Biofilter matrix, monitoring and long term implications

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Preferred matrix

- Four components:
  - Coir pith (instead of peat)
  - Oversize wood fibres (cheap structure)
  - Mature compost (nutrients and methanotrophs)
  - Expanded clay (structure and matrix)

Mixing and Covering

- Agricultural mixer
- Cover with wood fibre waste as moisture mitigation

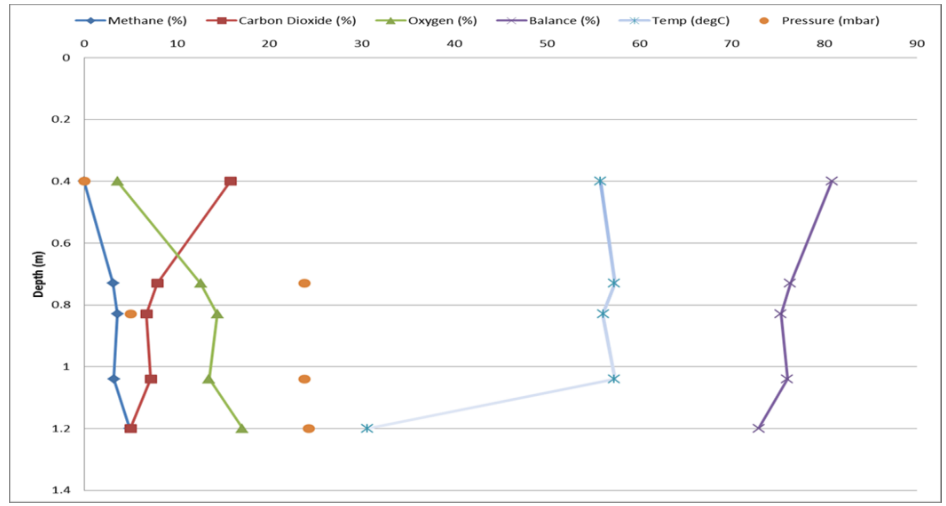
Surface flux & destruction efficiency

- Acumen project found flux box survey in same ballpark as other techniques

Technique	Methane flux kg hr^{-1}	Uncertainty ±kg hr^{-1}
DIAL	2.9	0.4
Flux box survey	0.71 – 2.71	0.31 –0.67
Flux sheet	0.70 – 2.54	-
Q-SES	0.629	0.124

Monitoring for permit

- Monthly vertical profiling
- Monthly FID survey of features (~100ppm CH_4)
- **Holistic** monthly health assessment
- Annual flux box of features and use 95th percentile



Monitoring points to note

- Gas volume out biofilter ≠ Gas volume into biofilter. $CH_4 + 2O_2 = CO_2 + 2H_2O$ Temperature and balance gas changes are key indicators of continued biofilter 'health'
- Features move around the surface
- Humidity is always 100% and shouldn't be monitored
- Some condensate, but very weak

Condensate

Client:	Norfolk County Council	Project:	Landfill Tender 2010
		Sample Point Name:	CC Norfolk CC FW Short
Folder No:	002747861	Sampled on:	20-Mar-14 @ 11:00
Comments:	Strumpshaw Condensate Drain		
Quote No:	6109	Matrix:	Freshwater

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Ammonia un-ionised as N	NoResult	mg/l				NLS	864
Temperature of Water	NoResult	Cel			None	FI	936
Ammoniacal Nitrogen as N	56.1	mg/l		0.03	UKAS	SX	25
Chloride	61.0	mg/l		1	UKAS	SX	25
Nitrogen : Total Oxidised as N	14.3	mg/l		0.2	UKAS	SX	25
Conductivity at 20C	3410	uS/cm		10	UKAS	SX	9
pH	6.96	pH Units		0.05	UKAS	SX	9
Carbon, Organic : Total as C :- {TOC}	205	mg/l		1	None	NM	1102

Outcomes

- Strumpshaw constructed for ~£25,000 (2014 prices)
- Destruction efficiency does vary but generally >90% using flux box testing
- At all sites where flare was struggling or gas too lean, the constant running of the biofilter has removed Permit non-compliances

Long term implications

- Biofilter teething issues resolved
- Reduced emissions to environment
- Reduced noise disamenity
- Reduced visual disamenity
- Reduced security risk disamenity

Future opportunities

- When gas production really drops, then possibility of passive biofilters using barometric fluctuations
- This technology can be applied now at a microscale for perimeter migration problems – Bioboxes over existing wellheads

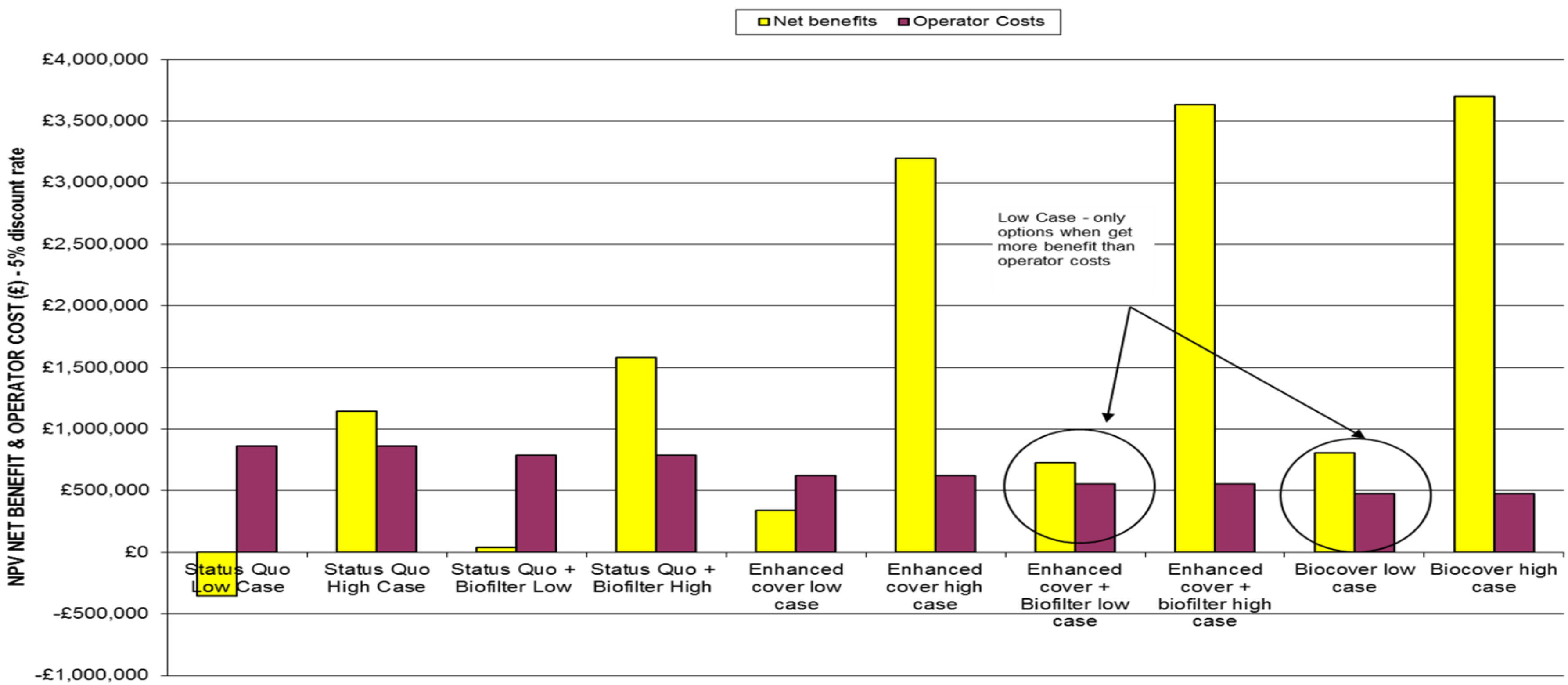
Biocover additional benefits

- Carbon capture
- Woodland creation plus diversity
- Biocrops
- Oxygenated recharge to underlying waste (maintain moisture and reduce leachate impact)

Status quo - flare

85% recovery	engineered cap	flare and blower installed									flare and blower replaced	
LOW CASE ENVIRONMENTAL COSTS AND BENEFIT	Years											
Costs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
capital costs	£500,000	£100,000	£0	£0	£0	£0	£0	£0	£0	£0	£0	£100,000
Security costs	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000
Blower operating cost	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179	£3,179
monitoring costs	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000
Flare carbon dioxide emissions (burned CH4 plus CO2 slippage) £9.5/tonne	£67,092	£60,341	£54,330	£48,967	£44,174	£39,882	£36,035	£32,581	£29,476	£26,682	£24,165	£21,895
Flare NOx emissions £154/tonne	£554	£498	£448	£404	£365	£329	£297	£269	£243	£220	£199	£181
Blower environmental costs	£118	£118	£118	£118	£118	£118	£118	£118	£118	£118	£118	£118
Methane leakage through cap £158/tonne	£39,780	£35,778	£32,214	£29,034	£26,192	£23,647	£21,366	£19,318	£17,477	£15,820	£14,328	£12,982
Oxidised methane plus carbon dioxide leakage through cap £9.5/tonne	£5,262	£4,733	£4,261	£3,841	£3,465	£3,128	£2,826	£2,555	£2,312	£2,093	£1,895	£1,717
total costs	£625,985	£214,647	£104,550	£95,543	£87,492	£80,284	£73,822	£68,020	£62,805	£58,112	£53,885	£150,073
benefits												
Reduced emissions to environment (low case)	£187,477	£168,602	£151,795	£136,799	£123,396	£111,397	£100,640	£90,981	£82,300	£74,487	£67,450	£61,104
Reduced noise disamenity (nill using flare)	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Reduced visual disamenity (nill using flare)	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Reduced security risk disamenity (nill using flare)	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
total benefits	£187,477	£168,602	£151,795	£136,799	£123,396	£111,397	£100,640	£90,981	£82,300	£74,487	£67,450	£61,104
NET BENEFITS	-£438,508	-£46,044	£47,244	£41,257	£35,905	£31,114	£26,818	£22,961	£19,495	£16,375	£13,565	-£88,969
PV benefits exc disamenity	**1,278,376**											
PV of disamenity avoided	**0**	To be calculated for other options, but zero for flare					Cost of methane emission				£158	
Total PV Benefits	**1,278,376**						Cost of carbon dioxide emission				£9.5	
NET PV benefits (5% interest rate)	**-354,365**						Cost of NOx emission				£154	
PV costs	**1,632,741**											
							Percentage capture				85%	
							Percentage leakage				15%	
BCR	**0.78**						Percentage methane leakage unoxidised				100%	
					Year 41- 50 gas generation based on asympotic gas generation from year 40.							

Cost benefit – Sardinia 2011



- Biocovers and windows also benefit from embedding carbon and woodland opportunities

Conclusion

- Biofilters are an established technology with the most benefit for the least cost (both monetary & environmental)
- Cost Benefit Analysis suggests that the best option for long term management of poor quality landfill gas is not a highly engineered system, but instead a biological system relying on natural oxidation mechanisms