Paul Mobbs,
Mobbs Environmental Investigations,
3 Grosvenor Road, Banbury, Oxon. OX16 8HN.
Phone/fax 01295 261864.
Email: mobbsey@gn.apc.org
URL http://www.gn.apc.org/pmhp/meir.htm

Mobbs' Environmental Investigations
* Environmental consultancy
* Research
* Campaigns coordination

Proof of Evidence

Lancashire Minerals and Waste Local Plan Inquiry

Supplementary Proof: '*Further Suggested Changes*'

Arrow No.	Inquiry objection ref.	Issue:	Plan references:
49	O/SFA/5159/3/2	Arisings, Capacity and Provision	Policy 277/Chapter 20
50	O/SFA/5159/3/3	Safeguarded Sites	Policy 278/Chapter 20
51	O/SFA/5159/3/4	Network of Sites	Policy 279/Chapter 20

For and on behalf of
ARROW

Objector no. 5159

Contents

Arisings, Capacity and Provision

ARROW Ref.: **49**
Inquiry Ref.: **O/SFA/5159/3/2**
Plan Ref.: Policy 277/Chapter 20

Introduction

This objection to the '*Further Suggested Changes*' to the deposit draft of the plan considers the content of Policy 277. This proof considers amendments/revisions to the earlier proofs, and then considers the objection to the revised policy in detail.

Amendments

<u>'Round Table' Proof</u> - Is the Proposed 25% Reduction in Landfilling Realistic, and does the Plan Promote and Effective Waste Management Strategy?

In this section I argue that the content of Structure Plan Policy 64 is not met by the policies of the draft plan and subsequent revisions. Policy 277 will still not meet the aims of Policy 64 of the Structure Plan. This is because in the strategy of the draft plan the only way to take material away from landfill. There is no provision of alternative capacity to enable this - not even the identification of sites for these alternative processes.

The figures presented at the beginning of this section of the 'Round Table' proof, because of the new waste figures from the Environment Agency, are amended as follows (figure from LCC's new waste statistics published with Chapter's 19/20 - table 11):

- 40% of Lancashire's household waste = 0.4 x 1,767,000 = 706,800 tonnes p.a.
- 25% of Lancashire's household waste = 0.25 x 1,767,000 = 441,750 tonnes p.a.

There is a great difference between these two figures. Over the lifetime of the plan the failure to meet the reclamation target will result in an additional 1,192,725 tonnes of household waste going to landfill (= 0.5 * [706,800-441,750] * 9)

We can also take this calculation further by considering the landfill diversion target set in Structure Plan Policy 64:

- Assume that 90% of waste in Lancashire goes to landfill, true arising = 3,130,000 * (1/9) * 10 = 3,477,778 tonnes p.a.
- 60% of this figure - the landfill target = 3,477,778 x 0.6 = 2,086,667 tonnes p.a.
- Reduction from current arising to landfill target = 1 - (2,086,667 / 3,130,000) = 33.3%

Therefore, in order to meet the landfill diversion target, the level of reduction necessary over the plan period is 33.3% (16.7% average) over the plan period, not 25% (12.5% average).

<u>'Session 3' Proof</u> - Appendix 3: Reassessment of Biodegradable Waste Requirement in Lancashire

This whole section is superseded by the new assessment in this proof.

Waste Arisings and Disposal Capacity

The figures presented in Lancashire County Council's new '*waste statistics*' are an improvement on the previous figures. However there is still, in our interpretation, a problem with the insistence on taking 1995 to 2006 as the basis for projections. It would be much better to consider just the need for new capacity, and not for the provision of void space for waste that's already in the ground.

Appendix 1 contains a reassessment of the waste arisings and capacity of sites in Lancashire, using the Environment Agency's latest data. This clearly shows that there is no need for new provision in the county during the plan period.

With regard to the reassessment of capacity, an interesting issue has arisen with regard to waste density. During the local plan inquiry the industry side have been requesting that lower figure for biodegradable waste density be used. For this reason I have used a figure of 0.77te/m^3 for these and previous calculations. However, at the Round O Quarry appeal inquiry, UK Waste used a figure of 1.0te/m^3. This inconsistency is very important in terms of planning for waste disposal in Lancashire since a higher figure makes the existing capacity last longer. I suggest that this issue is examined in detail with the industry representatives appearing at this inquiry.

There are realistic alternatives to landfill. These are detailed in Appendix 2. For this reason our assessment includes a further calculation - 50% waste reduction. This is being achieve elsewhere, so there is no reason to assume that it could not be replicated in Lancashire.

Criteria for new sites

Policy 77/277 set criteria for allowing the development of new sites. It is our view that these criteria are vague, and in practice unusable. There is no definition of what level of provision the County Council require to be held at any one time, and the proximity or design of sites which will be relevant to satisfy the '*environmentally acceptable disposal option*' criteria. If we give an example, currently the use of Policy 278 would indicate that the County Council wish to safeguard at least 10 to 15 years landfill capacity. Also, the lack of detailed alternatives to landfill would indicate that there is no other 'environmental option' other than landfill.

The criteria attached to Policies 77/277 are not workable, and should be rewritten with the appropriate reasoned justifications, or deleted. I would also suggest that particular care is taken with regard to the permitting of '*captive*' sites since these do not accord to the general criteria.

In conclusion…

Even on the basis of no reduction in waste volumes going to landfill, there is enough landfill capacity, even in the areas of the county which are currently running short of space, to last until 2006. The scenario that waste volumes will remain the same is unlikely. Therefore we can be confident that no new provision is needed during the plan period. **For this reason Policy 77/277 should be amended to prevent any new landfill sites being developed unless there are sufficiently strong reasons for doing so. No further release of new capacity is needed since it already exists.**

The criteria for allowing new landfill sites are unclear. **They should either be revised to give clear indications as to what arguments must be presented to justify a further release of capacity, or deleted.**

Safeguarded Sites

ARROW Ref.: **50** (additional to ARROW objection 32)
Inquiry Ref.: **O/SFA/5159/3/3**
Plan Ref.: Policy 278/Chapter 20

There is no policy justification for safeguarding sites. This will unnecessarily extend blight onto the surrounding land. In the case of Round O Quarry this blight is totally unnecessary since it is our view that the site is totally unsuitable for biodegradable waste disposal in any case.

There is no need for new provision of landfill during the plan. The trend in Government policy is to reduce reliance on landfill, to minimise waste arisings, and to find alternative management options. This will increase the lifetime of existing sites.

Selection of Round O Quarry

At no time has Lancashire County Council provided any evidence to support the selection of the sites in Policy 278. In particular no regard has been given to the suitability of the sites to take the waste types identified in the plan.

We have particular concern with regard to Round O Quarry for two reasons:

- **Health Effects** - it is our view that the proximity of Round O to existing and proposed development risks the health of those living in the area. This issue is detailed in Appendix 3.
- **Geology** - it is our view that the site has a complex and unpredictable geology. The general indication from a study of the geological structures in the area is that the site presents a high risk to groundwater and surface waters (primarily the River Tawd). This issue is detailed in Appendix 4.

A further difficulty with regard to Round O Quarry is access. This is referred to in Policy 278. The level of filling predicted in the recent application to fill the site with biodegradable waste would, in our opinion, have an undesirable impact on nearby development such as the Maharishi School, the development along the approach roads through Skelmersdale, and the villages in the area.

In conclusion…

The essence of the planning system is the protection of critical assets by the management of development. We have identified 'critical assets' in the local communities around Round O Quarry - in particular amenity and environmental quality. We believe that these must be protected within the strategy and policies of the local plan.

No evidence has ever been produced by Lancashire County Council to support the selection of Round O Quarry for this type of waste. We have provided evidence that the site is unsuitable, and in our view, is unlikely to ever be approved for the deposit of waste. It is clear that no regard has been given to the '*relevant objectives*' of the EC Framework Directive on Waste.

There can be no justification for the creation of a long term blight on large areas of land in Lancashire by 'safeguarding' the sites listed in Policy 278. In the case of Round O there is no justification for the selection of the site for that waste type. We request that Policy 278 is deleted.

Network of Sites

ARROW Ref.: **51**
Inquiry Ref.: **O/SFA/5159/3/4**
Plan Ref.: Policy 279/Chapter 20

We regard this policy as being '*void for uncertainty*'.

For example:

- What are the '*sub-divisions of Lancashire*' - they are not identified in the plan. Does it include the new Unitary Authorities? If it doesn't why are they being included in the calculations for this plan?
- What is an '*adequate network of sites*' - it could be interpreted in the context of Policy 279 as being primarily landfill. This is not our interpretation of an 'adequate network of sites' as defined in the EC Framework Directive on Waste, and the Waste Management Licensing Regulations 1994.

The draft of the plan does not, in our view, develop an '*integrated and adequate network of waste disposal installations*'[1]. There is too much emphasis on the development of landfill, and too little on other options.

We support the notion of developing a sub-regional assessment of waste capacity - this is the approach we took before the County Council presented their assessment. However we have to develop the 'integrated' network of different waste management options, in accordance with the Framework Directive and UK Government policy.

We therefore request that Policy 279 is redrafted to enable the sub-regional assessment and development of waste management facilities in the County. But unlike policy 279, we believe that the policy must refer to all waste management options, not just landfill.

[1] Article 5, EC Framework Directive on Waste

Appendix 1: Reassessment of Waste Capacity in Lancashire

In terms of the strategy within the Lancashire Minerals and Waste Local Plan, the provision of sites is driven by the need for disposal. Need is not however the only consideration. In estimating the need to provide landfill in the area we must consider:

- The quantities of waste currently produced;
- The effect of any national policies relating to the landfilling of waste;
- The effect of any national policies on the diversion of waste from landfill (by recycling or any other means);
- The availability of sites, and the scope for implementing other schemes in the area to divert waste away from landfill; and
- Any sub-regional factors which affect the provision of sites.

The data on waste arisings is very poor in the North West. The only quality data that is available on waste quantities is the site input data produced by the Environment Agency.

In terms of national guidelines, these are primarily given in the Government's Sustainable Waste Management Strategy[2]. However the national strategy is currently under review[3]. A consultation paper[4] was also recently published on a revision[5] of the sustainable waste management strategy. These changes will potentially mean that more waste will be diverted away from landfill, either by waste avoidance, minimisation, reuse or recycling. This will lower the demand for landfill significantly. Given the current direction of government policy on waste management, it would be inadvisable to give permission for a large expansion of landfill - above that which is foreseeably required to meet local need.

The original modelling of waste in Lancashire, undertaken for the Minerals and Waste Local Plan inquiry, used the old data from the Environment Agency. It has been revealed by the Agency that there were errors in these figures. The figures in this proof have been produced using the new figures for biodegradable site inputs[6]. However because the new capacity figures are unavailable the assessment is still for the period 1995 to 1997 - it does not include the figures for 1997-8 because these would only be of value with the corresponding capacity figures.

In calculating demand for landfill in Lancashire we therefore considered three scenarios for landfill need between 1997 and 2006:

- **Scenario 1 - no change**. This assumes that waste is landfilled at the same level.
- **Scenario 2 - 25% reduction in landfill** (12.5% total). This assumes that the County Councils targets are met.
- **Scenario 3 - 50% reduction in landfill** (25% total). This assumes that the greatest

---

[2] '*Making Waste Work - A strategy for sustainable waste management in England and Wales*', Cm3040, Department of the Environment/Welsh Office Dec. 1995.

[3] '*A New Waste Strategy Planned*', DETR Press Release 020 - 13 January 1998

[4] '*Less Waste: More Value*', DETR June 1998.

[5] '*Seven Ways to Tackle Waste*', DETR Press Release 453 - 9 June 1998

[6] '*Updated Waste Deposit Statistics for Lancashire*', circulated by the Programme Officer in July

effort to undertake waste minimisation and recycling takes place over the period of the plan. This target is not excessive given the performance of waste minimisation/reclamation schemes elsewhere in the UK and Europe[7].

Regarding the reductions in landfill, not that the total amount of waste 'diverted' from landfill over the period of the plan is the average diversion rate of the period (i.e., half the final rate given a linear change over the plan period). Therefore a 25% or 50% reduction in waste at the end of the plan period will not reduce landfill requirements by that figure over the plan period.

As part of the study the county was split into four areas, representing the four groupings of urban development. This enables the need for landfill to be considered on a sub-regional basis in order that the proximity principle can be considered with the provision of sites in the County. Figure 1[8] on the following page is shaded to indicate the population density in the county over 5 persons/hectare (lightest shading) and 40 persons/hectare (darkest shading).

Having assessed the waste deposits and waste density for each of the four areas, and the available landfill void, it is possible to project the remaining lifetime of the sites (note, the areas are indicated on figure 1).

		Group 1	**Group 2**	**Group 3**	**Group 4**
Scenario 1 - no change	Lifetime, 0.77te/m^3	2009.8	2006.7	2008.2	2003.2
	Lifetime, 1.0te/m^3	2013.5	2009.5	2011.5	2004.9
Scenario 2 - -25%	Lifetime, 0.77te/m^3	2011.6	2008.0	2009.8	2004.0
	Lifetime, 1.0te/m^3	2015.8	2011.2	2013.6	2006.0
Scenario 3 - -50%	Lifetime, 0.77te/m^3	2014.0	2009.8	2011.9	2005.1
	Lifetime, 1.0te/m^3	2018.9	2013.5	2016.3	2007.5

'Group 3' is the important one here - this covers West Lancashire, South Ribble and Chorley districts. The results of the analysis are very clear:

- Even if nothing is done about waste going to landfill, there is sufficient capacity to last until 2007.
- If the County meet their target, there is enough capacity to last well beyond the plan period - mid 2008.
- If we can achieve significant reduction in the quantities of waste going to landfill then landfill capacity in the area could conceivably last beyond the beginning of 2010.

The clear deduction that can be made from this analysis is that additional landfill capacity is not required in the southern/south-west part of Lancashire until the next local plan (post 2006). There are currently a number of landfills available between Skelmersdale and Chorley/Preston to meet demand.

[7] Refer to the evidence of Keith Collins, Appendix 2

[8] The base image, on which the landfills have been plotted, is figure 18 of Lancashire County Council's '*Environmental Audit*'.

ARROW's Waste Arising and Capacity Assessment

Table 1a: Sub-Regional Assessment of Waste Input

	Group 1	Group 2	Group 3	Group 4	Total
Site inputs, '96-7, tonnes	198,600	545,521	391,170	823,500	1,958,791
Assessment for 0.77te/m^3:					
Volume, m^3, @ 0.77 te/m^3	257,922	708,469	508,013	1,069,481	2,543,884
Total volume, 1997-2006	2,321,299	6,376,219	4,572,117	9,625,325	22,894,960
Plus 4% population growth '94-'06	2,414,151	6,631,268	4,755,002	10,010,338	23,810,758
Assessment for 1.0te/m^3:					
Volume, m^3, @ 1.0 te/m^3	198,600	545,521	391,170	823,500	1,958,791
Total volume, 1997-2006	1,787,400	4,909,689	3,520,530	7,411,500	17,629,119
Plus 4% population growth '94-'06	1,858,896	5,106,077	3,661,351	7,707,960	18,334,284

Table 1b: Biodegradable Waste Capacity Assessment

		Group 1	Group 2	Group 3	Group 4	Total
Permitted void, m^3		3,359,300	6,929,900	5,803,900	6,564,900	22,658,000
Scenario 1 (0% reduction)						
at 0.77te/m^3	input '97-'06	2,414,151	6,631,268	4,755,002	10,010,338	23,810,758
	duration, yrs	12.52	9.41	10.99	5.90	8.56
	expires	**2009.77**	**2006.66**	**2008.24**	**2003.15**	**2005.81**
at 1.0te/m^3	input '97-'06	1,858,896	5,106,077	3,661,351	7,707,960	18,334,284
	duration, yrs	16.26	12.21	14.27	7.67	11.12
	expires	**2013.51**	**2009.46**	**2011.52**	**2004.92**	**2008.37**
Scenario 2 (25% reduction)						
at 0.77te/m^3	input '97-'06	2,112,382	5,802,360	4,160,626	8,759,045	20,834,413
	duration, yrs	14.31	10.75	12.55	6.75	9.79
	expires	**2011.56**	**2008.00**	**2009.80**	**2004.00**	**2007.04**
at 1.0te/m^3	input '97-'06	1,626,534	4,467,817	3,203,682	6,744,465	16,042,498
	duration, yrs	18.59	13.96	16.30	8.76	12.71
	expires	**2015.84**	**2011.21**	**2013.55**	**2006.01**	**2009.96**
Scenario 3 (50% reduction)						
at 0.77te/m^3	input '97-'06	1,810,613	4,973,451	3,566,251	7,507,753	17,858,069
	duration, yrs	16.70	12.54	14.65	7.87	11.42
	expires	**2013.95**	**2009.79**	**2011.90**	**2005.12**	**2008.67**
at 1.0te/m^3	input '97-'06	1,394,172	3,829,557	2,746,013	5,780,970	13,750,713
	duration, yrs	21.69	16.29	19.02	10.22	14.83
	expires	**2018.94**	**2013.54**	**2016.27**	**2007.47**	**2012.08**

Table 1c: Biodegradable Waste Site Input and Capacity

Site	Average 1995-1997 input, te	Licensed void space, m^3	Licensed sites with unlicensed void, m^3	Permitted but unlicensed sites, m^3	Total permitted void, m^3
Group 1					
Salt Ayre	169,700	2,166,000	0	0	2,166,000
Cotestones	28,900	12,800	0	0	12,800
Ellel Quarry	0	0	0	1,180,500	1,180,500
Total	**198,600**	**2,178,800**	**0**	**1,180,500**	**3,359,300**
Group 2					
Jameson Road	139,250	462,300	1,000,000		1,462,300
Clifton Marsh	310,571	1,489,800	0	3,700,000	5,189,800
Woods Waste	95,700	277,800	0	0	277,800
Total	**545,521**	**2,229,900**	**1,000,000**	**3,700,000**	**6,929,900**
Group 3					
Much Hoole	12,700	0	0	0	0
Ulnes Walton	201,800	102,700	0	1,000,000	1,102,700
Withnell Quarry	104,150	1,084,800	0	0	1,084,800
Clayton Hall	19,350	1,459,400	0	0	1,459,400
White Moss Road	*53,170*	657,000	0	0	657,000
Rigby House Farm	0	0	0	1,500,000	1,500,000
Total	**391,170**	**3,303,900**	**0**	**2,500,000**	**5,803,900**
Group 4					
Whinney Hill	296,600	968,600	1,000,000	0	1,968,600
Rowley	188,850	161,100	0	600,000	761,100
Rakehead	72,650	142,300	0	0	142,300
Henthorne	58,800	553,800	0	0	553,800
Goosehouse	67,300	8,000	0	0	8,000
Duckworth Hall	13,850	0	0	0	0
Ford Quarry	35,500	990,900	1,000,000	0	1,990,900
Horncliffe Quarry	89,950	470,200	0	0	470,200
Enfield Quarry	0	0	0	670,000	670,000
Total	**823,500**	**3,294,900**	**2,000,000**	**1,270,000**	**6,564,900**
Total all groups:	**1,958,791**	**11,007,500**	**3,000,000**	**8,650,500**	**22,658,000**

Table 2: Other Landfill Site Input and Capacity

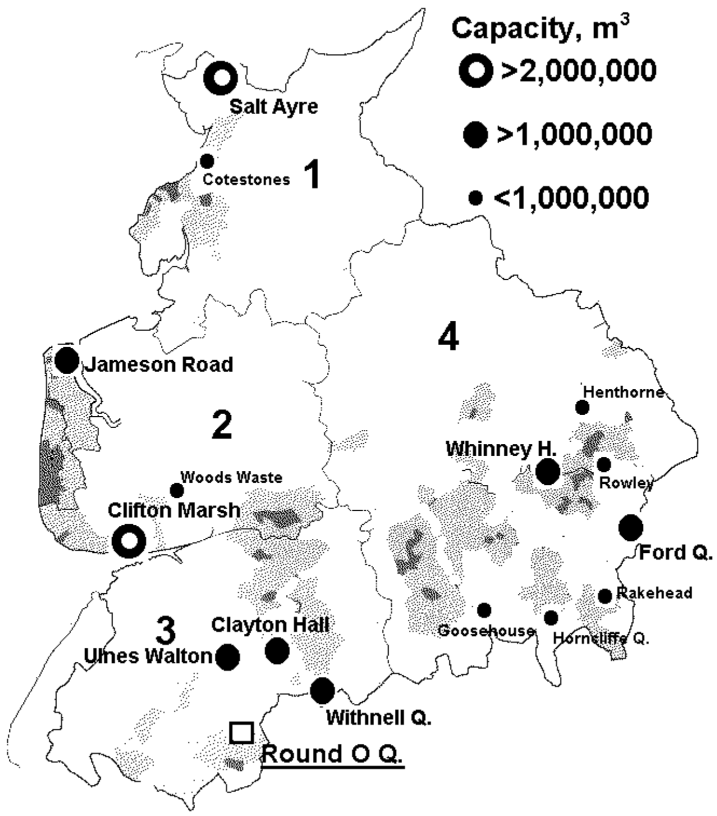
Site	Average 1995-1997 input, te	Licensed void space, m3	Licensed sites with unlicensed void, m3	Permitted but unlicensed sites, m3	Total permitted void, m3
Group 1					
(no sites)					
Total	**0**	**0**	**0**	**0**	**0**
Group 2					
Gift Hall Farm	0	200			200
Moss Side Lane	4,603	3,300			3,300
Lightfoot Green Farm	52,189	291,000			291,000
Red Scar	0	110,000			110,000
Total	**56,791**	**404,500**	**0**	**0**	**404,500**
Group 3					
Alty's Brickworks	16,970	16,800			16,800
Hardrock/Stoney Brow	78,389	10,000			10,000
Rough Park Quarry	3,797	3,600			3,600
Great Knowley	201,275	366,100			366,100
Lydiate Lane	0		1,553,700		1,553,700
Round O Quarry	0		3,000,000		3,000,000
Dalton Quarry	0		175,000		175,000
Holland Quarry	0		170,000		170,000
Total	**300,431**	**396,500**	**4,898,700**	**0**	**5,295,200**
Group 4					
Hillock Vale	0	15,000			15,000
Dales View Caravans	0	300			300
Thorney Height Quarry	0		40,000		40,000
Total	**0**	**15,300**	**40,000**	**0**	**55,300**
Total inert, all groups:	**357,222**	**816,300**	**4,938,700**	**0**	**5,755,000**
Captive/In-house Sites	**190,013**	**1,209,650**			**1,209,650**

Table 3: Total Landfill Input, Capacity and Surplus/Deficit in 2006

	Average Input 1995-7, te p.a.	+4% population growth, te p.a.	Total Landfill Requirement 1997-2006		
			0% reduction, te.	25% reduction, te	50% reduction, te
Biodegradable	1,958,791	2,037,143	18,334,284	16,042,498	13,750,713
Inert Waste	357,222	371,510	3,343,593	2,925,644	2,507,695
Captive	190,013	197,613	1,778,517	1,556,202	1,333,888
Total	2,506,025	2,606,266	23,456,394	20,524,345	17,592,296

	Volume Required '97-'06		Landfill Capacity, 1997, m^3	Surplus/deficit, m3, in 2006	
	25% reduction, m^3	50% reduction, m^3.		25% reduction, m^3	50% reduction, m^3
Biodegradable					
@0.77	20,834,413	17,858,069	22,658,000	1,823,587	4,799,931
@1.0	16,042,498	13,750,713	22,658,000	6,615,502	8,907,287
Inert Waste	1,950,429	1,671,797	5,755,000	3,804,571	4,083,203
Captive	1,556,202	1,333,888	1,209,650	-346,552	-124,238
Total					
@0.77	24,341,045	20,863,753	29,622,650	5,281,605	8,758,897
@1.0	19,549,130	16,756,397	29,622,650	10,073,520	12,866,253

Figure 1: Sub-Regions and biodegradable Landfills



Appendix 2: The Potential for Waste Recovery

This summary has been provided with the assistance of 'London Pride' who are actively working with local authorities in London, supported by grant aid, to massively increase on past recycling rates in very short periods of time. It is possible that London Pride might appear as witnesses for other parties in this inquiry.

1. The Possibilities of Diverting Waste from Disposal

It is well-documented that waste diversion (recycling plus composting) rates are rising rapidly across the Western World, with national rates now reaching over 30% in the U.S. and Germany. At the state and city level, the trend toward ever higher rates is even more clear. In the U.S., 7 states with a total population of over 55 million residents now have rates of over 40%, with similar numbers from German states as well. At the city and county/region level, the leading jurisdictions are now above 50%, 60% and even 70% - e.g.

- Alachua County, Florida (population 182,000) is at 74%;
- the Quinte and Bluewater regions of Ontario, Canada (populations totalling 200,000) are between 65%-75%;
- Passaic and Morris Counties in New Jersey (populations totalling over 898,000) are above 60%; and the cities of Seattle, Washington and San Jose, California (populations totalling over 1,300,000) are both at 50%.

These rates have been well-documented by state and provincial authorities, the U.S. EPA, etc.

What can be seen over the last decade's development of recycling and composting is a process whereby smaller towns and cities lead the way in testing new techniques, thus proving that higher rates are possible and cost-effective with the new systems, before they are taken up on a wider regional and national scale. In the same way - but with a significant time lag - the UK's national rate of 6% is expected to begin its climb toward higher rates, now that smaller U.K. communities, such as Wye in Kent (60%) and Bury-St. Edmonds (40%) are showing the way. e.g. Recent applications of more intensive recycling and composting techniques in London have lifted its rate from 6% to nearly 12% over the past year.

In contrast, the share of all waste managed through both incineration and landfill is in decline, with 'Energy From Waste' rates in the U.S., for instance, **falling** from 12% to 9%, and landfill rates falling from 80% to 61%, as recycling rose from 8% to 30% over the past decade.

This same process can be seen by looking at the recycled percentage in major manufactured materials, as the expansion and conversion of these industries must proceed apace in order to reprocess these materials. World steel production is already more than 50% from recycled scrap/cans/etc.; and world pulp and paper production is now more than 40% made from recycled inputs.

This has meant, of course, that the size of the recycling and composting industry itself has had to grow, and nations which have aggressively pursued the path of waste diversion have reaped enormous economic gains. e.g. A November 1997 report from Dresdner Kleinwort Benson found that the revamped German waste/recycling industry not only employed more than 150,000 employees, and was not only larger than "*sectors such as telecommunications and engineering*" but that it now "*dwarfs the retail and steel sectors.*" This massive, world-wide transformation then, has not only changed the face of waste management, it has changed many material manufacturing sectors, and it has brought large-scale, measurable economic benefits to nations such as Germany, the U.S. and Canada.

On the waste reduction front, similar progress has been made, with the German producer responsibility legislation stimulating remarkable reductions in packaging; and the Canadian Packaging Protocol achieving its goal of 50% recycling, reuse and reduction by 1996.

2. The 3R's and the Household, Commercial/Institutional, Industrial and Construction and Demolition Waste Streams

Most of the figures above are not just for household waste, but include large sections of other waste streams. The process of change tends to focus on residential waste because: it is the most publicly visible portion of the waste stream; each tonne of consumer packaging has, on average, ten tonnes of waste created in its mining/logging/reprocessing stages; and because the political basis for multi- sectoral change relies on a shift in public awareness and participation.

Dozens of detailed household waste composition studies recently completed in London have found that more than 40% of waste is classified as "*easily recyclable*"; with nearly another 40% classified as "*compostable*". The remaining 20% is made up of materials which can be re-used, recycled using more complex systems, reduced through producer or consumer changes, or which must be disposed of.

Waste coming through other channels and from other sectors is actually easier to divert - once the basic systems have been put in place, once resident awareness has begun to rise, and once waste management systems and regulations have begun their shift. e.g. C.A. site waste has an extremely high percentage of green waste, especially during the Spring and Summer. This material tends to come in significant amounts, and is largely clean of other contaminants. A diversion system for these materials is therefore quite simple: good site management to control where materials are dropped; containers for the source-separated material; a transportation system; and a composting site somewhere within hauling distance.

Another example is office waste, 70%-90% of which is office paper. The "*Green Workplace*" system developed in Ontario requires very little separation by staff, and has been found to achieve 70%-90% diversion very rapidly. Two pilot local authority buildings in Bexley and Haringey, London, implemented a basic version of this system in 1997, and achieved 63% and 70% measured diversions from their first week.

At the level of industrial waste, large-scale diversion can be even more rapid and more cost-effective, for a number of reasons. Such firms tend to have very large quantities of materials flowing through; in-house staff with time and responsibilities which enable a concentrated approach to change; a clear financial benefit, both from reducing waste disposal costs, but more importantly from increasing productivity and reducing purchases of material inputs. While there are thousands of industrial examples to choose from world-wide, the Green Industrial Analysis and Retrofit Programme in Ontario produced 80% reductions in solid waste, along with 20% energy savings and 30% water use reductions, for a minimal cost, and with paybacks to the firms involved of less than 18 months.

Construction and demolition waste is a major portion of U.K. waste going to landfill by tonnage - although rather less important in terms of its potential negative environmental effects. The Danes appear to be the world leaders in transforming this waste stream, as they have now reduced it by more than 70%. These materials can be reused onsite, recycled for use elsewhere, crushed at central sites, etc.

The changes taking place in the non-residential sectors can perhaps be best be seen by looking at some of the global firms in California, where front-line media/entertainment companies such as

Disney and Warner Brothers have now put in place recycling systems to rival those of more obviously "green" firms such as Xerox. In an increasingly global economy, and with corporate access to leading-edge information soaring as a result of the internet's growth, companies everywhere can benefit almost instantly from techniques and systems developed anywhere.

3. Waste Diversion Systems

The systems chosen to achieve these rates vary across nations, sectors, materials and so on - but most of the principles stay the same.

- Customer convenience is critical - which means easily accessible containers, regular service, clear and graphic promotion, etc.
- Avoid massive investment in fixed capital equipment - especially during the early stages of development. Industrialised nations are littered with expensive, complex, and ultimately uneconomic or ineffective "black boxes", sold to communities and firms by salespeople who promised "a magic solution to all your waste problems."
- Investment in promotion and education - in conjunction with the provision of a regular, convenient service - turns out to be most important. A community can have wonderful vehicles and Materials Recovery Facilities (MRFs) and such, but if the householder or business doesn't set materials out in the first place, the whole collection and processing infrastructure is effectively collecting air.
- Tackling all sectors of waste in a comprehensive, step-by-step manner leads to better results than any one system would achieve alone. Sometimes called the "live, work, learn and play" approach, its intention is to make sure that recycling, composting and reduction become part of the culture of a community - rather than a strange, one-off kind of activity.

As for particular systems, there are literally hundreds of different tools and methods available. The keys here are to create a system that is flexible, that allows communities and businesses to adjust over time, and which doesn't require massive start-up capital costs. It is for these reasons that most London Boroughs have chosen to start with weekly, kerbside collections using an open-top box. This system allows instant feedback to households on quality control, enables the community to make recycling a regular part of their lives, produces visible and tangible results, and doesn't require expensive centralised MRFs to start. They are already achieving participation rates of 60%-90% across London, from Hackney to Hounslow. Over time, more materials can be added to the boxes, the number of separate categories operatives sort materials into can be reduced as MRF capacity is built, etc. Home composting systems are similar in that they are quite easily managed by households with gardens, and can produce large-scale diversion at very low cost to the local authority. More complex and expensive kerbside collection of organics can then be considered for the remainder, once system are set in place, and the public well-educated in the importance of keeping materials clean.

4. The Speed of Change:

The speed with which a city or county can change its waste management practices is much faster than a decade ago, when most systems were being created from scratch. Very simply, the first kerbside boxes, MRFs and multi-compartment vehicles were created less than 15 years ago. Nowadays, many variants on these systems exist and are readily available. They are backed up with detailed training and promotional materials, and markets are growing daily. Some small communities in North America are now able to go from minimal recycling rates all the way to 60%-70%, in a matter of less than 2 years.

Nonetheless, the U.K. is just now beginning its period of explosive growth in the recycling sector, with a whole range of pieces being put in place, and it is inevitable that these will require more time than just 24 months to be fitted together. These tools include: small electric collection carts for urban areas; new paper mill expansions in Bridgewater, Shotton and Aylesford; steady planned increases in disposal taxes; the new Producer Responsibility and Packaging Recovery Note (PRN) schemes; landfill tax rebates; new doorstep collection methods for estate housing; new office recycling systems; expanded central composting sites and markets; the availability of training and employment subsidies through the New Deal; etc.

In other words, recycling and composting in the U.K. is entering a period of extremely rapid growth - similar to that found in Germany and Canada and the US from 1986-1995 - and communities can look forward to a wide range of economic, environmental and community gains, but it will probably take any community 2-3 years to first reach 25%, then another 3-5 to reach beyond 50%. Each community in the U.K. will probably follow a slightly different timeline, and use somewhat different methods - but together, the momentum and critical mass required for Britain to catch up and even surpass the results from other nations now appears to be coming into place.

Appendix 3: Landfill Gas and Health

Landfill Gas Composition

Landfill gas is usually made up primarily of carbon dioxide (CO_2 - from 60% to 40%) and methane (CH_4 - between 40% and 60%). Additionally there are a wide variety of other gases that are present in relatively small amounts (3 to 5% by volume). These gases include nitrogen and occasionally a small percentage of hydrogen and oxygen. Hydrogen sulphide and a wide range of specific organic compounds and inorganic products are also found. It is estimated[9] that as many as 350 different trace compounds may be found and most published research studies indicate that 100 to 200 compounds can be encountered at each site.

The risk from CO_2 and CH_4 is essentially that:

- CH_4 presents a risk of fire should it build up in any enclosed space or explosion should the concentrations be between 5% and 15% by volume.
- Both CH_4 and CO_2 represent a risk of asphyxiation should concentrations build up above 20%. This is particularly a problem in underground voids such as sewers.

The production of methane and other landfill gases is unpredictable. The Energy Technology Support Unit claimed[10] that "*no two sites are the same and prediction remains to a large extent a black art*." A study for the Department of Energy undertaken by the consultants Aspinwalls in 1984 concluded[11] that the average gas yield was 135 m^3 per tonne of biodegradable refuse. Gas yields varied between less than 10 m^3/ tonne to over 200 m^3/ tonne. A later study[12] by consultants ERL (Now ERM) in 1990 found a mean specific gas production rate of 222 m^3/ tonne (comprising 50% methane). The Department of Energy estimated that up to 400 m^3/ tonne is theoretically possible if the microbiological processes was optimised but indicated that much more research would be required in this area. Calculations supporting the DOE figure. However it is not only the gas production rate which is important but also the efficiency of gas capture.

Claims for the efficiency of gas capture vary widely. Independent critics have pointed out [13],[14] that 30-50% of methane leaks over the lifetime of a well-engineered site. Professor Ludwig Kramer, Head of Waste for DGXI supported this in his evidence to the House of Lords European Committee. ENDS reported[15] "*The Euro-Commission's waste policy chief, Ludwig Krämer is disputing the UK claims that landfill gas capture can be as high as 90%, giving a best performance of 60-70%. He also why there is no programme of retro-fitting landfills with gas collection systems, in his appearance before the House of Lords inquiry".*

Whilst no evidence has been presented in support of the claimed high levels of capture, either to this inquiry or to the Lords it is notable that Professor Kramer **did** provide papers to the Lords to support his position. It is notable also that a recent report for the Department of Trade and

[9] Schneider quoted in Landfill Gas – From Environment to Energy, Final report for the Directorate General Energy, Commission of the European Communities, A Gendebein et al, 1992 (p112)

[10] Prospects for Renewable energy in the Norweb area ETSU/NORWEB 1989

[11] Reported in National Assessment of Landfill Gas production, Department of Energy October 1990

[12] National Assessment of Landfill Gas production, Department of Energy October 1990

[13] ENDS 1990 ENDS Report 189, (p18-21), Environmental Data Services, London

[14] Wallis M K 1995 Reassessing methane from UK Landfills, in Waste Disposal by Landfill, ed. RW Sarsby, Balkema, Rotterdam

[15] *ENDS 276, p.33, January 1998*

Industry[16] comes to similar conclusions. The Authors wrote that: *"It has been shown in a previous study (CES 1995[17]), that economically viable power generation may exploit only between 30% and 50% of the potentially extractable LFG production over its cycle (i.e. only about 18% to 30% of the total LFG production*." Or alternatively 70% to 82% of gas would not be used for power generation and at least 40% would escape as fugitive emissions.

This low capture rate, even on modern landfill sites, is important in terms of the trace gases as large volumes are likely to leave the site. Toxicity is raised as an issue in paragraph 3.5 of WMP27:

> '*Some of the minor constituents of landfill gas could have toxic effects, if present in high enough concentrations. Operators should undertake an assessment of risk and where necessary apply control measures as required by the control of Substances Hazardous to Health Regulations 1988. Trace gases do not usually represent a health hazard following normal atmospheric dilution. Hydrogen sulphide is toxic at low concentrations, having occupational exposure standards of 10ppm (8 hour time Weighted Average reference period) and 15ppm (short term exposure, 10 minute reference period) (HSE Guidance EH40).*'

Adverse health effects have been reported by those working on landfill sites. In the State of New York, USA, employees currently working at a large municipal landfill expressed concern that they experience higher rates of illness than other municipal sanitation workers. Therefore, a study[18] was designed to examine acute health effects among employees working at the New York City Department of Sanitation, with special emphasis upon the landfill workers. Interviews conducted with 238 landfill and 262 off-site male employees asked questions about health symptoms experienced in the six months prior to the interview and about workplace exposures. This study found a higher prevalence among landfill employees of work-related dermatologic, neurologic, hearing, and respiratory symptoms, and sore and itching throats than among off-site employees. The respiratory and dermatologic symptoms were not associated with any specific occupational title or work task, other than working at the landfill. Off-site labourers experienced more neuromuscular symptoms and injuries.

More detail on landfill gas and development is given in chapter 9 of WMP27. This considers the development of land around landfill sites. WMP27 does not specifically consider development of a landfill next to existing land uses but we should assume that the same precautionary assessment procedure must apply. In practice the development of a new landfill near existing developments is more problematic because it can be difficult to retrofit gas protection measures into old buildings.

The composition of the gas also varies over time as the different stages of decomposition take place. The initial stages of decomposition, lasting only a few weeks or months, is an aerobic process, leading primarily to the production of carbon dioxide and water, and of course light volatile compounds boiled off by the heat generated by decomposition. Over the years the waste in the landfill undergoes further degradation until it reaches an advanced state of anaerobic decomposition when methanogenic bacteria begin to break down the organic content of the landfill to produce methane. The rate of breakdown and changes in the reactions are difficult to predict and depend upon a range of variables.

In addition to the production of a number of different chemical compound by the direct breakdown

---

[16] Methodologies for the assessment of the UK Landfill gas resource, ETSU BWM/00452/REP, Consultants in Environmental Sciences Ltd 1997

[17] A review of Landfill Gas Modelling Techniques, Environmental Technology Support Unit Report ETSU B/EW/00497/10REP

[18] '*Health Study of New York City Department of Sanitation Landfill Employees*', Kitty H. Gelberg PhD MPH, Journal of Occupational Medcine 39:11 (November 1997) pp 1103-1110

of substances in the waste, and by the action of bacteria, volatile substances in the waste fill can be driven off as gas by the heat generated during decomposition. The heavier fraction of these substances will actually condense in the landfill gas collection system. Particular problems in terms of volatilisation are organic and chlorinated organic solvents, and the heavier hydrocarbons. Although obviously hazardous materials such as solvents are usually dealt with as '*special waste*', such hazardous substances can legally be incorporated within ordinary wastes which is exempted from the Special Waste Regulations (such as domestic wastes), or provided the content falls below specified threshold criteria. Domestic, commercial and industrial waste is also very likely to contain some material that, in isolation, would be classed as 'special'.

WMP27 gives a brief breakdown of the compounds that make up trace gases in Appendix A (p.57). This is in fact extracted from Table 2.1 (p.134) of WMP26[19]. However a more detailed breakdown of landfill gas concentrations is given in Appendix 1 of WMP26.

For this review I have used the data from Appendix 1 of WMP26 – this is a fairly comprehensive list although the ranges reported may be limited as only six sites are included in the study. Levels of hydrogen sulphide are not given in Appendix 1, although there is a volumetric figure given in Annex 2,Table 2.1. This has been converted[20] to a gas concentration assuming standard pressure, molecular weight 34 and an ambient temperature of 20ºC. The figures in Table 2.1 are therefore changed as follows:

- Typical value, 0.00002% v/v == 0.2 ppm == 0.28 mg m^{-3}
- Maximum value, 0.0014% v/v == 14 ppm == 19.8 mg m^{-3}
- Calcium sulphate rich wastes, 35% v/v == 350,000ppm == 495,833 mg m^{-3}

Occupational vs. Long Term Exposure

As noted in the reference to WMP27 given above, the emphasis on toxicity is related to occupational exposure. This is accepted by the industry since there are many situations where operators could come into contact with landfill gas. In these situations the Health and Safety Executive set the occupational exposure standards. '*Occupational Exposure Limits*' are published every year in the '*EH40 series*' report[21]. However in relation to assessing the effects of emissions on public health these limits are not acceptable as they are based on an 8 hour per day or 10 minute exposure over the course of a working lifetime. There are no long term exposure levels (LTELs) set for the type of pollutants found in the trace gas from landfills. 'Standards' are commonly derived by adjusting the occupational figures by a compensating factor. This is chosen to allow for the longer exposure times and increased sensitivity to pollution of local residents who may, for example, be housebound:

- Where EH40 sets an '*occupational exposure limit*' (OEL), we take the OEL and divide it by 100;
- Where EH40 set a '*maximum exposure limit*' (MEL), we take the MEL and divide it by 500 (in recognition that the MEL should never be exceeded).

There are a number of different practices for producing LTELs from OELs or MELs. Consultants such as Environmental Resources Management also use the format I use. Others, for example AEA Technology, have used lower figures in past studies such as OEL/40 and MEL/100.

The exception to the above is the MEL for vinyl chloride. The EH40 document sets this as a

[19] Waste Management Paper 26 - '*Landfilling Wastes - A Technical Memorandum for the Disposal of Wastes on Landfill Sites*', DoE 1986.

[20] From Appendix B, HMIP Technical guidance Note D1… mg m^{-3} = level in ppm * (molecular weight / 24) * (293 / 293)

[21] Current version, EH40/98 - '*Occupational Exposure Limits 1998*', HSE 1998.

volumetric (v/v) figure. As with the examples before I have converted this to a gas concentration assuming standard pressure, molecular weight 62 and 20ºC…

- 7ppm == 18.1 mg m^{-3}

In the table below I list a number of figures from Appendix 1 of WMP26, the MEL/OEL and the LTEL (the MEL/500 or OEL/100 figure). A factor comparing these figures in then calculated by dividing the WMP26 level by the LTEL.

Table 4: Comparison of Occupational and Long Term Standards

Compound	**WMP26 level** mg m^{-3}	**EH40 OEL** mg m^{-3}	**EH40 MEL** mg m^{-3}	**Derived LTEL** mg m^{-3}	**WMP26 ÷ LTEL**
Benzene	0.4 to 114		16	0.032	12.5 to 3,562
Toluene	8 to >460	191		1.91	4.2 to >240
Xylene	34 to 470	441		4.4	7.7 to 107
Hydrogen sulphide	0.28 to 19.8	14		0.14	2 to 141
Ethyl benzene	17 to 330	441		4.4	3.98 to 75
Styrene	<0.1 to 7		430	0.86	0.1 to 8.1
Tricholoroethylene	<0.1 to 170		550	1.1	0.1 to 155
Vinyl chloride	0.1 to 177		18.1	0.036	2.6 to 4,658
Tetrachloroethylene	0.1 to 350	345		3.45	0.02 to 1

The important thing to note here is that although the lower '*WMP26÷LTEL*' figure is in some cases smaller than 1, all the higher figures are greater then or equal to 1. If the public were exposed to poorly diluted gases for a long period of time - as noted in paragraph 3.5 of WMP27 - this would pose a health risk. We have other examples in the UK where there have been warnings about the health effects of landfill gas. For example the consultants Entec said of the Nant y Gwyddon landfill that, "*exposure to undiluted landfill gas in some areas of the site… could* [be] *expected to result in rapid death*"[22].

For example, consider the level of hydrogen sulphide (H_2S) emitted from sites where large quantities of gypsum (for example, plasterboard or filter cake rich in calcium sulphate) have been tipped. The level noted in Table 2.1 of WMP26 was 35%v/v (495,833 mg m^{-3}). At this level, even if the gases from the site were diluted by a factor of a few million, the LTEL would still be exceeded off-site.

As noted in evidence tot he recent Round O quarry appeal inquiry, there exists the potential for substances in landfill emissions, "*at some time in the future, to be real health risks even at very low concentrations*"[23]. Although this comment was made in relation to landfill leachates, there is no reason why the same argument cannot be applied to landfill gas.

Another issue with regard to chemical mixtures is the effect of '*addition*' and '*synergism*':

- Where two chemicals have broadly similar physiological or toxicological effects they can be considered to be the same for the purposes of risk assessment. They are considered to be 'additive'. For example benzene and ethyl benzene act in a similar manner and the figures for these pollutants could be summed as indicated in EH40[24].
- Synergism is where two chemicals act together to promote the effect of one or both. This is a

[22] '*Investigation into Odour Problems, Nant y Gwyddon, South Wales: Final Report*', P.E. Scott et. al., Entec Consulting for the Environment Agency, Report no.97194, Jan. 1998.

[23] Final paragraph of section 5.2, '*Review of Alleged Health Effects at Landfill Sites*', D.J.V. Campbell, AEA Technology (for UK Waste Ltd.), Report no.AEA/WMES/20197001, August 1996.

[24] Paragraphs 67 to 75 and Part 3, EH40/98

very problematic thing to assess because work on the effects of chemical mixtures has only recently started. But there are some effects that are known, such as the combination of chloroform and carbon tetrachloride which produces an effect 4 times greater then the sum. Other industrial emissions and background pollutants, particularly combustion pollutants such as nitrogen oxides or sulphur oxides, also further complicates the issue of synergism.

- The Environment Agency report '*Guidance on the emission from different types of landfill gas flares*'[25] notes that: "*Combinations of odorous compounds can affect the olfactory senses in unpredictable ways, but in view of the large number of such compounds in LFG – less in flare emissions – there exists a significant potential for additive and synergistic effects*".

Additionally, the tipping of wastes in a landfill site, in particular bioactive wastes such as sewage sludge, gives rise to the emission of pathogens into the air. These can be carried on the wind some distance and can be inhaled or deposited on the body and clothing, or deposited on foodstuffs growing outdoors. Another hazard would be disposable nappies which, because of inoculations, can contain a live form of the polio virus. There is very little information on this aspect of landfill pollution. But unlike chemical pollution the issue here is not the level but merely the presence of these agents. This is because if they remain viable during transport they can multiply if deposited on the right type of media and pose a risk to health.

In conclusion, it can be clearly shown that exposure to landfill gas that has undergone little dilution does potential pose a health risk. There are many substances in landfill gas which are present above their occupational exposure limits, and certainly above long-term exposure limits.

Health Effects and '*The Lancet*' Study

The publication of the EUROHAZCON study in *The Lancet* of the possible effects of landfill on foetal development was timely. The results of the paper[26] are based on an epidemiological study looking at the incidence of certain birth defects on live and still born babies carried by parents living near landfills. The study shows a positive association between proximity to a landfill and the incidence of birth defects for a wide range of landfills around Europe.

Whilst epidemiology cannot prove causality I am aware of few publicly available data examining association between emissions and health effects. The reasons for this are:

- The regulatory bodies are reluctant to sponsor such detailed research. The North West Region of the Environment Agency recently commissioned a study from the London School of Hygiene and Tropical Medicine[27] which reviewed other health studies and The DoE waste technical division has published a paper on a modelling methodology. These reports add weight to the concerns raised in the Lancet paper.
- The industry has tried to lay down the potential problems of health effect, and certainly have made little effort to undertake the necessary studies to prove/disprove a causal link. Most applications, like this one, simply avoid addressing the issue for fear of fuelling public anxiety.

The Lancet paper is somewhat limited in that in looks only at birth defects. This is a useful indicator but one for which it will always be difficult to provide a model demonstrating causation because there is little toxicological data on the exposure levels which may cause, for example,

---

[25] p49, '*Guidance on the emission from different types of landfill gas flares*' Report No CWM 142/96A, R.C. Frost, J.E. Pearson and J. Sykes, AEA Technology 1997

[26] '*Risk of Congenital Abnormalities Near Hazardous Waste Landfill Sites in Europe: the EUROHAZCON Study*', The Lancet, vol.352, p423-427, 8th August 1998.

[27] '*Potential Human Health Effects of Landfill Sites*'. Report to the North West Region of The Environment Agency. Martine Vrijheid, Environmental Epidemiology Unit, London School of Hygiene and Tropical Medicine. March 1998.

gastroschesis.

Other studies indicate that health effect such as cancer, neurological problems and respiratory problems are also significant but sceptics will no doubt argue that other confounders may explain some of these effects.

The evidence now available, including the EUROHAZCON study gives us valuable new evidence for health effects from landfill sites. The decision on how to react to this information is essentially political rather than scientific and ultimately depends upon the risk that the authorities are prepared to allow the public to be exposed to

Developing a Source-Receptor Model for Landfills

It is clear of course that to demonstrate a link between landfill emissions and health we must develop a model that shows how the emissions enter the environment, how they are transported, and their fate… *a source-receptor model*. It is very difficult to undertake this for landfill, as the required standard of data does not exist as one body of evidence. However, it is possible to produce a simple model that can give indications about the potential effects of landfill emissions.

Even having defined our '*system*' - a representation of the landfill and its emissions - the next problem is to find a model to actually calculate the dispersion of pollutants in air. Most of the dispersion modelling systems available are intended for larger scale emissions, and are often not ideal for use in near field applications (less than 250 metres). For this reason I have used a dispersion model for this study based on the 'R91' model, but without the more complex features that later models take account of such as terrain, mixing heights and gas density. In any case given that we are considering near-field effects issues such as mixing height and atmospheric stability are not so critical.

The model is not intended to produce precise results - this would be inappropriate in any case given the uncertainties in the data upon which the model operates. But the model does have sufficient accuracy to give an indicative result of the likely dispersion of pollutants. In setting up the data to run the model I have assumed no particular wind direction or meteorological conditions. Wind speeds are taken as an average for the year. Many of the parameters relating to the flares, temperatures, etc. are assumed.

The model essentially considered two types of releases from a landfill site:

- Landfill gas that is released from a single point on a site;
- Landfill gas that is flared from a single point on a landfill site.

The essential difference between the two states we are considering - a flared and an unflared emission - is the plume rise function. Flared gas will be thermally buoyant while unflared gas will rise only as far as its kinetic energy will take it. The practical difference between these two states is that buoyant plumes rise higher, thus reducing ground level concentrations.

The model gives results in terms of a multiplication factor. The pollutant emission is set a 1mg m^{-3} and so to calculate the ground level concentration (GLC) of any pollutant you simply multiply the pollutant concentration in mg m^{-3} by the result of the model at the particular distance required. The results of the two models were plotted on the same graph - figure 1 below - for comparison.

The maxima predicted from the model are:

- For unflared gas, the maximum concentration is 0.0034 mg m^{-3} (per mg m^{-3} release) at 140 metres (equivalent to 3µg/mg, a dilution factor of 333);

- For flared gas, the maximum concentration is 0.00056 mg m^{-3} (per mg m^{-3} release) at 240 metres (equivalent to 0.6µg/mg, a dilution factor of 1,700).

Taking Table 4 given earlier, we can generate a more meaningful set of figures relating to modelled releases and the LTEL - this data is given in Table 2. For each pollutant we take the WMP26 level and multiply by the maximum level from the model to produce the ground level concentration (GLC) this. As with the previous table, this is divided by the LTEL to provide a comparison.

Figure 2:

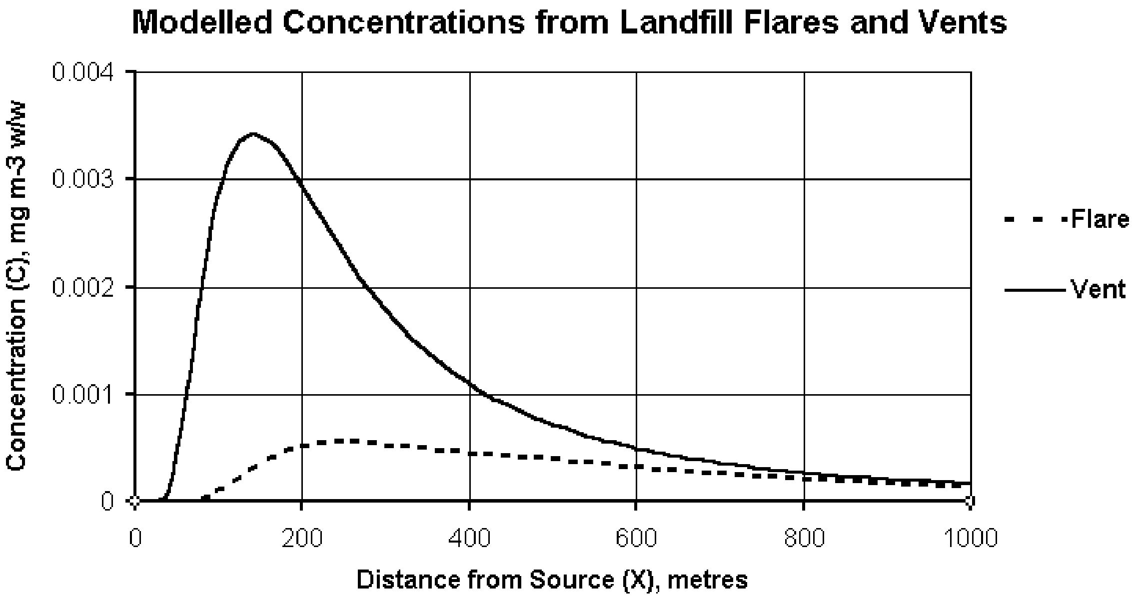


Table 5: Comparison of LTEL and Modelled Levels - Unflared Gas

Compound	WMP26 levels mg m^{-3}	Calculated GLC, mg m-3	Derived LTEL, mg m^{-3}	GLC ÷ LTEL
Benzene	0.4 to 114	0.0014 to **0.388**	**0.032**	0.043 to **12.113**
Toluene	8 to 460	0.0272 to 1.564	1.91	0.014 to 0.819
Xylene	34 to 470	0.1156 to 1.598	4.4	0.026 to 0.363
Hydrogen sulphide	0.28 to 19.8	0.0010 to 0.067	0.14	0.007 to 0.481
Ethyl benzene	17 to 330	0.0578 to 1.122	4.4	0.013 to 0.255
Styrene	0.1 to 7	0.0003 to 0.024	0.86	0.000 to 0.028
Tricholoroethylene	0.1 to 170	0.0003 to 0.578	1.1	0.000 to 0.525
Vinyl chloride	0.1 to 177	0.0003 to **0.602**	**0.036**	0.009 to **16.717**
Tetrachloroethylene	0.1 to 350	0.0003 to 1.190	3.45	0.000 to 0.345

Note, the 'pollutant maxima' level used to calculate the GLC is 0.0034 mg m^{-3}

As can be seen, two compounds - benzene and vinyl chloride, both known carcinogens - both exceed the LTEL. While the variability in this model cannot be relied upon to provide an accurate figure, the strength of the assessment procedure enables us to show that there is a possibility for high concentrations of toxins to be produced from landfill gas. There are therefore obvious implications for public health should landfill gas be vented within 400 to 500 metres of any dwelling or occupied structure.

Data on flare emissions is provided in the Environment Agency report '*Guidance on the emission from different types of landfill gas flares*'[28]. The report was undertaken to review the regulatory gap in standards for landfill gas flares and to inform the development of new standards. Concerns are raised about the effectiveness of open flares and recommends that in future no more open flares should be installed on UK landfill sites. AEA Technology, the authors of the report, also recommend that operators of landfill sites should undertake or commission an environmental assessment of the emissions from proposed flares that should use real emissions data and local meteorological data, and consider the impacts of the dispersed emissions in the vicinity. I consider that UK Waste should have undertaken such a study as part of the environmental information provided to this inquiry.

The results of the simple modelling exercise show that for unflared landfill gas the LTEL could be exceeded for two compounds - benzene and vinyl chloride. If we include other effects such as the addition or synergism between substances, or the current exposure levels then it is likely that other groups of chemicals would also exceed the LTEL. This simple assessment demonstrates that there is a possibility for high off-site concentrations of toxins to be produced from landfill gas. There are obvious implications for public health should landfill gas be vented within 400 to 500 metres of any dwelling or occupied structure.

In conclusion

There would be very large volumes of gas released from the site even with the best gas collection and control systems. These gases are likely to contain hundreds of toxic compounds.

Modelling indicates that there exists the potential for adverse health effects from the release of landfill gas – this supports the findings of the epidemiological work carried out by many agencies in this country and elsewhere that there is a link between landfill emissions and health. Improved data would improve the accuracy of the assessment. The purpose, however, was mainly to demonstrate the plausibility of a causal relationship.

In these circumstances a precautionary approach should be taken. Therefore all references to Round O quarry being used for the deposit of biodegradable waste must be removed from the plan.

[28] Report No CWM 142/96A

Appendix 4: The Geology of Round O Quarry

Introduction

Considering that the greatest protection against the migration of gases and leachate from a landfill is given by geology, it is very disappointing that Lancashire County Council have given no thought to the suitability of the sites selected in the plan for the deposit of waste.

In order to have a better understanding the local geological conditions I have obtained a photocopy of the British Geological Survey (BGS) map for the area. The relevant section of this map is shown of the following page (fig. 3). The map is particularly hard to read, partly because of the complex geology, but also because the map shows all the local coal seams. I have therefore produced a 'trace' of the original map to simply the main geological features, and exclude the coal seams. Finally, taking the data from the photocopy, I have plotted a geological section beginning at the eastern edge of the quarry, running through the middle of the quarry void, and terminating at the Upholland Fault.

Interpretation of the BGS 1:50,000 sheet

The area from Newburgh to the south-west, until the 'Boundary Fault' (the boundary between the Carboniferous (Westphalian) strata and Permian/Triassic sandstones) is a long plunging syncline (axis of plunge in the immediate area around Round O is very nearly south-west). This has been cut by the Upholland Fault and the Blaguegate Fault. In the immediate area around Round O Quarry this means that the 'end' of the syncline plunges at a steep angle[29] until it abuts the Upholland Fault. This same position is also the location of the River Tawd.

Evidence to the recent Round O Quarry appeal inquiry[30] notes that the groundwater gradient is expected to be trending to the north-west, following the River Tawd catchment. I do not see how this situation can arise in the immediate locality of Round O Quarry as the plunging syncline will effectively channel all water to the south-west until it meets the Upholland Fault. At that location it is likely that water will then begin to move north-west. This has important effects on the movement of seepage from the landfill. Instead of spreading by groundwater movement and diffusion into an ever broader cone, the pollutants would trend along the plunge of the syncline.

The movement of pollutants is not primarily controlled by groundwater flow. Another important factor is the density of the pollutants relative to water, and their solubility. In general the following can be said about pollutant movement in saturated rocks:

- Where the pollutants are less dense than water, and are partially/totally insoluble, they will float on the surface of the groundwater. The main effect of these pollutants will be to arise in high concentrations at springs since they are not readily dissolved throughout the water column.
- Where the pollutants are more dense than water, and are partially/totally insoluble, they will fall to the bottom of the water column (i.e., the first point where a change in permeability causes them to accumulate) and 'pond'. This 'pond' of material will then fall along the surface of the strata according to gravity, not groundwater flow.
- Where the pollutants are of neutral density, or are soluble, they will disperse through the water column. Their concentrations/mixing in these circumstances is primarily determined by the mode of groundwater flow (whether this is primarily pore flow or fracture flow).

[29] The precise angle of plunge, and associated dip on strata, is not readily determinable from the BGS sheet, and would need to be assessed by field surveys.

[30] Paragraph 2.4.2, 'environmental information' produced by RUST Environmental in support of UK Waste's Round O Quarry application, January 1997

The RUST study does accept that the strata of Round O Quarry are in hydrological continuity with the River Tawd - i.e., there are few low permeability strata between the two to effectively halt groundwater movement. However this statement does not tell us about the actual mode of movement. If the folding of the strata to form the syncline has led to extension and fracturing of the sandstones - which is highly likely - then it is possible that fracture flow could be a more effective conduit for groundwater than pore flow. In this case any pollutants in the water column would rapidly spread away from the site. There appears to have been no assessment of the likely conditions of the local strata in terms of pore and fracture flow.

Another issue is the possibility for water movement along the Upholland Fault. Given that the River Tawd is in contact with this fault, and that it is obviously part of the regional fault network (as opposed to small faults resulting from the relaxation of strata following the ice ages), it is likely that there is not just one fault - it will be a sequence of small faults trending along the same line. This increases the possibilities for groundwater movement by fracture flow, particularly if there was some compression in the faulting movement which caused shattering of the rocks along the face of the fault.

Finally, the RUST study notes the presence of boulder clay deposits around the area. It is crucially important that the extent of these deposits and their relation to the propose landfill are studied because it could act as a 'capping' to trap any migrating landfill gas. If there were boulder clay extending from the area of the quarry landfill gas could migrate some distance before coming to the surface. It was precisely this type of geology - a porous strata overlain by low permeability strata - which led to the migration of gas from the landfill at Loscoe and the explosion in a nearby building in 1986.

Conclusion

Having evaluated the information available from the RUST study and the BGS 1:50,000 sheet I conclude that this location is totally unsuitable for a landfill. This is because:

- The landfill is in hydrological continuity with the River Tawd. Given the proximity of the two - only 600 metres - any pollution emanating from the site could rapidly enter the water environment.
- The presence of a plunging syncline extending beneath the quarry and trending towards the River Tawd increases the risk that pollutants emanating from the quarry would be preferentially directed towards the river, and would not therefore undergo sufficient dilution to mitigate the effect of the seepage.
- Given the highly complex nature of the local geology it is likely that there is a higher than normal (compared to undeformed sandstone strata) likelihood that groundwater movement is by fracture flow rather than pore movement. This again increases the speed of migration, and it substantially reduces the level of dilution of the pollutants.

The RUST statement, while sufficiently identifying the local rocks, does not given any consideration to geological structures. These are as important as the rock types themselves. It is also not clear to what extent RUST's deductions are based on desk studies, and what data has been produced from field studies of the quarry and its surroundings.

In terms of landfill gas, the composition of the soil/subsoil is very important because there is the potential for gas to be trapped at high levels in the unsaturated sandstone. This gas would then move under pressure until it found a way to the atmosphere. Given the risks from gas migration in unsaturated strata capped by low permeability soils I would have expected there to be some information regarding the extent of local soil cover.

I do not see how this site could be considered as suitable for landfilling biodegradable materials given the legal restrictions imposed by the EC Groundwater Directive[31] and the relevant objectives of the EC Framework Directive on Waste.

Fig. 3 - BGS 1:50,000 Sheet No.84 ('Wigan') - Solid

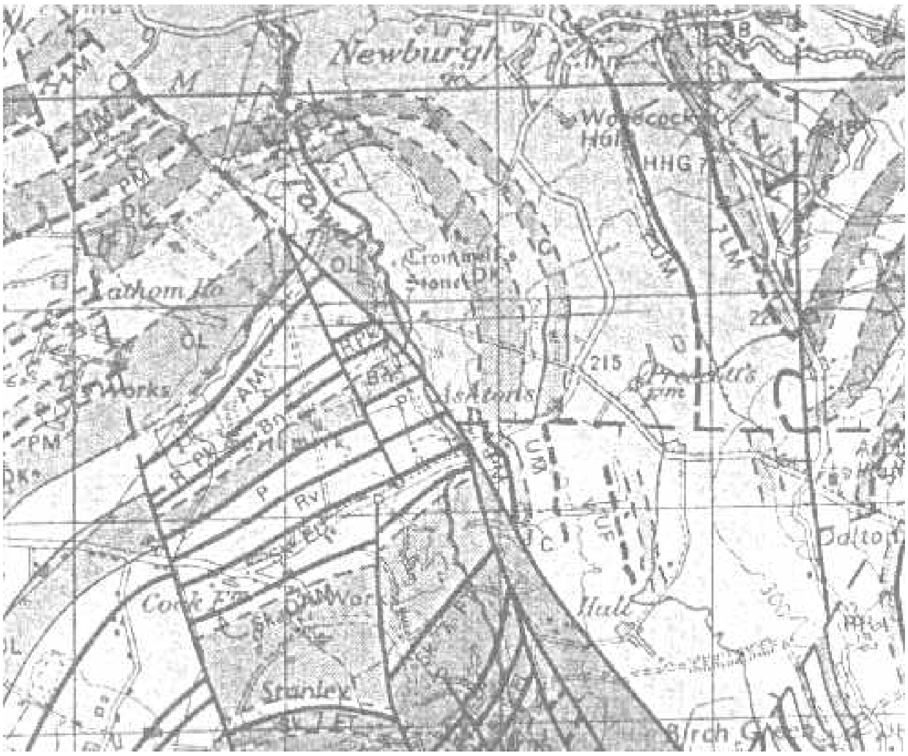
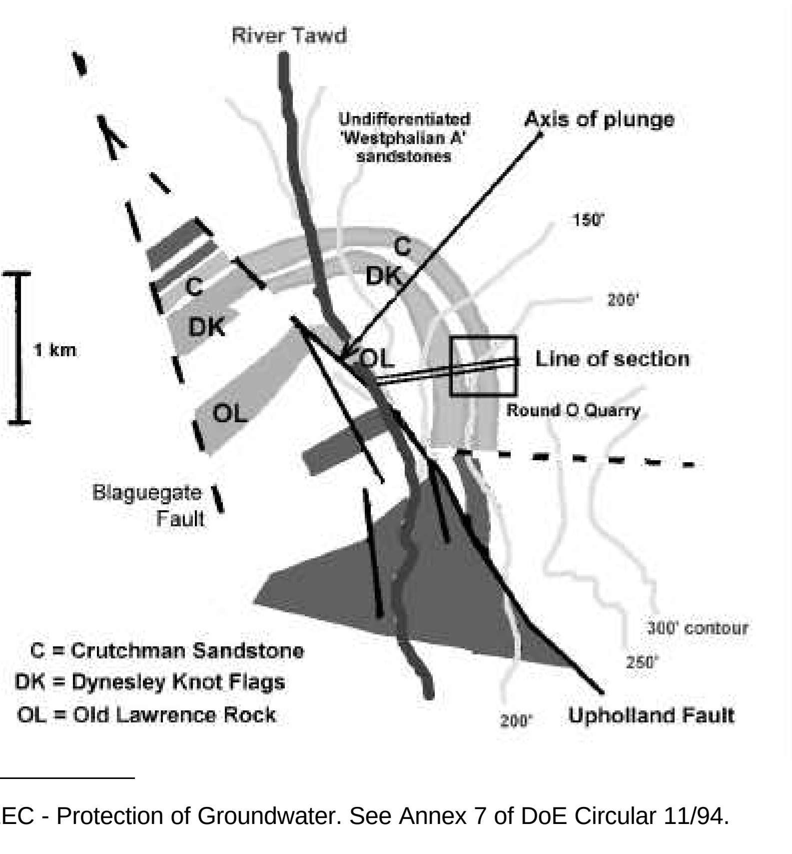
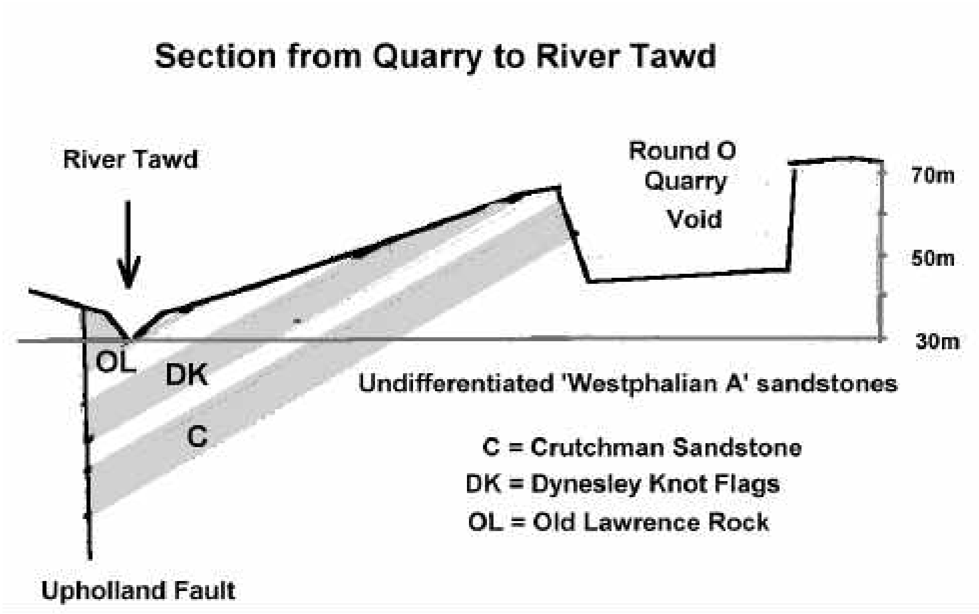


Fig 4 - Simplified trace of 1;50,000 BGS Sheet 84



[31] EC Directive 80/68/EEC - Protection of Groundwater. See Annex 7 of DoE Circular 11/94.

Fig 5 - Geological Section (from figure 4)



(vertical exaggeration x 25)

Note - the actual dip on the strata (C & DK) is likely not to be a straight line. The strata could be deformed into more of a parabola, but this is dependent on the size of the original fold, and to what extent the upper portions have been eroded away.