Inland Oil Spill – Well Blowout, 2004

Abstract

On September 10th 2004, while being decommissioned, an inland oil well suffered a blowout resulting in the release of about 4000m^3 of crude oil. The release spanned a four-day period, over which time the oil flowed from the fall-out zone into a natural ravine through dense deciduous woodland and into a small storm drain. A total area of over 1km^2 of forest was impacted. Following an emergency response to cap the well, the site was surveyed, an environmental action plan was drafted and the emergency clean-up response initiated.

The zonation of the affected area according to its proximity to the well head and physical characteristics allowed the prioritisation of response strategies and the most effective allocation of limited resources. A combination of fresh water flushing, gravity separation pits and mechanical pumping methods were used to remove oil, while selective felling, non-destructive pruning and oiled debris removal were employed in the woodland.

This case study represents a rare opportunity to learn from a large inland oil spill by looking at the response strategies employed and lessons learnt during the response.
The associated environmental impacts and site recovery are also discussed in conjunction with results from a post spill monitoring study.

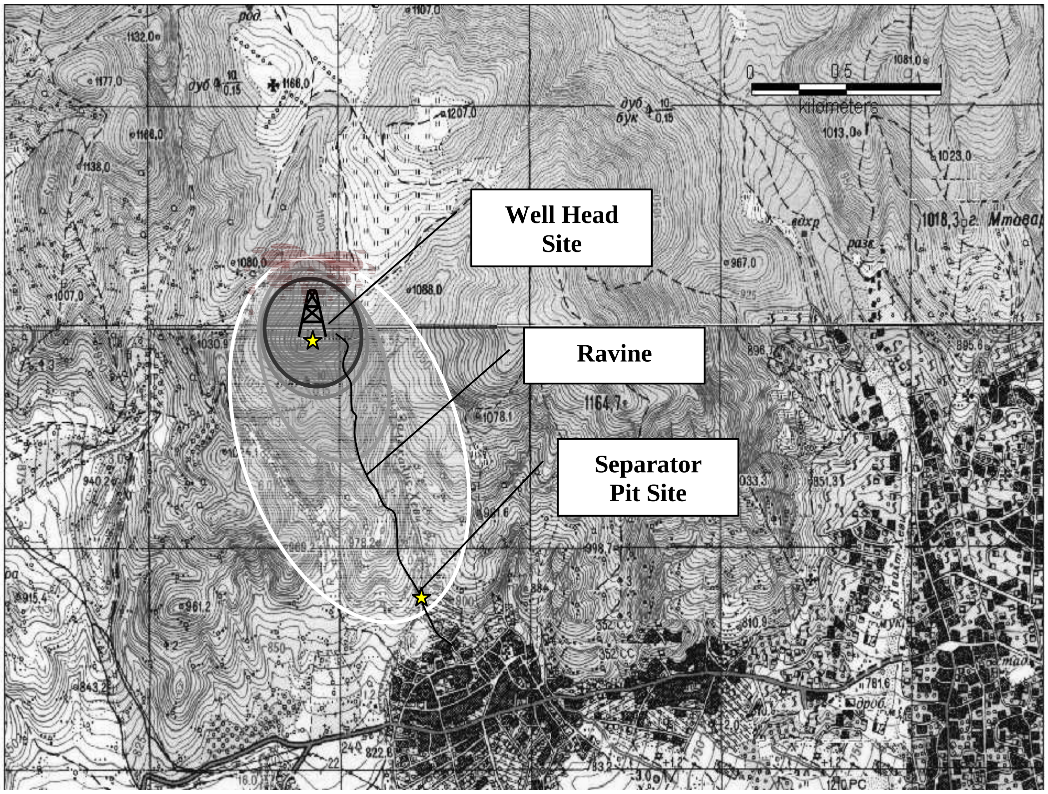
1. Introduction

Prestige, Sea-Empress, Exxon Valdez, these are just a few of the headline grabbing oil spills of the past two decades. These spills and others like them have provided a unique, if expensive, learning ground for the development of oil spill strategy and management. All were large spills, all had massive socioeconomic repercussions, and all were at sea. The spill response techniques honed during such spills remain largely unchanged today.

For inland spills, however, the responder's 'toolbox' of strategies is undeniably sparse. This paper discusses the strategies employed and lessons learnt during the response to an inland well blow-out by Oil Spill Response Ltd (OSRL) in 2004.

1.1 Spill Scenario

The well sits 800m above sea level in a clearing overlooking a village, about 40km east of the capital city. Set within the Caucasus mountain range the 400m diameter clearing in which the well sits is surrounded by mixed deciduous woodland. During routine decommissioning operations on September 10th 2004 the well suffered a blow-out, thought to be brought on by geological movements within the shaft. The oil, a light, sweet crude, was escaping at high pressure at a rate of 5-10000bbls/day blowing vertically 30m.



Map 1. Showing spill location.

After the initial notification of the spill on 13th September, Oil Spill Response Ltd (OSRL) mobilised their duty manager to assess the spill and arrived on scene on the 14th September, by which time the well had been capped. The total quantity of oil lost was thought to be 15, – 30,000 bbl.

2. Strategies Employed

2.1 Initial Response (0 – 4 days):

The initial assessment revealed the extent of the damaged caused in the four days before the well was capped. In addition to the effects of the spill itself, the actions taken in the four days until OSRL's arrival had exacerbated the impact. Large earth moving equipment was used to create earthen bunds and collection pits in an attempt to prevent the bulk of the oil migrating down the hillside (Fig. 1). Unfortunately this had limited success; the oil was mixed into the clay substrate and the pits were inundated by the volume of oil. A large volume of oil migrated down the hillside, following a natural ravine to the village, 2km away.

In an attempt to prevent the oil from migrating into the village earth dams were built across an area originally used for watering live stock and extracting potable water for the local community. The dams were partially successful in preventing the bulk of the oil from entering the village.

Figure 1. Showing wellhead operations prior to OSRL's arrival to the spill site.

2.2 Response (4 days and beyond):

A detailed assessment of the entire site was undertaken by environmental specialists from OSRL. From this survey the affected area was split into zones according to the degree of oil coverage. Three main zones were identified and response plans drafted, each time applying Net Environmental Benefit Analysis (NEBA). In this way the response option was weighed against its potential for causing further harm and the effect of leaving the oil *in-situ*. The selection and prioritisation of response options was also influenced by safety considerations such as remote working in inaccessible areas. Socioeconomic drivers, such as the effect on the village and the client's need to resume operations were also important factors that directed the response.

2.2.1 Zone A: Well Head

As the epicentre of the spill, this flat plateau consisting of clay-gravel mixed sediment suffered the worst contamination. With the oil largely contained within this area the response strategy was a simple clean-up, which comprised a number of phases:

- **Bulk Oil Removal**
- **Low-Pressure Flushing**
- **Oiled Sediment Removal**

September in this region generally experiences hot dry conditions. As such, water supplies quickly became the limiting factor in our response. To overcome this issue gravity separation techniques were employed to enable water to be decanted and recycled, thus concentrating the oil in-situ.

2.2.2 Zone B: Hillside / Ravine

The only mitigating measure conducted in this area by the client was the building of storage pits and earthen bunds as mentioned above. The hillside is characterised by its dense mixed deciduous trees and shrubs which suffered different degrees of disturbance dependant on the distance from the wellhead. This zone was, therefore, sub-divided.

2.2.2.1 Zone B1: Woodland Bordering Wellhead

Trees at the edge of the wellhead clearing suffered the most direct damage, with leaves and branches being stripped from some. To the south of the well the topography slopes steeply toward the village. Both airborne and surface flowing oil migrated in this direction, funnelled and concentrated into the ravine. Here oil coverage was almost complete, from tree-top to leaf-litter layer. This highly polluted area extended south for about 100m from the tree line.

Without historical precedent of forest spills from which to work, a variety of response options were explored. These are listed in Table1 along with their perceived benefits and drawbacks.

Table 1. Oil spill response options for the forest.

Technique	Advantages	Disadvantage	Comments
Felling	♦ Quick and easy removal of condemned trees ♦ Opens up area and allows easier clearance of oiled debris	♦ Erosion by destabilising topsoil ♦ Loss of established habitat hinders recolonisation ♦ Increased waste	A comprehensive management and regeneration programme would need to be put in place. Not the best time of year to begin this. Would need to prevent grazing of saplings.
Coppicing & Pollarding	♦ Removes oiled part of trees ♦ Encourages regrowth whist maintaining soil integrity ♦ Opens up woodland floor to opportunist species helping bind the soil further.	♦ Labour intensive ♦ Season specific, can leave tree open to infection / disease	This method may prove too labour intensive for little obvious immediate benefit.
Removal of leaf litter layer	♦ Will remove woodland floor oiling ♦ Prevents further oil ingress into substrate / humus layer	♦ If too much is removed there could be a nutrient deficit and further disturb the ecosystem ♦ Labour intensive ♦ Generates a lot of waste and presents a waste management issue*	* Various waste management options are available such as incineration, landfill, and land-farming, the viability of each will depend on national regulations on disposal of such hazardous wastes.
Leave alone / natural recovery	♦ Deciduous woodland so natural senescence of leaves expected in October ♦ Possible natural regeneration next spring	♦ Chronic release of oil in spring/summer ♦ In the event of heavy rainfall, oil could be transferred down the hillside and ravine, creating secondary contamination	Used until natural senescence of leaves in October, when an alternative option, such as recovery of leaf litter could be used. This would avoid repeatedly collecting the leaf litter, and disrupting the forest floor unnecessarily

The final action plan brought together a combination of response strategies for Zone B which was evaluated and approved by the Ministry for Environment and Woodland.

The felling of trees was considered a viable option in Zone B1 due to the number of trees condemned during the survey. Removal of these trees would reduce the threat of secondary contamination and chronic oiling from the remobilisation of oil and improved access to areas where bulk surface oil removal was required. The trees identified to be felled were clearly marked prior to felling, thus avoiding unnecessary removal and ultimately more waste.

Coppicing was recommended for trees within Zone B2 that were partly oiled and so presented a higher chance of recovery. This option resisted the removal of the entire tree, maintaining soil stability through root binding and allowing the ingress of opportunistic species through increased light fill. Following the coppicing, any remaining bulk oil was removed, followed by manual clean-up of residual oil on trees.

Leaf litter collection was considered as a final polish technique to be conducted after the senescence of leaves in the fall and after the completion of coppicing and felling. Only the top contaminated layer of leaves was recommended to be removed.

2.2.2.2 Zone B2: Woodland beyond the 100m zone

At approximately 100m from the tree-line the intensity of the pollution began to lessen, with trees and the leaf-litter layer suffering a less intense coverage. Coverage of the leaf litter layer was shallow, with only the top layer being affected.

Leaf litter removal and manual clean-up was the preferred response option for this low-priority area. This zone covered a large area and represented low-level contamination levels when compared to Zones A & B, it was therefore suggested that this area be tackled as part of the final polish.

2.2.2.3 Zone B3: The Ravine

The ravine cuts through the hillside in a southerly direction down to the village. Free flowing oil was present along the entire length of the ravine. The ravine's clay substrate, acted to prevent infiltration of oil. At the time of the survey a small flow of water was present which mobilised the stranded oil.

Due to the inaccessibility of this area it was recommended that low pressure / high volume flushing be used to drive the mobile oil down the ravine. This mobilised oil was captured in pits constructed on the outskirts of the village. It was deemed preferable to conduct this in a controlled fashion using recycled water from the flushing of the wellhead than wait until the rains of fall or the snowmelt of spring.

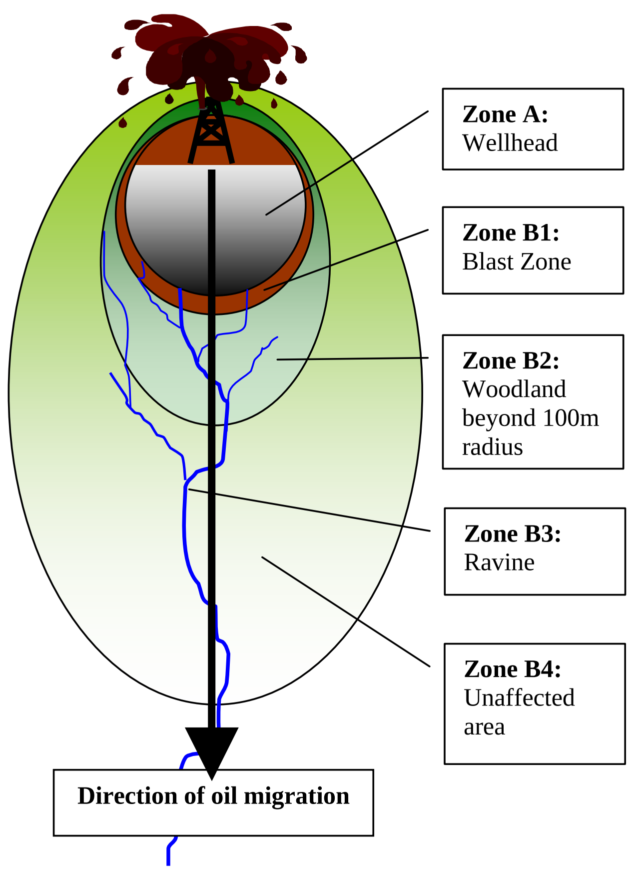


Figure 2. Showing the subdivision of Zone B.

2.2.3 Zone C: Village Outskirts / Pits

The initial actions taken by the client had trapped large quantities of oil in one area, at an elevation 200m below the wellhead where the ravine emerged from the woodland in the form of a small stream. The damming of this stream had temporarily interrupted the downstream movement of water through the village.

In an attempt to reinstate the stream's flow, the pre-existing pit was split into three to produce a crude oil/water separation facility (Fig.3). The top pit was used to collect and concentrate oil mobilised from the ravine, while allowing the separation of water and oil. The bottom water level was then allowed to decant at a controlled rate to the next pit, which was again allowed to settle and allowed any oil to accumulate on the surface for removal. Again the water was decanted into the third and final pit where sorbants were used to remove any trace of sheen ready for release downstream once hydrocarbon levels of 12mg/l or lower were reached. This level was given as the acceptable limit after consultation with the Ministry of Environment and levels were monitored by an independent agency.

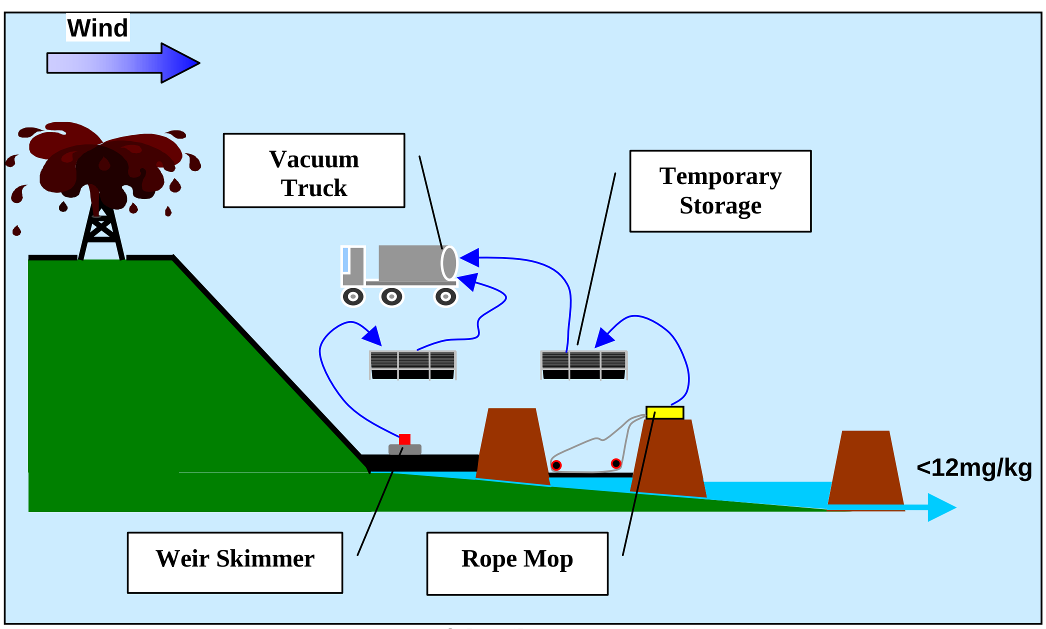


Figure 3. Diagrammatic representation of the oil / water separation pits.

3. Waste Disposal

Wellhead:

Waste disposal, became one of the limiting factors to the effectiveness of response. Initially waste was transferred to the client's pipeline, but unreliable pumps forced a change in tactic. 15,000 road litre tankers were then used to transport the liquid waste to the client's treatment facility, however due to poor access and logistical constraints a bottleneck in the process developed. Decanting water to decrease the total volume of liquid waste helped improve efficiency. With an asphaltene content of 1.8%, however, the oil's tendency to emulsify added to the waste disposal problems as the spill progressed.

Separator Pits:

Smaller gully suckers were used here to empty the temporary storage tanks, but again the removal rate of the skimmers was much quicker than the waste could be taken from site.

4. Responder Welfare

Air monitoring was conducted on all sites by the Ministry of the Environment. Initially the site at the wellhead was three times the recommended TWA for an 8hr working day at approximately 320ppm VOC. Work was, therefore, restricted at this site to 2.5hr per day per person until levels were consistently below 100ppm.

Under advice from the client, security was provided to all staff at all times during operations, this included transport to and from site.

5. Management

An Incident Command Structure (ICS) was set up by OSRL's duty manager, which allowed the response to be more effectively managed. OSRL staff played an integral role in this structure, working intimately with the client. Of primary concern to the client was getting the wellhead site sufficiently clean to allow pumping operations to be resumed from the rejuvenated well (Fig. 3). Daily meetings allowed a constant information flow between the on scene commander and operations manager, ensuring logistical requirements for the following days operations were met.

6. Post-Spill Activities

Following the demobilisation of OSRL's response on 20th October 2004, the rehabilitation scheme continued, managed by the client. OSRL revisited the site, 4 months after hand-over to assess progress.

The environmental action plan written by OSRL had been closely followed. Selective felling and the removal of oiled leaf litter, fallen branches and badly damaged trees had been removed as prescribed in the action plan (Fig. 4). The remaining trees within this area still showed signs of surface oiling but the majority of oiled leaves had fallen and been removed, thereby reducing the risk of chronic re-oiling.

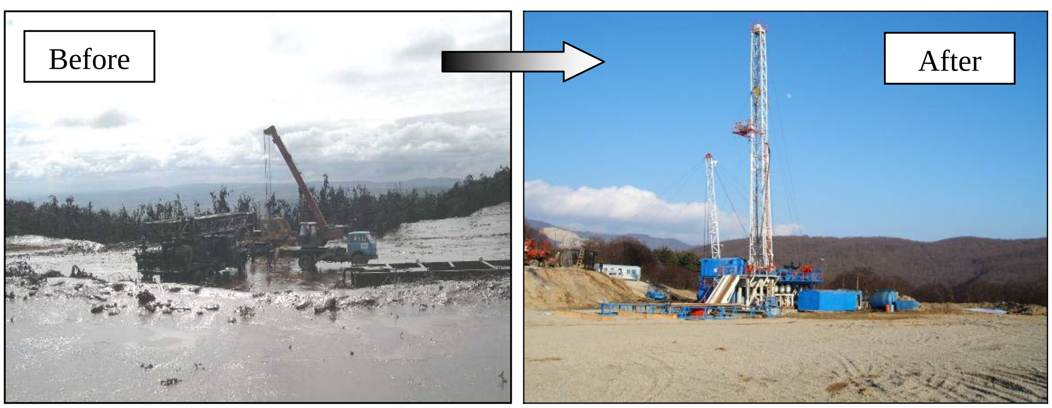


Figure 3. Showing the wellhead site immediately after the spill and four months after.

Figure 4. Showing the woodland site immediately after the spill and four months after.

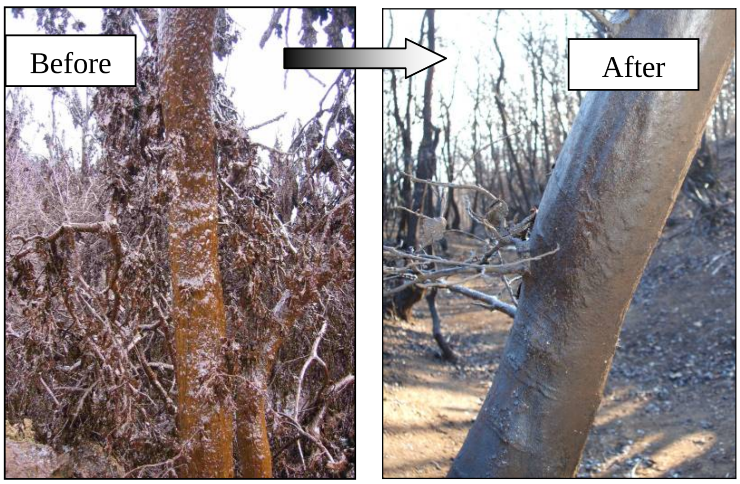


Figure 5. Showing the *in-situ* weathering of oil on a tree in the main fallout area.

Two deciduous trees that suffered the same exposure to the well blow out. A weathered surface deposit still remains on the bark, but it is thought that this will not have an effect on the survival chances of the tree. Of more concern is the infiltration of oil into the root system, which was limited by the thick leaf litter layer and clay substrate.

The weathering of any oil that was left *in-situ* was slowed due to the low temperatures experienced during the winter. It is thought that with the coming of summer the weathering process will accelerate and perhaps some remobilisation of oil will occur, for this reason the separation pits will remain as a permanent feature.

A bioremediation scheme was planned for the worst affected areas of the woodland which was due to start in the spring of 2004. It is hoped that this will accelerate the recovery of the woodland.

If following the spring the trees in the blast zone show no sign of recovery it is suggested that a replanting scheme be attempted. Trees characteristic of those species lost should be planted in addition to fast growing endemic species to further stabilise the area.

The pits remain in place and are manned in order to monitor the water flow and manually skim any sheen from the surface. The upper pits are still showing some surface sheen, though it is unclear whether this is as a result of oil mobilised from the ravine or chronic oiling from the pit itself. It is predicted that this sheen may increase during the wetter, warmer months as oil is remobilised and transported down the ravine.

The client maintains that the ground water in this area was unaffected by the spill, due in part to the clay sediment and also because of the deep groundwater level. However, two drinking water wells have been drilled for the local residents, who previous to the spill relied on a natural spring that may now be tainted by overland flow.

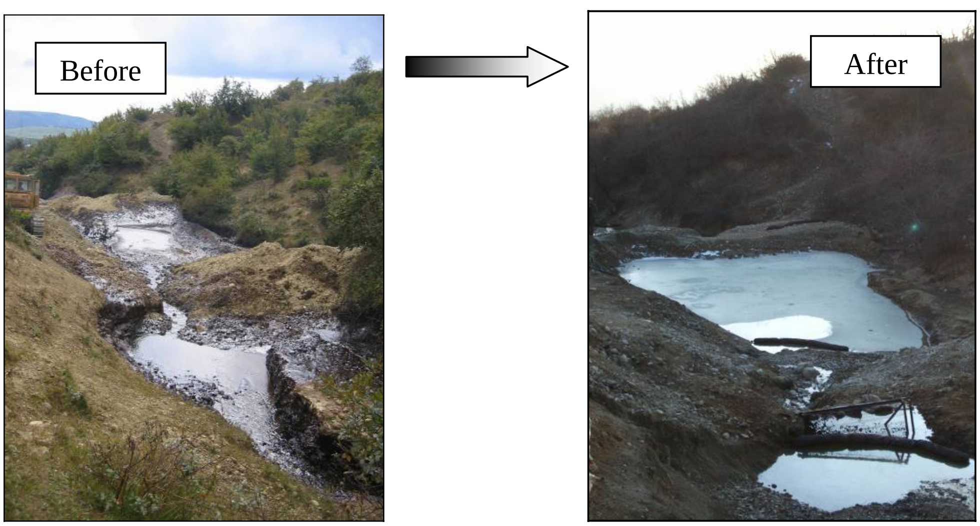


Figure 4. Showing a separation pit during and after the response.

The client has also planned to landscape the pit area to create a permanent facility for the collection and separation of runoff for this watershed using concrete pits and larger sluice gates. An independent hydro-geologist has been consulted to design this facility in order to withstand a 1 in 100 year event.

7. Lessons Learnt

This spill provided an invaluable opportunity to learn for all of those involved. The application of NEBA allowed the spill response to be shaped and tempered to avoid further avoidable damage. At times, however, this approach met with some resistance, especially when time constraints were of concern. Table 1 examines such an application of NEBA, where advantages and disadvantages were highlighted and mitigating measures explored. For example the removal of leaf litter would remove the oil, but could disrupt the ecosystem if completely removed. The preferred option here was selective removal of leaf litter to minimise disturbance.

The driving factor that shaped the response from the outset was the lack of an oil spill contingency plan (OSCP). A contingency plan is more than a document to dust off during emergencies; it lays out a structure from which to build a solid foundation of preparedness. It prescribes and defines the importance of training of staff, readiness of equipment and allows the identification of shortcomings through periodic audits.

The client did not have an OSCP and so lacked access to oil pollution equipment; a single pump was sourced and additional equipment was approved one week after the blowout. The client's staff were also untrained for such an outcome and as a result their initial actions exacerbated the damage caused. Without a well-defined list of contacts any emergency support from external agencies becomes delayed, in this case four days into the incident. Had a contingency plan been in place the damage caused by the spill may have been vastly reduced, through more effective response in those all important initial stages of the spill.

Valuable lessons were also learnt by OSRL. Strategies were tried and tested in the response to and rehabilitation from inland oil spills. Oil water separation pits were developed to great effect using a minimum of equipment. Woodland management methods were employed in conjunction with traditional clean-up techniques to rehabilitate without increasing the damage. The need to be almost totally self sufficient was also highlighted by the difficulties faced in obtaining reliable gas monitoring data. Historically, external agencies have been relied upon for gas monitoring, but gas monitoring skills and equipment are now essential additions to the responder's 'toolbox'.

Conclusion

The very nature of this spill presented many challenges to the response, but in doing so provided a unique learning opportunity for all involved. With the benefits of hindsight the fundamental importance of initial response choices have been highlighted, as they have been on many other spills. The lack of an OSCP exacerbated the problems encountered by the client in that no formal oil spill training had been undertaken by staff, no oil spill equipment was held, and no incident management structure existed to coordinate the spill.

The damage caused by the spill, however, was reduced by a number of factors; the clay substrate limited the ingress of oil, while the low water tables further reduced the risk to groundwater. The application and adaptation of oil spill response strategies in conjunction with forest management techniques were successfully combined through the application of NEBA.

The remediation project to stabilize and rehabilitate the site is ongoing, but the lessons learnt during the emergency phase are invaluable. As the pursuit of oil continues to take us further a field, we must remember the lessons learnt here and similar incidents. It is from these incidents that we can build our 'toolbox' of strategies, but they also act as a costly reminder to the old adage that prevention is always better than cure.