



# Process Wastes from the Paper Industry

*Paper - the sustainable, renewable choice*

## OVERVIEW

The Confederation of Paper Industries (CPI) is assisting members and other interested organisations in reviewing how value can be derived from process wastes, namely paper sludge (remaining after the papermaking process) and rejects (non-paper items included in incoming fibre for recycling). Such materials are generated by papermaking, and while much of this material is already used for various purposes, there is increasing interest in new and innovative use as a feedstock by other industry sectors.

This briefing paper provides an overview of the process wastes generated by the Paper Industry; highlights the variations in the wastes created due to the different types of paper being produced; groups wastes that are similar in characteristics; and informs on quantities produced by sub-sector.

The intent is to provide an initial overview for those interested in this topic and to generate more in-detail discussions.

The information and data presented is an overview of the full sector based on detailed discussions with mills covering 58% of the Paper Industry based on output, representing various regions in the UK and across all the sub-sectors.

Some summarised analysis is provided of the chemical and physical composition of the materials. However as much of the raw feedstock is drawn from post-consumer recycling, then intrinsically there will be variability. Depending on the intended use of the process wastes this issue will need to be addressed in any proposals.

A full list and location map for UK paper mills is provided at the end of the report.

## BACKGROUND

### The Paper Industry

The Paper Industry consists of a number of sub-sectors defined by the type of paper being produced:

**Packaging:** Paperboard and Containerboard liners and flutings – higher grammage papers produced for use in carboard and corrugated card products.

**Tissue & Hygiene:** lower grammage paper and tissue for use in tissues, wipes, personal care and hygiene products.

**Graphic Paper:** papers produced in a wide range of grammage for uses such as newspapers, copy and printer paper, writing paper and envelopes, magazines and brochures.

**Speciality:** papers produced for more niche markets such as craft and coloured papers, translucent papers, security papers, electrical insulation, filters and smart papers for electronics.

Fibre feedstock used by the Paper Industry is either a virgin pulp, recovered fibre or a combination of the two. The majority of fibre is wood based, with recovered fibre originating from various types of card and paper - though some fibre originates from cotton or other plant-based fibres.

The type of feedstock and the papermaking process involved have a major influence on the characteristics of the waste materials produced on different sites.

## PROCESS WASTES PRODUCED BY THE PAPER INDUSTRY

### Types of Process Wastes

**Paper Sludge** (also known as Paper Crumble). Paper sludge consists mainly of wet short cellulose fibres lost during various stages of the papermaking process, and elements from chemicals used in the process. In addition, the sludge may consist of minerals such as kaolins and carbonates where filler and coatings are present in the feedstock or process, plus inks and soaps if recycled fibre is being de-inked before use.

The composition of the paper sludge is dependent on the composition of the raw materials used in the process and the fibre preparation process itself. Mills using a virgin fibre feedstock will have small amounts of sludge compared to mills using paper for recycling as their feedstock.

The term 'sludge' can be misleading as it can be inferred as describing a fairly fluid material, whereas the paper sludge is usually solid in appearance due to the high fibre content even when moisture content is 50%+ (hence sometimes referred to as a 'crumble').

The paper sludge can be further sub-categorised as **de-inking sludge** where the sludge is produced from the de-inking process of recovered fibre, **papermaking sludge** for sludge produced from fibre and other materials removed during pulping and dewatering in the papermaking process, and **effluent sludge** resulting from on-site effluent treatment plants. Sludges from any given mill will likely be a combination.

The moisture content of paper sludge varies from 30%-80% with effluent sludge having the highest moisture content.

**Rejects.** Rejects are predominantly produced by mills using recycled fibre as their feedstock, arising from non-paper contaminants in the in-coming materials and consisting mainly of plastics, metal, fibre, glass, grit and sand. Where speciality materials are recycled, other reject streams are generated, for example the recycling of fibre from beverage cartons generates Polyal (polymer and aluminium mix).

The rejects can be further sub-categorised. **Pulper rejects** derived from the pulping process of recovered fibre and mainly consisting of larger reject fractions are generally high in plastic and metal content. Depending on the process and industry sub-sector, the pulper rejects can include baling wire and some fibre. **Screen and cleaner rejects** are removed at various points and consist of smaller fractions of plastics and metals (such as staples), glass, grit and sand.

Some types of waste can be split into distinct streams to separate out, for example, the sand and grit enabling better recovery of material and reducing landfill.

***Paper Ash:** some paper mills produce a paper ash from the incineration of a combination of paper sludge, paper rejects and other biomass. However, the number of mills producing paper ash is small and has reduced substantially over the last decade, therefore ashes are not covered in any detail in this briefing paper. If interested in this type of material, please contact CPI.*

## SUMMARY OF DATA COLLECTED

The amount of data provided by the different mills varied in quantity, largely driven by the requirements of the existing end use (see later). For paper sludge, those that landspread hold more data on physical properties and composition than those who supply paper sludge for animal bedding.

There is little data available for the physical properties and composition of rejects, with the exception of several mills that partially separate waste materials during the process to facilitate further recycling where markets are available. This lack of data has made it more difficult to identify and group similar reject streams across the paper industry and identify possible benefits to other industries to use the materials as their feedstock in any depth.

During telephone interviews more information was gained to provide an understanding of the impact of the paper making processes and input materials on the process wastes produced. This has allowed some grouping of similar process wastes.

It should be noted however, that all mills would be open to further analyse both the paper sludge and rejects to assist in identifying additional recycling/recovery opportunities.

## EFFECT OF PAPER MAKING PROCESSES AND INPUT MATERIALS ON PROCESS WASTES

### Use of Recovered Fibre vs Virgin Fibre

A mill using virgin pulp will generate no or only very low amounts of rejects as minimal contaminants are introduced with the feedstock.

In contrast, those mills with recovered fibre as a feedstock will produce a substantial reject stream. The type of reject content and volume will be dependent on the source of recovered paper. Sites using baled waste feedstock typically have a lot of baling wire in the rejects. A number of pulping processes use rope to capture the wire and larger reject fractions. (Rope is slowly and continually passed through the pulper mix as it is agitated, and larger rejects wrap round the rope for extraction. This leaves a clean mix of pulp and water, with only small fragments of rejects remaining for later removal via screening).

Levels of rejects vary greatly depending on the source of the recycled fibre and collection system. Rejects from post-consumer feedstock collected from domestic recycling systems are the highest and vary further depending on whether they are collected kerbside or via MRF sorting. Collections from pre-consumer locations such as retail stores are generally lower in reject content, while collections from sites in the supply chain processing paper products will be lower still.

De-inking sludge is only derived from mills that use recovered fibre as a feedstock and need to produce a very clean paper, as this necessitates the removal of the ink from the recovered fibre. In general mills producing cardboard will not de-ink their feedstock.

	Tissue & Hygiene	Packaging	Graphic Paper & Speciality
Mills using Recovered Fibre processed on site	Fourstones Sapphire Fourstones Hexham Northwood Chesterfield Northwood Disley Northwood Lancaster	DS Smith Kemsley Saica Manchester Smurfit Kappa B'ham Smurfit Kappa Kent Sonoco Stainland Romiley Board Mill	Palm Paper UPM Shotton Higher Kings Mill Sundeala Huhtamaki Vernacare
Mills using both Recovered Fibre processed on site & Virgin Pulp	Essity Prudhoe Essity Stubbins Kimberly Clark Flint		James Cropper Weidmann Whiteley
Mills using Virgin fibre or Recycled fibre not processed on site	Kimberly Clark Barrow Kimberly Clark Northfleet Essity Oakenholt Essity Manchester Essity Tawd Sofidel Leicester Sofidel Baglan Sofidel Lancaster Wepa Bridgend Tissue Mill	Iggesund Paperboard BillerundKorsnas Beetham	Portals Overton Portals Bathford UPM Caledonian St Cuthberts Paper Mill Hollingsworth & Vose Carlson Filtration Union Papertech Glatfelter Ahlstrom Munksjo Chirnside Devon Valley Ahlstrom Munksjo Radcliffe Arjo Wiggins Chartham Arjo Wiggins Stoneywood

### Production of Soft and some Speciality Paper

Some tissue and speciality paper mills require the paper to be soft in nature and therefore more unwanted filler-ash is discarded in the pulp-making process, producing a more ash rich paper sludge, whilst other mills will seek to maximise recovery and retain the ash in the recycled paper, meaning the sludge has a lower ash content. Further a small number of mills, generally making moulded pulp type products will have no (or very low levels) of sludge due to the processing system.

### Type of Effluent Treatment

The type of effluent treatment will determine the volume of effluent sludge produced and its characteristics. A mill utilising only a primary treatment stage will produce less than a mill with a secondary treatment stage and an anaerobic treatment plant will produce substantially less sludge than an aerobic treatment plant. Secondary treatment uses bacteria to reduce the sludge volume which can lead to the remaining sludge being more odorous. Flocculant used in settlement tanks can also make the sludge more difficult to dewater.

The effluent sludge is typically mixed back into the de-inking and papermaking sludge before final dewatering.

### Differences in Sub-sector Processes

The packaging sub-sector predominantly uses rope in the pulping process to remove contaminants due to the relatively high level of rejects in the incoming feedstock (the rope itself also becomes a waste). Rejects tonnes are generally higher in this sub-sector and the different types of contaminant materials are more onerous to separate due to them being tightly wrapped around the collection rope.

Sub-sectors producing higher levels of de-inking and papermaking sludge have an overall higher ash content in the paper sludge due to the higher ash content in the feedstock and the production process.

Effluent sludge has a higher organic content.

## GENERAL DATA ON PROCESS WASTES

### Paper Sludge – data generalised for sites processing recycled paper on-site

Sub-Sector	Tissue & Hygiene	Packaging	Speciality & Graphic Paper	Total
	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>
De-inking & Papermaking Sludge	157,974	65,095	134,500	357,569
Effluent sludge	21,240	84,331	1,221	106,792
<b>Total Paper Sludge</b>	<b>179,214</b>	<b>149,426</b>	<b>135,721</b>	<b>464,361</b>
Average Wet Tonne Sludge/paper production tonne	0.77	0.09	0.32	0.20
Range of Moisture Content *	47% - 58%	50% - 66%	35% - 81%	47% - 81%

\*Moisture Content was not provided for 2 packaging mills

### Rejects

Sub-Sector	Tissue & Hygiene	Packaging	Speciality & Graphic Paper	Total
	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>	<i>Wet Tonnes pa</i>
<b>Total Rejects</b>	<b>18,709</b>	<b>108,097</b>	<b>11,000</b>	<b>137,806</b>
Avg Wet Tonne Rejects/paper production tonne	0.081	0.070	0.028	0.063
Avg Moisture Content	62%	49%	50%	46%

## RANGES OF OTHER PHYSICAL PROPERTIES AND COMPOSITION OF THE PROCESS WASTES

### Paper Sludge

	Unit	Average	Minimum	Maximum
Organic Matter	%	59	32	88
Arsenic	mg/kg	1.22	0.69	2.14
Cadmium	mg/kg	0.21	0.10	0.38
Chromium	mg/kg	9.72	3.35	23.20
Copper	mg/kg	73.48	32.00	174.00
Lead	mg/kg	6.94	1.64	12.90
Mercury	mg/kg	0.13	<0.1	0.22
Nickel	mg/kg	4.87	1.70	9.50
Phosphorus	mg/kg	630.89	207.00	1,676.00
Potassium	mg/kg	474.11	30.00	1,121.00
Selenium	mg/kg	0.27	0.10	0.55
Zinc	mg/kg	61.01	22.80	98.20
Total Sulphur	mg/kg	1,242.56	482.00	2,876.00
Ammonium Nitrogen	mg/kg	339.94	<9.00	1,626.00
Nitrate Nitrogen	% w/w	10.00	<10.00	<10.00
Total Nitrogen	% w/w	0.72	0.26	2.03
Total Carbon	% w/w	25.55	5.68	39.00
Lime Equivalent (as CaCO <sub>3</sub> )	%	42.83	2.00	64.80

Compositional data was provided by all mills with the exception of one Tissue & Hygiene mill and three packaging mills

### Rejects

Sub-sector	Packaging <sup>#</sup>
Net CV (as received wet)	10-14 MJ/Kg
Gross Dry CV	26-32 MJ/Kg

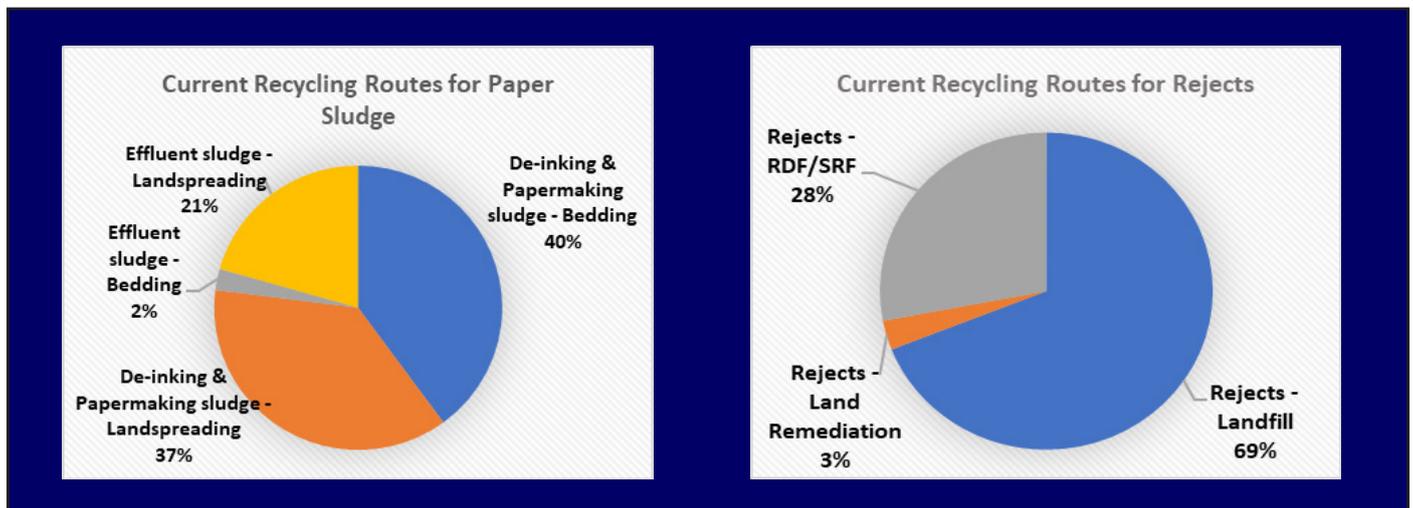
<sup>#</sup> Data on CV was only provided by one packaging mill

## CURRENT RECYCLING ROUTES FOR PROCESS WASTES

**Paper Sludge:** no paper sludge is routinely sent to landfill, instead it is commonly either used as an animal bedding (42%) or landspread (58%). It follows that alternative ideas for the use of this type of material need to be more attractive than the established recycling routes.

Paper mills have been spreading sludges on agricultural land for more than 35 years and over that period have demonstrated that this practice has proven agricultural benefit in improving soil structure and pH levels.\* Use of paper sludge as animal bedding has grown in the last decade and can either be used as supplied by the paper mill or supplied dry having been further dried by a third party.

**Rejects:** the majority of rejects produced by paper mills is still sent to landfill (69%). In some mills reject streams are separated with compliant streams being recovered as a refuse derived fuel (RDF), Solids Refuse Fuel (SRF) or incinerated on site (28%). Some separated streams of sand/grit etc are recovered and used in land remediation (3%). Note: percentages provided are based on dry tonnes



## POTENTIAL BENEFICIAL PROPERTIES FOR FEEDSTOCK IN OTHER INDUSTRIES

**Paper Sludge:** Deinking and papermaking sludges are generally higher in ash content, the ash often deriving from kaolins and carbonates used as fillers. The effluent sludges are more fibre rich and when dried produce an absorbent material. One sludge containing a high cotton fibre percentage has a notably higher net CV.

**Rejects:** High plastics content, reasonable metal content in some reject streams. Some reject streams (especially when tightly wrapped around rope) can contain reasonable amounts of fibre.

## POTENTIAL BARRIERS TO BE OVERCOME TO ENABLE USE FOR FEEDSTOCK IN OTHER INDUSTRIES

**Paper Sludge:** Some paper sludge is high in moisture content, making reuse more difficult and also lowering its calorific value. Most paper sludge has only been mechanically dewatered via dewatering tables and screw presses; non-mechanical methods can be more costly. Some paper sludges containing high levels of secondary effluent sludge can be odorous. The material is already used for agricultural soil improvement and animal bedding, so new uses need to provide viable and more attractive alternatives.

**Rejects:** Rejects are commonly high in moisture content. Rejects plastic content is formed from a variety of polymer types and can be 'dirty' from inks and chemicals used in the pulping and de-inking process. For some streams it can be hard to separate the different material types.

\*See: [https://thecpi.org.uk/library/PDF/Public/Publications/Guidance%20Documents/04-landspreadingcode\\_June16.pdf](https://thecpi.org.uk/library/PDF/Public/Publications/Guidance%20Documents/04-landspreadingcode_June16.pdf)

### List of Appendices

Appendix 1: List of UK Pulp & Paper Mills

Appendix 2: Map of UK Pulp & Paper Mills

Appendix 3: Example Flow Diagram of Basic Papermaking Production Process using Recovered Fibre

### Separate Confidential Documents held by CPI in connection with this Briefing Paper

Characteristics and Properties of Mill Process Wastes

Notes from Telephone Interviews with Mills Regarding Process Wastes

*These documents will only be released to third parties with full permission from the individual paper mill.*

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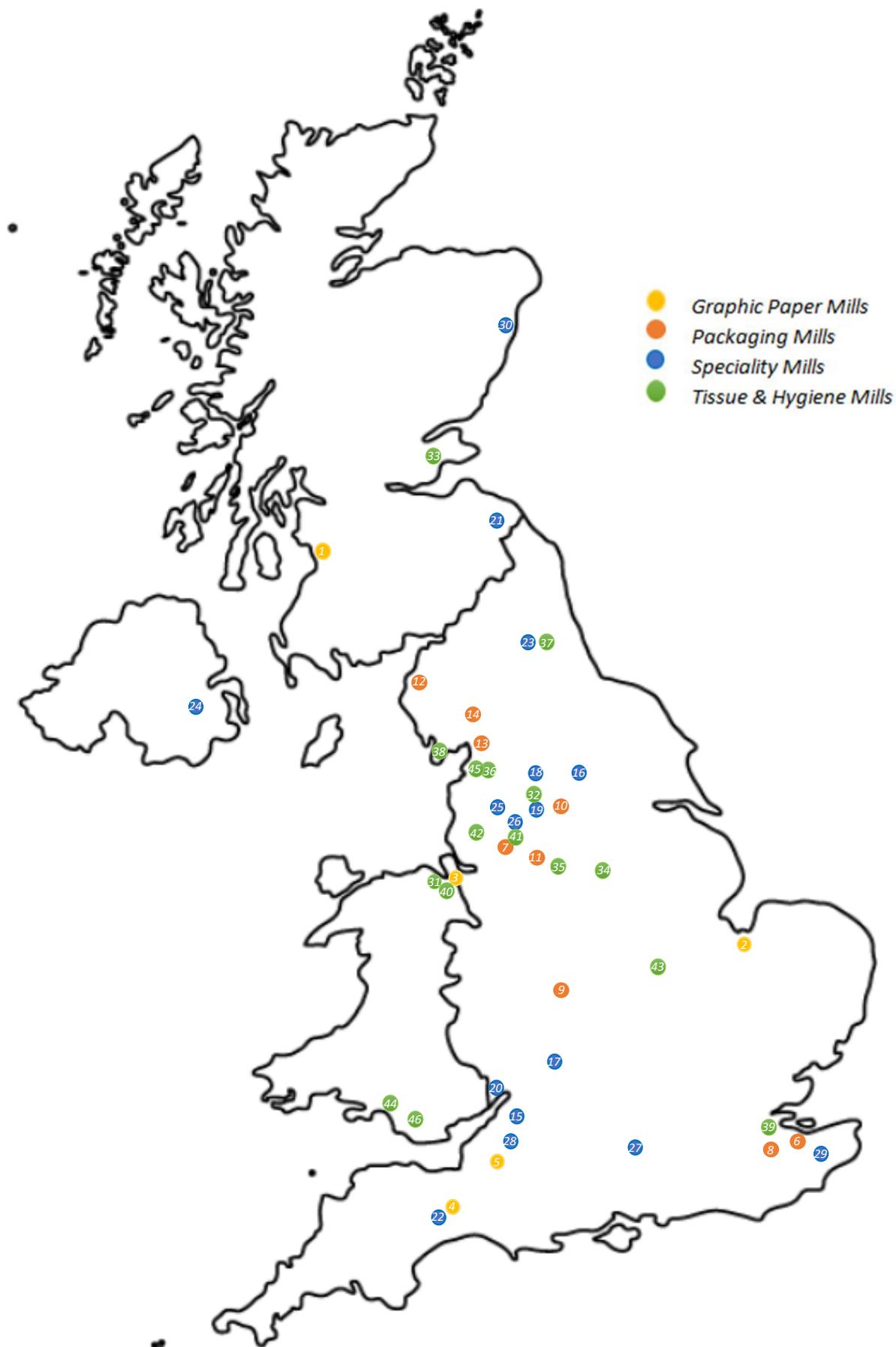
## APPENDICES

## Appendix 1: List of All CPI Member Paper Mills in the UK

Map Code	Mill name/operator	Location	Primary Product Type	Production Capacity	Main Types of Fibre Used
1	UPM Caledonian	Irvine, Ayrshire	Graphic Paper - magazine	260,000	Woodpulp
2	Palm Newsprint *	Kings Lynn, Norfolk	Graphic Paper - newsprint	400,000	Recycled
3	UPM Shotton	Shotton, Deeside	Graphic Paper - newsprint	260,000	Recycled
4	Higher Kings Mill	Cullompton, Devon	Graphic Paper- speciality	30,000	Recycled
5	St Cuthberts Paper Mill	Wells, Somerset	Graphic Paper- speciality	1,000	Woodpulp
6	DS Smith Kemsley *	Kemsley, Kent	Packaging - recycled fibre	800,000	Recycled
7	Saica Manchester *	Trafford, Gtr Manchester	Packaging - recycled fibre	450,000	Recycled
8	Smurfit Kappa Townsend Hook	Townsend Hook, Kent	Packaging - recycled fibre	260,000	Recycled
9	Smurfit Kappa SSK Birmingham *	Birmingham, W Midlands	Packaging - recycled fibre	230,000	Recycled
10	Sonoco Stainland *	Halifax, West Yorkshire	Packaging - recycled fibre	70,000	Recycled
11	Romiley Board Mill	Stockport, Gtr Manchester	Packaging - recycled fibre	50,000	Recycled
12	Iggesund Paperboard *	Workington, Cumbria	Packaging - speciality	220,000	Woodpulp
13	BillerudKorsnas Beetham	Beetham, Cumbria	Packaging - speciality	45,000	Woodpulp
14	James Cropper	Kendal, Cumbria	Packaging - speciality/Print & writings	50,000	Woodpulp/Recycled
15	Sundeala	Dursley, Gloucestershire	Speciality - board	5,000	Recycled
16	Weidmann Whiteley *	Otley, West Yorkshire	Speciality - electrical insulation	10,000	Woodpulp/Recycled
17	Hollingsworth & Vose	Cheltenham, Gloucester	Speciality - filtration	12,000	Glass
18	Carlson Filtration	Barnoldswick, Lancs	Speciality - filtration	2,000	Woodpulp
19	Union Papertech	Oldham, Gtr Manchester	Speciality - food & drink	6,000	Abaca
20	Glatfelter	Lydney, Gloucestershire	Speciality - food & drink	17,000	Abaca/Woodpulp
21	Ahlstrom Munksjo Chirnside	Chirnside, Scottish Borders	Speciality - food & drink	15,000	Abaca/Woodpulp
22	Devon Valley	Cullompton, Devon	Speciality - food & drink	7,000	Abaca/Woodpulp
23	Fourstones Paper Mill *	Hexham, Northumberland	Speciality - hygiene	6,500	Recycled
24	Huhtamaki	Lurgan, Northern Ireland	Speciality - moulded pulp	20,000	Recycled
25	Vernacare	Bolton, Gtr Manchester	Speciality - moulded pulp	9,000	Recycled
26	Ahlstrom Munksjo Radcliffe (note 3)	Bury, Gtr Manchester	Speciality - pulps abaca fibres	15,000	Abaca
27	Portals Overton *	Overton, Hampshire	Speciality - security papers	16,000	Cotton
28	Portals Bathford	Bathford, Somerset	Speciality - security papers	4,000	Woodpulp
29	Arjo Wiggins Chartham	Chartham, Kent	Speciality - translucent paper	10,000	Woodpulp
30	Arjo Wiggins Stoneywood	Aberdeen	Speciality/Graphic Paper	68,000	Woodpulp
31	Kimberly Clark Flint *	Flint, North Wales	Tissue & hygiene	30,000	Recycled
32	Essity Stubbins *	Bury, Gtr Manchester	Tissue & hygiene	55,000	Recycled
33	Sapphire Paper Mill *	Glenrothes, Fife	Tissue & hygiene	40,000	Recycled
34	Northwood Tissue (Chesterfield)	Chesterfield, Derbyshire	Tissue & hygiene	30,000	Recycled
35	Northwood Tissue (Disley)	Disley, Stockport	Tissue & hygiene	30,000	Recycled
36	Northwood Tissue (Lancaster)	Lancaster, Lancashire	Tissue & hygiene	11,000	Recycled
37	Essity Prudhoe *	Prudhoe, Northumberland	Tissue & hygiene	100,000	Recycled/Woodpulp
38	Kimberly Clark Barrow	Barrow, Cumbria	Tissue & hygiene	120,000	Woodpulp
39	Kimberly Clark Northfleet	Northfleet, Kent	Tissue & hygiene	80,000	Woodpulp
40	Essity Oakenholt	Oakenholt, North Wales	Tissue & hygiene	70,000	Woodpulp
41	Essity Manchester	Trafford Park, Manchester	Tissue & hygiene	50,000	Woodpulp
42	Essity Tawd	Skelmersdale, W Lancs	Tissue & hygiene	28,000	Woodpulp
43	Sofidel Leicester	Leicester, East Midlands	Tissue & hygiene	70,000	Woodpulp
44	Sofidel (Intertissue Baglan)	Baglan, South Wales	Tissue & hygiene	60,000	Woodpulp
45	Sofidel Lancaster	Lancaster, Lancashire	Tissue & hygiene	30,000	Woodpulp
46	Wepa Bridgend Paper Mill	Bridgend, Mid Glamorgan	Tissue & hygiene	50,000	Woodpulp
				<b>4,202,500</b>	

\*indicates the site provided data for this project

## Appendix 2: Map of UK Pulp &amp; Paper Mills



### Appendix 3: Example Flow Diagram of Basic Papermaking Production Process using Recovered Fibre

