#115, 1999 International Oil Spill Conference

COMPARATIVE COSTS OF LOW TECHNOLOGY SHORELINE CLEANING METHODS[1]

Karen J. Purnell
ITOPF
Staple Hall, Stonehouse Court, 87-90 Houndsditch, London, EC3A 7AX

ABSTRACT: *This paper examines the trends in costs associated with the various low technology shoreline clean-up methods that were used in the response to the SEA EMPRESS incident, by drawing on information gathered during the response and the subsequent claims for compensation from the local government councils involved. Analysis of the costs allowed the level of effort invested in shoreline cleaning to be quantified and re-enforced the view that the return on effort invested decreases progressively as the level of oiling reduces. The trends also reflect occasions where additional effort had to be expended at a later stage in the clean-up as a consequence of problems generated by some techniques used earlier in the response.*

Introduction

When the SEA EMPRESS first ran aground at the entrance to Milford Haven in South Wales, UK on the 15th February 1996, an estimated 2,200 m^3 of Forties Blend crude oil was spilt. During the next 6 days, further releases of oil occurred at each low water resulting in the eventual loss of 78,000 m^3 of crude oil and 530 m^3 of heavy fuel oil (HFO).

Oil first began to strand along the shoreline the same evening that the SEA EMPRESS grounded and, for the first few days, shoreline oiling was confined to beaches in and around the Haven (Figure 1). When the wind changed direction on the 23rd February, oil that had not dispersed at sea began to strand along the southern coast of Wales as far as Carmarthen Bay. By the 28th February most of the oil had stranded. Estimates of the shoreline oiling {Little et al.., in press} suggest that 5%–7% of the crude oil and 85%–95% of the HFO eventually contaminated over almost 200 km of shoreline.

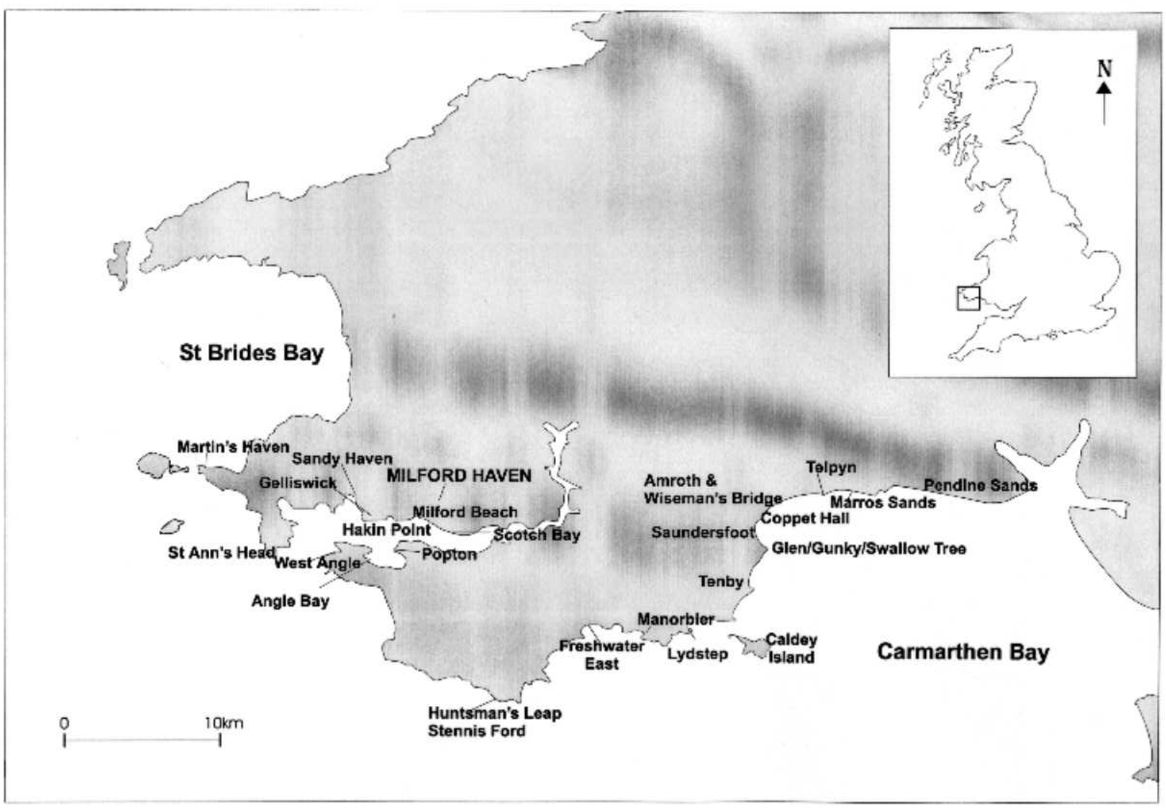

Figure 1. The Coastline Affected by the SEA EMPRESS incident.

South Wales is noted for its outstanding natural beauty and diverse coastal habitats such as rocky shores, mudflats and salt marshes, as well as its shingle, pebble and sandy beaches. Many of these areas have gained special status and, within the area affected by the *SEA EMPRESS,* there are more than 30 Sites of Special Scientific Interest (SSSI), 2 National Nature Reserves (NNR) and one of the UK's three Marine Nature Reserves (MNR). As a result, the region attracts many visitors with tourism contributing about £160 million ($250 million) to the local economy in the year before the SEA EMPRESS incident {SEEEC, 1998}. The region is also important for its oil refining capability and agricultural productivity, as well as supporting a thriving fish and shellfish industry. Consideration of the different and, sometimes conflicting, demands made on the coastal resources was a necessity in working towards a strategy of shoreline clean-up that was intended to prepare the region for its busy tourist season and yet minimise damage to the coastline by potentially intrusive clean-up techniques.

The UK's National Contingency Plan (NCP) for oil pollution incidents identifies the local government councils as being responsible for shoreline clean-up. Consequently, following the SEA EMPRESS incident it was the councils whose shorelines were affected by the oil that organised and initially paid for the clean-up. Technical assistance was provided to the councils by several organisations including the UK's national Marine Pollution Control Unit (MPCU).

To minimise the risk of environmental damage to the more sensitive shorelines, intrusive clean-up methods and heavy machinery were avoided wherever possible. Rocky shores that lay outside of the main amenity areas, together with inaccessible cobble and boulder shores, mudflats and salt marshes were generally allowed to clean naturally. In addition, a number of 'leave alone' sites were established around the coastline to facilitate studies of the fate of oil and the effects of shoreline clean-up {SEEEC, 1998}. Cleaning began on many other parts of the coastline on the 16th and 17th February, 1996 and was at its peak from the 24th - 29th February. At this point, over 950 people were involved and up to 100 separate sites around the coastline required cleaning. Initially, effort was directed towards removing bulk oil to prevent it from re-floating and re-contaminating other parts of the shoreline. Once this phase of the clean-up was complete, the councils turned their attention to addressing secondary clean-up. As the Easter period was approaching, priority was given to cleaning the main amenity beaches with clean-up of the more challenging locations being left to the summer months. Cleaning continued on some amenity and more challenging beaches throughout the summer and beyond.

The UK Government has indicated that it does not expect the total cost of the clean-up operations, both offshore and onshore, to exceed £23.5 million (~$37 million). With the exception of a small number of beaches, where UK Government contractors and oil company contractors were working during the first few weeks of the incident, the costs for shoreline cleaning are known.

The Selection of Low Technology Methods for Discussion. The MPCU has published a report which details its part in the response to the SEA EMPRESS incident {MPCU, 1996}. It has described the shoreline cleaning in terms of being either 'bulk oil removal' or 'secondary cleaning' and has listed fifteen different clean-up techniques that were employed depending on the location of the site and the type of oiled substrate. Thirteen of the methods listed are categorised in this paper as low technology in that they utilised equipment that was not specifically designed for oil spill response. Thus, a discussion of methods that involved the use of chemical dispersants (typically stockpiled in the UK for oil spill response) and bioremediation is omitted. Eight low technology methods are discussed in this paper and these have been listed, according to the nature of the substrate to which they were applied, as follows:

Sand	*Shingle/Pebble*	*Cobble*	*Rock*
- Scraping	- manual removal	- surf washing	- rock wiping
- Scraping and trenching	- pebble washing	- in-situ pit washing	
	- trenching and flushing		

Derivation of the Data. The costs associated with these eight techniques have been isolated from claims covering the first nine months of the clean-up, for a total of seventeen different beaches. It has also been possible to quantify the level of effort associated with each of the techniques in terms of the number of man-days involved. Consequently, the cost of manpower and equipment could be considered separately.

For each of the different types of beach, the daily costs associated with a specific technique were obtained by dividing the expenditure claimed by the number of days spent using that particular technique. The proportion of the total expenditure represented by a particular method of clean-up on any one beach, is expressed as a percentage of the total expenditure over the nine month period for that beach.

To allow the costs of the different methods to be compared and contrasted for different beach types, it was necessary to normalise the costs using a standard unit; in this case, one cubic metre of oil removed. To achieve this, attempts have been made to combine estimates of the volume of oil that initially stranded along the coastline {Little, et. al., in press} with field notes, photographs and other information produced at the time of the incident, to derive a best estimate of the volume of oil present at various stages of the clean-up. Recognising the difficulties associated with estimating the volume of oil, the costs so derived are intended to indicate trends rather than absolute values. Where the costs associated with a particular method of clean-up have been compared with the cost of landfill (as a means of comparing two different options for treating oily waste), the volume of contaminated substrate has been used rather than the volume of oil removed.

The trends that were observed from the analyses of the claims data are discussed for the different methods of clean-up and different beach substrates, in the following paragraphs.

Shoreline clean-up: an analysis of the costs and trends

General. The councils have claimed a total of £5.7 million ($8.8 million) during the first nine months of the incident of which, approximately 75% was spent actually cleaning the shoreline, whilst the remainder was incurred in managing the clean-up operations and in waste treatment charges. Of the 100 or so work sites, 20 beaches accounted for 87% of the total spent on clean-up (Figure 2). Approximately half of the 'top 20' beaches are amenity beaches, which either already have 'excellence' award status or are working towards attaining it. Thirteen of the seventeen beaches discussed in this paper are among the 'top 20' in terms of their expenditure.

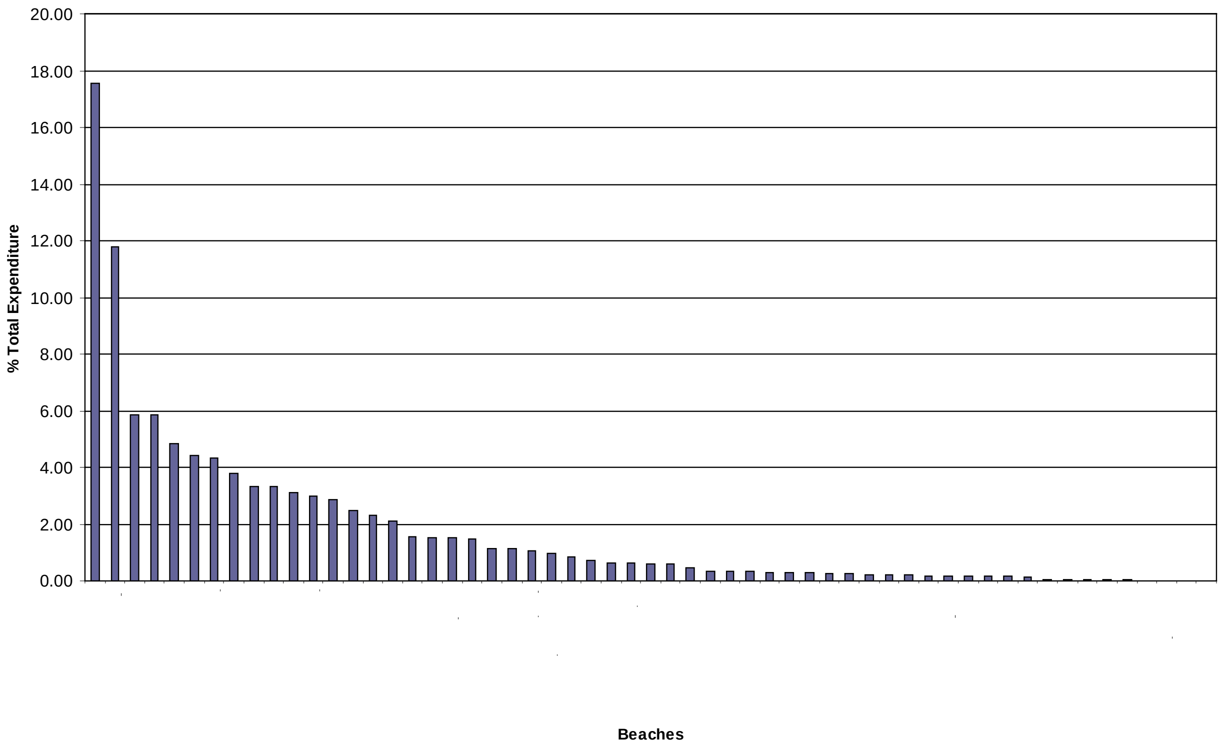

Figure 2. A Comparison of the Expenditure Incurred for Individual Beaches in Relation to the Total Expenditure Incurred from February 1996-October 1996.

When the daily costs for the beaches were reviewed, it was found that generally, and irrespective of the method used or the phase of the clean-up, the costs varied between a low of approximately £500/day ($800/day) and a high of £5,000/day ($8,000/day). The observed similarity in the daily costs for the majority of the beaches suggests that the resources allocated by the councils were broadly similar regardless of the quantity of oil present or the nature of the beach. Exceptions to this trend are noted for Saundersfoot and Pendine, where the daily costs were found to be significantly higher. These two exceptions are discussed in later paragraphs. If the costs of using low technology methods to clean the shoreline are considered in terms of the volume of oil removed at different stages of the clean-up (Figure 3), it is clear that the cost effectiveness of the technique reduces as the quantity of oil reduces. Similar trends were also noted following cost comparisons arising from spills internationally {Moller, *et. al*., 1987}.

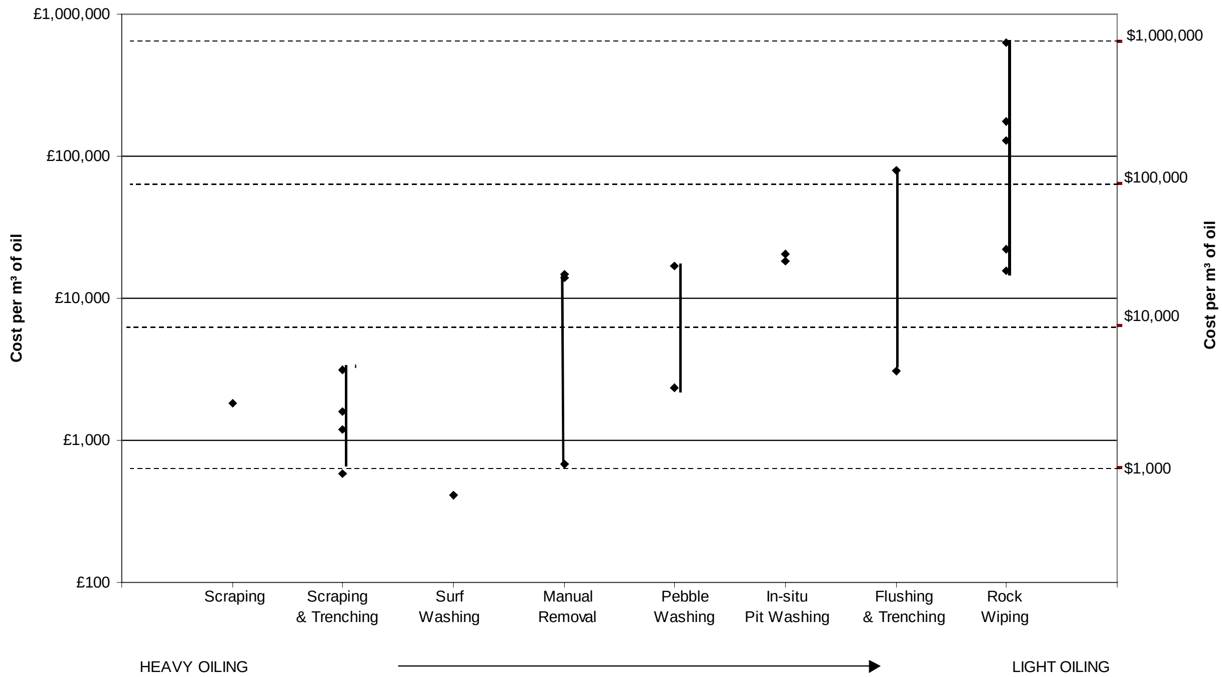

Figure 3. The Relationship between the Cost of using Low Techynology Shoreline Cleaning Methods at Various Stages of the Clean-up.

Sand beaches. *Scraping/Scraping & Trenching***.** Large volumes of bulk oil that had stranded on hard packed, sandy beaches were removed quickly and without generating excessive waste by scraping the oil directly from the surface of the sand. Generally, the oil was concentrated manually using rubber "squeegees" and then pushed into trenches dug parallel to the shore. However, on Pendine, which was almost 7km in length, the oil was collected using vehicles fitted with scraper blades and then transferred to temporary storage pits dug at the top of the beach. In both cases, the recovered oil was collected from the trenches and pits using vacuum trucks and then taken directly for treatment.

When the expenditure attributable to sand scraping on three beaches namely, Freshwater East, Saundersfoot and Pendine, was identified and compared it was found that the cost per m^3 of oil removed lay within the range, £600/m^3 (\$900/m^3) to £2,000/m^3 (\$3000/m^3). However, the daily costs for using this method of clean-up on these three beaches were found to be significantly different from each other and also, from the general trend observed for the other beach types. The daily costs for Saundersfoot and Pendine were found to be about £10,000 ($15,000) and £50,000 ($78,000) respectively, whereas the daily cost for Freshwater East was £2,500 ($4,000). The higher daily costs for Saundersfoot and Pendine reflect the decision to re-allocate large numbers of men and equipment to these beaches in response to heavy oiling which occurred along this part of the coastline following the change in wind direction on the 23rd February. On Pendine in particular, oil stranded along most of its length and considerable resources were utilised in a short space of time to remove large quantities of bulk oil from the sand before it could lift and re-contaminate less accessible beaches elsewhere.

When the costs incurred using this method of clean-up on these three beaches were compared with their total expenditures for the first nine month period of shoreline cleaning, it was found that the cost of using sand scraping accounted for more than 80% of the total expenditure on Pendine, but only 40% - 50% of the total for either Saundersfoot or Freshwater East (Figure 4). Upon closer examination, it was found that significant effort on these latter two beaches was expended throughout the summer months in re-excavating trenches that had been dug during the initial phase of the clean-up, and that were later found to be leaching oil. At both locations, trenches were dug low down the foreshore, which resulted in flooding of the trenches at high tide and oiled sand becoming buried. As the position of the trenches had not been marked at the time, it was necessary to dig a number of pits in the beach in an attempt to re-locate and re-excavate them. At Freshwater East a trench which became flooded before the oil could be removed was subsequently re-excavated generating about 600 tonnes of waste. This problem was not confined to these two beaches. Although not examined in detail in this paper, Tenby was another location where considerable effort was expended in re-excavating trenches to remove buried oil.

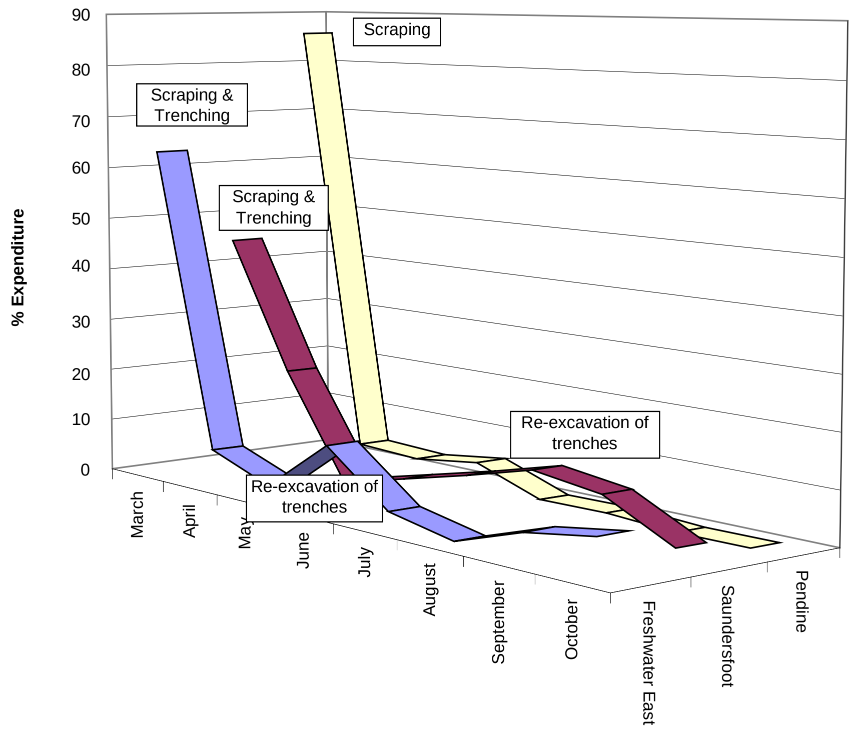

Figure 4. The Variation in Expenditure with Time using Scraping and Trenching on Sand Beaches.

In contrast, trenches were not dug on Pendine to aid the removal of the oil. Rather, oil that had been concentrated in bands along the shoreline was sucked directly into vacuum trucks or transported to temporary storage pits that had been dug above the high water mark. Once the removal of bulk oil was complete, comparatively little effort was then required to 'tidy' and maintain this beach during the tourist season. Consequently, virtually all the expenditure attributable to Pendine was incurred during the initial phase of the clean-up.

In future incidents, it may be more appropriate to pool the oil on the surface of the beach, as was done for Pendine. If necessary, the oil could be scraped into V-shaped wooden bunds to help concentrate the oil and thus, avoid digging trenches {MPCU, 1994}.

Shingle and Pebble Beaches. *Scraping/Flushing/Trenching.* Where vehicle access to low energy shingle beaches was possible, bulk oil was either collected into pools on the surface of the beach or flushed into trenches. The recovered oil was then removed using vacuum trucks and, either transferred to temporary holding tanks, or taken directly for treatment.

A comparison of the expenditure incurred during the bulk oil removal phase of the clean-up has been possible for three low energy shingle beaches namely, Scotch Bay, Hakin and Gelliswick. On Hakin and Gelliswick, oil was scraped directly from the surface of these beaches into trenches, in much the same way as for the sand beaches. However, on Scotch Bay, the oil was flushed into trenches using large volumes of low pressure water; the oil was then skimmed from the surface of the trenches using sorbent materials or vacuum trucks.

The expenditure per cubic metre of oil removed from these three beaches was found to lie in the range 1,000m^3 (\$1500/m^3) to £3,000/m^3 (\$4500/m^3). It was also found that the cost of using this method to remove bulk oil was approximately one-and-a-half times more expensive than using the same method on sandy beaches, primarily because a larger amount of equipment was used reflecting the fact that shingle beaches are more difficult to clean than sand beaches.

When the cost of using either scraping and trenching, or flushing and trenching to remove bulk oil, was compared with the total cost over the nine month period for Scotch Bay, Hakin and Gelliswick, it was found that the expenditure only accounted for 16% - 41% of the total. For Scotch Bay and Gelliswick, in particular, flushing and trenching operations took place on more than one occasion throughout the nine month period reviewed. Each time, the operations lasted for one month or more, eventually, in the case of Gelliswick, accounting for almost 80% of the total expenditure for this beach. As substantially less oil was present during the latter stages of the clean-up, the cost per cubic metre of oil removed was some twenty-five times greater than the cost for the same technique when used during the initial stages of the clean-up.

Shingle beaches are notoriously difficult to clean due to the tendency for oil to penetrate the substrate. At two locations, Gelliswick and Scotch Bay, oil had penetrated the shingle as far as the clay/mud base making clean-up of these beaches both prolonged and problematic. Whilst effective in removing bulk oil quickly, the combination of digging trenches and then flushing or scraping the oil into them, caused the oil to penetrate deep into the substrate generating additional work at a later stage in the clean-up. On Gelliswick, the trenches destabilised the beach material causing some areas of the beach to become waterlogged and soft. Where heavy oiling occurs on low energy shorelines in future incidents, it may be more appropriate to drag the oil off the beach from the seaward side at high tide, or to flush the oil into booms offshore, in preference to digging trenches.

Manual Removal of Oiled Material and Pebble Washing. During the secondary stage of the clean-up there were a number of shingle and pebble beaches that were leaching sheen/oil into environmentally sensitive locations or important amenity areas. Whilst some beaches were easily accessible, others were extremely difficult. This was partly due to tidal constraints and partly due to their location at the base of cliffs or along parts of the coastline where there was no access for vehicles. At four locations, West Angle, Lindsway, Huntsman's Leap and Stennis Ford, it was possible to use a crane to lower men and equipment onto the beach, whereas at other locations, such as Popton, Lydstep Caverns, and Angle Bay, oiled material was bagged and removed manually.

Once the oiled material had been excavated, consideration was given to either sending it directly to a landfill site for disposal (as had been done during the initial phase of the clean-up), or washing the material and returning it to the respective beaches. It was argued that washing and returning the material would be more appropriate since it would go someway towards 'conserving' the physical environment. The costing prepared at the time of the incident suggested that pebble washing would be as cost effective as landfill. Consequently, pebble washing was used fairly extensively during the secondary stage of the clean-up.

At some locations, a small washing station was set up on-site, whereas at other locations, the material was excavated and transported to a larger washing station off-site, at Kilpaison. Oiled shingle and pebbles were removed from the beach, screened and tipped into a lorry-mounted cement mixer where it was mixed with water and an oil releasing agent, or diesel, for about an hour. After the material had been agitated, the water was separated from the pebbles in the mixer and then decanted into temporary holding tanks. Any oil that had separated was periodically skimmed from the surface of these tanks.

The expenditure associated with excavating and washing oiled material either on-site or off-site, on four beaches, namely Lydstep Haven, Milford, Martin's Haven and West Angle, has been identified and compared with the cost of sending the same material to a landfill site. If the cost of excavation and pebble washing is considered in terms of the volume of contaminated substrate rather than volume of oil, the costs per cubic metre of material treated from three of the four beaches were found to be comparable at approximately £110/m^3 (\$170/m^3). For oiled shingle taken from West Angle and subsequently washed at the off-site washing station, the costs were found to be some five times higher. This is understandable when it is appreciated that the expenditure was almost exclusively attributable to the effort involved in excavating the oiled material from coves that were located at the base of inaccessible cliffs. Considerable effort was expended in cleaning these coves to address concerns over oil leaching into environmentally sensitive rock pools in the area. Consequently, more than 90% of the total expenditure for this beach was incurred in excavating, washing and returning the beach material.

From records that were kept during the operation of the washing station at Kilpaison, it has been possible to identify the proportion of material that was actually washed and returned to the beaches compared with the quantity of material entering the site. A total of 955 m^3 of material were brought to the washing station from fourteen different beaches. Of this, 190 m^3 (20%) were unaccounted for, but 365 m^3 (38%) of fines (clays and sediment) were screened out and sent to a landfarm site. A further 35 m^3 (4%) of oversized material (large cobbles and boulders) were separated and sent to a landfill site. Of the 955 m^3 of material entering the washing station, only 365 m^3 (38%) of material were eventually returned to the beaches. The quantity of oil reported to have been recovered was less than 1m^3.

The total cost of operating the washing station over a period of almost 70 days was approximately £150,000 (\$240,000). When these costs were added to the landfarming and landfill charges for the fines and oversized material, the cost increased to £170,000 (\$260,000) which equates to about £180 (\$280) per m^3 of material (excluding excavation). When compared with the cost of sending all the waste to a landfill site, the washing station operation was actually found to be about one-and-a-half times more expensive. In addition, given that only one third of the material was actually returned to the respective beaches and the remainder was either sent to a landfill or landfarm site, it is questionable whether the goal of returning the cleaned material to the beaches and preserving their physical structure was actually met.

Under current UK legislation, landfill is still a cost-effective and appropriate option for disposing of oiled shingle and pebbles. Increasingly, pressure is being exerted upon those responsible for the clean-up to use so-called 'environmentally friendly' methods to minimise waste. Whilst commendable, care needs to be taken to ensure that the methods chosen are appropriate for the type of waste being generated, particularly if it means that substantial quantities of clean material have to be disrupted to locate and excavate the oily material. Recognising that significant quantities of oil can be held in clays and sediments, it may be more appropriate to treat beach material containing a high proportion of fines in future incidents, by merely separating the fines and, where possible, returning the stained shingle and pebbles to high energy shorelines to be scoured naturally.

Cobble beaches. *Surf washing.* Following the experience of previous spills, trials to clean oiled cobbles by placing them in the high energy surf zone on Amroth were found to be successful {Lunel, et. al., 1996}. Therefore, oiled cobbles that had similarly become buried in a cobble berm on Marros, and which held an estimated 20 - 30 m^3 of oil, were placed in the surf zone to facilitate natural scouring. However, this method of cleaning proved to be less effective on Marros, possibly due to the increased weathering of the water-in-oil emulsion {MPCU, 1996}.

The expenditure incurred per cubic metre of oil removed using surf washing on Marros was found to be less than £500/m^3 (\$800/m^3). In terms of the number of man-days of effort, more than two thirds fewer man-days were involved in surf washing as compared with the average number of man-days involved in the other low technology methods used during this period of the clean-up. Thus, in the right circumstances, surf washing can be both a cost effective and efficient technique for cleaning oiled pebbles and cobbes.

In-Situ Pit Washing. In-situ pit washing was undertaken on two beaches where removal of large oiled cobbles was considered to be too difficult, namely Telpyn and Gunky. Large metal skips were sunk into the beach or, alternatively, large pits of 50 -100 tonne capacity were dug and lined with plastic. The oiled cobbles were added to the pits/tanks and washed with oil releasing agent and water. The oil layer that formed was skimmed from the water's surface and the cobbles returned to the beach. This technique was effective in removing the heavier contamination but left the cobbles stained. Therefore, the cobbles were not placed on the surface of the beach but buried in-situ.

The operations at Gunky not only involved taking material from this beach to wash, but also from two other beaches nearby, The Glen and Swallow Tree. These operations were further complicated by the fact that access to Gunky was only possible at low water and the beach was completely covered on a Spring high tide. This meant that any clean-up had to be undertaken and completed within a Neap tidal cycle to avoid having to suspend the operation. Although in-situ pit washing has been undertaken following oil spills in other countries, such as Korea, it was the first time that the technique had been used in the UK.

The costs per unit volume of contaminated substrate treated using in-situ pit washing were found to be in the range £200/m^3 (\$310/m^3) to £350/m^3 (\$550/m^3). Although two or three times higher than the cost of landfill, if the cost of excavation and transportation is added to the cost of landfill, in-situ pit washing becomes the most cost effective option. Consequently, in-situ pit washing was found to be both practical and cost effective and, at the same time, embraced the UK Government's policy of recycling waste wherever possible.

Rock/Boulder Beaches and Rock Platforms. *Rock Wiping.* As the temperatures increased in the region during the months leading up to the tourist season, the emulsion remaining at several locations around the shoreline began to break, thus reducing its viscosity. Several beaches with sand foreshores were also fringed by rocks and boulders and in some locations, extensive rock platforms bridged adjacent beaches, particularly in the northern part of Carmarthen Bay. Oil that had stranded in these areas became mixed with sand and formed an oil/sand coating on the surface of the rocks and boulders. It was found that this coating could be removed quite easily by scrubbing, brushing or wiping the surface. Consequently, after completion of all other clean-up operations, rock wiping was used as a final polishing technique on these surfaces.

Initially, rock wiping was undertaken only in localised areas near the main access points. However, this level of cleaning was extended to larger areas including the extensive rock platforms along the northern coastline of Carmarthen Bay. The clean-up was frequently frustrated by the constant movement of sand which could strip out, or deposit, more than 2 metres of sand during one tidal cycle. Thus, worksites were either buried or more oiled surfaces were exposed in areas that had already been cleaned. This resulted in a protracted clean-up, particularly at Wiseman's Bridge, Amroth, Telpyn and Marros.

Rock wiping typically involved four times as many man-days as the other low technology methods used earlier in the clean-up and, when the claims for rock wiping were examined, it was found that between 90% and 100% of the expenditure was incurred through manpower alone.

Where rock wiping was used to target localised contamination, the average cost per cubic metre of oil removed was found to be approximately £20,000/m^3 (\$30,000/m^3) which is comparable with the low technology methods used during the secondary phase of the clean-up but an order of magnitude greater than those methods used during the initial phase (Figure 3). Where rock wiping had been extended to address the substantial areas of rock platform between beaches, more than 90% of the total expenditure for these beaches was incurred using this method of final polishing. This observation is illustrated in the profile of expenditure for Marros (Figure 5). In addition, the average cost per cubic metre of oil removed was found to be at least two orders of magnitude greater than the average cost incurred during the initial stages of the clean-up (Figure 3).

Frequently, one of the main reasons for undertaking final polishing on high amenity beaches is to offset complaints from the public. However, it could be argued that the presence of beach cleaning personnel wearing protective clothing might, in itself, generate complaints or leave the impression that the beaches are not suitable for use. Where rapid cleaning of rocks and boulders in high amenity areas is warranted, high-pressure cleaning or chemical cleaners are likely to achieve an acceptable end-point in a shorter time-scale than rock wiping.

Whichever technique is chosen for final polishing, a balance must be struck between the desire to remove as much oil as possible, and the potential for the cleaning techniques themselves to cause more damage to the environment than if it were left to clean naturally. The efficacy of natural cleaning is rarely appreciated. Indeed, the constant scouring and re-deposition of large volumes of beach material is part of this process, often achieving a faster, more efficient clean-up of stained beach material than any form of final polishing and with far less effort.

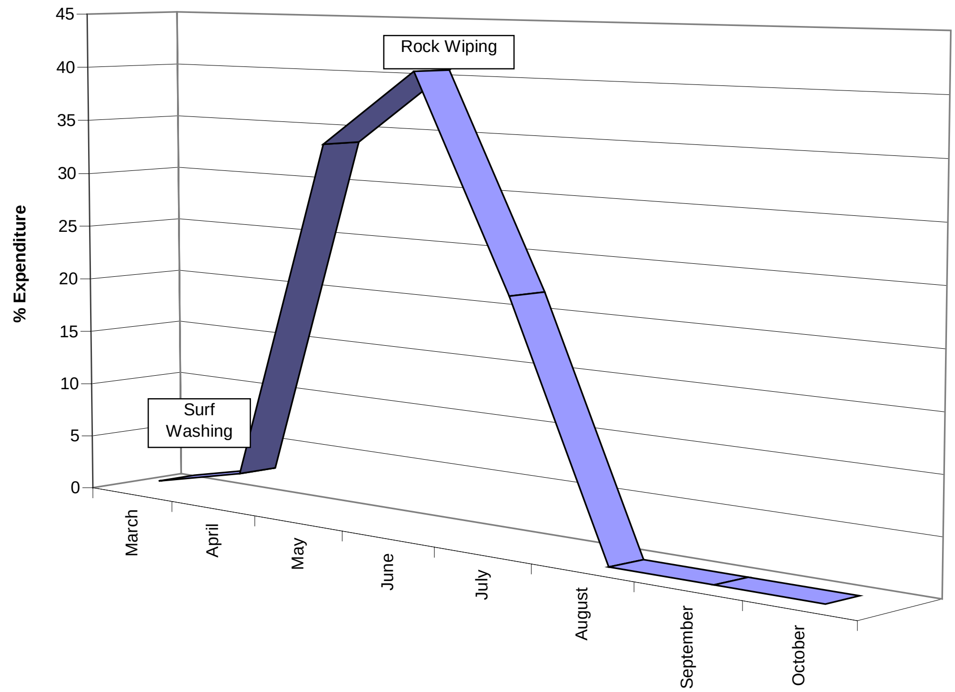

Figure 5. The Variation in Expenditure with Time on Marros using Surf Washing and Rock Wiping.

Conclusions

To avoid misinterpretation, any discussion of the costs associated with specific clean-up methods has to be undertaken with an understanding of the many variables that can influence them. By taking such variables as, worksite location, beach substrate, and volume of oil into consideration, and examining the expenditure incurred on seventeen different beaches during the initial nine month period of the clean-up, it has been possible to build up a more detailed picture of the shoreline response using low technology clean-up methods.

On some beaches, the majority of the expenditure was incurred during the removal of bulk oil, but for others, significant expenditure was incurred during the secondary and final stages of the clean-up. For some key amenity beaches, the 'tail' of expenditure represented the additional effort expended in reaching a high standard of cleanliness. For others, the 'tail' was indicative of occasions where the methods utilised earlier in the clean-up, specifically trenching, led to problems at a later stage. Even during the emergency phase of a major shoreline clean-up operation, it is important to consider the longer term consequences of any measures taken. The urge to remove as much bulk oil as possible in the short term must be weighed against the likelihood of causing unnecessary damage in the longer term.

Whilst not the only criterion against which to judge whether or not a particular method of clean-up is appropriate, cost effectiveness should be one of the key considerations. The analyses of the expenditure incurred in using low technology clean-up methods undertaken in support of this paper, have shown that some methods can be both cost effective and appropriate provided they are applied on the basis of a sound technical appraisal of the circumstances and with due consideration of the use of the area and the potential to cause greater damage.

The analyses have also demonstrated that if expenditure is monitored alongside the effectiveness of the clean-up, it can signal where a disproportionate amount of effort is being expended in relation to the benefits that might be expected and action can be taken to terminate the clean-up accordingly. In addition, a review of the expenditure during an incident 'de-briefing', can indicate occasions in the clean-up operation where problems occurred, thus providing an opportunity to reflect on the methods used and consider employing a different strategy in future.

It should be recognised that complete removal of every trace of oil is neither achievable in practice nor technically reasonable. A vital point in any clean-up operation is deciding when it is reasonable to call a halt to further expenditure. One simple test is to question whether a planned course of action, or an activity in progress, is an improvement on doing nothing and allowing natural processes to take their course. The question is thus, not 'can it be done?' but 'is there any benefit?'

Biography

Dr. Karen Purnell is a technical adviser with ITOPF and has attended a number of oil spill incidents internationally. Normally invited to attend on behalf of the vessel's insurers or the IOPC Funds, her role is to provide technical advice and to assist with the technical assessment of subsequent claims for compensation.

References

1. Final Report of the SEA EMPRESS Environmental Evaluation Committee (SEEEC).

The Environmental Impact of the Sea Empress Oil Spill. Published by the Stationery Office 1998. ISBN-0-11-702156 3.

2. Little D., Capogna-Bateman R., Colcomb K., Sommerville M., Lunel T., Swannell R., 1997. Response on Land to the SEA EMPRESS Oil Spill. The SEA EMPRESS Oil Spill Conference Proceedings Ed. R. Edwards. CIWEM Publications, Lavenham, UK. (In press).
3. Lunel T., Swannell R., Rusin J., Bailey N., Halliwell C., Davies L., Sommerville M., Dobie A., Mitchel D., & McDonagh M. Shoreline Clean-up during the Sea Empress incident: The role of surf-washing (clay-oil-flocculation), dispersants and bioremediation. Proc. 1996 Arctic and Marine Oil Spill Programme (AMOP), pp 1521-1540, 1996.
4. Moller T. H., Nichols J. A., Parker H. D., Comparative Costs of Oil Spill Cleanup Techniques. Proceedings of the 1987 Oil Spill Conference, American Petroleum Institute, Washington, D. C., pp 123-127.
5. The Marine Pollution Control Unit (MPCU). Oil Spill Clean-Up of the Coastline: A Technical Manual, 2nd edition. Produced by the Central Office of Information. J08-1309NJ. July 1994.
6. The Marine Pollution Control Unit (MPCU). The Sea Empress Incident. A Report by the Marine Pollution Control Unit. December 1996. Published by the Coastguard Agency, December 1996. ISBN-1-901518-00-0

1. The views here expressed are those of the authors and do not necessarily reflect those of the individual directors and members of ITOPF.