Carcass disposal: lessons from Great Britain following the foot and mouth disease outbreaks of 2001


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Summary
The foot and mouth disease (FMD) outbreak that occurred in the United Kingdom in 2001 was of an unprecedented scale and severity and presented a massive logistical challenge to Government. Over 6.5 million animals were slaughtered and disposed of, over 4 million as a direct result of disease and a further 2.5 million on welfare grounds. On-farm burial and on-farm burning were the principal routes for disposal at the commencement of the outbreak. On-farm burial was limited by legislation to protect groundwater supplies and pyre burning came increasingly under attack from local communities concerned about health risks from smoke and emissions. Burning also painted a vivid but distressing picture of the war against disease.

Increasingly, rendering capacity made an important contribution to disposal. The peak of the outbreak could only be managed by the development of a new disposal route – mass burial in engineered sites and by using licensed landfill where available. During the course of the outbreak, a disposal hierarchy was developed to reflect environmental and public health concerns, namely: rendering and incineration ranked first, licensed landfill next, followed by burning with mass burial or on-farm burial as the least preferred options. However, the campaign against the disease could not have been won without the tactical use of mass burial in addition to all the other available disposal routes. The authors describe the development and deployment of the disposal routes used in the 2001 outbreak.

Keywords

Introduction
The foot and mouth disease (FMD) outbreak that occurred in the United Kingdom (UK) in 2001 was quite different from the previous major outbreak in 1967 for several reasons. Firstly, geographic spread of the outbreak would appear to have been exacerbated by rapid and widespread animal movements, especially sheep, in which early identification of disease on clinical signs alone was difficult. Secondly, in 2001, the issue of bovine spongiform encephalopathy (BSE) and the impact of this disease on the disposal of cattle carcasses was a key issue and thirdly, environmental legislation and awareness has changed. At the commencement of the outbreak, the disposal options were effectively limited to on-farm burial and pyre burning. However, as the extent of the outbreak became clear, and the constraints of the two disposal routes became apparent, alternative disposal options were rapidly implemented.

The various options for disposal are described and statistics are presented for the animals slaughtered and disposal routes utilised. The pressing challenge during the outbreak was to match the limited disposal resources and develop new resources given the number of slaughtered animals which needed to be disposed of within very tight time-frames. The time from slaughter to final disposal had to be reduced as much
as possible to limit and control spread of the disease and minimise any potential risk to human health or the environment from contamination of surface and groundwater, or air pollution.

Changes since the 1967 outbreak that affected carcass disposal

A number of significant changes affected the disposal operations during the 2001 outbreak compared to that of 1967. These changes include the size of cattle and sheep populations and holdings, environmental and animal by-products legislation (4), farming and trading patterns, culling strategies and logistical factors relating to all the disposal routes. High employment levels in Great Britain (GB) also made it difficult to source both managers and workers to staff the many disposal activities.

The cattle population has remained broadly similar in GB since 1967, at 11-12 million head, but the sheep population has increased markedly from around 28 million ewes and lambs to over 40 million. At the same time, the number of holdings has decreased and the size of most holdings has become larger. Stocking rates have also increased. The distribution of pigs in GB has also changed markedly during this period with a high concentration in the eastern arable counties of England and far fewer in the western, more grass dominated areas of the country. The net effect of these changes has been that the flock or herd size culled during the 2001 outbreak was much larger than in 1967. Table I shows the number of animals slaughtered in 2001 compared to the numbers slaughtered during the 1967 outbreak.

Table I
Numbers of animals slaughtered on infected premises in the 1967 outbreak compared to numbers slaughtered in 2001

<table>
<thead>
<tr>
<th>Number of premises and animal details</th>
<th>1967 foot and mouth disease outbreak</th>
<th>2001 foot and mouth disease outbreak</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of premises</td>
<td>2,364 ‡</td>
<td>2,030 (c)</td>
</tr>
<tr>
<td>Cattle</td>
<td>211,825</td>
<td>306,053</td>
</tr>
<tr>
<td>Pigs</td>
<td>113,766</td>
<td>20,204</td>
</tr>
<tr>
<td>Sheep</td>
<td>108,345</td>
<td>954,139</td>
</tr>
<tr>
<td>Goats</td>
<td>51</td>
<td>882</td>
</tr>
<tr>
<td>Total animals</td>
<td>433,987 ‡</td>
<td>1,281,278</td>
</tr>
</tbody>
</table>

(a) Source: The Northumberland Report (13)
(b) Source: Department for Environment, Food and Rural Affairs (DEFRA) Disease Control System, 9 January 2002. Note figures are provisional and subject to change
(c) In 1967, there were 2,364 outbreaks on 2,346 farms, 18 of which were infected on two occasions
(d) Infected premises only
(e) Includes animals slaughtered as dangerous contacts

The contiguous cull policy also significantly increased the burden of disposal compared to 1967 where only infected stock and dangerous contacts were slaughtered. This contiguous cull policy, together with the culls in Cumbria and Dumfries, allied with larger holdings and therefore flock/herd size, account for the major difference in the numbers slaughtered during the two outbreaks (433,987 in 1967 compared to 4,042,166 in 2001).

Changes in environmental legislation also had a major effect on disposal. The need to obtain groundwater authorisations (3), before either on-farm burial or on-farm pyre burning could take place, introduced some procedural delays. More importantly, the groundwater authorisation risk analyses markedly reduced the number of sites on which either process could take place. This created a new disposal burden not encountered in 1967, namely, the disposal of large numbers of carcasses off-farm by means of rendering, disposal in licensed landfills, mass burial or remote burning. All of these new routes increased the logistical problems of carcass handling, transport and disposal. The development and rigorous enforcement of a strict biosecurity protocol was also required to permit these off-farm movements.

Patterns of farming and trading have changed markedly since 1967. The impact of the rapid and widespread movement of sheep, particularly through markets, which had taken place before the first case was confirmed, was not recognised until the disease had already been spread widely throughout the country. Good transport links, large lorries and the imperative to make a profit result in sheep moving rapidly over long distances and across international borders. The 2001 outbreak consisted of a series of interrelated mini-epidemics originating from a single source; disposal therefore had to be organised to match this pattern. Farmers and their workers and suppliers are also much more mobile, markedly increasing the risk of point-to-point transfer of the disease. Furthermore, milk is now collected by bulk tankers which have to enter farmyards close to livestock housing whereas in 1967, milk was mostly collected in churns from the roadside.

Lorries, excavating equipment and other machinery and plant were in plentiful supply throughout the course of the 2001 outbreak but the speed of spread and the extent of the outbreak posed substantial logistical problems. Organisation of contracts, management of contractors and the need for increasing numbers of contractors, supervisors and managers created serious problems for disposal operations. Material for pyre burning became increasingly difficult to obtain. Rapid price inflation was observed for sleepers and other fuel wood. Some poor quality coal made it difficult to achieve complete combustion and with less manual labour available, fire watching and tending were reported to be less efficient than in 1967.
Disposal options for carcasses

On-farm burial

On-farm burial was a major disposal method in the 1967 outbreak and was highlighted as the preferred disposal method in the 1968 Report of the Committee of Inquiry on Foot and Mouth Disease (The Northumberland Report) for rapid disposal of carcasses and elimination of virus load (13). This route was severely curtailed by environmental regulations in 2001. The method of burial remains much the same as before except that lime has ceased being added to burial pits since it has been found to inhibit the natural degradation process. The Environment Agency (EA) and Ministry of Agriculture, Fisheries and Food (MAFF) issued detailed guidance on the steps to be taken prior to burying carcasses in a joint statement on 28 February 2001 (11). This highlighted the need to protect the environment, in particular groundwater, and outlined the requirements of the 1990 Environmental Protection Act (1), the 1994 Waste Management Licensing Regulations (11) and the 1998 Groundwater Regulations (3).

This latter statute requires that a risk assessment be undertaken and that the EA issue a Groundwater Authorisation (GWA) prior to disposal. These environmental regulations did not exist in 1967 and were a major limitation to on-farm burial in many areas. Some proposed disposal sites were not found suitable for burial, being close to vulnerable water resources or located in major flood plains.

On-farm pyres

On-farm pyres were used extensively in 1967 for rapid disposal of carcasses and elimination of virus load and formed part of the MAFF contingency planning for FMD. Detailed decision-tree diagrams on the suitability of constructing on-farm pyres were also included in the joint statement by the MAFF and the EA (11). The guidance note also outlined the need to obtain a GWA from the EA, prior to construction of a pyre (Fig. 1).

Standing instructions (9) for pyre construction varied widely during the outbreak with considerable innovation to ease construction and improve burn rates and overall loading of stock. For the first time, large multiple pyres on single sites were utilised to burn stock from neighbouring farms.

Rendering

Rendering involves heating ground carcasses in large boilers to specific temperature, time and pressure combinations. Tallow (fat), meat-and-bone meal and steam (which is condensed) are the end-products of the process. The tallow and, in some cases, the meat-and-bone meal produced by rendering can be burned on-site to generate steam to heat the cookers. Meat-and-bone meal can also be used as fuel in specialised furnaces away from the rendering plant to generate electricity. The process therefore involves a degree of recycling and energy recovery. The normal rendering process is believed to destroy 98% of BSE prions (14) and is the preferred option for disposing of all cattle and the required option for disposal of cattle born before 1 August 1996 (or for which the age is unknown). Great Britain possesses about twenty rendering plants capable of disposing of mammalian carcasses. During the course of the outbreak, six plants were contracted to deal solely with FMD stock, representing a potential weekly capacity for 15,000 tonnes of carcasses. Detailed biosecurity measures were implemented at these plants, including changes to the treatment of waste air and water streams to avoid the possibility of any virus escape. Special arrangements for the transport of carcasses were also made and included a separate escort car accompanying every lorry, to provide emergency biosecurity cover in the event of an accident or incident involving the lorry or driver. At the time of writing (January 2002), all but one of these rendering plants have undergone a supervised disinfection regime and been returned to commercial use. Rendering for disposal of FMD carcasses was used in GB for the first time during this outbreak.

High-temperature incineration

Second to rendering, this is the preferred disposal route, but most incineration plants burn less than one tonne per hour and are not large enough to accommodate a whole bovine carcass. All facilities capable of receiving whole bovine carcasses were fully committed to the disposal of either BSE infected cattle, specified risk material (SRM) or cattle destroyed under the ‘over thirty months scheme’ (OTMS).

Mass burn sites

Stock from more than one farm was disposed of by burning, either on multiple pyres or in air curtain incinerators at these sites. The largest were at Ascott Farm in Devon, Eppynt in Wales, Catterick in Yorkshire and Hemscott Hill in County Durham, with three further sites in Scotland. Many smaller sites, however, were used to dispose of animals from neighbouring farms as well as those from the farm on which the pyre was located and were also regarded as mass burn sites.
**Mass burial sites**

Mass burial sites constituted an innovation for FMD management in GB. The need for the sites became apparent when the outbreak was increasing at an exponential rate and all other routes of carcass disposal had been exploited to their limits. Large sites were procured by the MAFF (five in England, one in Wales and one in Scotland) in which multiple pits, each capable of holding between 10,000 and 60,000 carcasses, were engineered (Fig. 2).

Initially, there were no proven designs for mass burial sites and the design and engineering features of the sites underwent very rapid development and change over four to six weeks at the peak of the outbreak. Initially consisting of large holes in the ground, pits were successively engineered with increasingly sophisticated liners and leachate collection systems to minimise risk to groundwater.

The severity of the emergency decreed that operational needs had to be met and little advance consultation or reference to stakeholders and environmental bodies could be made if the objective of preventing a public health or animal health disaster due to failure to dispose of carcasses were to be avoided.

All sites were risk assessed and granted groundwater authorisations and discussions on planning consents and other environmental matters were held retrospectively. All sites were ‘engineered’ to provide a safe disposal route and works are ongoing to provide leachate control and monitoring facilities.

Seven sites were procured as mass disposal sites, as follows:

- Ash Moor, Devon, England (not used)
- Great Orton, Cumbria, England
- Birkshaw Forest, Lockerbie, Scotland
- Throckmorton, Worcestershire, England
- Sennybridge (Eppynt), Powys, Wales (closed and reinstated)
- Widdrington, Northumberland, England

These sites were used (together with rendering and licensed landfill) to meet the peak demands for disposal and are regarded as national assets. All sites are currently ‘closed’ but it would not be responsible for the Government to entirely dismiss the possibility of a disposal outlet that might theoretically be needed at some point in the future. It should, however, be stressed that the Department for Environment, Food and Rural Affairs (DEFRA) has no plans to use them and that restoration schemes are currently being drawn up.

**Licensed commercial landfill**

As part of ongoing contingency plans, the EA identified possible licensed commercial landfill sites in England and Wales, which were suitable for the disposal of carcasses. An existing protocol between the MAFF, the Intervention Board [now the Rural Payments Agency (RPA)], the EA and the Environmental Services Association (ESA) (the waste industry trade body) usually limits carcass disposal to 5% of the existing permitted disposal inputs of waste. Only sites that satisfied EA requirements in terms of location with respect to flooding and aquifers, engineered containment, leachate management and gas management regimes, together with pre-requisite licence conditions, were considered.

In theory, landfill capacity could have comfortably absorbed all the stock slaughtered both in the FMD outbreak and from the subsequent Livestock Welfare Disposal Scheme (LWDS). However, few licensed landfill operators were prepared to accept carcasses, and then, because of the potential BSE risk, only sheep and pigs.

To develop sufficient capacity to meet the peak demands of the outbreak would have required Government to direct the landfill industry to take carcasses. There are risks associated with issuing directions. For example, directions provide the landfill operator with a defence against contravention of planning controls and this entails the risk of challenge under the Human Rights Act.

There were also obvious risks in putting FMD-infected stock into licensed landfill – but the disease risk would have been no greater than that taken with mass burial. The regulations, which enable directions to be issued, did not apply to the carcasses of ‘cattle born before 1 August 1996’ and therefore, rendering or commercial incineration would still have been required (5).

The most pressing problem in relation to the voluntary contracting of licensed landfill sites to meet either FMD or LWDS needs was the opposition of local public, local authorities, members of parliament (MPs), pressure groups and farmers near the sites.
Air curtain incinerators

Air curtain incinerators (ACIs) are devices originating from the United States of America and used principally for burning waste wood. Two designs exist, namely: one possesses an integral firebox while the other, a trailed version, requires that a pit be excavated to form the fire chamber. The principle of operation is that of a large fan creating a laminar airflow directed into the fire chamber, thus accelerating combustion. Within the containment of the fire chamber, the air stream forms a turbulent ‘rotary’ draught. Waste wood (mainly pallets) and carcasses are alternately fed into the combustion chamber and operations are continuous until the fire chamber has to be emptied of ash.

Air curtain incinerators were used to a limited degree in the FMD outbreak. The incinerators are mobile but only work effectively using dry, seasoned timber as a fuel. The tightly drawn air curtain incinerator regulations (6) prevent their use for anything other than an epidemic of FMD and even then, special conditions apply.

The incinerators possess a number of theoretical advantages, none of which have yet been fully substantiated in the field or by experimental trial, as follows:

– less noxious emissions than pyres
– consumption rates of 2-6 cattle or 8-16 sheep per hour dependent on model
– higher burn temperatures than pyres.

Trial work has been commissioned to evaluate these theoretical advantages under controlled conditions.

Other disposal options

Other disposal options, including hazardous and chemical waste incineration, industrial incineration and cold storage prior to disposal by the other routes described, were all investigated but were ruled out on grounds of excessive cost, insufficient capacity or because of difficulties in obtaining the required consents.

Development of a disposal hierarchy

An early priority was to agree on a carcass disposal hierarchy between all key stakeholders. This took account of the need to protect public health, to safeguard the environment and to ensure FMD disease control was not compromised. The cost of disposal was also a material but much less important factor. All groups agreed that rendering and fixed plant incineration were the preferred methods of disposal, but it was clear from the outset that these resources were not immediately available and even when exploited to their full, could only partially meet the need for disposal.

Commercial licensed landfill was agreed on as the next best environmental solution to the disposal of carcasses and there was confidence that disease risk from this route could be managed. However, a number of legal, commercial and local community problems were posed with the use of this route for FMD-affected stock disposal. In effect, these problems could not be addressed, but licensed landfill did play a critical role in the disposal of non-diseased stock slaughtered as part of the LWDS and for FMD-affected stock in Cumbria.

Pyre burning, used since the outset of the outbreak, increasingly caused public, scientific and political concerns. The adverse public perception of pyres, allied with concerns about the emissions of dioxins and the health effects from inhalation of smoke, led to increasing application of the precautionary principle in relation to pyre burning. The use of pyres was eventually discontinued on 7 May 2001 when the outbreak had subsided to about seven new outbreaks a day.

Guidance from the Department of Health (DoH) (7), issued at the end of April 2001, was that large pyres (1,000 or more cattle equivalents) should generally be built 3 km or more from local communities, such as villages. Members of the public were advised to avoid sustained exposure to smoke and irritants within the vicinity of pyres, particularly if suffering from asthma. This would limit the number of suitable sites and EA groundwater and local authority air quality assessments would be required, with resultant delays in disposal. There were also concerns over dioxins and other products of combustion and these concerns were important considerations in the development of the disposal hierarchy.

On-farm or mass burial was placed at the bottom of the disposal hierarchy, principally due to the implied risks of firstly, BSE and secondly, the general risk to groundwater from burying animals. However, it cannot be stressed too highly that this epidemic could not have been contained if on-farm burial and mass burial had not been available to the degree and at the time they were needed.

An assessment of risk due to BSE infectivity from the disposal of cattle as a result of FMD was commissioned by the MAFF on 28 February 2001 and an initial appraisal was presented the following day. More detailed modelling was subsequently undertaken and presented to the Spongiform Encephalopathy Advisory Committee (SEAC) on 30 March 2001 and the final report was published on 24 April 2001 (15).

The agreed generic disposal hierarchy for carcasses, reflecting advice from all stakeholders, was published by the DoH (7) on 24 April 2001 and is given in Figure 3.
Summary statistics – foot and mouth disease

Summary statistics for the 2001 FMD outbreak are presented in Table III.

**Table III**

**Summary statistics for the 2001 foot and mouth disease outbreak**

(Note: figures are provisional and subject to change)

<table>
<thead>
<tr>
<th>Summary statistics</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holdings affected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– infected premises</td>
<td>2,030</td>
<td></td>
</tr>
<tr>
<td>– dangerous contacts</td>
<td>7,494</td>
<td></td>
</tr>
<tr>
<td>(including 3,329 contiguous premises)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– slaughter on suspicion cases</td>
<td>257</td>
<td></td>
</tr>
<tr>
<td>Total holdings affected by the slaughter policy</td>
<td>9,781</td>
<td></td>
</tr>
<tr>
<td>Animals slaughtered for disease control measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– cattle</td>
<td>595,884</td>
<td>15%</td>
</tr>
<tr>
<td>– sheep</td>
<td>3,297,385</td>
<td>82%</td>
</tr>
<tr>
<td>– pigs</td>
<td>144,931</td>
<td>4%</td>
</tr>
<tr>
<td>– goats</td>
<td>2,368</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>– deer</td>
<td>1,017</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>– others</td>
<td>581</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>4,042,166</td>
<td></td>
</tr>
<tr>
<td>Animal slaughtered for welfare reasons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– under the Light Lamb Scheme</td>
<td>525,508</td>
<td></td>
</tr>
<tr>
<td>– under the Livestock Welfare Disposal Scheme</td>
<td>2,044,364</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>2,569,872</td>
<td></td>
</tr>
<tr>
<td>Total no. of animals slaughtered</td>
<td>6,612,038</td>
<td></td>
</tr>
</tbody>
</table>

Source: Department for Environment, Food and Rural Affairs (DEFRA) Disease Control System, 9 January 2002

In all cases, FMD carcasses were given priority for rendering and ‘over five-year-old’ cattle had priority for rendering or commercial incineration over sheep or pigs that could also be buried or consigned to landfills. Meat-and-bone meal derived from non-pressure cooking rendering methods had to be incinerated. Pressure cooking methods of rendering meant that the resultant meat-and-bone meal could either be incinerated or sent to commercial landfills. These requirements were established to minimise BSE risks and were not directly linked to eliminating FMD virus.

Guidance on which species could be disposed of by the various options was also provided and is summarised in Table II.

**Table II**

**Approved disposal routes for different species and age of stock**

<table>
<thead>
<tr>
<th>Method of disposal</th>
<th>Permitted animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rendering</td>
<td>All</td>
</tr>
<tr>
<td>Incineration</td>
<td>All</td>
</tr>
<tr>
<td>Landfill on approved sites</td>
<td>Sheep, pigs of any age and cattle born after 1 August 1996 (a)</td>
</tr>
<tr>
<td>Burning</td>
<td>All (b) (a limit of 1,000 cattle per pyre was introduced during the outbreak)</td>
</tr>
<tr>
<td>Mass burial or on-farm burial on approved sites</td>
<td>Sheep, pigs of any age and cattle born after 1 August 1996 (a)</td>
</tr>
</tbody>
</table>

(a) With permission of the landfill operator
(b) For cattle born before 1 August 1996, a local risk groundwater and air emissions assessment is required

Disposals – the early period

(20 February 2001-20 March 2001)

The first case of the 2001 FMD outbreak was confirmed on 20 February 2001 and disposal of the carcasses slaughtered under disease control measures was initially undertaken in accordance with the State Veterinary Service (SVS) guidance detailed in Chapter 3 of Veterinary Instructions, Procedures and Emergency Routines (VIPER) (9).

This guidance was that carcasses should be disposed of by the most expeditious means available and, except in rare cases, must be disposed of on the infected premises. Two methods were outlined as being suitable under the 1999 Animal By-Products Order, i.e. on-farm burial or cremation (14). These instructions include detailed guidance and directives on preparation of the sites and environmental issues.
Table IV
Summary table of weekly statistics 25 February-10 June 2001

<table>
<thead>
<tr>
<th>Week number</th>
<th>Week ending</th>
<th>Veterinarians deployed</th>
<th>Military deployed</th>
<th>Number of animals slaughtered</th>
<th>Number of animals disposed of</th>
<th>Number of animals awaiting slaughter</th>
<th>Number of animals awaiting disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 February 2001</td>
<td>421</td>
<td>0</td>
<td>2,911</td>
<td>1,223</td>
<td>9,513</td>
<td>1,688</td>
</tr>
<tr>
<td>2</td>
<td>04 March 2001</td>
<td>470</td>
<td>0</td>
<td>34,463</td>
<td>11,605</td>
<td>156,525</td>
<td>24,546</td>
</tr>
<tr>
<td>3</td>
<td>11 March 2001</td>
<td>689</td>
<td>0</td>
<td>78,785</td>
<td>62,291</td>
<td>239,198</td>
<td>41,040</td>
</tr>
<tr>
<td>4</td>
<td>18 March 2001</td>
<td>1,033</td>
<td>0</td>
<td>145,598</td>
<td>116,308</td>
<td>315,379</td>
<td>70,330</td>
</tr>
<tr>
<td>5</td>
<td>25 March 2001</td>
<td>1,152</td>
<td>500</td>
<td>297,109</td>
<td>239,526</td>
<td>489,880</td>
<td>127,913</td>
</tr>
<tr>
<td>6</td>
<td>01 April 2001</td>
<td>1,269</td>
<td>1,000</td>
<td>490,803</td>
<td>388,941</td>
<td>622,184</td>
<td>229,775</td>
</tr>
<tr>
<td>7</td>
<td>08 April 2001</td>
<td>1,437</td>
<td>1,600</td>
<td>615,753</td>
<td>627,540</td>
<td>498,426</td>
<td>217,988</td>
</tr>
<tr>
<td>8</td>
<td>15 April 2001</td>
<td>1,581</td>
<td>2,000</td>
<td>597,283</td>
<td>601,622</td>
<td>137,859</td>
<td>213,649</td>
</tr>
<tr>
<td>9</td>
<td>22 April 2001</td>
<td>1,635</td>
<td>1,900</td>
<td>428,618</td>
<td>517,924</td>
<td>152,316</td>
<td>124,343</td>
</tr>
<tr>
<td>10</td>
<td>29 April 2001</td>
<td>1,704</td>
<td>1,900</td>
<td>240,357</td>
<td>306,841</td>
<td>60,975</td>
<td>57,859</td>
</tr>
<tr>
<td>11</td>
<td>06 May 2001</td>
<td>1,720</td>
<td>1,500</td>
<td>113,092</td>
<td>159,043</td>
<td>30,637</td>
<td>11,908</td>
</tr>
<tr>
<td>12</td>
<td>13 May 2001</td>
<td>1,798</td>
<td>1,036</td>
<td>64,633</td>
<td>73,083</td>
<td>48,158</td>
<td>3,450</td>
</tr>
<tr>
<td>13</td>
<td>20 May 2001</td>
<td>1,817</td>
<td>619</td>
<td>63,471</td>
<td>60,379</td>
<td>46,985</td>
<td>6,550</td>
</tr>
<tr>
<td>14</td>
<td>27 May 2001</td>
<td>1,851</td>
<td>581</td>
<td>97,313</td>
<td>100,346</td>
<td>26,097</td>
<td>3,517</td>
</tr>
<tr>
<td>15</td>
<td>03 June 2001</td>
<td>1,552</td>
<td>498</td>
<td>72,490</td>
<td>67,080</td>
<td>28,303</td>
<td>8,927</td>
</tr>
<tr>
<td>16</td>
<td>10 June 2001</td>
<td>871</td>
<td>433</td>
<td>61,172</td>
<td>64,185</td>
<td>23,465</td>
<td>5,914</td>
</tr>
</tbody>
</table>

(a) There was military contact and short-term assignment from early on in the outbreak.

Carcasses from the premises early affected were generally disposed of by cremation on open pyres (with the first pyre being lit on 25 February 2001), or by on-farm burial. A few carcasses from dangerous contacts were also disposed of in licensed landfill sites in the early period of the outbreak.

The outbreak increased exponentially from the beginning of March (Table IV and Fig. 4). It became clear at all major Disease Control Centres (DCCs) that logistically, on-farm burial and burning supplemented by the increasing rendering supply was failing to keep up with the number of animals slaughtered. Even when mass burn sites burning stock from many farms were established, the tide could not be turned. Allied to this, obtaining a supply of suitable fuels proved difficult and was subject to severe demand-led price inflation. Labour to build and supervise pyres also became a limiting factor (Fig. 4).

Fig. 4
Distribution of confirmed new cases during the outbreak of foot and mouth disease in the United Kingdom in 2001
Several local DCC managers started to search for suitable sites with appropriate geology, on which to set up mass burial sites. Ash Moor in Devon was the first to be identified (15 March) followed by Great Orton, Cumbria (23 March), Birkshaw Forest, Dumfries (24 March), Throckmorton, Worcestershire (28 March), Eppynt (Sennybridge), Wales (28 March), Widdrington, Northumberland (30 March) and finally Tow Law, Durham (5 April).

Work commenced on these sites immediately and in the case of Great Orton, the site was open and receiving stock on 26 March 2001, three days after pathfinding. In Cumbria, three licensed landfill sites were also used to accept carcasses, eventually receiving 69,000 tonnes of FMD carcasses.

Rendering for FMD-affected stock did not become available until 9 March 2001. Thus for the earliest stage of the outbreak, with the exception of the carcasses from the first case at the Essex slaughterhouse, which were rendered, disposal was conducted solely on-farm burial or pyre burning. New rendering plants were contracted to FMD disposal as rapidly as could be achieved and a total of six were functional by 29 March 2001, providing a potential weekly disposal capacity of 15,000 tonnes. Removing normal business from these plants was possible because most of them were contracted to the disposal of the OTMS cattle and had ceased to operate because of the nation-wide movement ban. The United Kingdom Renderers Association was instrumental in ensuring that the flow of all other material that had to be rendered was accommodated in other plants. Any ‘clean’ animal by-products that could not be rendered because of the consequential loss of capacity in the industry, was permitted to go to commercial licensed landfills.

Disposals – peak of the outbreak (20 March 2001-20 April 2001)

The peak of the outbreak occurred in the period 20 March to 20 April. At this time, the number of cases per day accelerated from around 20 to a peak of 50 and then declined. During this time, a massive effort was made by exploiting all available resources for disposals to catch up with the large backlog generated by animals already slaughtered. Rigid application of the 24 h/48 h culling policy, whereby animals on infected premises had to be slaughtered within 24 h of report and those on all contiguous premises within 48 h, was generating massive numbers of carcasses (Fig. 5).

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Fig. 5
Cumulative number of animals condemned, slaughtered and disposed of during the foot and mouth disease outbreak in the United Kingdom in 2001

Source: Department for Environment, Food and Rural Affairs (DEFRA) Disease Control System, database as at 17:30, 25 November 2001
This is where the exploitation of mass burial sites saved the campaign. Without the use of massive industrial machinery, constant lorry flow from the farms and rapid disposal in large pits, the situation would have become impossible to sustain. Use of mass burial allowed the slaughter to continue as planned (Fig. 6). Failure of this disposal route would have made it impossible to continue the 24 h/48 h slaughter policy.

Disposal policy underwent a further change on 31 March with the ruling from SEAC/DoH that for BSE risk reasons, it was considered inadvisable to bury ‘over five-year-old’ cattle on-farm or in mass burial sites. This meant that this class of stock had to be rendered, further complicating the logistics of pick-up from farms (Table IV).

The period from 20 March was one in which the pressures on disposal were most acute and military deployment, following earlier planning sorties, rose from 0 to 2,000 at headquarters and in the regions – supplying vital co-ordination and disciplined logistical support to the business of managing all post-slaughter disposal operations. The week-by-week progress (Table IV) shows clearly that in spite of doubling and then redoubling disposal resources, no impact was made on the backlog until week 8/9 of the outbreak. This marked a real turning point in the epidemic. Control was being established and the disposal routes were more than coping with demand.

Disposals – the long tail of the outbreak (20 April 2001-30 September 2001)

Managing disposals through the long tail of the outbreak required dogged persistence. Widespread public outcry and media perception of the disastrous effect that pyre burning was having on the image of the UK abroad led to the cessation of this disposal route on 7 May. On-farm burial had already been curtailed by the ‘over five-year-old’ cattle ban and by difficulties in obtaining groundwater authorisations in many areas, such as Gloucestershire.

As numbers of cases began to decline, it became more difficult to keep mass burial sites open and functioning without causing severe nuisance. Mass burial sites work best when rapidly filled and capped. They do not function well when the supply is reduced to one or two lorry loads a day. At the same time, the environmental effects of mass burial sites – leachate production and odour, were beginning to be noticed and were amplified by warmer weather.

Rendering became the main disposal route in this latter period but geographical location, the subsequent small peaks of

![Fig. 6](https://example.com/fig6.png)

**Fig. 6**
Quantities of carcasses disposed of through different disposal routes during the foot and mouth disease outbreak in the United Kingdom in 2001
Mass burial sites were successively 'closed' in this period with the last carcasses entering Great Orton on 7 May. Ash Moor was not used during the outbreak and was closed on 14 May. Throckmorton ceased to be used on 19 May. Birkshaw Forest on 25 May; Widdrington on 28 May and Tow Law received its final carcasses on 14 October 2001. The Welsh site at Eppynt was not used as a permanent mass burial site because of groundwater problems and carcasses initially buried were exhumed and burnt. This site was opened on 5 April and was closed on 15 April.

Throughout the summer and autumn, although disposal was under control, a continuous juggling act was necessary to balance demand and supply. Under-exploited resources, such as the mass burial sites, had to be closed to avoid nuisance and under-exploited rendering plants were returned to normal use. By this time, the hierarchy had effectively lost on-farm burial and pyre burning as disposal routes. The remainder of the campaign was managed using rendering, limited air curtain incineration and the occasional incursion into northern mass burial and licensed landfill sites.

**Impact on public health and environment**

The Public Health Laboratory Service (PHLS), Communicable Disease Surveillance Centre (CDSC) on behalf of the DoH, coordinated a monitoring programme for the protection of public health during the FMD epidemic. The third report concluded that no evidence of transmission of FMD virus to humans was found, no case of gastrointestinal disease linked to animal disposals due to FMD had been reported from any areas affected by the outbreak, and a health impact assessment in north and east Devon found that pyres did not have any effect upon consultations or prescriptions for asthma or respiratory distress (8). The report also stated that four cases of Q fever had been identified amongst those involved in animal disposal and there was a reported reduction in the incidence of cryptosporidiosis in the north-west.

The Food Standards Agency (FSA) implemented a programme for monitoring of dioxins and dioxin-like products on herbage and in agricultural produce, such as milk and eggs produced in the vicinity of pyres (12). The FSA advised that there were no implications for human health from the consumption of milk or meat products produced near pyres.

The EA also reviewed the environmental impact of disposal operations and in an interim report concluded that the FMD disposal activities caused minimal adverse impact on the environment in the short term and appeared not to have harmed public health in any way (10).

**Conclusions**

The FMD epidemic which occurred in 2001 presented the UK Government and Agricultural Departments with the most serious animal health challenge since the FMD outbreak of 1967.

The 2001 outbreak was significantly different from the 1967 outbreak and required the development of new disposal routes as the scale of the outbreak became apparent.

Initially, disposal routes were limited to on-farm burial and pyre burning. Concerns over impact on groundwater, the health risks from BSE prions and dioxin emissions and negative media impact from images of 'Britain on fire' severely curtailed these disposal routes. Unlike the 1967 outbreak where virtually all carcasses were disposed of on-farm, in 2001 the majority of carcasses were disposed of off-farm under conditions of strict biosecurity.

The need to address environmental concerns, such as the potential impact of disposal routes on groundwater and of emissions on air quality, restricted some of the options for disposal and led to the introduction of disposal routes not used before in FMD control.

Rendering was mobilised rapidly but the available capacity was limited to 15,000 tonnes per week and was insufficient to cope with the peak demand (estimated to be around 10,000 tonnes per day at the peak for FMD carcasses alone). Rendering was however used as the first-line disposal route and coped with almost all of the tail of the epidemic.

Licensed commercial landfill was a key component of the disposal strategy, some 69,000 tonnes of FMD-affected carcasses having been disposed of by this route in Cumbria alone. These figures must be added to the LWDS carcasses, some of which were also disposed of in landfills. Local objections and pressure from MPs, local authorities and other action groups made the voluntary contracting of licensed landfills almost impossible in most areas. To have used commercial licensed landfills to fully deal with the outbreak would have required direction by the Secretary of State. This would still not have dealt with the disposal of 'over five-year-old cattle' and alternative disposal options would still have been required.

Mass burial sites were a new approach to disposal policy, and although it is acknowledged that they were introduced extremely rapidly and without much consultation, the use of mass burial allowed the slaughter to continue as planned. Failure of this disposal route would have made it impossible to continue the 24 h/48 h slaughter policy.

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L’élimination des cadavres : les enseignements de l’expérience britannique suite à l’épizootie de fièvre aphteuse en 2001


Résumé
De par son ampleur et sa gravité, l’épizootie de fièvre aphteuse survenue au Royaume-Uni en 2001 a été sans précédent et a constitué un énorme défi logistique pour les pouvoirs publics. Plus de 6,5 millions d’animaux ont été abattus et éliminés, dont plus de 4 millions des suites directes de la maladie et 2,5 millions pour des raisons liées au bien-être animal. En début d’épizootie, les méthodes d’élimination reposaient essentiellement sur l’incinération et l’enfouissement des animaux dans les exploitations. Tandis que cette dernière pratique était limitée par des mesures législatives destinées à protéger les nappes phréatiques, les bouchers étaient de plus en plus critiqués par des collectivités locales, inquiètes des risques que la fumée et les émanations faisaient courir à la santé publique. Si l’incinération illustrait parfaitement le combat contre la maladie, elle constituait aussi un spectacle pénible.


Mots-clés
Eliminación de cadáveres animales: enseñanzas que aporta la experiencia británica después del brote de fiebre aftosa de 2001


Resumen
El brote de fiebre aftosa que se declaró en el Reino Unido en 2001, de magnitud y gravedad sin precedentes, planteó enormes dificultades logísticas al Gobierno británico. Se sacrificaron y decomisaron más de 6,5 millones de animales (más de 4 millones a consecuencia directa de la enfermedad y otros 2,5 millones por motivos relacionados con el bienestar de los animales). En las primeras fases del brote se eliminaban los cadáveres animales procediendo sobre todo a enterrarlos o incinerarlos en la propia explotación ganadera. Ulteriores medidas legislativas impusieron límites al enterramiento dentro de las explotaciones con el fin de proteger el suministro de aguas freáticas. Las piras crematorias, por otra parte, fueron suscitando una creciente oposición de las comunidades locales, preocupadas por los riesgos sanitarios que pudieran derivarse del humo y las emisiones. La incineración de los cadáveres animales, además, constituía una ilustración explícita pero también muy penosa de la guerra que se libraba contra la enfermedad.

La evolución de la capacidad de tratamiento de los cadáveres animales contribuyó sensiblemente a las labores de eliminación. En el momento más álgido de la epidemia, fue posible combatirla gracias a una nueva vía de eliminación: el enterramiento masivo de los cadáveres animales en fosas artificiales, excavadas bajo control técnico en vertederos autorizados cuando se disponía de alguno. En el curso del brote se estableció una jerarquía entre los métodos de eliminación de cadáveres que diera cabida a las preocupaciones en materia ambiental y de salud pública: el procesamiento técnico de los cadáveres animales o su incineración en primer lugar; los vertederos autorizados como segunda alternativa; y por último las dos opciones menos deseables, la quema con inhumación masiva o el enterramiento en la propia explotación. Sin embargo, la campaña de lucha contra la enfermedad no hubiera culminado con éxito sin el uso táctico de inhumaciones masivas para complementar los demás procedimientos de eliminación. Los autores describen la evolución y aplicación de los procedimientos de eliminación utilizados durante el brote de 2001.

Palabras clave

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References


