SECTION 5 : SOILS AND GEOLOGY

5.1 INTRODUCTION

5.1.1 Outline of Study

The following study will present available information on the soils and geology of the area within and immediately outside the application site, together with an interpretation of the existing local geological environment. It will identify how this environment will be altered by the proposed remediation works and, where possible, will identify how these impacts may be mitigated.

5.1.2 Difficulties Encountered in Compilation

No significant difficulties were encountered in the compilation of this section of the Environmental Impact Statement.

5.1.3 Personnel

This study of soils and geology was undertaken and prepared by :

Peter Glanville, B.A., Ph.D., Geomorphologist, John Barnett and Associates Ltd
Derek Luby B.E., M.Sc., D.I.C., M.I.E.I., Geotechnical Engineer, John Barnett and Associates Ltd

5.1.4 Consultations

In undertaking this study, documentation and information was obtained from the following bodies:-

- Quarternary Section, Geological Survey of Ireland, Haddington Road, Dublin 4
- Bedrock Geology Section, Geological Survey of Ireland, Haddington Road, Dublin 4
- Groundwater Section, Geological Survey of Ireland, Haddington Road, Dublin 4
- Roadstone Dublin Ltd., Fortunestown, Tallaght, Dublin 24
- Wicklow County Council, County Buildings, Wicklow
- Environmental Protection Agency, Johnstown Castle, Co. Wexford.

5.2 RECEIVING ENVIRONMENT

5.2.1 Outline of the Baseline Study

This study was prepared using previously published regional geological and geomorphological data, together with site-specific ground investigation information in respect of Roadstone Dublin's landholding at Blessington. Existing exposures of in-situ soil deposits were also visually inspected to assist in the interpretation of ground conditions occurring across and beyond the Waste Licence Application site.

5.2.2 Quaternary Geological and Geomorphological Setting

The location of sand and gravel deposits immediately north of the town of Blessington, coupled with its proximity to a large population centre in the Greater Dublin Area, has meant that historically the area has always supported businesses (including Roadstone Dublin and its predecessor companies) engaged in sand and gravel extraction activity. The extracted sand and gravel is generally processed and supplied to the construction industry as drainage stone or mortar sand or alternatively, is used to produce construction materials such as blocks, paving blocks, roof tiles, ready-mix concrete and asphalt.

Sand and gravel soils can only be extracted where they occur, and in Ireland, their location and nature is principally determined by glacial processes which occurred in the geological past.

Quaternary geology comprises the study of soils deposited or formed during the last 2 million years. Such soils are termed quaternary soils. The two main types of quaternary soil in Ireland are glacial till, deposited at the base or margins of ice sheets, and sand and gravel soils, whose deposition is generally associated with the melting of ice sheets, at the end of periods of glaciation. Other extensive quaternary soils in Ireland include basin and blanket peat, river alluvium and estuarine deposits.

Sand and gravel deposits are broadly categorised as glacio-fluvial outwash deposits, and can consist of esker, outwash and deltaic soils deposited beneath, or at the edge of, the melting ice sheets. The majority of quaternary soils in Ireland were formed or deposited during, or at the end of, the last glaciation, termed the 'Midlandian Glaciation'. In Ireland, the maximum extent of this glaciation occurred approximately 24,000 to 20,000 years ago. However, by around approximately 11,000 years ago, the associated ice sheets had largely retreated and melted from the island of Ireland.

The quaternary landforms and processes which formed the sand and gravel deposits on the areas around the Roadstone Dublin landholding, in the townlands of Dillionsdown, Deerpark and Newpaddocks, immediately north-west of Blessington, have been extensively studied and described by several researchers over the years, amongst them Farrington (1957), Cohen (1977), Synge (1977), and more recently, Philcox (2000).

Published studies indicate that the quaternary sand and gravel soils at Blessington were formed by a combination of glacial deposition processes at the maximum and end of the last glaciation, specifically ice marginal, glacio-lacustrine, deltaic and glacio-fluvial outwash deposition.

During the maximum of the last glaciation, the Midlandian ice sheet covered most of central Ireland. The ice sheet spread out from central Ireland and pushed in a south-easterly direction to the edge of the Wicklow Mountains, terminating and forming an end-moraine approximately 1km to 2km north-west of Blessington. A glacio-lacustrine lake was formed by melt water in front of this ice sheet, and was bound to the north and west by the face of the ice sheet and to the east and south by the Wicklow Mountains. At the contact between the ice front, the end-moraine and the glacio-lacustrine lake, deltaic deposits were formed when sediment laden glacial melt water from the ice sheet flowed into the lake, depositing transported sediment as it did so. The build up of this sediment over time formed the glacio-lacustrine delta complexes at Blessington. The regional quarternary geology and geomorphology is summarised on Figure 5.1.

The worked out sand and gravel deposits at Dillonsdown and those at Deerpark and Redbog which are currently being excavated are classified as a *glacio-lacustrine delta complex* (Philcox, 2000), as numerous deltas were deposited by meltwater flowing into the glacio-lacustrine lake. The various deltas did not form distinct morphological features as they were contiguous and overlapping, with later deltas being deposited on earlier ones as the level of the glacio-lacustrine lake and location of the ice sheet front fluctuated. Over time, the delta complex formed a significant deposit consisting of sands and gravels, with some silt and clay also present.

As the Midlandian ice sheet began to melt and retreat, the barrier forming the northern and western edges of the glacio-lacustrine lake, the ice sheet itself, was removed and the lake began to drain. As the lake drained, the water cut a series of distinct channels or spillways around the margin of the former lake. As the lake was being lowered there would have been numerous small outflow channels around the margins of the lake. Four of these channels have been identified by Philcox (2000) in the vicinity of Roadstone Dublin's landholding and are referred to as 'late channels' (see Figure 5.1).

Later, as the glacio-lacustrine lake level was progressively lowered, a number of the outflow channels developed into major channels from the lake, one of these was immediately to the south-west of Deerpark townland, is locally known as Glen Ding. This glen consists of a narrow steep sided gorge, approximately 750m long, and cuts through the end moraine and delta complex (see Figure 5.1).

The exposed delta complex facies and sedimentary units, in the existing sand and gravel pits have been described in detail by Philcox (2000). The stratigraphy within the exposed faces of the delta complex indicates that the facies are highly variable both laterally and vertically, with the absence of any marker beds (i.e. distinctive sedimentary beds) which may be traced across the various exposures. By its very nature, the stratigraphy within the glacio-lacustrine delta complex is highly variable over short distances, due to the very dynamic environment in which the sediment was deposited. The deposition environment at various times was controlled by changes in the position of the ice front, the level of the glacio-lacustrine lake and the glacio-fluvial dynamics at the ice sheet margin which controlled sediment source, volume and transport.

5.2.3 Regional Quaternary Geology

The 1855 1:63,360 scale (1") Geological Map of the Blessington area (Sheet 120) published by the Geological Survey of Ireland (GSI) indicates that the quaternary soils in the vicinity of the

application site comprises '*drift deposits, chiefly limestone gravel*'. Some deposits described as '*alluvial, peat bog or other superficial covering*' are indicated to occur immediately to north and west of the site (around Redbog, Co. Kildare).

More recently published geological data from the GSI indicates that the quaternary soils in the immediate vicinity of the application site includes *limestone sands and gravels, tills with clasts of sandstone and chert, peat and lacustrine sediments*. Near-surface bedrock is indicated to exist at several locations around Roadstone Dublin's landholding.

The approximate plan extent of the various quaternary soils occurring around the application site is shown on the extract from the 1:25,000 *Regional Quaternary Geological Map of Kildare / West Wicklow* published by the Geological Survey of Ireland reproduced in Figure 5.2.

5.2.4 Regional Solid Geology

The recent 1:100,000 scale solid geology map (*Geology of Kildare – Wicklow (Sheet 16)*) published by the Geological Society of Ireland indicates that the regional bedrock geology at the site comprises largely greywackes and shales with some slates, all forming part of the Kilcullen Group which is believed to be entirely of Silurian age. Strata within this sedimentary suite are indicated to dip and young towards the north-west. An extract from the above map is reproduced as Figure 5.3.

5.2.5 Available Ground Investigation Information

An overview of previous ground investigations (pre-2003) and the more recent ground investigations is presented in the following sections. The location and plan layout of available ground investigation information across Roadstone Dublin's landholding is shown on the 1:10,000 site plan attached in Figure 5.4.

5.2.5.1 Previous Ground Investigations

In November 1996, 6 No. air rotary / ODEX exploratory holes were drilled by Glover Site Investigations Ltd to depths of between 10m and 40.5m below existing ground level in Glen Ding, at the south-western end of Roadstone Dublin's landholding, immediately beyond the current extraction area at Deerpark (wells designated BH1 to BH6). Although no soil samples were retrieved for laboratory testing or analysis, the drillholes were logged by taking 'grab' samples at regular depth intervals. On completion, standpipes were installed in each drillhole for water level monitoring purposes.

In May 2002, 3 No. air rotary / ODEX exploratory holes were each drilled to 19m depth below existing ground level by Glover Site Investigations Ltd. under the supervision of staff from White Young Green. Of these, 2 No. were drilled near the unauthorised landfill at Area 4 (GW4/1 and GW4/2) , the other near the unauthorised landfill at Area 6 (GW6/4). Although no soil samples were retrieved for laboratory testing or analysis, the drillholes were logged by taking 'grab' samples at regular depth intervals. On completion, standpipes were installed in each drillhole for water level monitoring purposes.

The location of the exploratory drillholes is indicated on the 1:10,000 scale site plan provided in Figure 5.4. Details of these ground investigations are provided in Appendix 5A of this report.

5.2.5.2 Phase 1 Environmental Investigation

From December 2002 through to February 2003, Wicklow County Council undertook an environmental investigation at a number of areas within Roadstone Dublin's lands at Blessington. The investigation, designated Phase 1 Environmental Investigation, comprised excavation of large trial pits through backfilled soils to depths in excess of 15m in order to establish what materials had been used in the backfilling and restoration of exhausted / worked-out sand and gravel pits to former ground level. These trial pit excavations did not encounter or penetrate undisturbed in-situ soil deposits.

This investigation uncovered evidence of unauthorised disposal of domestic, commercial and industrial (DCI) waste at three separate locations within Roadstone Dublin's landholding (designated Areas 1, 4 and 6). A number of soil samples were taken at these locations during this investigation for chemical analysis and testing

The locations of the exploratory trial pits are shown on the 1:10,000 scale site plan provided in Figure 5.4, together with the inferred plan extent of the buried DCI waste. For ease of reference, each trial pit was identified by two numbers: the first identified the area under investigation, the second the sequence of trial pit excavations in that particular area. The extent of the buried DCI waste is also indicated and is largely inferred on the basis of visual observations made during this investigation.

Details of this ground investigation are provided in a report prepared by John Barnett and Associates' dated March 2003, entitled '*Investigation into Illegal Waste Disposal on Lands at Dillonsdown, Deerpark and Newpaddocks, Blessington, Co. Wicklow*', a copy of which is reproduced in Appendix 6B.

5.2.5.3 Phase 2 Environmental Investigation

On completion of Wicklow County Council Phase 1 Environmental Investigation in each of Areas 1, 4 and 6, groundwater wells and cable percussion boreholes were drilled in order to install groundwater and landfill gas monitoring instruments. This work also yielded information about the undisturbed soil deposits immediately beneath the materials used to backfill the worked out sand and gravel pits.

Glover Site Investigations Ltd. drilled 9 No. groundwater / landfill gas monitoring wells immediately outside the inferred perimeter of the DCI waste at each unauthorised landfill site in February and March 2003. Of these, 4No. were at Area 1 (GW1/1 to GW1/4), 2 No. were at Area 4 (GW4/3 and GW4/4) and 3 No. were at Area 6 (GW6/1, GW6/2 and GW6/3). Although no soil samples were taken from the air rotary / ODEX drillholes for laboratory testing or analysis, each borehole was logged by staff from John Barnett and Associates from 'grab' samples taken at regular depth intervals during drilling. The location of these monitoring wells is indicated on the 1:10,000 scale site plan provided in Figure 5.4. Construction records for these monitoring wells are reproduced in Appendix 5B.

Irish Geotechnical Services Ltd. bored 11 No. cable percussion boreholes inside the inferred perimeter of the buried domestic and commercial waste at Areas 1, 4 and 6 in February and March 2003. The boreholes were bored to depths of between 12.5m and 27.5m below existing ground level. 5 No. of the boreholes were located in Area 1 (BH1/10 to BH1/14), 3 No. in Area 4 (BH4/10 to BH4/12) and 3 No. in Area 6 (BH6/10 to BH6/12).

In-situ Standard Penetration Tests and falling head tests were carried out within the boreholes to get an indication of relative density and permeability respectively. Bulk soil samples were taken at 2m depth intervals and where possible, relatively undisturbed U100 samples of cohesive samples were taken. Groundwater monitoring standpipes and landfill gas monitoring valves were installed in the boreholes on completion to provide for environmental monitoring of groundwater and landfill gas within the waste bodies. Soil samples were sent for detailed inspection and geotechnical laboratory testing. Selected soil samples were also forwarded to AlControl Laboratories for chemical testing. The location of the exploratory drillholes is indicated on Figure 5.4. Details of these ground investigations are provided in the report prepared by IGSL Ltd., reproduced in Appendix 5C.

Subsequently, in June 2003, an additional 2 No. groundwater monitoring wells (GW6/5 and GW6/6) were installed down hydraulic gradient of the unauthorised landfill at Area 6, within the new housing development immediately to the east. 2 gas monitoring boreholes were also drilled adjacent to these wells (BH6/5A and BH6/6A). In September 2003, a further 3 No. additional groundwater monitoring wells were installed down hydraulic gradient of the unauthorised landfill sites in Area 1 and Area 4, one at Santry Hill (GWR1), one at the toe of Glen Ding Ridge (GWR2) and one south of the existing silt ponds (GWR3). The location of these additional wells and boreholes is indicated on Figure 5.4 and construction records reproduced in Appendix 5B.

5.2.5.4 Landfill Ground Investigation

2 No. cable percussion boreholes (BHl1 and BHL2) and 4 No. trial pits (TPL1 to TPL4) were excavated by IGSL Ltd. in August 2003 around the site which was initially selected for the proposed landfill, south-west of the unauthorised landfill at Area 1. The boreholes extended to depths of between 20.0m and 25.0m below existing ground level while the trial pits were excavated to between 4.0m and 4.3m below existing ground level.

In-situ Standard Penetration Tests and falling head tests were carried out within the boreholes to get an indication of relative density and permeability respectively. Bulk soil samples were taken from both the boreholes and trial pits for geotechnical laboratory testing.

Additional ground investigation, comprising 1No. cable percussion borehole (BHL3) and 2 No. trial pits (BHL5 and TPL6), was undertaken by IGSL Ltd. at the re-positioned landfill site in February 2003. Bulk soil samples were taken from the borehole for geotechnical laboratory testing.

As the trial pits excavated by IGSL Ltd. encountered evidence of Made Ground (soil with intermixed construction and demolition (C&D) waste) locally across the footprint of the proposed engineered landfill, an additional five trial pits (TPL10 to TPL14) were excavated by John Barnett and Associates in March 2004. Of two trial pits excavated adjacent to IGSL's, one (TPL10) encountered evidence of C&D waste to 2.5m, consistent with IGSL's finding; the other (TPL11) found no evidence of Made Ground, in contrast with IGSL's finding of Made Ground to 4m depth. Three other trial pits across the proposed landfill footprint encountered no evidence of Made Ground or intermixed C&D waste.

At the time of the trial pit excavations at the proposed landfill site in March 2004, it was obvious that the Made Ground and intermixed C&D waste occurred within a localised bowl-shaped depression. It is postulated that at some unknown time in the past, in-situ sand and gravel was locally excavated to facilitate burial of construction and demolition waste and that the bowl-shaped depression of the excavated void arose on account of instability in the surrounding sand and gravel.

The landfill borehole and trial pit locations are shown on a larger 1:2000 scale plan in Figure 5.5. Details of the landfill ground investigations are provided in Appendix 5D.

5.2.6 Geotechnical Interpretation : Ground Conditions

Based on the available ground investigation information outlined above, the general subsoil profile beneath Roadstone Dublin's landholding at Blessington is inferred to comprise, either in part or whole, the following sequence of subsoils and / or bedrock:

- Made Ground consisting principally of backfilled sandy gravelly clay (glacial till) and fine sandy silt generated by aggregate processing activities, with or without inclusions of C&D waste, and in Areas 1, 4 and 6, with seams of buried DCI waste;
- Fine sandy silt (backfilled fines from aggregate processing)
- Glacio-lacustrine and deltaic sands and gravels (undisturbed in-situ deposits)
- Glacial till (gravelly clay)
- Bedrock (comprising weathered phyllite, slate and greywacke)

The distribution and characteristics of each of these strata, as well as the groundwater regime, are described in more detail in the following sections. The distribution and characteristics of the Made Ground and the underlying fine sandy silt (where present) are described on an area by area basis.

Cross sections across Roadstone Dublin's landholding are provided in Figures 5.6 and 5.7.

5.2.6.1 Made Ground

At the unauthorised landfill site at Area 1 (Dillonsdown), Made Ground is generally described as *mottled brown to black, sandy gravelly CLAY to very clayey GRAVEL* or *brown to grey/brown, fine sandy SILT to silty fine SAND*, intermixed with pockets and seams of *cobbles and brick, timber, plastic, concrete, paper and occasional glass and rubber waste*. This stratum extended to depths of between 7.0m and 15.3m below existing ground level (between 222.7mOD and 230.7mOD approximately).

At the unauthorised landfill site at Area 4 (Deerpark), Made Ground is generally described as *mottled brown, grey/brown and black, fine sandy SILT* and *silty gravelly fine SAND to silty sandy GRAVEL with occasional cobbles and boulders*, intermixed with pockets and seams of *rubber, paper, plastic, glass, concrete and wood waste*. This stratum extended to depths of between 2.0m and 6.8m below existing ground level (between 214.0mOD and 220.7mOD approximately).

At the unauthorised landfill site at Area 6 (Newpaddocks), Made Ground is generally described as *mottled black, brown and grey, silty fine SAND and fine sandy SILT/CLAY* or *sandy gravelly CLAY with cobbles* intermixed with pockets and seams of *wood, plastic, paper, metal and ceramic waste*. This stratum was found to extend to between 7.7m and 9.3m below existing ground level (between 206.0mOD and 211.5mOD approximately).

Made Ground, described as very sandy gravel with many cobbles and boulders and occasional plastic, glass and brick and some metal and tyres was encountered locally to 2.3m and 4.0m depth in trial pits excavated at proposed landfill site, immediately south of the existing unauthorised landfill site at Area 1. No Made Ground was encountered within the boreholes or trial pits excavated in August 2003 at the original site of the engineered landfill, immediately to the west of the proposed landfill site, nor was any encountered in the boreholes undertaken in Glen Ding during November 1996 (immediately west of the current extraction area).

Particle size distribution curves for Made Ground are generally consistent with the above field descriptions and indicate that the material varies from well-graded *gravelly sandy CLAYS* (inferred backfilled glacial till) to *clayey GRAVELS* or *fine sandy SILT* (inferred to be arisings from aggregate processing activity). The variation in grading is reflected in the total fines content of the tested materials, which ranges between 13% and 72% by weight of the soil.

5.2.6.2 *Fine Sandy Silt*

In general, a layer of silt between 1.8m and 8.2m thick was observed beneath the Made Ground in Area 1. This stratum is generally described as *firm to stiff, brown, laminated, sandy SILT or CLAY*. It is not continuous across the site however and in particular is absent at boreholes BH1/10, BH1/11A and BH1/13.

At Area 4, the layer of silt was only encountered in borehole BH 4/10 beneath the Made Ground. The layer, which is just 0.8m thick, is described as *brown, gravelly sandy SILT*.

At Area 6, a layer of silt between 7.0m and 7.8m thick was generally present beneath the Made Ground. As at Area 1 however, the layer is not continuous and is absent at borehole BH6/11. The material at this site is typically described as *very soft, brown, slightly sandy silt / CLAY.*

Silt was not encountered in any of the boreholes undertaken at the western end of Roadstone Dublin's landholding during November 1996 (immediately west of the current extraction area), nor in any of the trial pits or boreholes undertaken immediately west of the proposed engineered landfill during August 2003. A layer of borderline sandy SILT / silty fine SAND was recorded in one of the trial pits (TPL12) excavated beneath the footprint of the landfill in February / March 2004.

Particle size distribution curves for the backfilled silt indicate that it is principally comprised of fine soils (silt and clay sized particles), with the total fines content of the backfilled silt ranging from 73% to 99% of the soil by weight. With the exception of the silt encountered at trail pit TPL12, it is inferred that this layer of silt comprises waste arisings from aggregate washing and processing activities, which were subsequently re-used to restore and backfill exhausted or worked-out sand and gravel pits across Roadstone Dublin's landholding. In contrast, the silt encountered in trial pit TPL12 is interpreted to be naturally occurring, and intermixed within the sand and gravel deposits.

5.2.6.3 *Sands and Gravels*

Naturally occurring, highly variable glacio-lacustrine deltaic deposits of sand and gravel, generally described as *loose, brown, silty fine SAND* to *medium dense to dense, brown, gravelly SAND* to *slightly clayey sandy GRAVEL or very sandy COBBLES* were recorded in all except one of the boreholes and groundwater wells (borehole BH6/10) drilled in recent ground investigations across Roadstone Dublin's landholding at Blessington (waste at borehole 6/10 was underlain by *sandy / gravelly CLAY*).

The extent and distribution of the sand and gravel deposits encountered in boreholes and groundwater wells is highly variable in terms of lateral continuity, thickness and composition. The thickness of these deposits ranges from 3.0m on locally elevated ground east of Glen Ding woods to in excess of 29m at Area 6. The depth to these deposits varies from 0.0m (ground surface) at the undisturbed ground east of Glen Ding woods to 17.0m below existing ground level at the backfilled sand and gravel pit at Area 1.

With the exception of the Made Ground encountered locally in trial pit TPL5, TPL6 and TPL10, undisturbed sand and gravel deposits occur around the site of the proposed engineered landfill at or immediately below ground level. It is understood that the in-situ materials below existing ground level were never excavated as the proportion of silt and clay in the deposits occurring locally around this area are too high to justify commercial extraction and processing.

Grading curves obtained from particle size distribution (PSD) tests on samples of glacio-lacustrine deltaic sands and gravels indicate that these deposits can typically be described as *slightly silty SAND to coarse sandy GRAVEL* with some *slightly silty gravelly SAND*. Total fines content for these deposits generally varies between 1% and 24% by weight of soil, a relatively small number of tests indicate that this can increase locally to between 37% and 73%.

The variability in distribution and composition of the sand and gravels is consistent with existing knowledge about their depositional environment, discussed previously in Section 5.2.2.

5.2.6.4 Glacial Till

Glacial till was found to occur within or beneath the glacio-lacustrine sands and gravels at a number of areas across the site. This material which is generally described as *stiff to hard, brown or grey/brown, silty sandy to very sandy gravelly to very gravelly clay* has a maximum proven thickness of 7.7m.

5.2.6.5 Weathered Bedrock

Across Roadstone Dublin's landholding, weathered bedrock was encountered only beneath elevated ground east of Glen Ding woods and immediately north and east of the unauthorised landfill at Area 1, at depths of between 4.6m and 30.5m below existing ground level. The bedrock encountered in drillholes east of Glen Ding woods is typically described as *blue and green PHYILLITE and SLATE* or *blue / grey GREYWACKE with minor slate beds*.

5.2.7 Soil Contamination

As part of the environmental investigation, a number of samples of soil within the buried waste in each area were tested to establish the concentration of a number of contaminants including metals, inorganic and organic matter. A number of tests were also undertaken on soil samples immediately above and below the buried waste bodies.

Contaminant testing and subsequent risk assessment indicated that the concentration of phosphorous and strontium in the soil within the unauthorised landfill at Area 1 was high enough to give rise to potential contamination of groundwater (levels in excess of drinking water standards) were they to leach out and migrate downstream to a receptor (eg. groundwater abstraction well). Chemical analysis of groundwater samples taken around this area did not however identify any concentration of strontium in excess of drinking water standards.

Testing of soil sampled within the unauthorised landfill at Area 4 did not reveal any contamination high enough to give rise to potential contamination of groundwater.

Testing of soil sampled within the unauthorised landfill at Area 6 indicated that the concentration of strontium and zinc were high enough to give rise to potential contamination of groundwater were they to leach out and migrate downstream to a receptor. Chemical analysis of groundwater samples taken around this area did not however identify any concentration of strontium or zinc in excess of drinking water standards.

Full details of the soil contaminant testing and environmental risk assessment are provided in the report entitled '*Investigation into Unauthorised Tipping on Lands at Blessington, Co. Wicklow, Environmental Risk Assessment and Management* Strategy' prepared by Parkman International (now Parkman Mouchel) in August 2003. A copy of this report is reproduced in Appendix 6A.

5.2.8 Overview of Available Information

Philcox (2000) has described and mapped the exposed delta facies in existing pit exposures along the length of the delta complex, and has identified variable soil and stratigraphy throughout. In particular, he noted the absence of a 'marker bed' that could be traced across the deltaic soil complex. The high degree of lateral and vertical variation in the nature and composition of the

undisturbed soil deposits is due to the depositional environment and the complex interaction of the processes which formed the glacio-lacustrine delta complex, north-east of Blessington and across Roadstone Dublin's landholding.

This is consistent with the available groundwater well and cable percussion borehole data, which also indicate a high degree of lateral and vertical variation in the composition and thickness of both backfilled and undisturbed soils across Roadstone Dublin's landholding. Wells and boreholes located less than 100m apart generally indicate a different soil stratigraphy, with no obvious evidence of a laterally continuous stratum between them.

5.3 IMPACT OF REMEDIATION WORKS

5.3.1 Do-nothing Scenario

Left unattended, the buried waste at the three unauthorised landfill sits in Areas 1, 4 and 6 would continue to degrade and decompose under anaerobic conditions and produce both leachate and landfill gas, which would in turn give rise to

(i) a potential risk to groundwater quality in the underlying sand and gravel aquifer (from which a number of housing developments down hydraulic gradient source their drinking water) and
(ii) potential build up of landfill gas in confined spaces at adjoining residences.

A detailed risk assessment of the existing situations has been undertaken by Parkman International (*now* MouchelParkman) and a copy of its report is reproduced in Appendix 6A.

5.3.2 Short-Term Impacts

The excavation, stockpiling and formation of earth bunds using fine sandy silty soils above the buried waste may give rise to elevated levels of fugitive dust at or beyond the Applicant's landholding, if windy conditions arise during a sustained dry weather period in the course of the proposed site remediation works. These impacts are discussed in detail in Section 7 of this report (Air Quality).

In the short-term, during the site remediation works, any unsealed, unvegetated soil surfaces, including excavation side slopes, exposed to moderately heavy to intense rainfall events will be vulnerable to erosion by surface water run-off. Left unmanaged, run-off of eroded soil could eventually give rise to discharge of silt at surface watercourses.

At the unauthorised landfill sites, the removal of the existing soil cover above the buried waste will mean that the moisture content of the waste may increase somewhat while it is exposed to the elements. The increase in moisture content could result in accelerated degradation and decomposition of the waste and cause further leaching of some contaminants out of the waste bodies, into the underlying soil.

Granular materials required to construct temporary haul roads between the unauthorised landfill sites and the engineered landfill can be sourced from the existing sand and gravel pit. A suitable source of clay for the basal liner of the engineered landfill (glacial till) has been identified off-site at the Applicant's Huntstown Quarry in North Dublin and will have to be imported to site via road.

5.3.3 Long-Term Impacts

The principal long-term impact of the proposed site remediation works is that it provides for a reduction of the potential for future soil and groundwater contamination on account of ongoing degradation and decomposition of buried waste at three unlined, unauthorised landfill sites across the Roadstone Dublin landholding at Blessington.

In excavating and removing the buried waste and contaminated soil and transferring it to fully lined, engineered landfill facility with proper environmental management and control of any potentially mobile liquid-phase contaminant (leachate) or landfill gas or off-site to licensed waste facilities if necessary, the proposed remediation scheme reduces existing long-term environmental risks.

There is a residual risk that small undetected pockets of waste or contaminated soil could remain in-situ at the unauthorised landfill sites following the excavation and removal of the buried waste.

There is a residual risk that some leakage of leachate could occur out of the basal liner of the proposed engineered landfill, increasing contaminant levels within the underlying in-situ soils.

5.3.4 interaction with Other Environmental Receptors

The presence of contaminated soil or degrading waste within backfilled soil material offers significant potential for groundwater contamination as infiltrating rainfall or leachate by-products percolate down to the underlying sand and gravel aquifer. This issue is discussed in detail in Section 6 of the EIS.

Excavation and transfer of the buried waste may give rise to significant odour and dust nuisance and concerns for public health. These issues are discussed in detail in Section 7 of this report (Air Quality).

5.4 MITIGATION MEASURES

In order to reduce the potential for fugitive dust emissions from soil stockpiles or perimeter earth mounds at the unauthorised landfill sites during the remediation works, a number of dust control measures will be implemented. These measures are discussed in detail in Section 7 of this report (Air Quality).

In order to reduce the risk of soil erosion by surface water run-off, a network of temporary drainage ditches will be excavated around each unauthorised landfill site and the proposed engineered landfill to intercept surface water and divert it away from working areas. Intercepted surface water should be diverted either to

(i) temporary sumps or soakaways or
(ii) existing surface water settling ponds or lagoons around Roadstone Dublin's landholding.

The existing settling ponds or lagoons are not directly connected to any surface watercourse flowing out Roadstone Dublin's landholding. Water diverted to these areas is ultimately recycled in aggregate processing or concrete production or discharged to groundwater.

Where feasible in the short-term, consideration will be given to vegetating exposed soil surfaces on perimeter earth mounds. The volume of stockpiled soil to a minimum insofar as possible.

In order to minimise any possible increase in the moisture content of the waste and the potential for further leaching of contaminants out of the buried waste into the underlying soil, excavations of unauthorised landfill sites and placement of waste at the proposed engineered landfill site should be managed so as to minimise water ingress. Specifically waste should be excavated in small areas ('strip mining') and soil (or alternative) cover should be placed over the exposed waste at the end of each working day and at weekends and public holidays.

Any excess in-situ soil arising from the excavation and construction of the proposed engineered landfill should either be re-used in backfilling the unauthorised landfill sites following the removal of buried waste and potentially contaminated soil. No excavated soils will be exported off-site.

Any excavated soil re-used in the backfilling and restoration of the unauthorised landfill sites should be subject to validation testing to confirm that it is uncontaminated.

In order to manage any residual risk that undetected pockets of waste or contaminated soil remain in-situ following the remediation works and present a risk to the underlying groundwater aquifer, the existing groundwater monitoring programme should continue for a period of at least five years subsequent to the excavation and removal of waste. The results of this monitoring should be furnished to the regulatory authorities and reviewed with them on a regular basis (to be agreed). The extent of the existing groundwater monitoring programme is outlined in Section 6 of the EIS.

Measures to mitigate residual risks to soil presented by the engineered landfill itself include prior construction of leachate drainage / collection systems and surface water management systems and implementation of CQA procedures during installation of the landfill liner. These measures are discussed in greater details in Section 6 of the EIS.

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GLOSSARY OF GEOLOGICAL AND GEOMORPHOLOGICAL TERMS

Delta : Fan shaped alluvial deposit at the mouth of a river formed by successive layers of deposited sediment.

Deltaic : Description of sediment and sedimentary facies deposited in a delta.

Esker : Ridge of partially sorted sand and gravel deposited by meltwater flowing in a channel at the base of an ice sheet

Facies : The lateral and vertical character of an exposed geological unit.

Glacio-fluvial : A term referring to the processes and landforms related to the action of glacial meltwater. Such processes may occur beyond the edge of the glacier or ice sheet, or within or beneath a glacier or ice sheet. Due to the large volumes of water available, glaciofluvial deposition frequently results in the formation of extensive outwash plains.

Glacio-lacustrine : A term given to those sediments deposited in lakes or ponds formed by meltwater from a glacier or ice sheet.

Midlandian : The name given to the last Pleistocene glacial stage in Ireland. During this stage the southern most portion of Ireland was not covered by the ice sheet and experienced permafrost conditions.

Moraine : An accumulation of material which has been transported by and deposited at the margins of a glacier or Ice sheet

Outwash : Material of glaciofluvial origin deposited beyond the limits of a glacier or ice sheet.

Quaternary : The last 1.8 to 2 million years in geological time. The quaternary was characterised by up to 17 periods of glaciation in the northern hemisphere. Evidence for the last two glaciations may be found in Ireland, the Munsterian and the Midlandian.

Till : The term given to sediment which is deposited beneath a glacier or ice sheet.

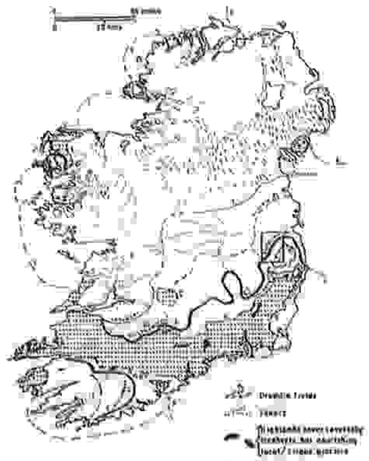
(Adapted from the Dictionary of Physical Geography, John Whittow)

APPENDICES

Appendix 5A	Existing Ground Investigation Information
Appendix 5B	Groundwater Well Installation Records
Appendix 5C	Unauthorised Landfill Sites : Ground Investigation Report
Appendix 5D	Landfill Site : Ground Investigation Reports

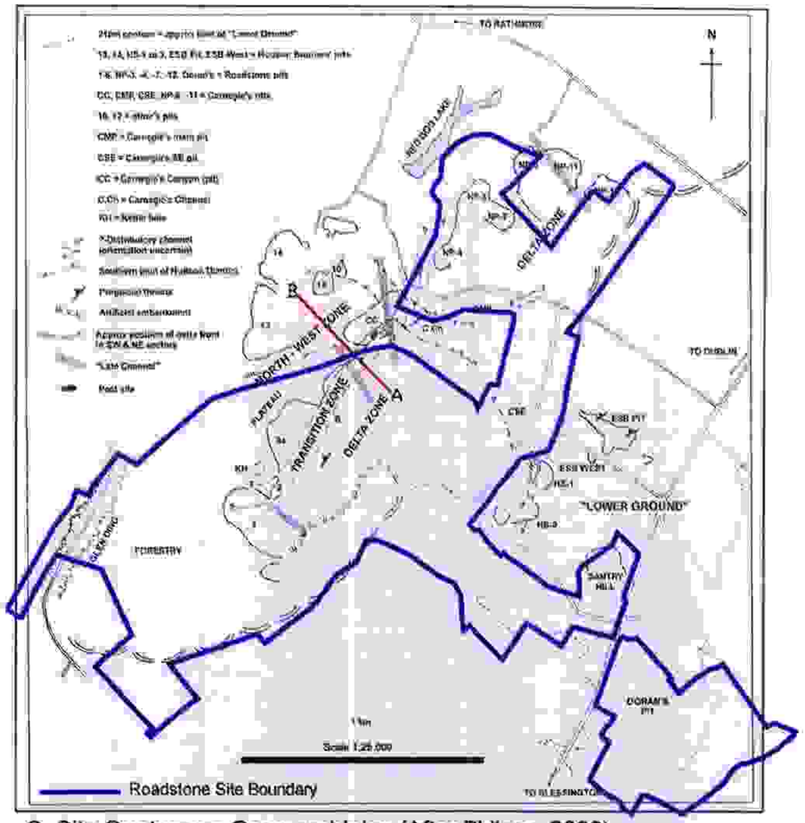
FIGURES

A. Irish Quaternary Geomorphology

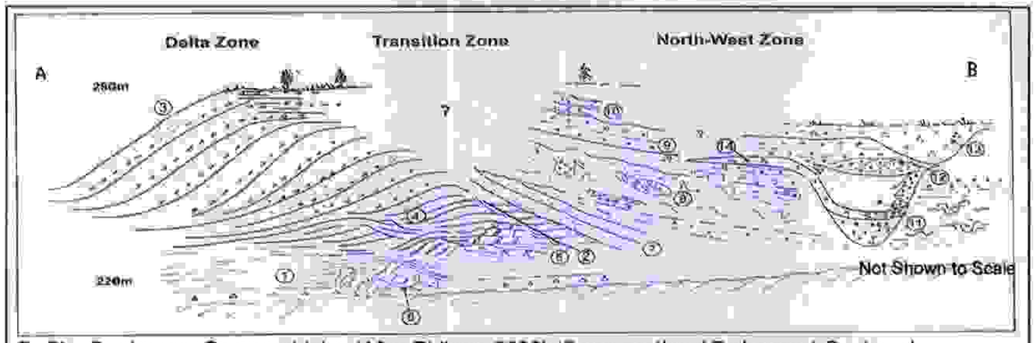


B. Regional Quaternary Geomorphology

(After Philcox, 2000)



C. Site Quaternary Geomorphology (After Philcox, 2000)



D. Site Quaternary Geomorphology (After Philcox, 2000) (Cross-section AB shown at C, above)

Schematic diagram showing relationships between the main sedimentary units in the Blessington gravel pits; not to scale, O.D. levels approximate, Lower Ground excluded. Areal zones located in Fig.2. Relationship between most of succession in North-West Zone (NWZ) and main delta foresets is not known. 1. Mainly horizontal sand with ripple drift, thin graded beds, small dunes and low-relief channels; delta bottomsets and distal fan sediments. Basal diamict (till) overlain by interlaminated silt and clay, grading up into sand. 2. Ice-contact surface (Figs. 5,6). 3. Delta foresets <40 m high; topsets c.5 m thick (Fig.4). 4. "Pre-delta" foresets, covering smaller-scale sediment lenses in early fan (Fig.7). 5. Ice-contact thrust complex (Fig.10). 6. Proglacial thrust complex (Fig.12a). 7. Back-slope sediments in Transition Zone, thickening away from crest (Fig.6). 8. Deepark Facies: irregular beds ranging from laminated silt to boulder gravel, often highly contorted (Fig.13). Facies thins onto crest of Transition Zone (Fig.6). 9. Top Gravel: coarse boulder gravel covering most of NWZ. 10. Late Diamict (till) is highest unit across most of NWZ. 11. Carnegie's Channel cuts across all zones (Fig.2). Filled mainly with marginal talus gravel and deltaic bottomset sand. 12. Small-scale delta foresets, covered by boulder beds (=9). 13. Late Channel, filled mainly with dirty gravel (solifluction deposit?). Diamict (=10) present locally. 14. Hudson Diamict (till) (see Fig.2 for distribution), interfingering within channel with Laminated Unit (clay & silt). Sand above this is Light Brown Unit.

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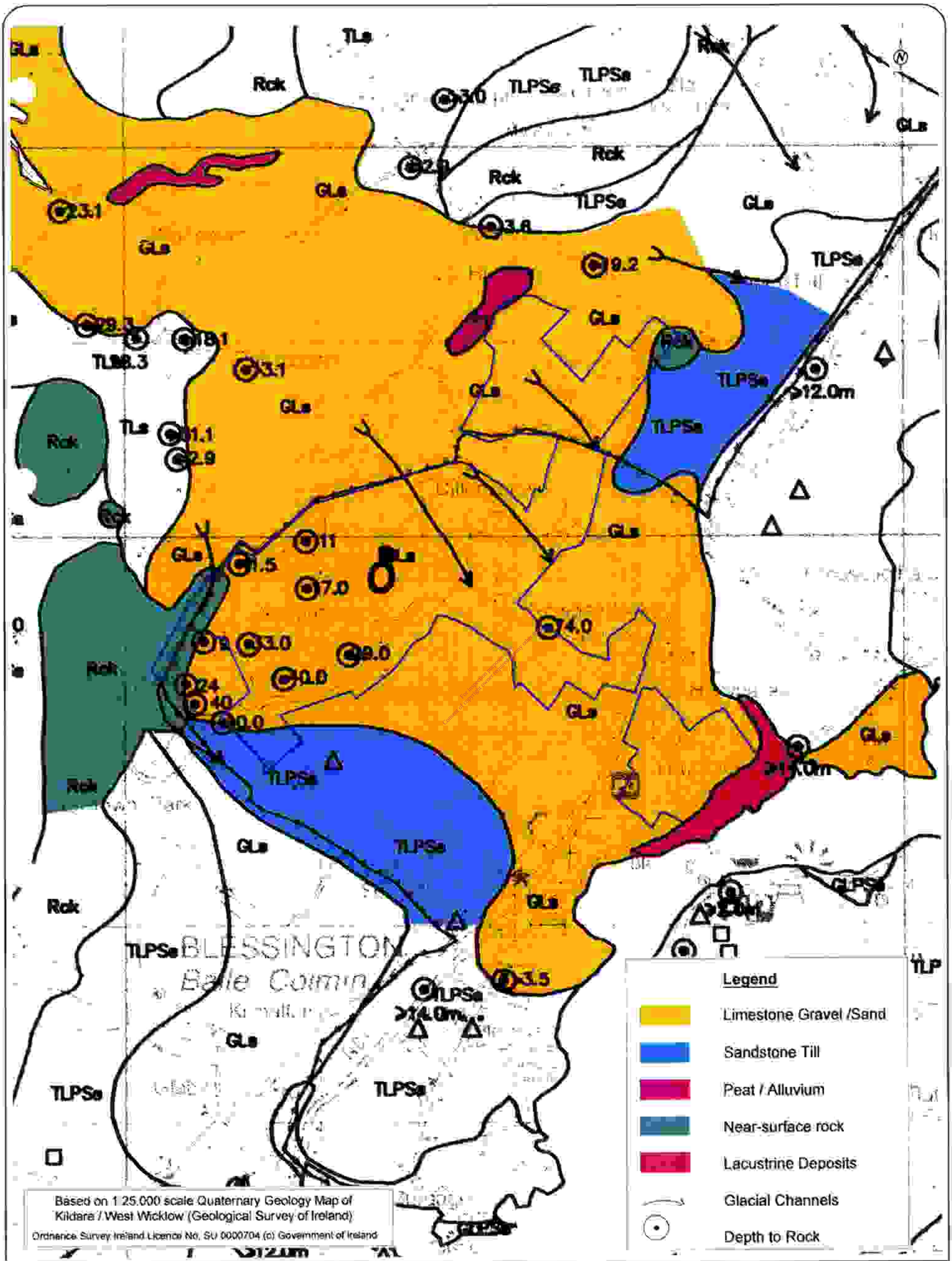
Rev.	Date	By	Description
0	Dec 03	PG/PM	

Site:	Lands at Blessington, Co. Wicklow
Project:	Remediation of Unauthorised Landfill Sites
Title:	Quaternary Geology and Geomorphology
Drawn: PMC	Scale: Not Shown To Scale
Job. no: 2901/10	Date: Dec 2004

FIGURE 5.1



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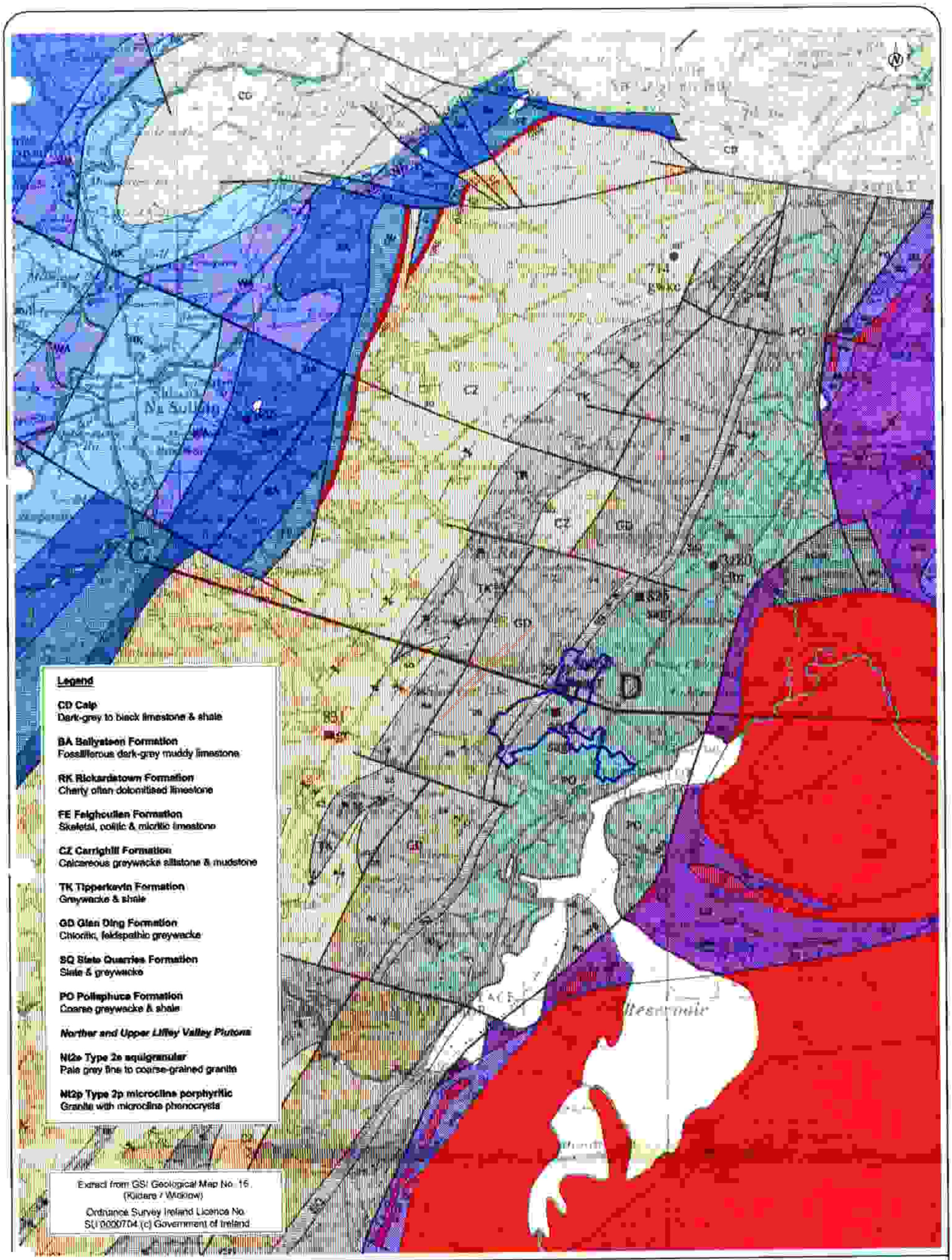
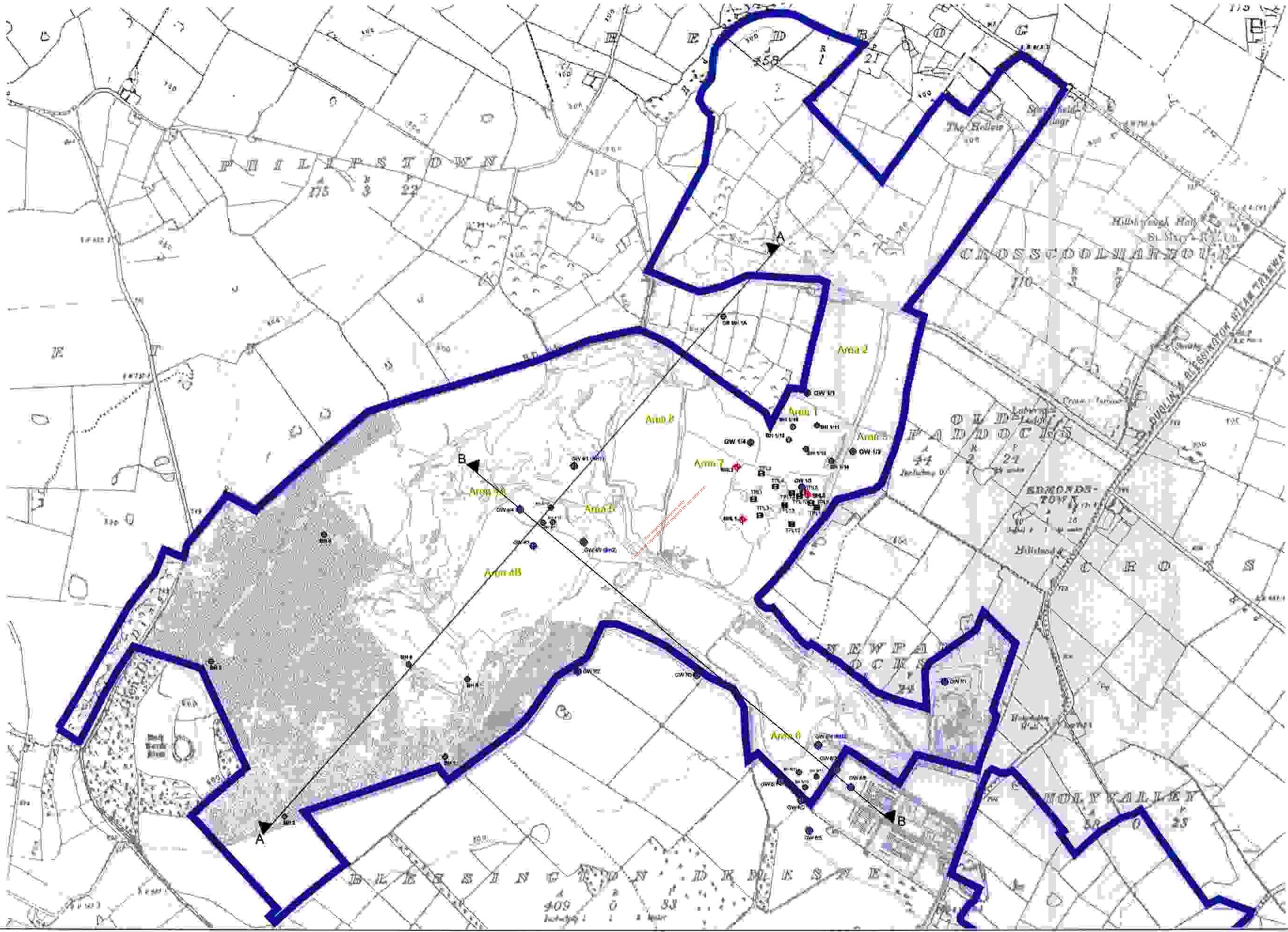
Roadstone Dublin Landholding

Rev.	Date	By	Description
0	Dec 03	SMD/PM	

Site:	Lands at Blessington, Co. Wicklow		
Project:	Remediation of Unauthorised Landfill Sites		
Title:	Regional Quaternary Geology		
Drawn: SMD/PM	Scale: 1:25,000	FIGURE 5.2	
Job. No: 2001/10	Date: Dec 2004		





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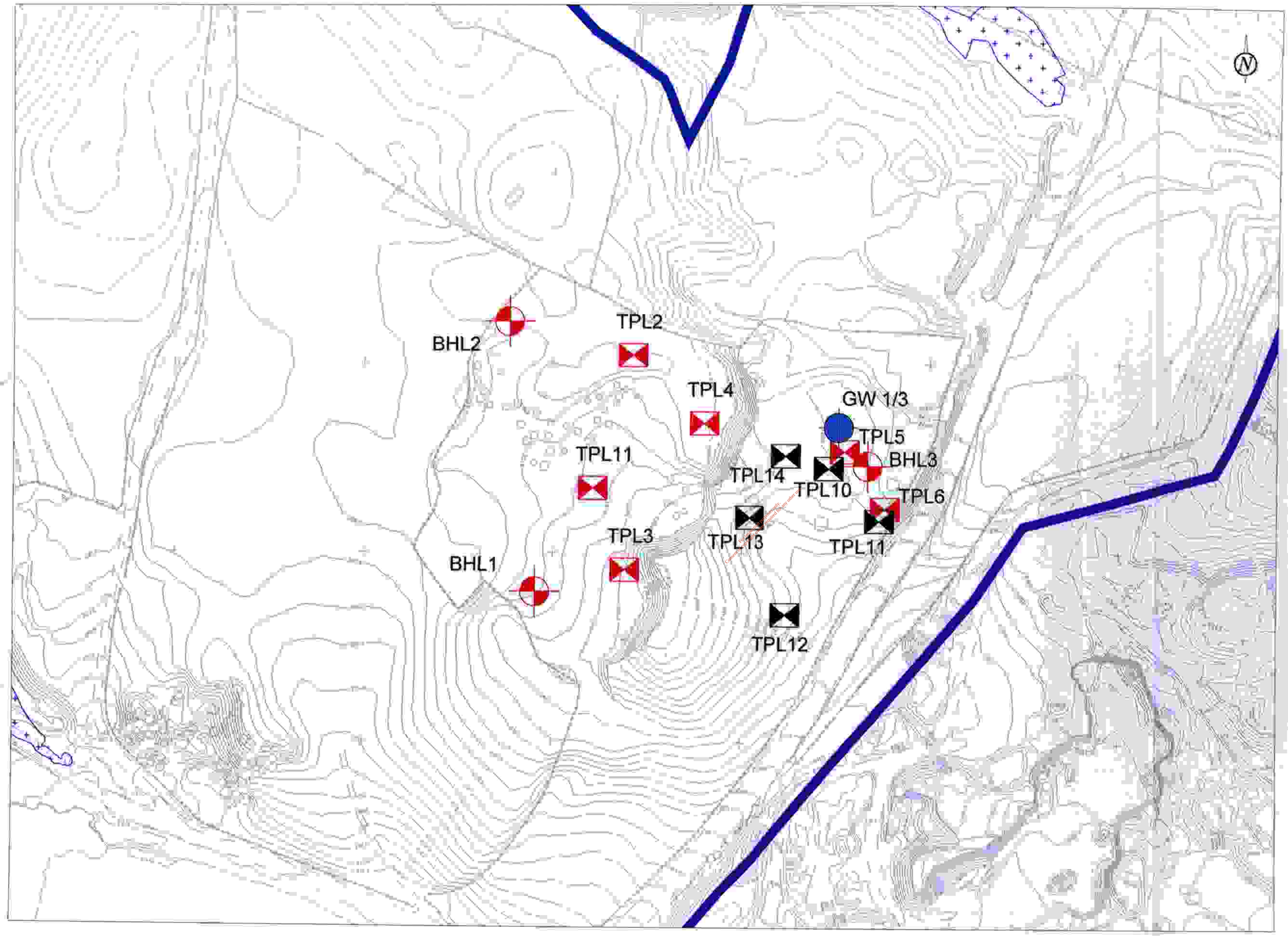
Rev.	Date	By	Description
0	Dec 03	SMD/PM	

Site:	Lands at Blessington, Co. Wicklow		
Project:	Remediation of Unauthorised Landfill Sites		
Title:	Boreholes / Trial Pit / Groundwater Well Locations		
Drawn: SMD/PM	Scale: 1:10,000	FIGURE 5.4	
Job. No. 2901/10	Date: Dec 2004		



Trail Pit Locations

TPL1 E 298021 N 215934 Ground Level 232

TPL2 E 298042 N 216004 Ground level 229

TPL3 E 298038 N 215891 Ground Level 236

TPL4 E 298080 N 215968 Ground Level 230

TPL5 E 298155 N 215953 Ground Level 236

TPL6 E 298176 N 215923 Ground Level 238

TPL10 E 298147 N 215945 Ground Level 238

TPL11 E 298173 N 215917 Ground Level 233

TPL12 E 298124 N 215968 Ground Level 236

TPL13 E 298104 N 215919 Ground Level 237

TPL14 E 298124 N 215951 Ground Level 237

Borehole Locations

BHL1 E 297990 N 215879 Ground Level 231.7

BHL2 E 297977 N 216022 Ground level 239.5

BHL3 E 298137 N 215946 Ground Level 237.9

Groundwater Well Locations

GW 1/3 E 298147 N 215984 Ground Level 237.7

Notes;

Locations of Trial Pits TP10 - TP14 approximate only

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Legend

- Roadstone Dublin Landholding
- Trial Pit Location
- Groundwater Wells
- Boreholes

Rev.	Date	By	Description
1	Mar 04	SMD/PM	
0	Dec 03	SMD/PM	

Site:	Lands at Blessington, Co. Wicklow
Project:	Remediation of Unauthorised Landfill Sites
Title:	Proposed Landfill Site - Ground Investigation Locations
Drawn: SMD/PM	Scale: 1:2000
Job. No: 2901/10	Date: Dec 2004

FIGURE 5.5

SOUTH-WEST

NORTH-EAST

Ground Level

Reduced Level (mOD)

240

230

220

210

200

BH2 (1996)

BH5 (1996)

BH6 (1996)

BH4/11

GW4/4

BH4/10

GW4/3

GW4/1

Legend

- Made Ground
- Waste
- (Sandy) SILT
- SAND and/or GRAVEL
- Gravelly CLAY
- ROCK
- Groundwater Strike
- Groundwater Rise
- Groundwater Table

Horizontal Scale	1:500
Verttical Scale	1:200

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Rev.	Date	By	Description
0	Dec 03	EC / EK	

Site:	Lands at Blessington, Co. Wicklow
Project:	Remediation of Unauthorised Landfill Sites
Title:	Geological Cross-Section A - A
Drawn: EC / EK	Scale: 1:5000
Job. no: 2901/10	Date: Dec 2004

FIGURE 5.6

NORTH-WEST

SOUTH-EAST

Reduced Level (mOD)

220

210

200

190

180

Ground Level

GW4/4

GW4/3

GW4/2

BH6/11

GW6/3

GW6/6

GW6/1

Legend

- Made Ground
- Waste
- (Sandy) SILT
- SAND and/or GRAVEL
- Gravelly CLAY
- ROCK
- Groundwater Strike
- Groundwater Rise
- Groundwater Table

Horizontal Scale	1:500
Verttical Scale	1:200

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Rev.	Date	By	Description
0	Dec 03	EC / EK	

Site:	Lands at Blessington, Co. Wicklow		
Project:	Remediation of Unauthorised Landfill Sites		
Title:	Geological Cross-Section B - B		
Drawn: EC / EK		Scale: 1:5000	FIGURE 5.7
Job. no: 2901/10		Date: Dec 2004	