Environment Agency

Evidence

Material comparators for end-of-waste decisions

Construction materials: natural limestone aggregate

Report – SC130040/R11

Version 2

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Executive summary

This report details the work carried out to characterise natural limestone aggregate, a key comparator. This information will inform end-of-waste assessments for waste-derived materials intended to replace natural limestone aggregate used in construction.

The Waste Framework Directive (Article 6) provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires the Environment Agency to consider the environmental and human health impacts from materials in comparison with their non-waste material alternatives.

> ‘It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects.’

Market research was used to define natural limestone aggregate as an ordinary comparator and a literature review was used to identify any existing published data.

A limited number of suitable pre-existing datasets were found during the literature review.

Twenty samples of natural limestone aggregate were collected from various suppliers across England. Analytical data from these samples are presented in this report.

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be appropriate or that further analysis or improved treatment processes may be warranted.

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Contents

1 Introduction

To define end-of-waste criteria, the Environment Agency requires a set of ordinary material comparator data for use as a benchmark against which other materials and wastes can be assessed.

The Waste Framework Directive (Article 6) provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires the Environment Agency to consider the environmental and human health impacts from materials in comparison with their non-waste material alternatives.

> 'It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects.'

The purpose of this report is to provide an evidence base of the composition and characteristics of natural limestone aggregate which is defined as an ordinary material comparator that is currently permitted for use in construction.

This report provides the results from the primary analysis of 20 natural limestone aggregate samples.

Two other reports cover ordinary material comparators for construction materials:

- concrete blocks
- non-waste wood for construction and manufacturing

2 Definition

Limestones are sedimentary rocks. For the purpose of this project they can be broadly divided into two types:

- limestone – the dominant carbonate mineral is calcium carbonate
- dolostone and magnesite-stone – the dominant carbonate mineral is magnesium carbonate in the form of dolomite, ankerite or magnesite (Hallsworth and Knox 1999)

The term 'dolomitic' is used where dolomite makes up 10–50% of the carbonate within the limestone (Hallsworth and Knox 1999).

Dolostones and magnesite-stones are defined as carbonate sediments which are dominantly (>50%) composed of magnesium carbonate in the form of dolomite, ankerite or magnesite (Hallsworth and Knox 1999).

Chalk is a type of very fine grained limestone (BGS 2006).

2.1 Material properties relevant to use

Limestone aggregate has been used in the construction industry for many years. Crushed limestone is highly durable, and its low water absorption makes it ideal for outdoor projects such as road building.

In Great Britain, limestone (including dolomite) provides 49% of the crushed rock aggregate produced (BGS 2013). Natural limestone aggregate can be sub-divided in a number of ways including by origin, grading and end use. The three main types are described below.

2.2 Carboniferous limestone

Limestones of Carboniferous age are the major source of limestone aggregate and represent one of the largest resources of good quality aggregate in Britain. These limestones are commonly thickly bedded and consistent, enabling them to be quarried extensively and economically. They typically produce strong and durable aggregates, with low water absorption, suitable for roadstone (sub-base and lower layers) and concreting aggregate. The quality of the limestone resources and their ease and economy of working may be affected by a number of geological factors such as alteration by dolomitisation, degree of faulting and folding (BGS 2013).

Limestone can differ in composition which can affect the end use. For example, the limestones of the Mendips are faulted and folded with many clay-filled fissures contaminating the resource. These limestones are ideal for large-scale quarrying for crushed rock aggregate but are generally unsuitable for high purity industrial uses (BGS 2013). In contrast, the limestones of Derbyshire are flat-lying and noted for their chemical uniformity and consistency over wide areas. They are quarried for industrial use as well as for aggregate (BGS 2013).

Carboniferous limestone is also quarried in parts of the North Pennines, around the fringes of the Lake District, and in North and South Wales (BGS 2013).

2.3 Dolostone/magnesite-stones (dolomitic)

The Permian limestone, which outcrops in a narrow, easterly dipping belt for some 230 km between Newcastle and Nottingham, is mainly dolomite and calcareous dolomite, but in places there is gradation into limestone. These Permian limestones and dolomites are highly variable and are much softer than typical Carboniferous limestone with higher porosity. Hence, they are generally quarried for their industrial uses or for low-grade aggregate applications such as sub-base roadstone and fill. However, some beds are sufficiently strong, sound and durable to be used as concreting aggregate and several quarries near Maltby, South Yorkshire, and near Durham produce high-quality aggregate materials are commonly thickly bedded and consistent (BGS 2013).

2.4 Chalk (Jurassic and Cretaceous limestone)

Some of the Jurassic and Cretaceous (the Chalk) limestones are hard enough to be quarried for less demanding aggregate applications (BGS 2013).

Chalk is used in the manufacture of lime, cement, quicklime, putty, plaster and mortar. As a raw material for building, chalk is very limited as it has little resistance to water and frost, and degrades rapidly. Nevertheless, it can frequently be found as in fill, covered by protective layers, inside walls and buildings (Belchalwell 2013).

3 Comparator sub-types

A total of 20 natural limestone aggregate samples were obtained from a variety of suppliers across England to provide a cross-section of the main types of natural limestone aggregate used in construction. The samples can be further divided into sub-types. Figure 3.1 shows a breakdown of the samples by sub-type.

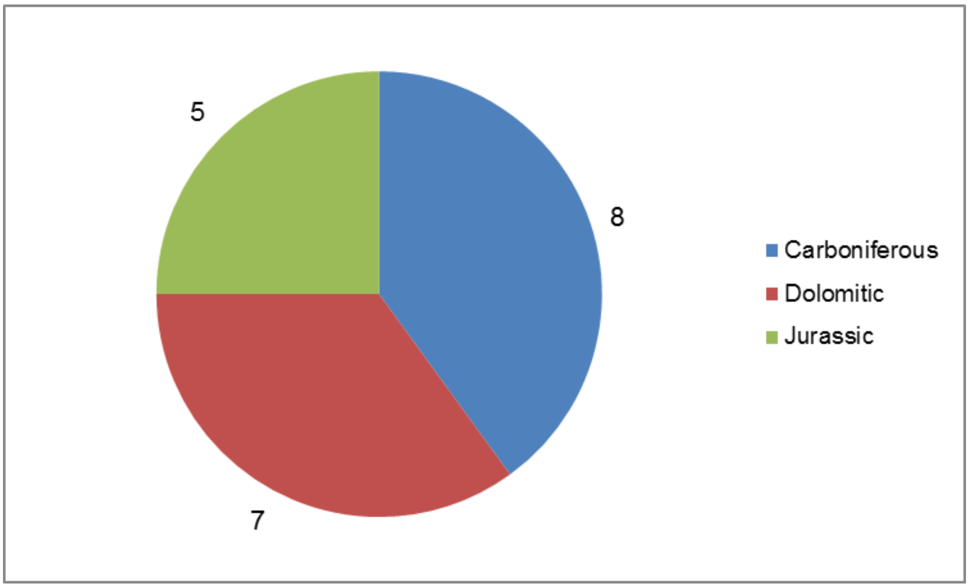

Figure 3.1 Number of natural limestone aggregate samples by sub-type

4 Material sources and sampling procedure

The British Aggregates Association members list (BAA 2005) and the *Directory of Mines and Quarries 2010* (BGS 2010) were used to produce a list of natural limestone aggregate suppliers. Natural limestone aggregate samples were requested from all these suppliers to ensure sampling of a cross-section of limestone types. Samples were collected from those willing to participate.

Samples were taken in accordance with BS EN 932-1:1997 (BSI 1997).

5 Analytical parameters

The main parameters determined, together with units of measurement, are summarised in Tables 5.1 to 5.4.

Testing was carried out in accordance with in-house methods documented by the Environment Agency's National Laboratory Service (NLS) which meet the requirements of the performance standards of the Environment Agency's monitoring certification scheme (MCERTS). Specific tests used are outlined in the tables. Other test methods are available.

In the tables, ‘LE’ refers to the NLS Leeds laboratory and ‘SAL’ refers to Scientific Laboratories Ltd.

Table 5.1 Analysis: physical properties

Parameter/ determinand	Test method used	Unit
Particle size distribution (PSD)	SAL determination of percentage particles. The particle size distribution calculates the percentage of a sample which is distributed via sieving between 2 and 20 mm, between 20 and 50 mm, and over 50 mm. The determination is performed on the >2 mm fraction of the sample (that is, the fraction of the sample that does not pass through the 2 mm sieve).	%
pH	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘as received’ sample	–
Electrical conductivity	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘as received’ sample	mS/cm
Dry solids @ 30°C	LE P soil preparation 01 – sample air dried at <30ºC in a controlled environment until constant weight is achieved	%
Dry solids @ 105°C	LE I dry solids (105ºC) – thermally treated, determined by gravimetry	%
Loss on ignition (LoI) @ 500°C (organic matter content)	Loss on ignition (500ºC) – thermally treated, determined by gravimetry	%
Moisture content	Parameter by calculation	%

Table 5.2 Analysis: metals

Parameter/ determinand	Test method used	Unit
Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, vanadium, zinc	LE I metals (ICP-OES) 01–- digestion block aqua regia extracted under reflux; determined by inductively coupled plasma optical emission spectrometry (ICP-OES)	mg/kg
Chromium VI	Hexavalent chromium by spectrophotometry	mg/kg

Table 5.3 Analysis: organic contaminants

Parameter/ determinand	Test method used	Unit
Polycyclic aromatic hydrocarbons (PAHs) (USEPA16)[1]	Organics dichloromethane (DCM) extracted; hexane exchange determined by gas chromatography–mass spectrometry (GCMS) (scan mode)	µg/kg
Benzene, toluene, ethylbenzene and xylenes (BTEX)	Organics DCM extracted; hexane exchange determined by GCMS (scan mode)	µg/kg
Polychlorinated biphenyls (PCBs)	LE O HRMS3 – dioxins; furans – toluene accelerated solvent extraction (ASE); three-stage clean-up; determined by high resolution GCMS	µg/kg
Hydrocarbons (C5–C44)	LE O EPH >C5-C44 (GC-FID) 01 – hydrocarbon screen including aromatic/aliphatic banding by gas chromatography-flame ionisation detector (GC-FID) from ‘as received’ sample	mg/kg
Hydrocarbons (C10–C40)	LE O EPH >C5-C44 (GC-FID) 01 – hydrocarbon screen including aromatic/aliphatic banding by GC-FID from ‘as received’ sample	mg/kg

Notes: [1] List of 16 PAHs classified by the US Environmental Protection Agency (USEPA) as priority pollutants.

Table 5.4 Analysis: leaching test

Parameter/ determinand	Test method used	Unit
Leaching test	LE P leachability 01– Leaching method – two-stage BS 12457-3 from ‘as received’ sample	mg/kg
Antimony, leachable	Digestion block aqua regia extracted under reflux; determined by inductively coupled plasma mass spectroscopy (ICP-MS)	mg/kg
Arsenic, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Barium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Boron, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-OES	mg/kg
Cadmium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Chromium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Chromium (IV), leachable	Hexavalent chromium by spectophotometry	mg/kg
Copper, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Iron, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-OES	mg/kg
Lead, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Mercury, leachable	Mercury (leach) – by cold vapour atomic	mg/kg

Parameter/ determinand	Test method used	Unit
	fluorescence spectroscopy (CV-AFS); dry weight (DW) result calculated from ‘as received’ sample	
Molybdenum, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Nickel, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Potassium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-OES	mg/kg
Selenium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Sodium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-OES	mg/kg
Vanadium, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Zinc, leachable	Digestion block aqua regia extracted under reflux; determined by ICP-MS	mg/kg
Chloride, leachable	Nutrients (leach) – by colorimetry; DW result calculated from ‘as received’ sample	mg/kg
Fluoride, leachable	Nutrients (leach) – by colorimetry; DW result calculated from ‘as received’ sample	mg/kg
Sulphate, leachable	Anions leach – determined by ion chromatography	mg/kg
Phenols, monohydric leachable	Phenols (leach) – reaction; by colorimetry DW result calculated from ‘as received’ sample	mg/kg
Dissolved organic carbon (DOC), leachable	DOC (leach) – by colorimetry; DW result calculated from ‘as received’ sample	mg/kg
Total dissolved solids (TDS), leachable	TDS (leach) – by gravimetry; DW result calculated from ‘as received’ sample	mg/kg

6 Existing data

A limited number of datasets relating to natural limestone aggregate were identified during the literature review. These data are presented in Tables 6.1 to 6.4.

Table 6.1 Solid composition testing in accordance with BS EN 13657:2002

(a)

Sample ID	Dry matter	Al	Sb	As	Ba	B	Cd	Ca	Cl	Cr	Co	Cu	CN	F	Fe	Pb
	%	mg/kg (DW)														
Limestone A*	97.9	1547	<1	<1	19.1	17.5	<0.02	285692	53.1	10.8	5.6	9.2	<0.1	5.2	4535	<0.5
Limestone A*	99.5	2815	<1	<1	21.9	3.1	<0.02	290677	42.7	10.4	1.6	<0.5	<0.1	5.4	4900	<0.5
Limestone A*	97.6	2037	<1	<1	18.7	4.9	<0.02	313975	35.1	8.0	1.1	<0.5	<0.1	2.4	3712	<0.5
Limestone A*	98.5	2130	<1	<1	22.6	16.8	<0.02	401123	28.5	11.5	1.4	<0.5	<0.1	2.1	3609	<0.5
Limestone B+	97.7	610	<1	<1	798.0	13.2	1.6	393370	20.3	4.9	1.0	<0.5	<0.1	9.4	672	45.5
Limestone B+	98.6	357	<1	<1	871.0	11.0	1.0	378617	24.7	5.0	1.2	<0.5	<0.1	7.5	901	22.9
Limestone B+	97.6	283	<1	<1	622.0	<2.0	1.4	317049	27.5	4.2	1.1	<0.5	<0.1	8.3	420	27.8
Limestone B+	98.5	340	<1	<1	1558.0	11.8	<0.02	311427	31.3	4.9	1.6	<0.5	<0.1	7.8	1091	37.6

(b)

Sample ID	Mg	Mn	Hg	Mo	Ni	K	Se	Na	Si	SO_4	Tl	Sn	V	Zn
	mg/kg (DW)													
Limestone A*	12029	660.0	<0.05	<0.5	18.8	687.0	< 0.5	447	21.2	66.0	<1	<1	10.8	7.7
Limestone A*	3808	221.0	<0.05	<0.5	14.2	1331.0	< 0.5	342	21.8	90.1	<1	<1	9.7	26.4
Limestone A*	3581	199.0	<0.05	<0.5	16.1	861.0	< 0.5	333	109.0	105.0	<1	<1	9.2	50.3
Limestone A*	3532	162.0	<0.05	<0.5	15.9	1189.0	< 0.5	126	52.4	217.0	<1	<1	8.8	15.3
Limestone B+	1390	95.4	<0.05	<0.5	3.8	254.0	< 0.5	120	128.0	52.2	<1	<1	7.5	92.4
Limestone B+	1349	110.0	<0.05	<0.5	3.6	224.0	< 0.5	113	108.0	43.9	<1	<1	8.0	87.4
Limestone B+	1402	95.7	<0.05	<0.5	7.0	<20.0	< 0.5	274	174.0	76.4	<1	<1	8.1	84.5
Limestone B+	1414	112.0	<0.05	<0.5	3.1	72.7	< 0.5	391	115.8	51.9	<1	<1	8.6	87.6

Notes: Data provided by the Environment Agency
*Pre-bagged Type 1 limestone from builders' merchant in north of England
+Pre-bagged Type 1 limestone from builders' merchant in the Midlands

Table 6.2 Upflow percolation column testing in accordance with CEN/TS 14405:2004

(a)

Sample ID	L/S	pH	Conductivity	Eh	Cl	F	SO_4	DOC	CN total
	l/kg		mS/cm	mV	mg/l	mg/l	mg/l	mg/l	mg/l
Limestone A*	0.10	8.07	0.468	402	21.50	0.476	136.00	1.26	0.005
Limestone A*	1.99	8.20	0.143	394	2.10	0.337	24.40	0.50	0.005
Limestone A*	9.89	8.45	0.075	367	2.40	0.200	5.00	0.50	0.005
Limestone A*	0.10	8.15	0.816	426	20.70	0.243	291.00	1.23	0.005
Limestone A*	2.07	8.16	0.232	377	1.78	0.277	52.10	0.51	0.005
Limestone A*	10.00	8.61	0.053	287	1.00	0.200	5.00	0.50	0.005
Limestone A*	0.10	7.86	1.175	412	40.10	0.348	517.00	1.80	0.005
Limestone A*	2.00	7.94	0.194	392	1.59	0.354	45.20	0.52	0.005
Limestone A*	9.94	8.38	0.052	306	1.00	0.200	5.00	0.50	0.005
Limestone A*	0.10	7.69	1.401	415	30.40	0.308	628.00	3.87	0.005
Limestone A*	1.98	7.98	0.247	402	1.65	0.416	63.20	0.50	0.005
Limestone A*	10.01	8.17	0.067	362	1.00	0.200	5.00	0.50	0.005
Limestone B+	0.10	7.93	0.529	392	20.5	1.900	45.50	1.23	0.005
Limestone B+	1.93	7.88	0.097	404	1.00	2.240	7.92	0.50	0.005
Limestone B+	10.02	8.70	0.075	362	1.00	1.690	5.00	0.50	0.005
Limestone B+	0.11	7.80	0.530	402	22.7	1.750	44.40	3.51	0.005
Limestone B+	2.00	7.85	0.092	402	1.00	2.220	7.46	0.52	0.005
Limestone B+	9.92	8.53	0.044	325	1.00	1.560	5.00	0.50	0.005
Limestone B+	0.10	8.03	0.518	387	20.1	1.460	39.50	2.85	0.005
Limestone B+	2.06	8.04	0.093	392	1.00	2.090	6.62	0.53	0.005
Limestone B+	9.93	8.51	0.044	320	1.00	1.570	5.00	0.50	0.005
Limestone B+	0.10	7.91	0.570	412	23.80	1.090	43.10	1.26	0.005
Limestone B+	1.96	8.07	0.110	378	1.26	2.180	8.55	0.71	0.005
Limestone B+	9.95	8.49	0.047	287	6.60	0.200	5.00	0.50	0.005

(b)

Sample ID	L/S	Al	As	B	Ba	Ca	Cd	Co	Cr total	Cr VI
	l/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Limestone A*	0.10	0.00631	0.0013	0.1000	0.14300	56.60	0.00005	0.0003280	0.020900	0.02130
Limestone A*	1.99	0.09850	0.0010	0.0756	0.01520	17.00	0.00005	0.0000500	0.001070	0.00146
Limestone A*	9.89	0.12400	0.0010	0.1010	0.00501	6.53	0.00005	0.0000500	0.000500	0.00040
Limestone A*	0.10	0.00372	0.0010	0.1040	0.07800	120.00	0.00005	0.0006920	0.021600	0.02220
Limestone A*	2.07	0.07100	0.0010	0.0898	0.03110	28.00	0.00005	0.0000636	0.000777	0.00091
Limestone A*	10.00	0.10200	0.0010	0.0900	0.01090	8.12	0.00005	0.0000500	0.000500	0.00040
Limestone A*	0.10	0.00200	0.0010	0.0646	0.03660	202.00	0.00005	0.0010000	0.000500	0.00040
Limestone A*	2.00	0.01900	0.0010	0.0762	0.01330	27.70	0.00005	0.0000914	0.000500	0.00074
Limestone A*	9.94	0.03610	0.0010	0.0895	0.00712	7.62	0.00005	0.0000500	0.000545	0.00040
Limestone A*	0.10	0.00381	0.0010	0.1140	0.06930	257.00	0.00005	0.0029900	0.014100	0.01520
Limestone A*	1.98	0.04620	0.0010	0.0648	0.02830	36.70	0.00005	0.0002210	0.000500	0.00069
Limestone A*	10.01	0.07320	0.0010	0.1060	0.01330	8.31	0.00005	0.0000500	0.000500	0.00040
Limestone B+	0.10	0.00701	0.0010	0.1360	0.08540	71.60	0.00005	0.0001160	0.002500	0.00270
Limestone B+	1.93	0.14000	0.0010	0.1150	0.38200	14.80	0.00005	0.0000500	0.000669	0.00098
Limestone B+	10.02	0.09090	0.0010	0.0773	0.87700	7.54	0.00005	0.0000500	0.000500	0.00040
Limestone B+	0.11	0.00424	0.0010	0.1360	0.08970	72.80	0.00005	0.0001850	0.001860	0.00218
Limestone B+	2.00	0.12600	0.0010	0.1130	0.39300	14.10	0.00005	0.0000500	0.000500	0.00064
Limestone B+	9.92	0.07500	0.0010	0.0846	0.88500	7.57	0.00005	0.0000500	0.000500	0.00040
Limestone B+	0.10	0.00618	0.0010	0.1360	0.09700	73.40	0.00005	0.0001290	0.003290	0.00355
Limestone B+	2.06	0.15000	0.0010	0.1110	0.40100	14.10	0.00005	0.0000500	0.000540	0.00059
Limestone B+	9.93	0.10600	0.0010	0.0837	0.87700	7.54	0.00005	0.0000500	0.000500	0.00040
Limestone B+	0.10	0.00503	0.0010	0.1430	0.10500	78.70	0.00005	0.0001590	0.002200	0.00232
Limestone B+	1.96	0.13800	0.0010	0.1130	0.39800	16.30	0.00005	0.0000500	0.000500	0.00065
Limestone B+	9.95	0.10800	0.0010	0.0800	0.99800	7.65	0.00005	0.0000500	0.000500	0.00040

(c)

Sample ID	L/S	Cu	Fe	Hg	K	Mg	Mn	Mo	Na
	l/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Limestone A*	0.10	0.001	0.004	0.00002	5.570	14.700	0.004540	0.002680	11.700
Limestone A*	1.99	0.001	0.004	0.00002	2.330	4.460	0.000380	0.005450	1.950
Limestone A*	9.89	0.001	0.004	0.00002	0.662	1.610	0.000200	0.001010	0.368
Limestone A*	0.10	0.001	0.004	0.00002	9.110	13.700	0.010800	0.004130	12.200
Limestone A*	2.07	0.001	0.004	0.00002	3.060	3.270	0.000874	0.003480	1.770
Limestone A*	10.00	0.001	0.004	0.00002	0.871	0.899	0.000200	0.001030	0.366
Limestone A*	0.10	0.001	0.004	0.00002	13.700	23.100	0.016800	0.003650	22.200
Limestone A*	2.00	0.001	0.004	0.00002	3.520	3.210	0.000549	0.004620	1.760
Limestone A*	9.94	0.001	0.004	0.00002	0.966	0.895	0.000200	0.000815	0.332
Limestone A*	0.10	0.001	0.004	0.00002	16.300	27.100	0.041300	0.004340	18.700
Limestone A*	1.98	0.001	0.004	0.00002	4.440	3.990	0.002790	0.005490	1.800
Limestone A*	10.01	0.001	0.004	0.00002	1.290	0.908	0.000200	0.000889	0.357
Limestone B+	0.10	0.001	0.004	0.00002	2.180	6.840	0.001940	0.046700	16.600
Limestone B+	1.93	0.001	0.004	0.00002	0.500	1.060	0.000200	0.010900	1.060
Limestone B+	10.02	0.001	0.004	0.00002	0.500	0.217	0.000200	0.001450	0.299
Limestone B+	0.11	0.001	0.004	0.00002	2.210	6.770	0.002550	0.048400	17.200
Limestone B+	2.00	0.001	0.004	0.00002	0.500	0.967	0.000200	0.010800	1.160
Limestone B+	9.92	0.001	0.004	0.00002	0.500	0.220	0.000200	0.001740	0.314
Limestone B+	0.10	0.001	0.004	0.00002	2.390	6.610	0.002220	0.044200	16.600
Limestone B+	2.06	0.001	0.004	0.00002	0.500	0.911	0.000200	0.011300	1.150
Limestone B+	9.93	0.001	0.004	0.00002	0.500	0.207	0.000200	0.001720	0.320
Limestone B+	0.10	0.001	0.004	0.00002	2.580	7.150	0.003600	0.038000	18.000
Limestone B+	1.96	0.001	0.004	0.00002	0.500	1.130	0.000200	0.012600	1.520
Limestone B+	9.95	0.001	0.004	0.00002	0.500	0.240	0.000200	0.001920	0.313

(d)

Sample ID	L/S	Ni	Pb	Sb	Se	Si	Sn	Tl	V	Zn
	l/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Limestone A*	0.10	0.00155	0.000719	0.001540	0.001050	2.540	0.0005	0.000100	0.003980	0.02930
Limestone A*	1.99	0.00050	0.000200	0.001700	0.000842	1.350	0.0005	0.000100	0.001010	0.00200
Limestone A*	9.89	0.00050	0.000200	0.000602	0.001190	1.540	0.0005	0.000100	0.000915	0.00200
Limestone A*	0.10	0.01010	0.000200	0.001930	0.006260	2.590	0.0005	0.000127	0.004020	0.02630
Limestone A*	2.07	0.00111	0.000200	0.001660	0.001420	1.300	0.0005	0.000100	0.000997	0.00200
Limestone A*	10.00	0.00050	0.000200	0.000939	0.001040	1.350	0.0005	0.000100	0.000961	0.00219
Limestone A*	0.10	0.03010	0.000200	0.002000	0.010600	2.800	0.0005	0.000261	0.000304	0.00268
Limestone A*	2.00	0.00242	0.000200	0.002210	0.001360	1.190	0.0005	0.000100	0.000236	0.00200
Limestone A*	9.94	0.00050	0.000200	0.000890	0.001060	1.180	0.0005	0.000100	0.000886	0.00200
Limestone A*	0.10	0.05760	0.000200	0.002680	0.013400	2.830	0.0005	0.000203	0.002920	0.04420
Limestone A*	1.98	0.00578	0.000200	0.002350	0.001730	1.310	0.0005	0.000100	0.000782	0.00200
Limestone A*	10.01	0.00050	0.000200	0.001080	0.001106	1.220	0.0005	0.000100	0.000926	0.00200
Limestone B+	0.10	0.00120	0.000200	0.001990	0.000175	1.560	0.0005	0.000155	0.000531	0.00713
Limestone B+	1.93	0.00050	0.000200	0.001060	0.000400	0.575	0.0005	0.000100	0.000391	0.00200
Limestone B+	10.02	0.00050	0.000200	0.000228	0.000444	1.060	0.0005	0.000100	0.000824	0.00200
Limestone B+	0.11	0.00143	0.000200	0.002990	0.002330	1.610	0.0005	0.000180	0.000489	0.01820
Limestone B+	2.00	0.00050	0.000200	0.001140	0.000363	0.625	0.0005	0.000100	0.000427	0.00200
Limestone B+	9.92	0.00050	0.000200	0.000262	0.000414	1.130	0.0005	0.000100	0.000829	0.00200
Limestone B+	0.10	0.00180	0.000200	0.002050	0.002250	1.850	0.0005	0.000196	0.000639	0.01080
Limestone B+	2.06	0.00050	0.000200	0.001010	0.000391	0.671	0.0005	0.000100	0.000817	0.00334
Limestone B+	9.93	0.00050	0.000200	0.000262	0.000438	1.150	0.0005	0.000100	0.000816	0.00200
Limestone B+	0.10	0.00153	0.000208	0.002060	0.002210	1.960	0.0005	0.000250	0.000672	0.01130
Limestone B+	1.96	0.00050	0.000200	0.001250	0.000406	0.678	0.0005	0.000100	0.000598	0.00200
Limestone B+	9.95	0.00050	0.000200	0.000353	0.000524	1.060	0.0005	0.000100	0.000972	0.00200

Notes: Data provided by the Environment Agency
*Pre-bagged Type 1 limestone from builders merchant in North of England
+Pre-bagged Type 1 limestone from builders merchant in the Midlands
Eh = reduction potential; L/S = liquid solid ratio

Table 6.3 Limestone analysis (parts per million)

(a)

	Al	**As**	**Ba**	**Ca**	**Cd**	**Cl**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**K**	**Mg**	**Mn**	**Mo**
Natural limestone[1]	1627.7	nd	nd	529,770	nd	223.6	nd	nd	nd	978.5	nd	184.6	2716	339.6	nd
Derbyshire, UK – Bee Low Limestones[2]									4	100					
North Pennines, UK – Malham Formation[2]									1	0					

(b)

	Ni	**O**	**Pb**	**S**	**Sb**	**Se**	**Si**	**Sn**	**Sr**	**Tl**	**V**	**Zn**
Natural limestone[1]	nd	221,025	nd	205.3	nd	nd	4484.6	nd	473.2	nd	nd	88.3
Derbyshire, UK – Bee Low Limestones[2]			10									21
North Pennines, UK – Malham Formation[2]			1									9

Notes: [1] WRAP (2008) (nd = not measurable or not detectable by X-ray fluorescence spectrometry)
[2] Harrison (1993)

Table 6.4 Leaching test results

(a)

	As	Ba	Cd	Cr	Cu	Hg	Mo	Ni	Pb	Sb	Se	Zn
	mg/kg (DW)											
Cheddar limestone 4/20 mm [1]	<0.100	<0.100	<0.005	<0.100	<0.100	<0.0020	<0.100	<0.200	<0.5000	<0.040	<0.0200	<0.100
Cheddar limestone 10/20 mm [1]	0.031	0.140	<0.005	<0.010	<0.010	<0.0050	<0.010	<0.010	<0.0100	<0.010	<0.0100	<0.010
Cheddar limestone 4/10 mm [1]	0.050	0.085	<0.005	0.034	0.018	<0.0050	0.019	<0.010	0.0800	<0.010	0.0110	0.160
Peak District limestone 4/20 mm [1]	0.060	2.000	<0.005	1.200	0.086	<0.0050	0.230	0.032	<0.0100	<0.010	0.0210	0.050
Cheddar limestone 10/20 mm [2]	<0.010	<0.10	<0.005	<0.020	<0.050	<0.0020	<0.100	<0.020	<0.0100	<0.010	<0.0200	<0.050
Cheddar limestone 10/20 mm [2]	0.042	0.250	<0.0025	<0.005	<0.005	<0.0025	<0.005	<0.005	0.0055	<0.005	<0.0050	0.031
Cheddar limestone 4/10 mm [2]	0.160	0.650	<0.0025	<0.005	<0.005	<0.0025	<0.005	<0.005	0.0080	<0.005	<0.0050	0.032
Peak District limestone 4/20 mm [1]	0.055	<0.025	<0.0025	<0.005	<0.005	<0.0025	0.0065	<0.005	0.0210	<0.005	<0.0050	<0.005

(b)

	SO_4	Phenols	DOC	TDS	pH	TOC	Total PCB	Total BTEX	Total PAH	TPH	Cl	F
	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)		% C	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)	mg/kg (DW)
Cheddar limestone 4/20 mm [1]	<200.0	<0.50	<10	<2000	7.3		<0.0100	<0.010	<0.0200	<0.10	<20.0	3.1
Cheddar limestone 10/20 mm [1]	64.0	<0.30	59	900	8.5	0.0059	<0.0100	<0.050	<0.0200	<0.10	100.0	2.0
Cheddar limestone 4/10 mm [1]	140.0	<0.30	53	1100	8.2	0.0053	<0.0100	<0.050	<0.0200	<0.10	35.0	2.7
Peak District limestone 4/20 mm [1]	100.0	<0.30	110	28000	12.0	0.0110	<0.0100	<0.050	<0.0200	0.26	1600.0	<10.0
Cheddar limestone 10/20 mm [2]	<240.0	<0.50	<50	<250	7.7		<0.0010	<0.100	0.0038	<0.10	<20.0	<2.0
Cheddar limestone 10/20 mm [2]	2.9	<0.15	14	410	8.0	0.0028	<0.0035	<0.025	<0.0100	0.43	3.8	0.1
Cheddar limestone 4/10 mm [2]	3.4	<0.15	17	395	8.0	0.0033	<0.0035	<0.025	<0.0100	0.60	3.9	0.1
Peak District limestone 4/20 mm [2]	15.0	<0.15	16	435	7.9	0.0031	<0.0035	<0.025	<0.0100	0.48	3.1	2.3

Notes: [1] Test method = BS EN 12457-2:2002
[2] Test method = BS EN 1744-3:2002
Source: WRAP (2007)

7 Primary data

7.1 Statistical analysis of data

All ‘less than’ values were taken as the measured value. The mean, median, minimum, maximum and 90th percentile were calculated for each analyte.

Box plots can be used to graphically represent groups of quantitative data. The sample minimum, lower quartile (Q1), median (Q2), upper quartile (Q3) and sample maximum are used. The median is indicated by the horizontal line that runs across the box. The top of the box is 75th percentile (upper quartile or Q3). The bottom of the box is the 25th percentile (lower quartile or Q1). The interquartile range is represented by the height of the box (Q3 – Q1). A smaller interquartile range indicates less variability in the dataset while a larger interquartile range indicates a variable dataset. Whiskers extend out of the box to represent the sample minimum and maximum. Outliers are plotted as asterisks and are defined as data points that are 1.5 times the interquartile range.

Outliers can adversely affect the statistical analysis by:

- giving serious bias or influence to estimates that may be of less interest
- increasing the error variance and reducing the power of statistical tests
- decreasing normality (if non-random) and altering the odds of type I and II errors

A box and whisker plot of loss on ignition for natural limestone aggregate is shown in Figure 7.1. This diagram demonstrates the issue of outliers in the dataset.

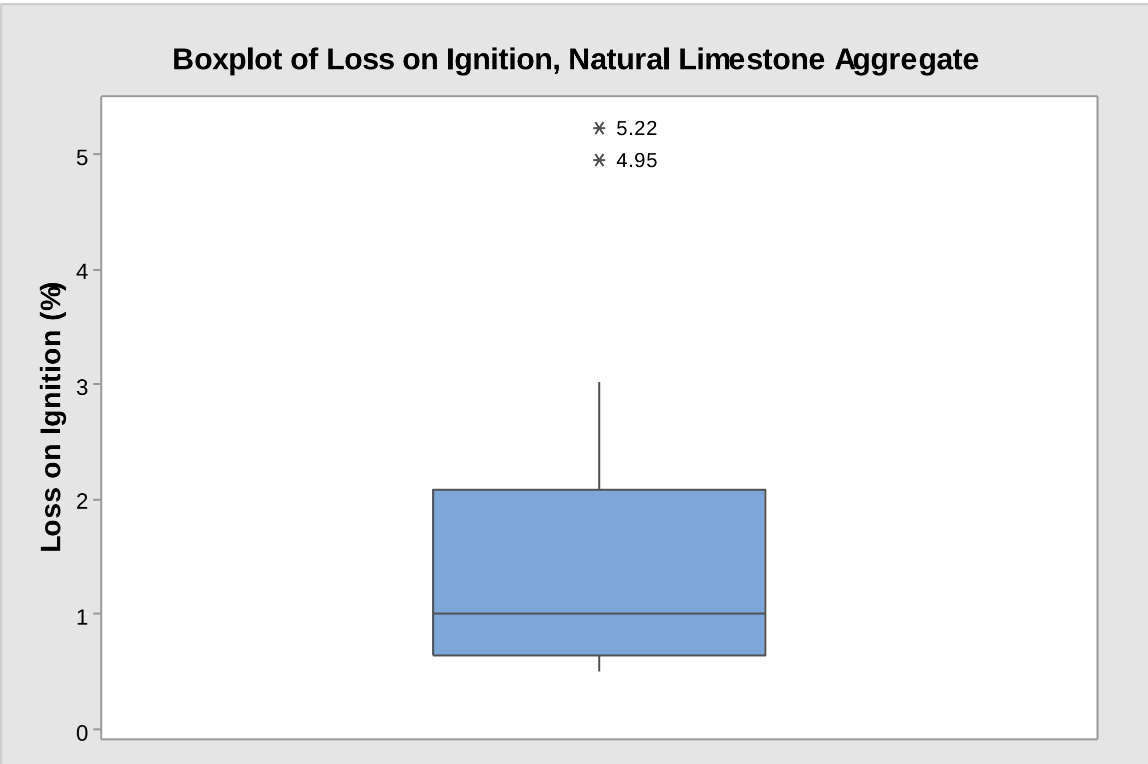

Figure 7.1 Boxplot of loss on ignition for natural limestone aggregate

It is important to provide a reasonable sized dataset for comparison purposes. Where there is sufficient sample size (≥10) to calculate a 90th percentile of the data, the 90th percentile has been calculated.

7.2 Using the data tables

Data are presented in tables summarising:

- physical properties
- metals
- organic contaminants
- leachability

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be appropriate or that further analysis or improved treatment processes may be warranted.

Due to difficulties encountered during sample preparation, the limit of detection (LOD) for some analytes was elevated above the target limit of detection.

7.3 Primary data tables

Primary data are shown in Tables 7.1 to 7.7.

Table 7.1 Primary data for natural limestone aggregate: physical properties

Sample ID	Moisture content air dried @ 105°C	Dry solids @ 30°C	Dry solids @ 105°C	LoI @ 500°C	PSD 2–20 mm	PSD 20–50 mm	PSD > 50 mm	Loose bulk density	Conductivity	pH
	%	%	%	%	%	%	%	kg/m^3	mS/cm	
Limestone 01	0.0	99.3	100.0	4.95	57.4	<0.1	<0.1	1391	0.0724	9.57
Limestone 02	0.0	99.4	100.0	<0.50	74.3	<0.1	<0.1	1395	0.3700	11.00
Limestone 03	3.2	91.5	96.8	0.63	32.4	<0.1	<0.1	1236	0.0852	8.82
Limestone 04	0.1	98.7	99.9	<0.50	66.9	<0.1	<0.1	1430	0.1260	10.10
Limestone 05	6.7	90.6	93.3	1.10	23.3	<0.1	<0.1	1136	0.1070	9.33
Limestone 06	0.5	97.2	99.5	0.67	71.5	<0.1	<0.1	1422	0.4010	10.80
Limestone 07	2.0	94.9	98.0	0.64	44.9	19.1	<0.1	1395	0.0562	9.03
Limestone 08	5.6	93.6	94.4	1.20	12.1	<0.1	<0.1	-	0.0518	9.30
Limestone 09	4.9	94.0	95.1	0.89	11.4	<0.1	<0.1	-	0.0591	9.45
Limestone 10	3.4	96.0	96.6	0.63	5.0	<0.1	<0.1	-	0.0573	9.05
Limestone 11	7.9	90.5	92.1	1.44	4.8	<0.1	<0.1	-	0.0695	9.46
Limestone 12	3.5	95.9	96.5	2.46	14.0	<0.1	<0.1	1322	0.0640	9.55
Limestone 13	1.0	99.4	99.0	1.81	66.5	<0.1	<0.1	1349	0.0913	9.34
Limestone 14	0.3	99.5	99.7	<0.5	45.3	<0.1	<0.1	1225	0.0405	9.23
Limestone 15	0.2	99.2	99.8	1.96	60.8	<0.1	<0.1	1306	0.0475	9.20
Limestone 16	4.4	94.4	95.6	3.02	71.4	<0.1	<0.1	1442	0.1240	10.10
Limestone 17	0.2	98.8	99.8	5.22	58.6	<0.1	<0.1	1298	0.1460	8.89
Limestone 18	1.6	96.8	98.4	0.79	34.1	<0.1	<0.1	1508	0.2780	8.39
Limestone 19	4.0	97.0	96.0	2.11	39.1	<0.1	<0.1	1589	0.0873	9.11
Limestone 20	0.2	99.4	99.8	<0.5	100.0	<0.1	<0.1	1597	0.0524	9.29
Mean	2.5	96.3	97.5	1.58	44.7	1.1	0.1	1378	0.1193	9.45
Median	1.8	96.9	98.2	1.00	45.1	0.1	0.1	1393	0.0788	9.32
Minimum	0	90.5	92.1	0.5	4.8	0.1	0.1	1136	0.0405	8.39
Maximum	7.9	99.5	100	5.22	100	19.1	0.1	1597	0.4010	11.00
No. of samples	20	20	20	20	20	20	20	16	20	20
90^{th} percentile	5.7	99.4	99.9	3.21	71.8	0.1	0.1	1549	0.2872	10.17
LOD	n/a	0.5	0.5	0.5	n/a	n/a	n/a	n/a	0.01	0.20

Notes: – Particle size reduced, loose bulk density test not conducted.
n/a = not applicable

Table 7.2 Primary data for natural limestone aggregate: metals (mg/kg DW)

(a)

Sample ID	Al	Sb	As	Ba	Be	Bo	Cd	Ca	Cr	Cr VI	Co	Cu	Fe	Pb	Li
Limestone 01	267	<1.00	<0.50	14.00	<0.100	1.43	0.308	381000	6.33	<0.6	0.122	2.20	336	1.06	13.60
Limestone 02	524	1.37	1.60	44.00	<0.100	1.84	0.220	371000	7.37	<0.6	0.360	19.10	2370	4.17	13.30
Limestone 03	2660	<1.00	8.35	9.02	0.155	4.41	<0.200	365000	7.11	<0.6	1.340	5.05	6630	1.35	15.50
Limestone 04	786	1.36	<0.50	108.00	<0.100	2.03	2.080	373000	6.32	<0.6	0.545	49.20	1900	14.00	13.60
Limestone 05	723	<1.00	0.60	30.80	<0.100	26.30	0.752	220000	3.77	<0.6	1.020	7.24	3060	16.00	9.95
Limestone 06	3320	2.06	2.37	88.10	<0.100	8.63	0.254	349000	9.11	<0.6	1.240	35.90	5910	25.10	15.50
Limestone 07	2170	<1.00	2.54	36.40	0.149	3.19	0.294	351000	6.94	<0.6	0.825	5.37	2730	7.01	14.80
Limestone 08	1890	<1.00	1.32	7.79	<0.100	5.82	<0.200	325000	3.48	<0.6	0.537	7.22	3510	2.01	12.10
Limestone 09	1460	<1.00	0.73	14.60	<0.100	21.10	0.432	212000	2.67	<0.6	0.384	7.97	1860	16.40	11.70
Limestone 10	1180	<1.00	8.17	7.32	<0.100	3.38	<0.200	331000	3.32	<0.6	1.640	5.31	4390	2.99	11.00
Limestone 11	1230	1.51	1.31	64.20	<0.100	21.00	0.683	193000	4.36	<0.6	0.754	22.60	3040	15.40	9.81
Limestone 12	1350	<20.00	<0.50	16.70	<0.100	11.80	0.727	223000	4.65	<0.6	1.130	22.10	2450	11.30	6.68
Limestone 13	1640	<20.00	1.73	43.80	<0.100	5.40	0.701	351000	6.49	<0.6	0.677	14.10	1470	8.25	12.70
Limestone 14	510	<20.00	0.78	9.22	<0.100	1.53	0.363	380000	5.89	<0.6	0.400	6.25	777	3.21	12.60
Limestone 15	1910	<20.00	1.25	68.20	<0.100	7.24	0.260	321000	12.60	<0.6	0.708	21.30	2180	6.93	12.20
Limestone 16	1180	1.48	1.80	24.50	<0.100	10.60	0.744	212000	5.60	<0.6	3.190	29.40	3690	57.50	4.34
Limestone 17	611	<20.00	0.68	722.00	<0.100	1.50	<0.200	217000	3.06	<0.6	<0.100	8.28	5850	2.39	7.95
Limestone 18	2710	<1.00	6.62	8.50	<0.100	14.10	0.236	340000	9.55	<0.6	0.876	1.82	6210	1.74	16.40
Limestone 19	1450	<1.00	2.47	80.10	<0.100	3.03	4.280	351000	2.71	<0.6	0.734	3.47	2950	12.40	3.34
Limestone 20	348	<1.00	0.62	7.88	<0.100	<1.00	1.080	413000	4.31	<0.6	0.251	1.02	446	12.70	14.40
Mean	1396	5.89	2.22	70.26	0.105	7.77	0.711	313950	5.78	0.6	0.842	13.75	3088	11.10	11.57
Median	1290	1.18	1.32	27.65	0.100	4.91	0.336	344500	5.75	0.6	0.721	7.61	2840	7.63	12.40
Minimum	267	1.00	0.50	7.32	0.100	1.00	0.200	193000	2.67	0.6	0.100	1.02	336	1.06	3.34
Maximum	3320	20.00	8.35	722.00	0.155	26.30	4.280	413000	12.60	0.6	3.190	49.20	6630	57.50	16.40
No. of samples	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
90th percentile	2665	20.00	6.78	90.09	0.105	21.01	1.180	380100	9.15	0.6	1.370	30.05	5940	17.27	15.50
LOD	50	1	0.5	0.5	0.1	1	0.2	60	0.5	0.6	0.1	1	200	1	1

(b)

Sample ID	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	Tl	Sn	Ti	V	Zn
Limestone 01	3540	96	<0.2	<1	1.26	19.4	141	<1	<1	69	297.0	<1	<1.00	<3.0	5.45	13.9
Limestone 02	1400	329	<0.2	<1	2.13	153.0	177	<1	<1	208	436.0	<1	1.11	30.0	12.70	28.1
Limestone 03	2860	128	<0.2	<1	4.79	107.0	704	<1	<1	204	309.0	<1	<1.00	33.7	13.50	18.6
Limestone 04	1010	117	<0.2	<1	2.06	105.0	146	<1	<1	252	135.0	<1	2.26	47.4	3.49	50.7
Limestone 05	108000	626	<0.2	<1	1.43	55.2	299	<1	<1	209	81.1	<1	<1.00	10.5	3.46	37.1
Limestone 06	2880	219	<0.2	<1	10.40	194.0	1180	<1	<1	496	175.0	<1	4.52	98.4	6.12	65.5
Limestone 07	1690	314	<0.2	<1	3.21	78.2	585	<1	<1	75.3	271.0	<1	<1.00	18.3	5.75	13.7
Limestone 08	3270	260	<0.2	<1	2.13	151.0	841	<1	<1	225	279.0	<1	<1.00	21.5	6.72	21.3
Limestone 09	105000	227	<0.2	<1	1.50	70.2	620	<1	<1	418	89.5	<1	<1.00	19.7	4.38	57.1
Limestone 10	3160	432	<0.2	<1	1.77	433.0	398	<1	<1	227	334.0	<1	<1.00	21.0	11.60	18.2
Limestone 11	101000	286	<0.2	<1	2.84	117.0	507	<1	<1	538	65.8	<1	4.56	49.5	2.88	99.0
Limestone 12	128000	590	<0.2	<1	3.07	95.9	588	<1	<1	450	57.4	<1	1.50	29.6	2.45	81.1
Limestone 13	25600	174	<0.2	<1	5.01	91.2	811	<1	<1	277	256.0	<1	1.29	34.5	6.02	57.5
Limestone 14	3760	93.3	<0.2	<1	2.28	38.7	228	<1	<1	138	228.0	<1	<1.00	10.4	2.47	20.7
Limestone 15	36500	115	<0.2	<1	5.57	175.0	1030	<1	<1	307	215.0	<1	1.65	41.5	4.38	45.2
Limestone 16	125000	692	<0.2	<1	6.43	137.0	346	<1	<1	486	27.3	<1	3.27	41.9	2.59	241.0
Limestone 17	119000	1620	<0.2	<1	3.20	95.2	300	<1	<1	511	59.6	<1	<1.00	11.1	3.66	14.2
Limestone 18	1580	111	<0.2	<1	5.29	81.3	1300	<1	<1	168	299.0	<1	<1.00	4.32	15.60	20.7
Limestone 19	7360	262	<0.2	<1	5.39	320.0	614	<1	<1	143	814.0	<1	<1.00	<3.0	3.98	448.0
Limestone 20	1200	135	<0.2	<1	1.10	25.8	176	<1	<1	54.6	262.0	<1	<1.00	<3.0	3.54	12.8
Mean	39091	341	0.2	1	3.54	127.2	550	1	1	273	234.5	1	1.61	26.6	6.04	68.2
Median	3650	244	0.2	1	2.96	100.5	546	1	1	226	242.0	1	1.00	21.3	4.38	32.6
Minimum	1010	93	0.2	1	1.10	19.4	141	1	1	55	27.3	1	1.00	3	2.45	12.8
Maximum	128000	1620	0.2	1	10.40	433.0	1300	1	1	538	814.0	1	4.56	98.4	15.60	448.0
No. of samples	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
90^{th} percentile	119600	633	0.2	1	5.66	206.6	1045	1	1	498	344.2	1	3.40	47.6	12.78	113.2
LOD	20	2	0.2	1	0.6	10	50	1	1	10	1	1	1	3	0.1	2

Table 7.3 Primary data for natural limestone aggregate: hydrocarbon screen (mg/kg DW)

Sample ID	Hydrocarbons C5–C44	Hydrocarbons C10– C40
Limestone 01	<50.0	<50.0
Limestone 02	<50.0	<50.0
Limestone 03	<50.0	<50.0
Limestone 04	<50.0	<50.0
Limestone 05	<50.0	<50.0
Limestone 06	<50.0	<50.0
Limestone 07	<50.0	<50.0
Limestone 08	<50.0	<50.0
Limestone 09	61.5	<50.0
Limestone 10	<50.0	<50.0
Limestone 11	<50.0	66.6
Limestone 12	<50.0	<50.0
Limestone 13	<50.0	<50.0
Limestone 14	<50.0	<50.0
Limestone 15	<50.0	<50.0
Limestone 16	51.5	<200.0
Limestone 17	<50.0	66.6
Limestone 18	82.9	<50.0
Limestone 19	<50.0	<100.0
Limestone 20	122.0	<50.0
Mean	55.9	61.7
Median	50.0	50.0
Minimum	50.0	50.0
Maximum	122.0	200.0
No. of samples	20	20
90^{th} percentile	63.6	69.9
LOD	50	50

Table 7.4 Primary data for natural limestone aggregate: PAHs (USEPA 16) (μg/kg DW)

(a)

Sample ID	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene
Limestone 01	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 02	1.95	<1.00	<20	<20	26.9	39	22.00	<20.0
Limestone 03	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 04	0.156	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 05	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 06	0.301	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 07	6.570	3.33	<20	114	130.0	176	102.00	55.3
Limestone 08	0.343	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 09	0.520	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 10	0.258	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 11	0.550	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 12	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 13	3.550	2.20	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 14	0.311	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 15	0.742	1.03	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 16	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 17	<0.100	<1.00	<20	<20	<20.0	<20	<6.00	<20.0
Limestone 18	0.441	<1.00	<20	<20	<20.0	<20	8.31	<20.0
Limestone 19	<0.800	<8.00	<200	<200	<200	<200	<50.00	<200.0
Limestone 20	<0.900	<9.00	<200	<200	<200	<200	<60.00	<200.0
Mean	0.900	1.93	38	43	43.8	47	16.62	39.8
Median	0.327	1.00	20	20	20.0	20	6.00	20.0
Minimum	0.1	1.00	20	20	20.0	20	6.00	20.0
Maximum	6.570	9.00	200	200	200.0	200	102.00	200.0
No. of samples	20	20	20	20	20	20	20	20.0
90th percentile	2.110	3.80	38	123	137.0	178	51.00	69.8
LOD	0.1	1	20	20	20	20	6	20

(b)

Sample ID	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Limestone 01	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 02	<30	4.01	39.9	<10	<30	<10.0	<20.0	36.4
Limestone 03	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 04	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 05	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 06	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 07	123	25.40	222.0	<10	151	11.9	75.1	202.0
Limestone 08	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 09	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 10	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 11	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 12	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 13	<30	<3.00	<20.0	10	<30	20.2	51.9	<20.0
Limestone 14	<30	<3.00	<20.0	<10	<30	10.1	<20.0	<20.0
Limestone 15	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 16	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 17	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 18	<30	<3.00	<20.0	<10	<30	<10.0	<20.0	<20.0
Limestone 19	<200	<20.0	<200.0	<80	<200	<80.0	278.0	<200.0
Limestone 20	<300	<30.0	<200.0	<90	<300	<90.0	<200.0	<200.0
Mean	57	6.37	49.1	18	58	18.1	46.3	47.9
Median	30	3.00	20.0	10	30	10.0	20.0	20.0
Minimum	30	3.00	20.0	10	30	10.0	20.0	20.0
Maximum	300	30.00	222.0	90	300	90.0	278.0	202.0
No. of samples	20	20.00	20	20	20	20	20	20
90th percentile	131	20.54	200.0	17	156	26.2	87.6	200.0
LOD	30	3	20	10	30	10	20	20

Table 7.5 Primary data for natural limestone aggregate: PCBs (μg/kg DW)

(a)

Sample ID	PCB-008	PCB-020	PCB-028	PCB-035	PCB-052	PCB-077	PCB-101	PCB-105	PCB-118
Limestone 01	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 02	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 03	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 04	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 05	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 06	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 07	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 08	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 09	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 10	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 11	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 12	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 13	<2	<2	<2	<2	<1	<2	<200	<1	<100
Limestone 14	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 15	<2	<2	<2	<2	<1	<2	<5	<1	<4
Limestone 16	<2	<2	<4	<2	<1	<2	<2	<1	<1
Limestone 17	<2	<2	<2	<2	<1	<2	<300	<60	<200
Limestone 18	<2	<2	<2	<2	<1	<2	<2	<1	<1
Limestone 19	<20	<20	<2	<20	<8	<20	<20	<8	<8
Limestone 20	<20	<20	<2	<20	<9	<20	<20	<9	<9
Mean	4	4	2	4	2	4	29	5	17
Median	2	2	2	2	1	2	2	1	1
Minimum	2	2	2	2	1	2	2	1	1
Maximum	20	20	4	20	9	20	300	60	200
No. of samples	20	20	20	20	20	20	20	20	20
90^{th} percentile	4	4	2	4	2	4	38	8	18
LOD	2	2	2	2	1	2	2	1	1

(b

Sample ID	PCB-126	PCB-128	PCB-138	PCB-149	PCB-153	PCB-156	PCB-169	PCB-170	PCB-180
Limestone 01	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 02	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 03	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 04	2.08	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 05	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 06	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 07	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 08	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 09	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 10	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 11	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 12	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 13	<100	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 14	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 15	<7.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 16	<1.00	<1	<1	<1	<1	<0.9	<0.9	<4	<1
Limestone 17	<200	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 18	<1.00	<1	<1	<1	<1	<0.9	<0.9	<2	<1
Limestone 19	<8.00	<8	<8	<8	<8	<7.0	<7.0	<8	<8
Limestone 20	<9.00	<9	<9	<9	<9	<8.0	<8.0	<2	<9
Mean	17	2	2	2	2	1.6	1.6	2	2
Median	1.00	1	1	1	1	0.9	0.9	2	1
Minimum	1.00	1	1	1	1	0.9	0.9	2	1
Maximum	200	9	9	9	9	8.0	8.0	8	9
No. of samples	20	20	20	20	20	20	20	20	20
90th percentile	18.10	2	2	2	2	1.5	1.5	2	2
LOD	1	1	1	1	1	0.9	0.9	2	1

Table 7.6 Primary data for natural limestone aggregate: BTEX (µg/kg DW)

Sample ID	**1,2-Dimethylbenzene [*o*-Xylene]**	**Benzene**	**Dimethylbenzene sum of (1,3- 1,4-)**	**Ethylbenzene**	**Toluene [Methylbenzene]**
Limestone 01	<1	<1.00	<3	<0.7	<4.00
Limestone 02	<1	<1.00	<2	<0.6	<3.00
Limestone 03	<1	<1.00	<2	<0.6	<4.00
Limestone 04	<1	<1.00	<2	<0.5	<3.00
Limestone 05	<1	<1.00	<3	<0.7	<4.00
Limestone 06	<1	<1.00	<2	<0.5	<3.00
Limestone 07	<1	<1.00	<2	<0.6	<3.00
Limestone 08	<1	<1.00	<2	<0.5	<3.00
Limestone 09	<1	<1.00	<2	<0.5	<3.00
Limestone 10	<1	<1.00	<2	<0.5	<3.00
Limestone 11	<1	<1.00	<2	<0.5	<3.00
Limestone 12	<1	<1.00	<2	<0.5	<3.00
Limestone 13	<1	2.61	<2	<0.5	3.78
Limestone 14	<1	<1.00	<2	<0.5	<3.00
Limestone 15	<1	1.65	<2	<0.5	3.20
Limestone 16	<1	<1.00	<2	<0.5	<3.00
Limestone 17	<1	<1.00	<2	<0.5	<3.00
Limestone 18	<1	<1.00	<2	<0.5	<3.00
Limestone 19	<1	<1.00	<2	<0.5	<3.00
Limestone 20	<1	<1.00	<2	<0.5	<3.00
Mean	1	1.11	2	0.5	3.20
Median	1	1.00	2	0.5	3.00
Minimum	1	1.00	2	0.5	3.00
Maximum	1	2.61	3	0.7	4.00
No. of samples	20	20	20	20	20
90^{th} percentile	1	1.07	2.1	0.6	4.00
LOD	1	1	2	0.5	3

Table 7.7 Primary data for natural limestone aggregate: leachable (mg/kg DW)

(a)

Sample ID	Sulphate, leachable as SO_4	Chloride, leachable	Fluoride, leachable	Monohydric phenols, leachable	TDS, leachable	DOC, leachable as C
Limestone 01	210.0	<148	1.040	<0.4	959	11.40
Limestone 02	177.0	<161	<0.500	<0.4	927	10.40
Limestone 03	222.0	<130	2.100	<0.4	755	10.60
Limestone 04	106.0	<131	<0.500	<0.4	588	5.42
Limestone 05	65.1	<114	1.450	<0.4	<306	3.69
Limestone 06	260.0	<178	3.990	<0.4	906	11.50
Limestone 07	256.0	<140	<0.520	<0.4	1130	25.00
Limestone 08	150.0	<118	2.490	<0.4	<647	7.33
Limestone 09	129.0	<146	3.540	<0.4	571	7.72
Limestone 10	204.0	<144	3.140	<0.4	612	9.64
Limestone 11	379.0	<246	<1.710	<0.4	1410	22.00
Limestone 12	201.0	<228	1.920	<0.4	1350	17.90
Limestone 13	260.0	<169	2.460	<0.4	781	18.00
Limestone 14	80.6	<113	1.300	<0.4	<218	7.48
Limestone 15	182.0	<144	3.250	<0.4	<400	7.77
Limestone 16	377.0	<256	1.030	<0.4	1610	16.70
Limestone 17	155.0	<414	1.370	<0.4	1160	9.90
Limestone 18	345.0	<100	0.884	<0.4	793	6.02
Limestone 19	127.0	<100	1.330	<0.4	<451	<5.99
Limestone 20	<333.0	<100	<0.595	<0.4	<443	3.36
Mean	210.9	164	1.756	0.4	801	10.89
Median	202.5	144	1.410	0.4	768	9.77
Minimum	65.1	100	0.500	0.4	218	3.36
Maximum	379.0	414	3.990	0.4	1610	25.00
No. of samples	20	20	20	20	20	20
90^{th} percentile	348.2	247	3.279	0.4	1356	18.40
LOD	50	100	0.5	0.4	1	2

(b)

Sample ID	Sb, leachable	As, leachable	Ba, leachable	Bo, leachable	Cd, leachable	Cr, leachable	Cr VI, leachable	Cu, leachable	Fe, leachable
Limestone 01	0.1750	<0.0080	0.984	<2.62	<0.001	0.1190	<0.0733	0.0747	<2.050
Limestone 02	0.1500	<0.0080	0.370	<2.57	<0.001	0.0967	<0.0613	0.0549	<1.990
Limestone 03	0.0880	<0.0121	0.115	<2.55	<0.001	0.0785	<0.0662	0.0431	<2.090
Limestone 04	0.0857	<0.0080	2.280	<2.61	<0.001	0.0610	<0.0479	0.0492	<2.040
Limestone 05	0.0364	<0.0080	0.256	<2.52	<0.001	<0.0215	<0.0300	0.0170	<1.940
Limestone 06	0.1560	<0.0080	0.727	<2.60	<0.001	0.1030	<0.0674	0.0614	<2.030
Limestone 07	0.1690	<0.0080	0.169	<2.61	<0.001	0.1260	<0.0748	0.1790	<2.070
Limestone 08	0.0798	<0.0080	<0.100	<1.00	<0.001	0.0461	<0.0514	<0.0202	<0.311
Limestone 09	0.1460	<0.0080	0.375	<1.00	<0.001	0.0601	<0.0555	0.0357	<0.300
Limestone 10	0.1250	<0.0080	0.168	<1.00	<0.001	0.0886	<0.0655	0.0469	<0.300
Limestone 11	0.2870	<0.0080	1.540	<1.00	<0.001	0.1400	0.0584	0.1060	<0.300
Limestone 12	0.2170	<0.0080	0.497	<1.01	<0.001	0.0704	<0.0340	0.0353	<0.300
Limestone 13	0.2270	<0.0080	1.120	<1.05	<0.001	0.1230	<0.0733	0.0790	<0.790
Limestone 14	0.0785	<0.0080	0.226	<1.00	<0.001	0.0510	<0.0300	0.0317	<0.330
Limestone 15	0.1270	<0.0080	1.840	<1.03	<0.001	0.0713	<0.0408	0.0468	<0.300
Limestone 16	0.3310	<0.0080	0.812	<1.00	<0.001	0.0966	<0.0509	0.0681	<0.300
Limestone 17	0.1230	<0.0080	3.980	<1.00	<0.001	0.0432	<0.0300	0.0420	<0.300
Limestone 18	<0.0100	<0.0080	<0.106	<2.56	<0.001	<0.0052	<0.0300	<0.0616	<0.300
Limestone 19	<0.0103	<0.0080	1.380	<1.00	<0.001	<0.0050	<0.0300	<0.0101	<0.300
Limestone 20	<0.0100	<0.0080	<0.100	<1.00	<0.001	0.0070	<0.0300	<0.0100	<0.300
Mean	0.1316	0.0082	0.857	1.64	0.001	0.0707	0.0500	0.0536	0.932
Median	0.1260	0.0080	0.436	1.02	0.001	0.0709	0.0512	0.0469	0.306
Minimum	0.0100	0.0080	0.100	1.00	0.001	0.0050	0.0300	0.0100	0.300
Maximum	0.3310	0.0121	3.980	2.62	0.001	0.1400	0.0748	0.1790	2.090
No. of samples	20	20	20	20	20	20	20	20	20
90th percentile	0.2330	0.0080	1.884	2.61	0.001	0.1233	0.0733	0.0817	2.052
LOD	0.01	0.008	0.1	1	0.001	0.005	not given	0.01	0.3

(c)

Sample ID	**Pb, leachable**	**Hg, leachable**	**Mo, leachable**	**Ni, leachable**	**K, leachable**	**Se, leachable**	**Na, leachable**	**V, leachable**	**Zn, leachable**
Limestone 01	<0.0434	<0.000105	<0.0402	<0.0100	19.5	<0.0100	31.00	0.0941	0.0752
Limestone 02	<0.0253	<0.000104	<0.0489	<0.0100	20.4	<0.0100	38.00	0.0999	0.0503
Limestone 03	<0.0200	<0.000104	0.0896	<0.0100	17.0	<0.0100	25.60	<0.0226	0.0662
Limestone 04	<0.0216	<0.000104	<0.0404	<0.0103	<13.9	<0.0100	22.00	0.0694	0.0530
Limestone 05	<0.0200	<0.000104	<0.0331	<0.0100	<10.2	<0.0100	14.50	<0.0200	0.0407
Limestone 06	<0.0202	<0.000104	<0.0451	<0.0100	20.5	<0.0100	45.80	0.0777	0.0490
Limestone 07	<0.0223	<0.000104	<0.0367	<0.0102	20.7	<0.0100	28.20	0.1170	0.0591
Limestone 08	<0.0200	<0.000118	<0.0531	<0.0100	27.7	<0.0100	26.10	<0.0274	0.1960
Limestone 09	<0.0200	<0.000118	<0.0369	<0.0100	18.4	<0.0100	39.00	<0.0330	0.1840
Limestone 10	<0.0200	<0.000118	0.0630	<0.0100	21.6	<0.0100	36.80	0.0537	0.1690
Limestone 11	<0.0200	<0.000118	0.0940	<0.0135	42.9	<0.0100	97.10	0.0992	0.1520
Limestone 12	<0.0200	<0.000105	<0.1210	<0.0100	25.3	<0.0100	74.30	0.0841	<0.2490
Limestone 13	<0.0200	<0.000105	0.0621	<0.0115	30.6	<0.0100	49.70	0.1830	<0.1040
Limestone 14	<0.0212	<0.000104	<0.0343	<0.0148	<9.8	<0.0100	18.20	0.0659	0.1140
Limestone 15	<0.0200	<0.000105	<0.1610	<0.0103	26.0	<0.0152	38.00	0.1180	<0.0999
Limestone 16	<0.0200	<0.000104	<0.0339	<0.0100	34.8	<0.0100	84.60	0.0803	<0.0770
Limestone 17	<0.0200	<0.000104	<0.0342	<0.0166	24.4	<0.0100	123.00	0.0412	<0.1010
Limestone 18	<0.0200	<0.000104	0.0789	<0.0101	10.6	<0.0108	<6.48	<0.0200	0.0419
Limestone 19	<0.0200	<0.000118	0.0667	<0.0100	7.3	<0.0171	<5.12	<0.0200	<0.0790
Limestone 20	<0.0200	<0.000118	<0.0398	<0.0100	<4.3	<0.0100	<6.75	<0.0200	<0.0795
Mean	0.0217	0.000108	0.0606	0.0109	20.3	0.0107	40.51	0.0673	0.1020
Median	0.0200	0.000105	0.0470	0.0100	20.5	0.0100	33.90	0.0677	0.0793
Minimum	0.0200	0.000104	0.0331	0.0100	4.3	0.0100	5.12	0.0200	0.0407
Maximum	0.0434	0.000118	0.1610	0.0166	42.9	0.0171	123.00	0.1830	0.2490
No. of samples	20	20	20	20	20	20	20	20	20
90^{th} percentile	0.0226	0.000118	0.0967	0.0136	31.0	0.0112	85.85	0.1171	0.1852
LOD	0.02	0.0001	0.02	0.01	4	0.01	3	0.02	0.03

References

BAA, 2005. *Alphabetical listing of BAA members* [online]. Lanark: British Aggregates Association. Available from: http://www.british-aggregates.co.uk/directory/az_members.html [Accessed 25 July 2014].

BELCHALWELL, 2013. *Chalk (calcium carbonate ($CaCO_3$)* [online]. Available from: http://archive.today/www.belchalwell.org.uk [Accessed 25 July 2014].

BGS, 2006. *Mineral planning factsheet, limestone*. Keyworth, Nottingham: British Geological Society.

BGS, 2010. *Directory of mines and quarries 2010* [online]. Keyworth, Nottingham: British Geological Society. Available from: https://www.bgs.ac.uk/mineralsuk/mines/dmq.html [Accessed 25 July 2014].

BGS, 2013. *Mineral planning factsheet, construction aggregates.* Keyworth, Nottingham: British Geological Society.

BSI, 2007. B*S EN 932-1:1997 Tests for general properties of aggregates. Methods for sampling*. London: British Standards Institution.

HALLSWORTH, C.R. AND KNOX, R.W., 1999. *BGS Rock Classification Scheme, Volume 3, Classification of sediments and sedimentary rocks.* British Geological Survey Research Report, RR 99-03. Keyworth, Nottingham: British Geological Society.

HARRISON, D.J. 1993. *Industrial mineral laboratory manual, limestone*. BGS Technical Report WG/92/29. Keyworth, Nottingham: British Geological Society.

WRAP, 2007. *Testing of concrete to determine the effects of groundwater.* Banbury: Waste & Resources Action Programme.

WRAP, 2008. *Investigation into EC aggregate test methods and their potential impact on RSA.* Banbury: Waste & Resources Action Programme.

List of abbreviations

Ag	Silver
Al	Aluminium
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
BTEX	Benzene, toluene, ethylbenzene, xylene
C	Carbon
Ca	Calcium
Cd	Cadmium
Chromium VI	Chromium Hexavalent
CN	cyanide
Co	Cobalt
Cr	Chromium
Cu	Copper
DCM	dichloromethane
DOC	dissolved organic carbon
DW	dry weight
EC	electrical conductivity
Eh	reduction potential
Fe	Iron
GC-FID	gas chromatography-flame ionisation detector
GCMS	gas chromatography–mass spectrometry
Hg	Mercury
HPLC	high performance liquid chromatography
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectroscopy
ICP-OES	inductively coupled plasma optical emission spectrometry
K	Potassium
LE	Leeds laboratory of NLS
Li	Lithium
LOD	limit of detection

LoI	loss on ignition
L/S	liquid solid ratio
MCERTS	Environment Agency's Monitoring Certification Scheme
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NEN	Netherlands Standardization Institute
Ni	Nickel
NLS	National Laboratory Service [Environment Agency]
P	Phosphorus
PAH	polycyclic aromatic hydrocarbon
Pb	Lead
PCB	polychlorinated biphenyl
PFA	pulverised fuel ash
SAL	Scientific Analysis Laboratories Limited
Sb	Antimony
Se	Selenium
Sn	Tin
Sr	Strontium
TDS	total dissolved solids
Ti	Titanium
Tl	Thallium
USEPA	United States Environmental Protection Agency
V	Vanadium
Zn	Zinc

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