to establish whether there are any environmental issues that may impact upon the Site, including records of any landfills in the vicinity.

The following points summarise information gained from the RPS May 1999 Environmental Review:

- The Site was open farm land from at least 1868 until 1898, with a wooded area in the north. From 1913 the Site was shown as a gravel pit until 1932 after which the pit is shown as disused, to 1954. On maps from 1965 to 1971 the Site was shown as a refuse tip, and from 1976 as a disused refuse tip.

- Four licensed water abstractions are present within 2km of the Site. The closest is situated 750m west of the Site for washing sand and gravel, vehicle washing and dust suppression measures and abstracts from the River Terrace gravels (Hall Aggregates Ltd). The nearest abstraction point

for public water supply is 1700m to the south west and abstracts from the Chalk (Sutton and East Surrey Water PLC).

- The Site according to the Environment Agency and the London Borough of Sutton comprises a landfill Site, which closed in the late 1960's. The waste included domestic waste, builder's waste, glass, paper, plastic, coal fragments, ash, wood, tyres, rubber and some asbestos containing material.

- Seven records exist for other landfill Sites within 500m of the Site. The closest of significance is that of Beddington Farm Road, which forms the southern section of Beddington Lane Landfill Site and is recorded as 'moderately' contaminated (current Connex Site). In addition to contaminants associated with the landfill materials, the Site is known to be contaminated with fuel which has leaked from underground storage tanks. Methane is present and consequently the buildings have gas control measures installed.

- The former Higgs and Hill Site to the immediate east (current scrap yard) is known to have elevated concentrations of carbon dioxide in some locations with localised contamination present, associated with leaking lubricant from one of the Site's former uses. Methane levels have been shown to lie below trigger levels.

- The former Blue Circle Site on Therapia Lane, to the northeast is also known to have fill on-Site comprising rubble, glass, china and rubber with some leather and metals.

- Environment Agency data indicates that they hold no records of major or significant pollution incidents within 500m of the Site. According to English Nature there are also no records of Sites of Special Scientific Interest (SSSI) within 1km of the Site.

RPS was further commissioned by Quintain Estates & Development PLC to undertake a Site investigation of Beddington Lane Landfill (Ref KE2079/016R, August 1999). This investigation was designed on the basis of previous environmental assessments of the Site. A copy of this report is presented in Appendix C.

The following points summarise information gained from the RPS August 1999 Site Investigation:

- The Site investigation included the installation of 9 landfill gas and groundwater monitoring wells, laboratory analysis of 24 soil and 27 groundwater samples from the boreholes and monitoring of groundwater levels and landfill gases on 3 occasions. (Note: CRA believes that the number of groundwater samples collected, however, based on the laboratory analysis certificates was 9, and not 27).

- Made Ground was found up to 10.3m bgl, comprising domestic landfill waste with silt, sand, gravel, brick, ash and wood.

- Groundwater was encountered within all boreholes at depths between 2.60m and 7.37m bgl.

- Of 24 soil samples analysed, 22 samples were found to contain elevated concentrations of one or more determinands.

- Methane was detected in boreholes at concentrations up to a maximum of 17.2% by volume.

- Carbon dioxide was detected in boreholes at concentrations up to a maximum of 22% by volume.

- Oxygen levels in boreholes were found to be depleted to a minimum of 0.0% by volume.

- Reference to gas monitoring by Square Root Ltd (Job No. NL8C 7135; Ref. WH002590) is given in a report submitted to Quintain Estates & Development PLC by RPS in August 1999. Results of the monitoring carried out by Square Root Ltd for the London Borough of Sutton were made available to RPS on 19 July 1999, and were used to design their Site investigation. The

monitoring data were not presented in their report, and therefore were not available to CRA for comment.

- RPS undertook a Site investigation at a neighbouring property, the former Phillips Site, 138 Beddington Farm Road, in August 1996 on behalf of Parlison Properties Ltd and Croydon Land & Estates Ltd (Ref. KE1019). The complete report and results, however, were not available for review by CRA.

  This report detailed an assessment of ground conditions on land adjacent to the south of the Site which involved the collection and analysis of soil and groundwater samples, and monitoring of the soil atmosphere for landfill gas and volatile organic compounds.

3.4 Investigations by CRA

CRA undertook preliminary gas monitoring on the existing nine RPS boreholes on 21st February 2000 on behalf of ProLogis. The results were presented as a letter report (Ref MM/sa/14647 29th February 2000) which indicated the following;

- Groundwater elevations varied between 29.56m (RPS BH2) and 32.34m AOD (RPS BH5).
- Methane concentrations varied between 'not detected' and 5.2% (by % v/v).
- Carbon Dioxide concentrations varied between 6.1% and 15.2 % (by % v/v).
- Oxygen concentrations varied between 13.9% and 0.0% (by % v/v).

The water level and gas monitoring data from the February 2000 monitoring event are presented in Appendix H along with data collected subsequently.

CRA undertook further works between 6th-8th March 2000 to confirm the absence of Chalk bedrock beneath the fill material, as noted by RPS. The investigation confirmed the following;

- Chalk, as described by RPS was found to be Chalk spoil, which had been imported onto the site, presumably as part of the former landfilling activities. Terrace Deposits and London Clay were confirmed by the drilling of a borehole by CRA adjacent to that of RPS borehole 1.
- Gas concentrations, measured at probe locations around the perimeter of the landfill were found to be close to background levels. Methane was not detected, and Carbon Dioxide concentrations did not exceed 3.6% (by % v/v).

The borehole information from the March 2000 investigation is presented in Appendix D. The gas monitoring data from the March 2000 monitoring event are presented in Appendix H.

4.0 CURRENT FIELD INVESTIGATION

4.1 General

The main body of intrusive works was carried out over the period of October to December 2000 and included trial pitting, cable percussive drilling, window sampling, cone penetrometer tests, landfill gas / volatile vapour and groundwater level monitoring.

Investigative locations are presented diagrammatically in Appendix E.

4.2 Trial Pits

A total of 29 trial pits were excavated to depths between 2.70m and 3.90m. A total of 19 trial pits were advanced around the perimeter, on top of the landfill, and a further 10 trial pits were advanced within the central areas. In total 72 solid samples were taken for chemical analysis. All trial pits were logged to BS5930:1999, by CRA's on-Site geologist.

Trial pits were advanced by JCB 3X and a 0.60m backhoe bucket, with waste replaced and compacted in reverse order of which it was excavated. Trial pit logs are presented in Appendix F.

4.3 Laboratory Analyses

From the 72 samples collected for analysis, a total of 50 samples were submitted for laboratory analysis based upon visual descriptions and with design requirements in mind.

Selected samples were analysed for certain parameters including Loss on Ignition % @ 450°C, Moisture Content, Organic Matter (%), Asbestos Fibres (%), Asbestos ID (%) and Asbestos Content (Estimated %).

A summary of the results is presented as Table 1 in Appendix G, along with the Laboratory Certificates of Analysis and Chain of Custody Documentation.

4.4 Interior Boreholes

A total of 11 cable percussion boreholes were advanced through the waste fill by Geotechnical Developments (UK) Ltd, under sub-contract to CRA. Boreholes BH2 to BH12 were all advanced through waste fill and into the London Clay on top of the landfill. Borehole termination depths varied between 20m and 30m bgl. Borehole 1 was not advanced because of access difficulties. Boreholes without installations were backfilled with bentonite clay and arisings.

Well monitoring installations were installed in Boreholes 2, 3, 6, 8, 9 and 11, with screening depths between 1.00m and 11.00m bgl.

Borehole logs for the interior boreholes are presented in Appendix E.

4.5 Perimeter Boreholes

A total of 7 Window Sampling Boreholes fitted with 19mm standpipes were installed, where possible at the base of the waste fill adjacent to the Site perimeter. Window Sample boreholes WS7 and WS7A were abandoned due to the presence of concrete hardstanding. Completed borehole depths varied between 7.00m and 10.00m bgl and screening depth ranged from 1.00m to 8.00m bgl.

Borehole logs for the perimeter boreholes are presented in Appendix E.

4.6 Cone Penetrometer Testing

A total of 30 Cone Penetrometer Tests (CPTs) were carried out within the interior of the landfill to depths ranging between 0.34m and 10.05m bgl, using a 20t capacity hydraulic penetrometer mounted on a truck.

Tests were made using a $15cm^2$, 100Pa capacity two channel electric cone, which gave measurements of cone end resistance and local side friction.

Results of the cone penetrometer testing are presented in Appendix E.

4.7 Geotechnical Testing

Selected soil samples from the borehole installation were submitted for geotechnical testing. The tests that were performed include:

- Particle Size Distributions;
- Classification Tests (Moisture Contents and Atterberg Limits); and
- Triaxial Shear Strength Laboratory Tests.

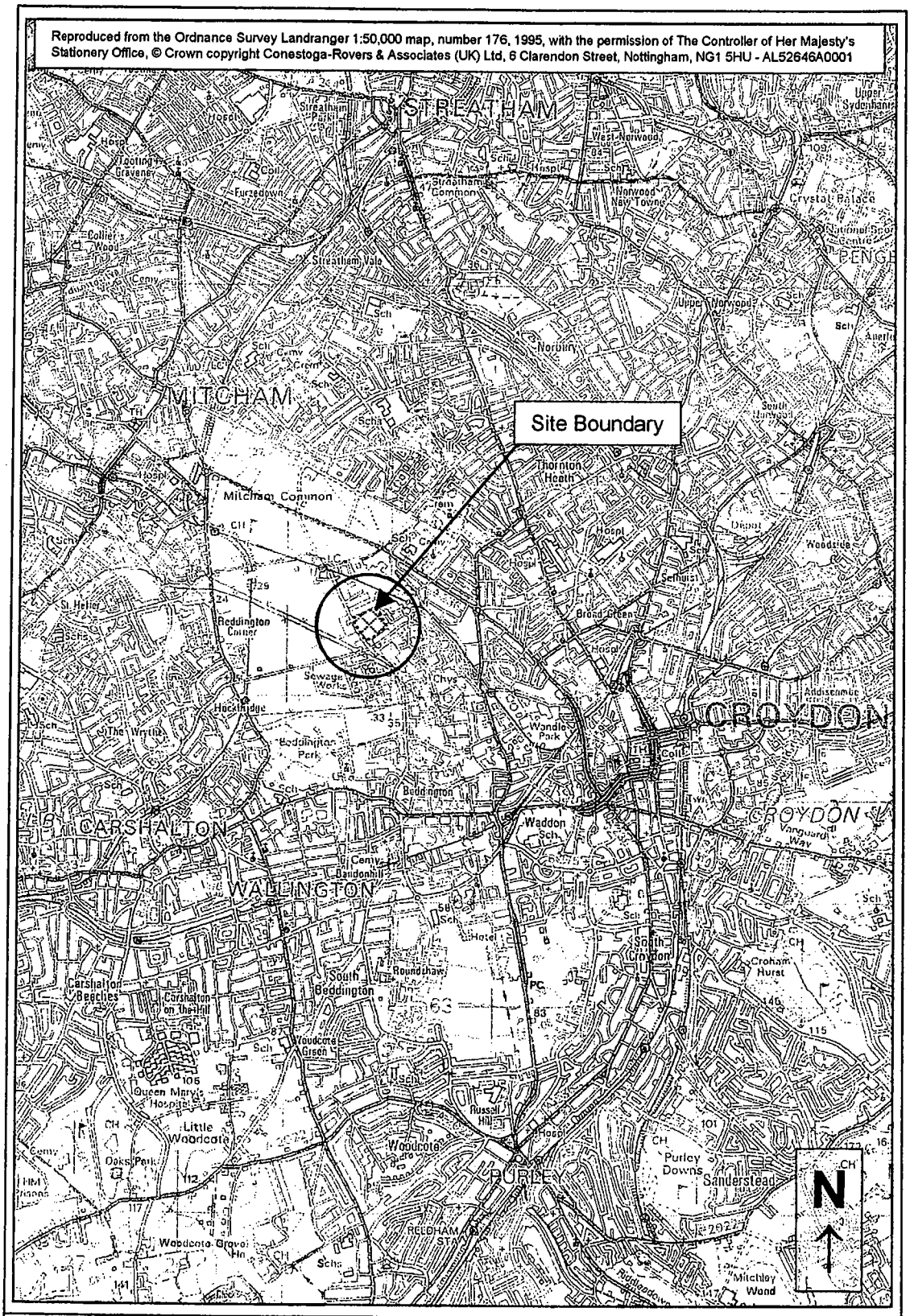
The geotechnical testing results are provided in Appendix E.

4.8 Landfill Gas and Groundwater Level Monitoring

Data collected on-Site during monitoring events conducted by CRA, in the form of groundwater level and landfill gas measurements, were documented.

Elevation levels of all recently installed boreholes and those boreholes installed by RPS were also obtained by Global Positioning System (GPS) and level survey.

Levelling information, and monitoring data collected to date for the monitoring wells installed during the current investigation by CRA are presented in Appendix H.



Legend	FIGURE 2.1	SITE LOCATION MAP
Scale Approx. 1:50,000	BEDDINGTON LANE LANDFILL SITE, BEDDINGTON, LONDON *Prologis Developments Ltd*	

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