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Experiences and learning around the decontamination and remediation of explosives facilities

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Abstract:

The explosives industry is an old industry and as such explosives facilities have been in existence for many years and operated at a time when environmental considerations were less stringent than they are today. As companies shrink their footprint they are faced with the remediation of land, contaminated with explosives and chemicals, to a level that will enable alternative land uses. It is these alternative land uses that ultimately dictate the level of remediation that is required for a contaminated site.

The first step in the remediation of sites is the historic review, followed by site characterization, development of an action plan, implementation of the action plan which comprises a number of phases, peer review and then final land release.

The phases of the action plan include public interaction, expert review (if still available), explosive decontamination and chemical remediation. Explosive decontamination is determined by the type of explosive contamination and remediation by the type and amount of chemical contamination. Decontamination and remediation can become very costly but there are opportunities to minimise these costs.

AEL Mining Services operates numerous sites particularly in Africa and in Indonesia. Of these the largest manufacturing sites are in Modderfontein and in Mogwase in South Africa and in the Kafironda Factory in Mufulira, Zambia. Following their establishment in 1896, 1981 and 1965 respectively, all three sites experienced a growth phase followed by a reduction or modification of the manufacturing activity and the concurrent reduction in the extent of their operating footprint. Once the operating footprint had been reduced the challenge that had to be faced was whether remediation of the previous operating footprint should be done immediately or delayed until such time that the land was required for an alternative use. All these sites were also exposed to different chemical and explosives technology which complicated the final remediation effort.

More recently the decision as to when remediation should commence is aided by a remediation determination matrix which comprises a number of criteria that include health risk, environmental risk, legal compliance and lastly the need to develop the land for alternative land uses such as commercial, residential or recreational.

In the past, facilities were most often closed but left intact in the eventuality that they may be required again. During this time, however, little or no maintenance was done on the facilities or on the land that they occupied and this eventually resulted in the buildings becoming dangerously dilapidated and overgrown. This state, apart from posing a safety hazard, then presented a greater challenge when it was eventually decided to demolish, decontaminate and remediate the site and often resulted in the need for greater expenditure and expertise than if it had been done earlier.

Environmental legislation and common sense dictate that environmental impact is best managed through prevention or minimisation of pollution. As the explosives industry is an old industry, and despite the inherent additional safety precautions required, environmental impacts were not always taken into consideration during the operational phase or else good environmental control methodologies were not available. Environmental contamination also resulted from catastrophic plant explosions particularly during the days of nitroglycerine based explosives. In addition, remediation was often not considered during the operational phase of the life of a plant. This meant that the major remediation work was left to after the plant had ceased operating and in some cases even many years later.

The problem of leaving remediation to later is that often maintenance and ongoing use of these areas is discontinued with the result that vegetation hides walkways, roads and other structures such as pits and soakaways and breaks up mounds and buildings. Climatic conditions also take their toll on signs, which makes it more difficult to identify areas of potential contamination, and buildings. Vandals add to the disintegration of a site by stripping ceilings, electrical and plumbing fittings. Depending on how long after a plant's closure it is remediated operational memory often disappears as well. These issues now become a major hurdle in the preparation for the remediation of a site.

The remediation of an old site requires the development of a remediation plan that includes the following steps:

Step 1: An historic review: The historic review should be conducted with current operating personnel and depending on the age of the facility with previous operating personnel. This typically involves setting up a meeting, preferably over a lunch, where people are relaxed and are more inclined to talk about things that went wrong or things that were done incorrectly such as spillages, disposal of off-spec or waste raw materials or products. The best people to have at these meetings are the operators or supervisors that operated these facilities over many years. A map of the site being reviewed should be available as this jogs the memory and can simultaneously be used to note the location of spillages, pipe ruptures etc. Explosive and chemical contamination should be noted separately as they will need to be dealt with independently. Ideally a number of people from the same work area should be present as comments by one person often trigger another person's memory.

Step 2: Identification, based on the historic review, of areas contaminated with explosives and/or chemicals

Step 3: Clearing of vegetation: This involves use of fire and possibly cutting of trees and shrubs in order to facilitate access to the contaminated area

Step 4: Develop plant decontamination plan: methodology must consider the waste management hierarchy (prevent, reuse, recycle, treatment, disposal)

i. Decontaminate equipment (explosives and chemical contamination)
ii. Isolate all services
iii. Remove equipment for
    a) secure storage, if to be used elsewhere, with an inventory of items
    b) sale for reuse
    c) sale as scrap
iv. Remove services such as electricity, air, steam

Step 5: Treatment of explosive contaminated areas: Areas contaminated with explosives must be decontaminated before any other remediation can be done. Decontamination is done either through the application of desensitizers depending on the type of explosive or blasting. If blasting is to be done, neighbouring communities will need to be informed depending on their proximity to the site. These local communities may comprise members of the public, local authorities, other businesses.

Step 6: Peer review: Depending on the extent of explosive contamination and the duration of the explosive decontamination exercise the progress and completeness of the process should be peer reviewed either at periodic intervals during the decontamination phase or at the end. This peer review must be documented and becomes part of the final report on the decontamination of the site. It is also important to keep the explosive authorities in the loop.

Step 7: Chemical contamination: Once the site is clear of explosive contamination and there is chemical contamination of the site both the lateral and vertical extent and type of chemical contamination will need to be confirmed.

The results of the determination of the chemical contamination and the intended end use for the site will determine the method and extent of remediation to be done. Remediation will include the demolition of buildings, structures, buildings slabs, foundations and drains.

Step 8: Contouring: In order to ensure that the remediated site blends into the environment the site will be contoured and planted/seeded with vegetation indigenous to the area.

Step 9: The remediation is peer reviewed, preferably by an independent external person or organisation and a report on the peer review provided.

Step 10: A land release document is prepared providing information (methodology, analytical results, peer review, etc) on the remediation of the site to the intended land use. Photographic records play a crucial role in the report.

It is important that all information from the remediation process is documented in detail and records kept. Photographs form a vital part of the documentation of the remediation process and must be taken before, during and after remediation.

Experiences from the remediation of a large open area at Mogwase, South Africa: remediation

The explosives testing range at Mogwase in the North West Province of South Africa (figure 1) had been used for about 15 years for the destruction of large quantities of blasting explosives and accessories and also for special tests such as metal cladding, emulsion detonability and local quality control.

Figure 1: Location of the Mogwase site

The bulk of the manufacturing operations ceased in 1994 including the explosives firing range. Due to the short operational period, personnel on site knew what activities had taken place at the range as well as the location of each of these activities.

An initial site visit showed that an area of 300m by 300m (90 000m^2) (figure 2) was contaminated with visible and buried detonators and associated components (partially detonated detonators, explosive contaminated debris, connectors, safety fuse and electric detonator wire). Because the site had been vacated for 3 years it was covered in grass and had extensive growth of thorn trees (figure 3) and some of the twenty one explosive pits had filled with water (figure 4).

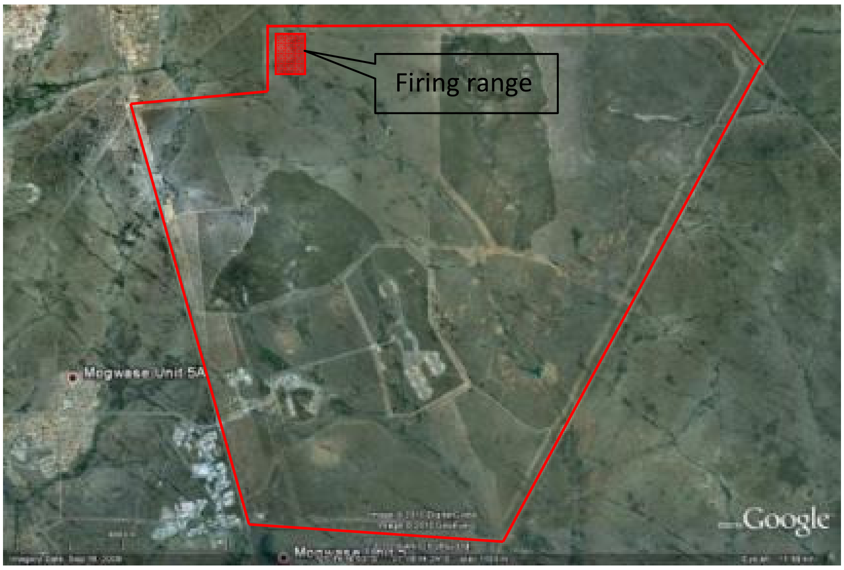

Figure 2: The remediation site at the Mankwe Factory

Figure 3: Grass and Acacia tree cover

Figure 4: Explosive pit filled with water

A remediation plan was developed and approved by the Chief Inspector of Explosives. Remediation commenced on 14 July 1997 and was completed by 26 August 1997.

The plan included:

a) The identification of a suitable contractor with knowledge of explosives to do the remediation
b) The development of a formalised methodology for the remediation of the site following a hazard study
c) The training of personnel involved in the remediation programme
d) Implementation of the methodology (taking into consideration problem areas such as vegetation, soil type, weather)
e) Regular review of the methodology
f) Regular review (audits) by persons required to close out the remediation work (4 levels of audit):

i. Standby auditing – the standby was allocated by the factory and was present daily to ensure that the correct methodology was followed
ii. Project Manager – to audit the methodology on a periodic basis and take steps to correct any problems identified by the standby
iii. Consultants – visit the site on a weekly basis to monitor the effectiveness of the methodology and to provide advice on any changes that need to be made
iv. External auditor – to audit the appropriateness of the method and verify that the agreed method was adhered to

g) Photographic record of progress and recording of data as progress is made e.g. number of detonators found in each block as this would be used to determine whether the remediation area must be increased in size.
h) Report writing
i) Record of decision on success of decontamination.

The plan was implemented:

Step 1 The grass was burned to get a clear view of the ground surface
Step 2 Where detonators were found in trees, the trees were burned and then removed
Step 3 The remediation site was divided into blocks (50m x 50m) using dropper poles and tape, these were further sub-divided into lanes 5m wide using rope, each block was numbered. There were a total of 36 blocks.

Figure 5: The remediation site divided into blocks

Step 4 Three people teams were used in grids to inspect the site.

Figure 6: Teams walking the blocks collecting detonators

A visual inspection was conducted for detonators and associated components by the teams of people walking up and down and left and right in the lanes. This meant that the ground was inspected four times. Detonators and associated components found were placed in buckets half filled with oil. Buckets with live detonators were emptied into larger drums.
The area was then checked with a metal detector.
In the first visual inspection 548 live detonators were found.

Figure 7: Checking with metal detectors

Step 5 A mechanical rake was used to break up the top 50mm of the soil surface. The soil was first raked in one direction then again at 90 degrees to the first direction. People walked behind the rake collecting detonators and associated components. The mechanical raking also resulted in the collection of the burned grass which was hand raked into piles which were then burnt.

Step 7 The area was checked with metal detector.
In the raking phase 265 live detonators were found

Step 8 The soil was then ripped 250mm deep using a mechanical ripper and the area cross ripped at 90 degrees. People walked behind the ripper collecting detonators and associated components that were exposed.

Figure 8: Area ripped

Step 9 The area was checked with metal detector to pick up any detonators under the ground. The entire area was again raked with the mechanical rake.
In the third round inspection 154 live detonators were found.

Step 10 The area around the pits was graded and the mounds of soil hand raked into a thin layer and checked for detonators and associated components.

Due to the effectiveness of the grading, the entire 300m by 300m area was also graded and raked. In this process 83 live detonators were found.

Figure 9: Area graded

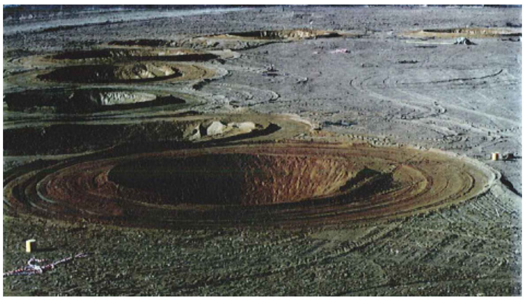

Figure 10: Graded pits and surrounds

Step 11 The 21 explosive pits were then decontaminated:

- The grass in each pit was burned.
- Each pit was visually inspected and live detonators and associated components removed.
- The soil in each pit was loosened by firing a series of explosive charges connected with detonating cord
- Rubber rakes and prodders were used to further loosen soil in and around the walls of the pits to a depth of 500mm
- A metal detector was used to check that no detonators were left in the pits
- As fly soil from the destructions in the pit may have covered some detonators, the ridges of the pit were graded down to 250mm lower than the original

surface level. The soil was raked out to a thin layer and visually inspected for detonators and associated components.

Step 12 Effectiveness of decontamination was assessed:
In order to determine the effectiveness of the decontamination trenches 1 meter deep, 1 meter wide and 2 meter long were dug in selected areas in order to determine the depth of excavation necessary to remediate the site. Inspection of the trenches found no live detonators and associated components deeper than the 250mm.

Figure 11: Trench to assess effectiveness of decontamination

Step 13 Final audit of remediation conducted:

- The Site Manager at the factory randomly selected 25 sites where the soil was sifted. No live detonators or associated components were found during this process
- The AEL Consultant selected two 50 meter lanes for regrading. In one lane one block was graded in the second lane eight blocks were graded. The heaped lines of soil were then raked out to a thin layer and the grass raked into heaps by the auditing teams. The grass was then burned. Four detonators were initiated during this process.
    - Following this the entire site was again raked with the mechanical and hand rakes and grass collected in the raking process burned. During the burning of the grass two detonators exploded. The hand raking revealed four detonators.

Step 14 Due to the four detonators that were found, the process was reviewed and in January 1998, a mechanical sieve was introduced for the physical sieving of the soil.

- The sieve consisted of a hopper, 6mm sieve and 3 conveyor belts
- The sieve was commissioned by sieving soil into which 20 empty detonator casings were mixed
- Material less then 6mm was collected from the conveyor belt by tipper truck for reuse on the ground; all particles > 6mm were collected onto the

second conveyor belt which dropped the material onto a third slow moving conveyor belt. Operators then selected the detonators into buckets containing oil.

- This process took until 23 April 1998 when an audit confirmed that there were no more detonators and the area was decontaminated.
- In the final audit 30 front end loader buckets of soil were randomly selected and sieved. No detonators or any debris related to explosives was found. The coarse material was sieved 4 times and only small pieces of exploded detonators were found.

Figure 12: The remediated site in 2010

LEARNING:

- *Firing of detonators should be done in a meshed area to minimise the dispersion of fired detonators*
- *Explosive debris must be collected daily to prevent the burying of fired detonators and waste by subsequent firing and by rainstorms*
- *Weekly "chicken" parade to be held to check the area for detonators and associated components*
- *Remediate the site as soon as activities have ceased to prevent problems with growth of grass, trees and rain.*

Experiences from the decontamination and demolition of nitroglycerine buildings at Modderfontein, South Africa: public participation

The manufacturing of nitroglycerine (NG) manufacturing at Modderfontein ceased in 1994. Production buildings were decontaminated soon after production stopped. However, the drains leading from the buildings were never decontaminated. In 2005 it was decided that while people with experience in nitroglycerine and knowledge of the manufacturing buildings were still around, decontamination should be completed. By this time grass and trees had encroached on the buildings and mounds, signs indicating buildings or building numbers had become illegible and walkways and roads were overgrown.

It was necessary to bring in retired employees who had worked in the area to identify the location of the various buildings and services and indicate where spillages had taken place that would have contaminated drains and ponds systems related to the drains.

A decontamination programme was set up commencing at east side of the old NG factory and ending at the western side of the NG Factory. The first step in the decontamination programme was to burn the grass in order to reveal the old walkways and drains.

Consultants were identified and contracted to do the blasting and the interpretation of the blasting result to establish whether there had been any sympathetic detonations indicating the presence of NG.

Because tenants of the Modderfontein Industrial Complex occupied buildings in the proximity of the old NG factories and busy factory roads, which skirted them, needed to be closed during the blasting operation, an extensive public participation programme was implemented.

The programme was directed at two interest groups: members of the public based outside of the Modderfontein Industrial Complex and those based inside the Modderfontein Industrial Complex. Members of the public based outside the Complex were informed of the explosive decontamination project and its progress through written articles in the local media. Members of the public, tenants, of buildings inside the Modderfontein Industrial Complex were informed that a lengthy decontamination process was to start. An email data base of tenants was set up so that they could be warned the day before the blasting was due to be done. On the day of the blasting the relevant roads were closed and a siren was sounded to warn everyone that the blast was imminent. The emails also enabled the tenants to raise any concerns regarding the blasting. A telephone hotline was also available for members of the public to lodge any complaints. In order to respond to complaints regarding blast and vibration, monitoring equipment was set up during the blasting which was done once a week.

Experiences from the remediation of explosive waste disposal sites in Modderfontein, South Africa: cost reduction in chemical remediation

The black powder plant operated from 1965 to 1993. During this time any waste (plant equipment, bitumen, etc) from the plant was disposed onto a site in Modderfontein which became known as the Black powder dump.

Figure 13: Part of the black powder dump before remediation

The dump was about 10 000 m^2 in area and was of variable depth up to about 3 m. Test pits were excavated to determine the content of the dump as well as the extent and type of chemical contamination present. Toxicity Characteristic leach procedures (TCLP) were used to determine the leachability of the chemical contaminants as this would indicate the environmental risk and dictate the type of disposal required. It was established that the dump comprised heterogeneous material and amongst the chemical contaminants lead was present.

The easiest option was to remove the entire contents of the dump to a hazardous landfill site. The cost estimate for this was R15,4 million (2008). However, it was decided not to follow this route but to rather segregate the different materials, conduct atomic adsorption analyses on the material which would then determine whether the material had to be disposed to a hazardous landfill site, could be treated and delisted to a lower class landfill site which had lower disposal costs or whether it could remain in situ or could be recycled such as metal. The final cost for the waste separation option which included disposal and backfilling was R9.5 million (2008).