Transport for London
London Underground

Category 1 Standard

1-026 Topographical Surveys and Mapping

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MAYOR OF LONDON

Contents

1 Purpose

1.1 The purpose of this standard is to define the requirements for and the procedures for performing and recording topographical surveys and to define the controls on the use of Ordnance Survey (OS) mapping.

2 Scope

2.1 The scope of this standard is to define:

a) the requirements for topographical surveys and mapping performed by LU and its Suppliers surveying LU fixed assets;

b) the requirements for topographical surveys and mapping for projects promoted by LU or its Suppliers on land and assets not currently owned by LU and;

c) the procedures to control the use of OS mapping and other OS survey products that are licensed to LU.

2.2 This standard replaces 1-026 A1

3 Requirements

3.1 London Survey Grid and datum

3.1.1 London Survey Grid (LSG) definition

3.1.1.1 All topographical survey and mapping work shall be reported on the London Survey Grid.

Note:	The London Survey Grid is a Transverse Mercator Projection with parameters chosen to minimise grid distortion caused by the Earth's curvature over the LU area. The distortion is such that for large portions of the area projection corrections can be ignored. The Grid was formerly known as the LU Grid, the LUL Grid or the Crossrail Grid

A network of primary survey stations with London Survey Grid co-ordinates has been established across London.

3.1.1.2 LSG height datum shall be used. The LSG height datum level is set at approximately 100m below OS Datum at Newlyn.

Note:	The LSG height datum is an orthometric height datum chosen to provide positive values for areas of interest to LU. This datum is realised by the network of OS benchmarks that have been connected by spirit levelling to LU survey control points. . In areas that will interface with Crossrail projects the Crossrail First Order benchmarks should be used. Trials in 2009 indicated that GPS survey heights can be transformed using the Ordnance Survey Geoid Model 2002 (OSGM02), plus the 100m shift, to produce acceptable LSG Height Datum values

The London Survey Grid is defined by the following parameters:

Parameter	Value
Spheroid	WGS 84
Semi major axis	6,378,137.000m
Semi minor axis	6,356,752.3142m
1/f (f = earth's flattening)	298.25722356300
e″	0.00669437999013
Datum	Xrail84 *
Projection	Transverse Mercator
Central meridian	W000°-09'-30"
Latitude of true origin	N051°-10'-00"
Easting of true origin/ central meridian	78,250.000m
Northing of true origin	-2,800.000m
Central meridian scale factor	0.9999999

- Xrail84 * = Datum as derived by the Crossrail project in 1984.

3.1.2 Grid computation

3.1.2.1 Distances shall be reduced to the WGS 84 spheroid.

3.1.2.2 The London Survey Grid scale factors given in Attachment 7.1 shall be used.

3.1.3 Relationships between London Survey Grid and other grids

3.1.3.1 ***Ordnance Survey grid*** (also known as the British National Grid or OSGB36)

3.1.3.1.1 The formulae in Tables 1 and 2 in Attachment 7.3 shall be used for conversion of OS mapping to and from London Survey Grid within the areas shown in Attachment 7.2. These formulae are accurate to a commensurate standard as the OS mapping ie +/- 400mm.

3.1.3.1.2 To obtain more precise conversions of existing survey information held on the OS grid a local best fit formula shall be derived from the nearest primary or other common survey control stations.

3.1.3.2 ***JLE grid***

The formulae in Tables 3 and 4 in Attachment 7.5 shall be used for conversion of JLE digital data to and from London Survey Grid within the areas shown in Attachment 7.4.

Note:	Automation of conversion. LU holds a grid converter utility designed to convert MicroStation 2D and 3D design files from one co-ordinate system to another. It will change a file's scale, rotation, location, working units and global origin.

3.1.4 Control surveys

3.1.4.1 Primary Control stations consist of the original control points that were used as a basis for the Crossrail and Earth Structures Projects and were confirmed by the 2002 re-observation programme. These are considered to be permanent points in long term stable locations. The co-ordinate values shall not be changed without an amendment to this standard. These surveys have been computed as a single coherent system known as the London Survey Grid based on WGS84. Transformation parameters have been established to the National Grid (OSGB36). In 2002 a re-observation program was carried out by LU which proved the consistency of the original work and established transformation parameters to ETRS89. Further analysis by Prof Marek

Ziebart of University College London in April 2009 confirmed the transformation parameters. The list of Primary control points is included as Attachment 7.6

Note:	Primary Control Surveys have been carried out for the Crossrail Project and the LU Earth Structures Project.

3.1.4.2 Secondary control points consist of control schemes that are based on Primary control and have been adjusted by a rigorous method. These control points shall be permanent points in long term stable locations. The co-ordinate values may be varied as a result of re-observation and re-computation. Such variations shall only be introduced after the LU Land Survey Manager has notified all parties that have received a controlled issue of this information and no objections have been raised. Secondary control points shall be the minimum requirement for surveys in project interface areas.

3.1.4.3 Third order control points consist of control schemes that are based on any combination of Primary, Secondary or Third Order control and have been adjusted by a rigorous method. The control points shall be established to be durable and stable for the duration of the project. The project surveyor may only vary the co-ordinate values as a result of re-observation and re-computation in which case the point will be re-numbered. The LU Land Survey Manager shall distribute revised values to parties that have received a controlled issue of this information.

3.1.4.4 Fourth order control points consist of control schemes that are based on any combination of Primary, Secondary or Third Order control. The control points may be in situation where the durability or stability is doubtful or where conditions have prevented a rigorous regime of observation and computation. The project surveyor may vary the co-ordinate values as a result of re-observation and re-computation. The LU Land Survey Manager shall not further distribute this information.

3.1.5 GPS and ETRS89

The following Seven Parameter Transformation shall be used when converting ETRS89 data onto the London Survey Grid based on the Geoid model OSGM02

Method	Seven Parameter
Rotation about x axis	-0°00'03.577824"
Rotation about y axis	0°00'03.484437"
Rotation about z axis	0°00'02.767646"
Translation along x axis	19.019m
Translation along y axis	115.122m
Translation along z axis	-97.287m
Scale factor (PPM)	18.60847540

Note:	The convention used for the rotations is that a positive rotation acts in a clockwise sense as viewed along the rotation axis looking towards the origin. Checks should be made to ensure that this notation is used correctly.
Note:	GPS has been used to establish the entire primary control network, and is now routinely used for survey work. The transformation parameters between London Survey Grid and ETRS89 allow the use of recorded base station data from the National GPS Network service.

3.2 Ordnance Survey mapping

3.2.1 Supply of data

3.2.1.1 LU shall supply OS data for use on projects related to LU infrastructure and operations.

3.2.1.2 LU departments and suppliers wishing to obtain OS digital data and copyright licensing shall contact the LU Land Survey Data Manager.

3.2.1.3 Requests shall be submitted in the form given in Attachment 7.7

3.2.1.4 Suppliers shall enter into a Contractor Licence Agreement with the LU Land Survey Data Manager and abide by the copyright conditions as described in the Appendix 1 Licensed Use of the Public Sector Mapping Agreement (PSMA) Member Licence. The current form of Contractor Licence Agreement and copyright conditions are to be found in Attachment 7.11.

3.2.1.5 The recipient of data issued by LU shall acknowledge receipt within 10 working days.

3.2.1.6 The LU Land Survey Data Manager shall maintain records of requests for OS data and issue data in a controlled manner.

Note:	LU has a licence for the business use of OS digital data, which falls under the Copyright, Designs and Patents Act. Failure to comply with this procedure could lead to an infringement of Crown copyright which is a criminal offence under the Act, and would also lead to the loss of LU's licence and expose the company to civil proceedings for damages.

3.2.2 Copyright requirements

3.2.2.1 LU is a party to the TfL member licence to use OS data under the PSMA for the supply and use of digital data and licensing of copyright works.

3.2.2.2 Users of OS data shall abide by the terms of the agreement which shall be for Internal Business Use (including display and promotion) and limited internet applications only.

Note:	There is a Public Sector Mapping Agreement between the DCLG and OS for the supply of OS mapping data to all public bodies. LU receives data licensed under this agreement through TfL. The Public Sector Mapping Agreement, which may be varied from time to time, at present, includes the provision of the products listed in table below. Additional products are now made available free to use known as OS Open Data. All products are available free of charge and can be supplied as national coverage. The Public Sector Mapping Agreement, which may be varied from time to time, at present, covers the provision of the following:

PSMA data Product	Update Cycle	Notes
MasterMap; Topography	On Line, Change only update	
MasterMap; Integrated Transport Network inc. Road Routing Information	On Line, Change only update	
1:10,000 Raster	Annual, Change only update	To be withdrawn in 2013
1:50,000 Raster	Annual, Change only update	

PSMA data Product	Update Cycle	Notes
Address-Point	Quarterly	To be replaced by National Address Gazetteer in 2011
Code Point	Quarterly	
Code Point with Polygons	6 Monthly	
1:25,000- Raster	Annual	
Vector Map Local	Annual	
OpenData Product	**Update Cycle**	Notes
1:50,000 Scale Gazetteer	Annual, Change only update	
1:250,000 Colour Raster	Annual	
Boundary-Line	6 Monthly	
Code-Point Open	Quarterly	
Land-Form Panorama	Not Maintained	
Meridian 2	6 Monthly	
MiniScale	Annual	
OS Locator	6 Monthly	
Strategi	Annual	
Vector Map District	Not specified	
Street View	6 Monthly, Change only update	

3.3 Topographical surveys

3.3.1 The Supplier shall appoint a Survey Co-ordinator / Project Manager

3.3.2 The Supplier shall advise the LU Land Survey Manager of the nominated Survey Co-ordinator/Project Manager.

3.3.3 The Supplier's Survey Co-ordinator shall prepare and promote model specifications for the various types of survey carried out.

Note: The following surveys are typically used:

- Land surveys;
- Building surveys:
- Un-connected survey – Using simple methods which do not enable one part of the survey to be related to another, this would not normally be acceptable for LU work;
- Semi-connected survey – One floor (normally the ground floor) is surveyed with all parts connected by instrumental control. Other floors are matched by assuming verticality of common features;
- Fully connected survey – All floors are instrumentally related to a common survey control framework.
- Buried utilities surveys:
- Record information – Underground service information to be taken from statutory or other authorities' record drawings and plotted to agree as closely as possible with surveyed surface features;
- Direct visual surveys – Accessible inspection chamber covers should be lifted where permissible and services positively identified;

- Direct visual surveys supplemented by record drawings – Accessible inspection chamber covers should be lifted where permissible and services positively identified. Routes of services between access points to be taken from record drawings and plotted to agree as closely as possible with surveyed surface features and trench scars where obvious;
- Full investigation including electronic tracing – Services to be fully investigated by visual survey supplemented by electronic, or other tracing of inaccessible routes.
- Track Surveys
- Detailed surveys of track alignment for track design purposes
- Clearance surveys to establish the clearance between line side objects and rolling stock
- Scanned Surveys
- Track trolley mounted scan surveys
- Tripod mounted static scan surveys

3.3.4 The items listed in Attachment 7.8 are typical items for inclusion in the model specifications.

3.3.5 The Supplier shall establish procedures to record and monitor survey activities.

3.3.6 Survey control

3.3.6.1 The Supplier's Survey Co-ordinator shall obtain a list of relevant LU survey stations from the LU Land Survey Data Manager.

3.3.6.2 The Suppliers Survey Co-ordinator shall advise the LU Survey Manager in writing of any inconsistencies or inaccuracies found in the information supplied by the LU Survey Data Manager.

3.3.7 Survey requirements

The survey requirements will be defined in the site specific survey specification. The following should be used as guidance for minimum standards:

3.3.7.1 The maximum planimetric error between permanent survey control stations shall not exceed 1 part in 20,000 for distances exceeding 200 metres. For shorter distances the maximum error shall not be greater than 10mm.

3.3.7.2 The height difference between any two points used as permanent bench marks shall not be in error by more than ± 12 x k mm, where k is the square root of the distance in kilometres between the points being considered, or ± 5mm, whichever is the greater.

3.3.7.3 For Land Surveys:

a) The accuracy of planimetric detail shall be such that the plan position of any well defined point of detail shall be correct to within 0.3mm r.m.s.e. at the plan scale when checked from the nearest permanent control station;

b) Ground survey spot levels on hard surfaces shall be correct to ± 10mm r.m.s.e. and elsewhere to ± 50mm r.m.s.e., except on ploughed or otherwise broken surfaces;

c) At least 90% of all contours shall be correct to within one half of the specified contour interval;

d) Any contour which can be brought within this vertical tolerance by moving its plotted position in any direction by an amount equal to 1/10th of the horizontal

distance between contours, or 0.5mm at plan scale, whichever is the greater, shall be considered as correct.

3.3.7.4 For Building Surveys:

a) The maximum error between permanent survey control stations shall not exceed ± 5mm or 1 part in 10,000 for distances exceeding 50 metres;

b) The height difference between any two points used as permanent bench marks shall not be in error by more than ± 3mm on any floor or by more than ± 1.5mm per metre of height between floors;

c) In fully-controlled surveys the absolute plan position of well defined detail shall be accurate to ± 15mm at 1:50 scale or ± 30mm at 1:100 scale, when checked from the nearest survey control station on that floor;

d) Directly measured figured dimensions shall be quoted to the nearest 0.01 metre;

e) The quoted level of any feature relative to the nearest bench mark on that floor shall be to ± 5mm.

3.3.8 Survey report

3.3.8.1 The Supplier shall ensure a technical report is prepared for each survey.

3.3.8.2 The technical report shall confirm that the survey meets the requirements as laid down in the site specific survey specification.

Note:	The technical report is intended to assist future users in making a judgement about the suitability, quality and accuracy of the survey.

3.3.8.3 The report shall contain details of control points established during the survey.

3.3.8.4 A Survey Station record sheet shall be prepared for each control point which shall contain the information highlighted in Appendix 7.9 and may also contain additional information and photographs.

3.3.8.5 Survey Control point details shall be delivered as a spreadsheet in the form given in Attachment 7.9.

3.3.9 Retention of survey information

3.3.9.1 Survey information shall be retained in a form compliant with the LU Standard 1-691 (Information).

3.3.9.2 CAD information shall comply with LU Standard 1-037 (Computer Aided Design Data).

3.3.9.3 The Supplier's Survey Co-ordinator shall be the custodian of the survey information, and shall supply a copy of the information to the LU Land Survey Manager within one month of completion of the survey.

Note:	The LU Land Survey Manager may release this information, without reference to the Supplier, or their Surveyor, subject to such rules and conditions as may be determined by LU and the requirements of the Freedom of Information Act and the Environmental Information Regulations. Surveys shall be procured so that the IPR in the survey information is vested in LU and IPR issues are not an inhibitor to the free use of survey information within LU..

3.4 Digital tunnel outline maps

Note:	The LU Land Survey Manager is required to maintain maps to show the outline of the London Underground tunnels to supply to internal and external bodies legitimately requiring information about the location of LU infrastructure.

3.4.1 Preparation of digital tunnel outline maps

3.4.1.1 Tunnel outline map files shall be prepared as digital files in Bentley MicroStation Design file (.dgn) format.

3.4.1.2 Individual files shall represent a single line of the Underground network.

3.4.1.3 Separate tunnel outline map files shall be held in two dimensional and three dimensional design file format.

3.4.1.4 Filenames shall use the three letter abbreviation for the line followed by a 2 or 3 to indicate a 2D or 3D file followed by TNL to indicate a Tunnel file, followed by the extension .dgn to indicate a MicroStation design file, e.g. BAK2TNL.dgn

3.4.1.5 The running tunnels and cross passages shall be represented by separate lines showing:

a) intrados at horizontal axis;

b) extrados at horizontal axis;

c) extrados at tunnel crown;

d) intrados at tunnel crown;

e) running edge of rails.

3.4.1.6 Tunnel crown levels related to LU Datum shall be recorded at significant points on the tunnel maps, e.g. changes in section.

3.4.1.7 The following shall be recorded for tunnel linings at change of section and at no greater than 200m intervals:

a) construction material;

b) bolted or expanded;

c) nominal internal diameter;

d) nominal external diameter.

3.4.1.8 A survey reference box shall be displayed adjacent to the survey area, summarising relevant survey reference information.

Note: This information should include:

a) survey drawing numbers, dates, authors;

b) revision and approval dates;

c) general notes and remarks.

A sample survey reference box is shown in Attachment 7.10.

3.4.1.9 The extent of each survey shall be shown with survey flags, annotated where necessary to identify overlapping surveys.

3.4.2 Updating tunnel outline map

The Supplier shall notify LU of updates of the tunnel maps produced from information from measured surveys within one month following their preparation.

3.5 Information management

3.5.1 Survey data

3.5.1.1 The Supplier shall deliver a copy of all completed survey reports, survey drawings and the relevant method statement and specification to the LU Land Survey Manager.

3.5.1.2 All land, utility and building surveys shall be delivered in digital form as two or three dimensional Bentley MicroStation Design File (.dgn) format and include details of how the drawing is structured (levels, colours, style, etc.).

3.5.1.3 Survey information shall include metadata to enable the data to be held in the LU CAD Document Management System conforming to ISO 19115:2003 Geographic information – Metadata.

3.5.2 Survey control information

3.5.2.1 The LU Land Survey Data Manager shall hold and maintain the information as listed in Attachment 7.9 about the LU survey stations.

3.5.2.2 The LU Land Survey Data Manager shall prepare and maintain a network diagram of the LU survey stations.

3.5.2.3 The LU Land Survey Data Manager shall make available details of relevant LU survey stations and the relevant part of the network diagram to surveyors who have been commissioned to carry out survey work for LU.

3.5.2.4 The LU Land Survey Data Manager will assign an accuracy classification to each survey control point, which will be issued to users on request.

3.5.2.5 The Supplier shall advise the LU Land Survey Data Manager in writing of any inconsistencies or inaccuracies in the information supplied by the LU Land Survey Co-ordinator.

3.6 Evidence of compliance

Compliance with the requirements of this standard shall be demonstrated to LU by each party contracted to LU. Additionally LU may audit compliance as part of its surveillance regime.

4 Responsibilities

4.1 **The LU Land Survey Manager** is the custodian of LU survey information. He shall also be responsible for ensuring that the digital tunnel outline maps are updated to include new information from each survey completed.

4.2 **The Supplier** is responsible for appointing a competent Survey Co-ordinator**/Project Manager.**

4.3 **The Supplier's Survey Co-ordinator/Project Manager** is responsible for preparing specifications for survey work, approving Surveyor's Method Statements and the design of survey ground marks. He shall receive data from the Supplier, retain for his record and pass on to the LU Land Survey Manager. He shall update the digital tunnel outline maps and inform LU of the update.

5 Supporting information

5.1 Background

5.1.1 This standard is one of a suite of standards produced by the LU Project Directorate, Engineering Information Manager.

5.1.2 The suite consists of standards as follows:

Standard Number	Title
1-026	Topographical Surveys and Mapping

5.2 Safety considerations

5.2.1 The correct use of survey information and the London Survey Grid is important in establishing the position of the LU Infrastructure especially where this is underground. The use of the incorrect survey grid has been established as a contributory factor involving asset damage and service disruption.

6 Reference Section

6.1 References

6.1.1 National standards

Document no.	Title
ISO 19115	Geographic Information - Metadata

6.1.2 LU company documents

Document no.	Title
1-037	Computer Aided Design Data
1-622	Glossary of terms and abbreviations

6.2 Abbreviations

The following abbreviations are created:

a) within London Underground's Glossary of Terms (1-622) (a Category 1 Standard);
b) from published sources that are clearly identified.

Abbreviation	Definition	Source
CAD	Computer Aided Design	a
DGN	Intergraph MicroStation Design Format	a
ETRS89	European Terrestrial Reference System 1989	a
GPS	Global Positioning System	a
IPR	Intellectual Property Rights	a
JLE	Jubilee Line Extension	a
LU	London Underground	a
OS	Ordnance Survey	a
OSGM02	Ordnance Survey Geoid Model 2002 *www.ordnancesurvey.co.uk/gps/docs/osgm_report.doc*	b

Abbreviation	Definition	Source
r.m.s.e.	Root mean square error	a
WGS 84	World Geodetic System 1984	a

6.3 Definitions

The following topic specific definitions are created:

a) within London Underground's Glossary of Terms (1-622) (a Category 1 Standard);
b) from published sources that are clearly identified.

Term	Definition	Source
Bench mark	a fixed point used for levelling whose height above datum is known	a
Custodian	- a person nominated to be responsible for nominated documents and for their maintenance and update	a
Design file	Computer generated data file containing constituent CAD data file elements of the drawing	a
Easting	distance in metres in the east or west direction from the false origin of the grid	a
ETRS89	The European Terrestrial Reference System 1989 is the standard precise GPS co-ordinate system throughout Europe. In 2000, the difference between the WGS84 and ETRS89 co-ordinates was about 25 cm, and increasing by about 2.5 cm per year. ETRS89 has been officially adopted as a standard co-ordinate system for precise GPS surveying by most national mapping agencies in Europe.	a
JLE Grid	a 'flat earth' projection. With an extent of 11 kilometres the maximum distortion due to ignoring effects of the earth's curvature is 1 part in a million. Original observation and computations were made in 1990. Additional observations were taken in 1992 and the primary network re-computed. Co-ordinates were linked to the OS values at Cheviot House.	a
London Survey Grid	a transverse Mercator projection with parameters chosen to minimise grid distortion caused by curvature of the earth over the LU area	a
LU Land Survey Manager	the person appointed by LU to be the custodian of land survey information for LU.	a
LU survey station	a permanent ground mark co-ordinated to the London Survey Grid and contained on the LU Land Survey Co-ordinator's controlled list of survey stations	a
MicroStation	proprietary two and three dimensional CAD drafting software package supplied by Bentley Systems, Inc.	a
Network diagram	a diagram, not necessarily to scale, showing the relationship between survey stations	a
Northing	distance in metres in the north or south direction from the false origin of the grid	a
OS grid	is the national grid co-ordinate system for Great Britain. The co-ordinate system is based on the transverse Mercator projection, with parameters chosen to cover the whole of Great Britain. More correctly known as British National Grid (BNG) or OSGB36	a
Scale factor	ratio of a distance on the spheroid to that on the grid	a

Term	Definition	Source
Supplier	Supplier to London Underground, the primary organisation or individual that is selected to deliver a product, service or facility to London Underground and contracting directly to London Underground. This includes Consultants, Contractors and PFI Contractors and excludes organisations or individuals selected by and contracting directly to them.	a
Surveyor	an external company or LU manager appropriately qualified and experienced to undertake land survey work	a
True origin	the point where the spheroid and grid are coincident, hence grid north equals true north	a

6.4 Technical content manager

Paragraph number	Technical content manager
All	LU, Project Directorate, Engineering Information Manager

6.5 Document history

Issue no	Date	Changes	Author
R9	July 2007	Standard 2-01030-004 re formatted and re-numbered to 1-026, no technical changes have been made to the content other than changing references to other Standards where their numbers have changed.	
A1	October 2007	Authorised for use. Previous authorisation is valid	
A2	March 2011	Reviewed and revised to change from the term LU Grid to London Survey Grid as per DRACCT No. 0329. Also, Incorporate G-026 into this standard to reflect current best practise in this specialist field and withdraw G-026.	Richard Barrett

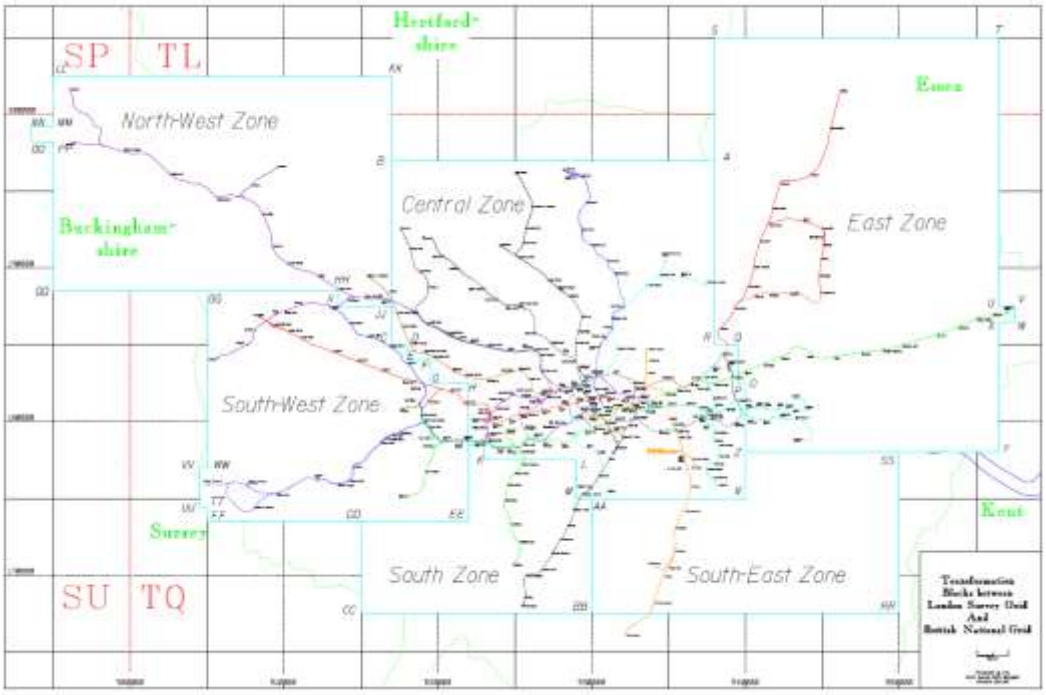
7 Attachments

7.1 London Survey Grid Scale Factors

London Survey Grid eastings	London Survey Grid scale factor	Correction mm per km
48,000	1.0000111	11
49,000	1.0000104	10
50,000	1.0000097	10
51,000	1.0000090	9
52,000	1.0000084	8
53,000	1.0000077	8
54,000	1.0000071	7
55,000	1.0000065	7
56,000	1.0000060	6
57,000	1.0000055	5
58,000	1.0000049	5
59,000	1.0000045	4
60,000	1.0000040	4
61,000	1.0000036	4
62,000	1.0000031	3
63,000	1.0000028	3
64,000	1.0000024	2
65,000	1.0000021	2
66,000	1.0000017	2
67,000	1.0000015	1
68,000	1.0000012	1
69,000	1.0000010	1
70,000	1.0000007	1
71,000	1.0000005	1
72,000	1.0000004	0
73,000	1.0000002	0
74,000	1.0000001	0
75,000	1.0000000	0
76,000	1.0000000	0
77,000	0.9999999	0

London Survey Grid eastings	London Survey Grid scale factor	Correction mm per km
78,000	0.9999999	0
79,000	0.9999999	0
80,000	0.9999999	0
81,000	1.0000000	0
82,000	1.0000001	0
83,000	1.0000002	0
84,000	1.0000003	0
85,000	1.0000005	0
86,000	1.0000006	1
87,000	1.0000008	1
88,000	1.0000011	1
89,000	1.0000013	1
90,000	1.0000016	2
91,000	1.0000019	2
92,000	1.0000022	2
93,000	1.0000026	3
94,000	1.0000029	3
95,000	1.0000033	3
96,000	1.0000038	4
97,000	1.0000042	4
98,000	1.0000047	5
99,000	1.0000052	5
100,000	1.0000057	6
101,000	1.0000063	6
102,000	1.0000068	7
103,000	1.0000074	7
104,000	1.0000080	8
105,000	1.0000087	9
106,000	1.0000094	9
107,000	1.0000101	10

7.2 British National Grid (OSGB36) to London Survey Grid transformation blocks



NOTE: This map contains coloured lines marking the boundaries of the transformation blocks. These may be obscured if this page is reproduced in black and white.

British National Grid Co-ordinates								
Point	**Easting**	**Northing**	**Point**	**Easting**	**Northing**	**Point**	**Easting**	**Northing**
A	538,000	197,000	R	538,000	185,000	II	513,500	187,500
B	517,000	197,000	S	538,000	205,000	JJ	517,000	187,500
C	517,000	185,000	T	556,500	205,000	KK	517,000	202,500
D	518,000	185,000	U	556,500	187,500	LL	495,000	202,500
E	518,000	184,000	V	557,500	187,500	MM	495,000	199,250
F	519,500	184,000	W	557,500	186,500	NN	493,500	199,250
G	519,500	182,500	X	556,500	186,500	OO	493,500	198,250
H	522,000	182,500	Y	556,500	178,000	PP	495,000	198,250
I	522,000	178,500	Z	540,000	178,000	QQ	495,000	188,500
J	523,000	178,500	AA	530,000	175,000	RR	550,000	167,500
K	523,000	177,500	BB	530,000	167,500	SS	550,000	178,000
L	529,000	177,500	CC	515,000	167,500	TT	505,000	174,500
M	529,000	175,000	DD	515,000	173,500	UU	504,500	174,500
N	540,000	175,000	EE	522,000	173,500	VV	504,500	177,000
O	540,000	182,500	FF	505,000	173,500	WW	505,000	177,000
P	539,500	182,500	GG	505,000	188,500			
Q	539,500	185,000	HH	513,500	188,500			

7.3 Factors for conversion between London Survey Grid and British National Grid

	North West area	South West area	Central area	East area	South area	South East area
Rotation (Rot)	358°.55579884	358°.55810730	358°.55752333	358°.55728250	358°.56006098	358°.55962194
Scale factor (SF)	1.000254411	1.000243743	1.000192479	1.000146053	1.000217914	1.000152383
Shift Eastings	-454195.142	-454182.581	-454157.420	-454133.105	-454163.487	-454129.735
Shift Northings	-131867.340	-131886.233	-131872.044	-131861.837	-131899.767	-131885.180
P=SFxCos(Rot)	0.999936674	0.999927024	0.999875520	0.999829003	0.999902061	0.9999836358
Q=SFxSin(Rot)	-0.025209808	-0.025169252	-0.025178154	-0.025181187	-0.025134508	-0.025140520
Note: Rotation is a conventional anticlockwise angle						
For converting British National Grid to London Survey Grid the conversion equations are: $E._{\text{London Survey Grid}} = (E._{\text{British National Grid}} \times P) - (N._{\text{British National Grid}} \times Q)$ + shift Eastings $N._{\text{London Survey Grid}} = (N._{\text{British National Grid}} \times P) + (E._{\text{British National Grid}} \times Q)$ + shift Northings						

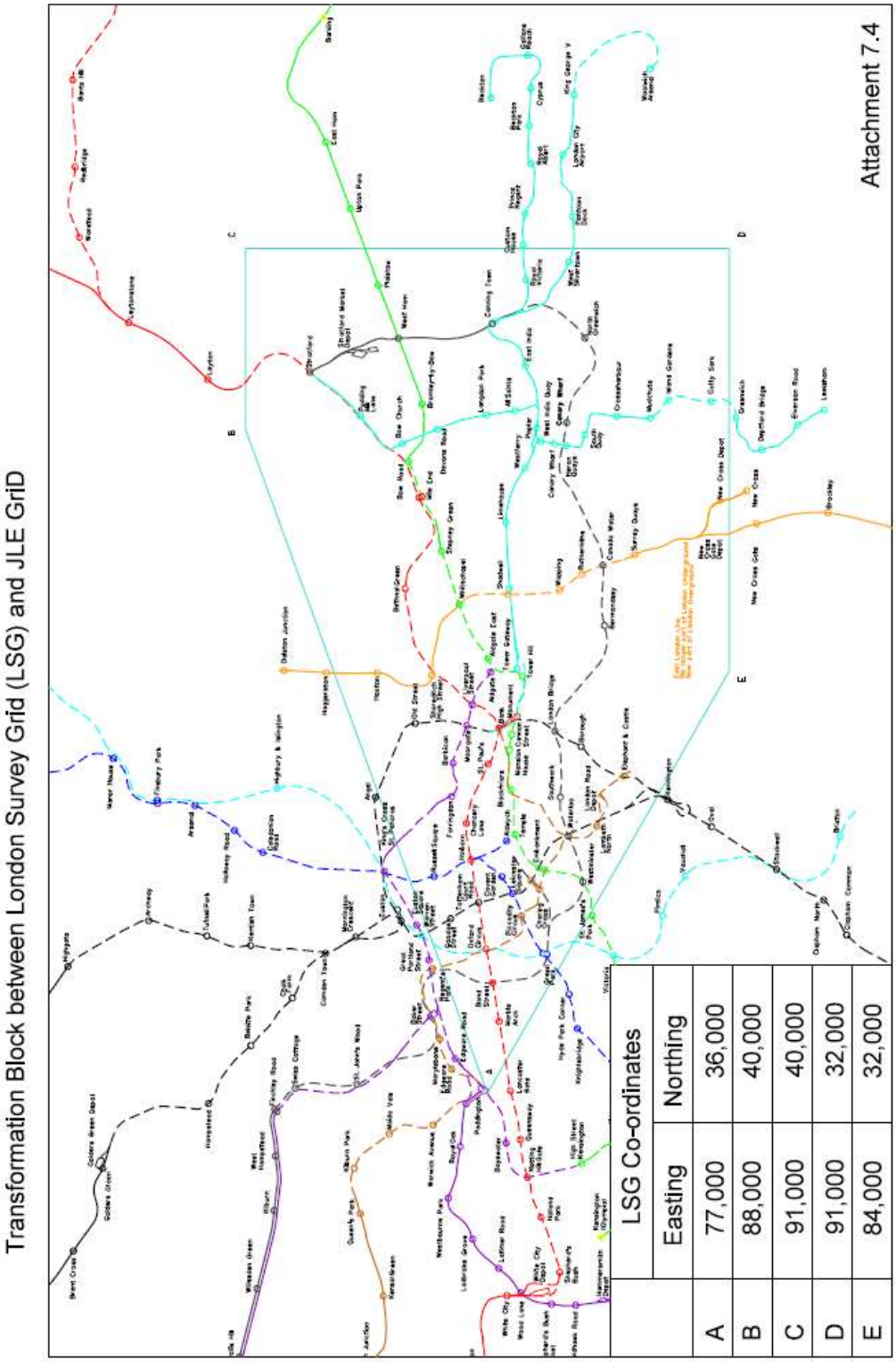
Table 1 Factors for conversion of British National Grid to London Survey Grid

	North West area	South West area	Central area	East area	South area	South East area
Rotation (Rot)	01°.44420116	01°.44189270	01°.44247667	01°.44271751	01°.439938901	01°.44037806
Scale factor (SF)	0.999745653	0.999756316	0.999807558	0.999853968	0.999782133	0.99984764
Shift Eastings	450612.718	450610.266	450607.111	450603.379	450607.363	450602.420
Shift Northings	143236.271	143238.209	143235.329	143233.058	143239.590	143236.998
P=SFxCos(Rot)	0.999428078	0.999439752	0.999490721	0.999537011	0.999466418	0.999531712
Q=SFxSin(Rot)	0.025196986	0.025156987	0.025168464	0.025173833	0.025123557	0.025132860
Note: Rotation is a conventional anticlockwise angle						
For converting London Survey Grid to British National Grid the equations are: $E._{\text{British National Grid}} = (E._{\text{London Survey Grid}} \times P) - (N._{\text{London Survey Grid}} \times Q)$ + shift Eastings $N._{\text{British National Grid}} = (N._{\text{London Survey Grid}} \times P) + (E._{\text{London Survey Grid}} \times Q)$ + shift Northings						

Table 2 Factors for conversion from London Survey Grid to British National Grid

Note: Transformation blocks given in tables 1 and 2 have been created such that the differences along the boundary edges when using adjacent sets of conversion parameters is within the 1:1,250 mapping accuracy of ± 400mm, equivalent to 0.3mm at map scale.

7.4 London Survey Grid to JLE grid transformation block



7.5 Factors for conversion between London Survey Grid and JLE grids

Rotation (Rot)	358°.55814059
Scale factor (SF)	0.99999717553
Shift Eastings	66,231.840 m
Shift Northings	-7,897.815 m
P=SFxCos(Rot)	0.9996805496
Q=SFxSin(Rot)	-0.0251624670
For converting JLE Grid to London Survey Grid the conversion equations are: $E._{\text{London Survey Grid}} = (E._{\text{JLE grid}} \times P) - (N._{\text{JLE survey grid}} \times Q)$ + shift Eastings $N._{\text{London Survey Grid}} = (N._{\text{JLE grid}} \times P) + (E._{\text{JLE survey grid}} \times Q)$ + shift Northings	

Table 3 Factors for conversion from JLE grid to London Survey Grid.

Rotation (Rot)	01°.44185941
Scale factor (SF)	1.00000282446
Shift Eastings	-66,409.786 m
Shift Northings	6,228.771 m
P=SFxCos(Rot)	0.9996861968
Q=SFxSin(Rot)	0.0251626091
For converting London Survey Grid to JLE Grid the conversion equations are: $E._{\text{JLE grid}} = (E._{\text{London Survey Grid}} \times P) - (N._{\text{London Survey Grid}} \times Q)$ + shift Eastings $N._{\text{JLE grid}} = (N._{\text{London Survey Grid}} \times P) + (E._{\text{London Survey Grid}} \times Q)$ + shift Northings	

Table 4 Factors for conversion from London Survey Grid to JLE grid.

Note:	The transformation parameters listed were produced from a survey linking 13 common survey control stations in March 1998. Checks at platform level were made between the London Survey Grid and JLE grid survey stations at Waterloo, London Bridge and Canada Water; the worst linear agreement being 20mm.

7.6 Primary Control Survey Stations

Primary	London Survey Grid				ETRS89		
ID.	Easting	Northing	Level		Latitude	Longitude	Height
Coldharbour Farm	46361.463	51436.772	269.250		51°39'10.70333"N	0°37'07.46043"W	214.518
Woodoak Farm	53381.506	48723.612	181.780		51°37'44.19131"N	0°31'01.61567"W	127.050
Northwood	59856.174	46617.755	172.620		51°36'36.94875"N	0°25'24.60943"W	117.890
Potters Crouch	62699.360	60269.761	218.110		51°43'58.97747"N	0°22'59.03900"W	163.379
Belmont	66880.348	46173.863	205.120		51°36'23.25284"N	0°19'19.52792"W	150.389
Northwick Park	67132.785	43064.558	159.280		51°34'42.66530"N	0°19'06.05689"W	104.550
Richmond Park	68789.410	28207.392	156.040		51°26'42.04359"N	0°17'38.59546"W	101.310
Arkley Reservoir	72798.176	50771.145	244.790		51°38'52.32048"N	0°14'12.27308"W	190.059
Parsonage Farm	73391.128	60967.109	210.250		51°44'22.23903"N	0°13'41.94128"W	155.519
Pollards Hill	80377.022	23572.176	164.900		51°24'12.32820"N	0°07'38.68851"W	110.169
CRP08	85139.159	35988.862	138.710		51°30'53.95951"N	0°03'31.45489"W	83.980
CRP09	89078.330	38845.733	121.470		51°32'26.17548"N	0°00'06.85567"W	66.740
Pole Hill	89084.473	49493.790	191.350		51°38'10.70718"N	0°00'05.35162"W	136.619
Monkhams Hall	89435.862	56969.529	182.990		51°42'12.56647"N	0°00'13.78286"E	128.259
London Cemetery	92293.548	40746.816	113.570		51°33'27.43244"N	0°02'40.24986"E	58.840
Garland Hill	97913.484	23544.634	180.510		51°24'10.22224"N	0°07'28.51579"E	125.778
Dog Kennel Hill	98574.848	46845.271	184.500		51°36'44.06493"N	0°08'07.56697"E	129.769
Little Tawney Hall	101119.124	53502.584	171.720		51°40'19.11488"N	0°10'21.35841"E	116.989
Romford Common	103125.267	46081.679	171.540		51°36'18.70046"N	0°12'03.85359"E	116.809
Little Tomkyns Farm	107520.335	43599.754	174.690		51°34'57.63555"N	0°15'51.47932"E	119.958
North Ockendon	110084.438	39449.241	140.930		51°32'42.84291"N	0°18'03.29210"E	86.199

Primary	British National Grid (OSGB36)			
ID.	Easting	Northing	Level	DESCRIPTION
Coldharbour Farm	495651.749	195811.887	169.250	O.S. Pillar 2nd.Order. Height to bracket
Woodoak Farm	502736.180	193277.140	81.780	O.S. Pillar 3rd.Order. Height to bracket
Northwood	509260.020	191335.609	72.620	Brass Rivet
Potters Crouch	511757.480	205051.440	118.110	O.S. Pillar 3rd.Order. Height to bracket
Belmont	516291.420	191068.930	105.120	O.S. Pillar 3rd.Order. Height to bracket
Northwick Park	516622.066	187967.597	59.280	Brass Rivet
Richmond Park	518651.426	173160.233	56.040	O.S. Pillar 2nd.Order. Height to bracket
Arkley Reservoir	522090.190	195812.700	144.790	O.S. Pillar 3rd.Order. Height to bracket
Parsonage Farm	522425.970	206018.180	110.250	O.S. Pillar 3rd.Order. Height to bracket
Pollards Hill	530349.360	168818.410	64.900	O.S. Pillar 3rd.Order. Height to bracket
CRP08	534797.127	181348.683	38.710	Bolt
CRP09	538662.387	184303.243	21.470	Bolt
Pole Hill	538400.586	194946.428	91.350	O.S. Pillar 2nd.Order. Height to bracket
Monkhams Hall	538563.362	202427.410	82.990	O.S. Pillar 2nd.Order. Height to bracket
London Cemetery	541828.530	186284.370	13.570	Survey Bolt
Garland Hill	547878.520	169231.370	80.510	O.S. Pillar 3rd.Order. Height to bracket
Dog Kennel Hill	547953.500	192538.250	84.500	O.S. Pillar 3rd.Order. Height to bracket
Little Tawney Hall	550328.900	199256.600	71.720	O.S. Pillar 3rd.Order. Height to bracket
Romford Common	552521.150	191889.650	71.540	O.S. Pillar 3rd.Order. Height to bracket
Little Tomkyns Farm	556976.930	189519.450	74.690	O.S. Pillar 3rd.Order. Height to bracket
North Ockendon	559644.340	185435.160	40.930	O.S. Pillar 3rd.Order. Height to bracket

7.7 Form to request the supply of Ordnance Survey digital data

Project Name ……..

	Originator / Authoriser	**Contractor**
	Please complete details below of person in TfL requesting the data for their use or use by their contractors	*If data is requested for distribution to an external contractor complete their details below.*
Contact Name		
Organisation Name		
E-mail address		
PO Box		
Building Name / No.		
Street		
Post Town		
County		
Postcode		
Phone / Fax		

OS Product	Tick Formats Required			
MasterMap, Topography	GZ			
MasterMap, ITN	GZ			
MasterMap CAD version	DGN		DWG	
1:10,000 Scale Raster	TIF			
1:25,000 Scale Raster	TIF			
1:50,000 Scale Raster	TIF			
1:250,000 Scale Raster	TIF			
Address-Point	CSV		NTF	
Code Point with Polygons	MID-MIF			
Code Point	CSV		NTF	
Boundary-Line	NTF		DGN	
Street View	TIF			
VectorMap Local	GZ			
Meridian 2	NTF			

Extent	e.g. A tile list TQ3181 or London Borough Brent etc					

Special Requirements				
Grid System	London Survey Grid		British National Grid	
Updates Required	Yes		No	
Project End Date				
Other Requirements				

Note, all products are available in BNG, MasterMap CAD DGN is also available in LSG

7.8 Typical items for inclusion in a model survey specification

Survey title
Summary of requirements

Description of the site to be surveyed
Site hazards and access arrangements

Survey control
Survey grid and height datum to be used
Horizontal control network, design and accuracy
Vertical control network, design and accuracy
Details of LU survey stations to be used

Mapping
Detail to be surveyed
Accuracy
Additional information required - e.g. names, type

Digital data
Data file structure
Data standards
Data transfer format
Graphical definition requirement

Presentation of final drawings
Size
Colour
Number
Material

Programme
Works programme
Progress reports

Method statement
Survey title
Survey organisation
Project or job name
Job Manager name
Brief description and purpose of the survey
Location of the survey
Brief scope of work
Personnel to be employed
Equipment and resources to be used
Detailed technical methodology
Delivery schedule
Quality checks to be applied
Safety arrangements

Information and materials to be delivered
Sample, proof and final data
Return of information supplied by LU

Technical report
Survey registration number
Survey title
Survey organisation
Project or job name
Brief description and purpose of the survey
Technical specifications for the work
Agreed amendments and variations
Variations to the accepted method statement
The actual delivery schedule
Quality management procedures employed with the results of tests carried out
Horizontal and vertical network diagrams
Abstracts of adjustments to observations carried out showing accuracy of data
List and details of LU survey station and bench marks used
List, details and description of all survey control points and bench marks established

Bill of quantities

7.9 Survey station records

Records should be submitted in a spreadsheet format with the column headings and field formats as shown below. Diagrams to be included in the survey station record should be in Bentley MicroStation Design file (.dgn) format, photographs may be from digital cameras or a scanned graphical image in TIF or JPEG format. All the fields listed should be included in the spreadsheet, the fields shown in **bold** must include data, the remaining columns are optional or may be completed subsequently.

Column Name	Format	Description	Example	Field Length	Obligation
PGM	Text	Survey Station name	*CRP08*	32	**Mandatory**
ORG_EST_MARK	Text	Organisation establishing and checking the survey station	*CROSSRAIL*	50	**Mandatory**
ESTABLISHED_DATE	Date YYYY_MM_DD	Date survey station established	*1996_11_05*	10	**Mandatory**
MARK_DESCRIPTION	Text	Description of the ground mark	*OS 3rd Order Roof Bolt*	50	**Mandatory**
Easting	Number (Double)	Easting	*85139.159*	10	**Mandatory**
Northing	Number (Double)	Northing	*35988.862*	10	**Mandatory**
Height	Number (Double)	Level	*138.71*	8	**Mandatory**
Grid	Text	Information to describe the spatial reference system	*JLE*	12	**Mandatory**
Datum	Text	Information to describe the vertical reference system	*ODN*	12	**Mandatory**
Location_Description	Text	Information to describe the location	*Lambeth North Station Concourse*	100	**Mandatory**
DIAGRAM	Logical	Yes / No	*Y*	1	**Mandatory**
LCS	Text	Location Code	*M154*	5	**Mandatory**
ALIAS	Text	Alternate name or number	*Cheviot House*	32	Optional additional information
Project Description	Text	Information to describe project	*Station Modernisation Project*	50	Optional additional information

Column Name	Format	Description	Example	Field Length	Obligation
Line_Owner	Text	London Underground Line operating trains in location	*Jubilee*	25	Optional additional information
LAST_VISIT_DATE	Date YYYY_MM_DD	Date of last known visit	*1996*	10	Optional additional information
STATUS	Text	Condition at last visit	*ok*	80	Optional additional information
NOTES	Text	Details of any special condition	*24 hours notice required*	80	Optional additional information
ACCESS_INST	Text	Access instructions	*Tel Security office 0207 790 1818*	250	Optional additional information
Diagram_Drawn_By	Text	Author of witness diagram	*CD*	16	Optional additional information
Diagram_Drawn_Date	Date YYYY_MM_DD	Date of drawing completion	*2010_12_25*	10	Optional additional information
Diagram_Verification_By	Text	Authorising authority of witness diagram	*AEL*	16	Optional additional information
Diagram_Verification_Date	Date YYYY_MM_DD	Date witness diagram was checked	*2010_10*	10	Optional additional information
Diagram_Rev	Text	Revision of drawing	*A*	2	Optional additional information
SIN	Text	Code for LU job	*W124*	5	LU use only
CONTROL_ORDER	Text	1st Order, 2nd Order etc	*2nd Order*	9	LU use only
HEIGHT_ORDER	Text	1st Order, 2nd Order etc	*3rd Order*	9	LU use only
Grade	Text	Confidence level in information A, B, C, D, N, S, P	*A*	1	LU use only
PHOTO_Link	URL	Link to digital photographs	*http://intranet.mr.int*	250	LU use only
Drawing_Link	URL	Link to Drawing file of station record sheet	*http://intranet.mr.int*	250	LU use only

Note: Confidence levels are selected from the lookup table in the Survey Control Database

7.10 Sample survey reference box

No.	SURVEY/SOURCE DATA			
AUTHOR				
DATE		REF No.		
TUNNEL UPDATE INFORMATION				
REV	DESCRIPTION	DATE	AUTH.	APP.
COMMENTS				
Plan accuracy Level Accuracy				
File transfer format				

7.11 The Ordnance Survey Contractor Licence Agreement

Introduction

Transport for London is a member of the Public Sector Mapping Agreement which licenses a range of Ordnance Survey data products for use within London Underground. This licence extends to use by London Underground's contractors carrying out work for LU when the contractor enters into an OS Contractor Licence Agreement with LU. The contractor licence agreement may be downloaded from the Ordnance Survey website together with additional information.
http://www.ordnancesurvey.co.uk/oswebsite/business/sectors/government/psma/index.html