Considerations for Recovery of Large Areas of a Nuclear Facility for Re-Use – 15147

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ABSTRACT

This paper highlights a number of factors an organization might consider for recovery of a facility, using a successful example from the UK. In 2013 a power failure led to the shutdown of the ventilation system that caused loose contamination to be deposited over large sections of man-accessible areas of plant after the evacuation of personnel. The successful initiation of emergency Command and Control arrangements during the Response phase, saw several key responders brought together to offer technical direction across many disciplines. The actions of the Command and Control unit prevented any further spread contamination to other areas of the facility and any external release. This enabled the return of the plant to an operational status which forms an important mission enabler for the site hazard reduction programme.

Intervention at an early stage during the Response phase of the incident saw the cessation of traditional dilute chemical wet decontamination approach that would otherwise leave a legacy of slow leaching contamination; to that of containment and ultimate removal of loose contamination using strippable coatings. Doing so established a more rapid and reliably 'clean' access or pathway into the plant to establish the full extent of the situation.

The scale and scope of the decontamination requirement was steadily revealed through a number of controlled re-entries to the plant. A number of other techniques were considered and employed to address the different areas making use of available plant resources to deliver the successful ‘self-help’ recovery of the plant using multi-disciplinary teams.

As Response switched to Recovery, it was important to set out and agree which strategic option should be adopted to return the facility to normal operation. Equally, it was necessary to verify which equipment had been affected by the power outage and repair as required. Furthermore, equipment with designated safety functions had to be maintained alongside the Recovery activities. A careful balance of priorities demanded an unparalleled depth of plant knowledge to address this, whilst still keeping site and external stakeholders informed. The engagement by the plant workforce to take on the decontamination challenge to enable recovery of their plant supported by other teams formed a critical step in the speed of recovery.

INTRODUCTION

The Sellafield Site

Sellafield Limited is the operator of the Sellafield nuclear site in the UK. The site is approximately 6 km^2 and features approximately 300 buildings with a meaningful radioactive inventory. These buildings include 2 reprocessing plants and a number of liquid and solid waste treatment facilities. As the UK nuclear capability has expanded, the Sellafield site has evolved to its current condition to one that is compact and highly integrated with upstream and downstream facilities (see Figure 1).

Figure 1 – Aerial Photograph of the Sellafield Site, UK.

Building information

Like many waste treatment plants, the facility is equipped with its own ventilation and filtration system to abate discharges from the numerous highly active cells that form the process (see Figure 2). The building is 90 x 31 meters and spans 7 floors with multiple workfaces, with many services e.g. chillers, compressed air; accommodated in over 300 discrete rooms within the building. The facility has operated for over 10 years and to very high standards of cleanliness from robust contamination control measures in normal operation prior to the event. Whilst the man access areas were nominally defined as a C2 area (see Table I for designations), in reality contamination levels were akin to C0. The plant is furnished with several overhead cranes, and many 100's of meters of cable trays for power and control cables, instruments etc, with each workface having multiple trays. Major plant operations are normally conducted through shielded windows and over 100 Master Slave Manipulators (MSM) see Figures 3 & 4.

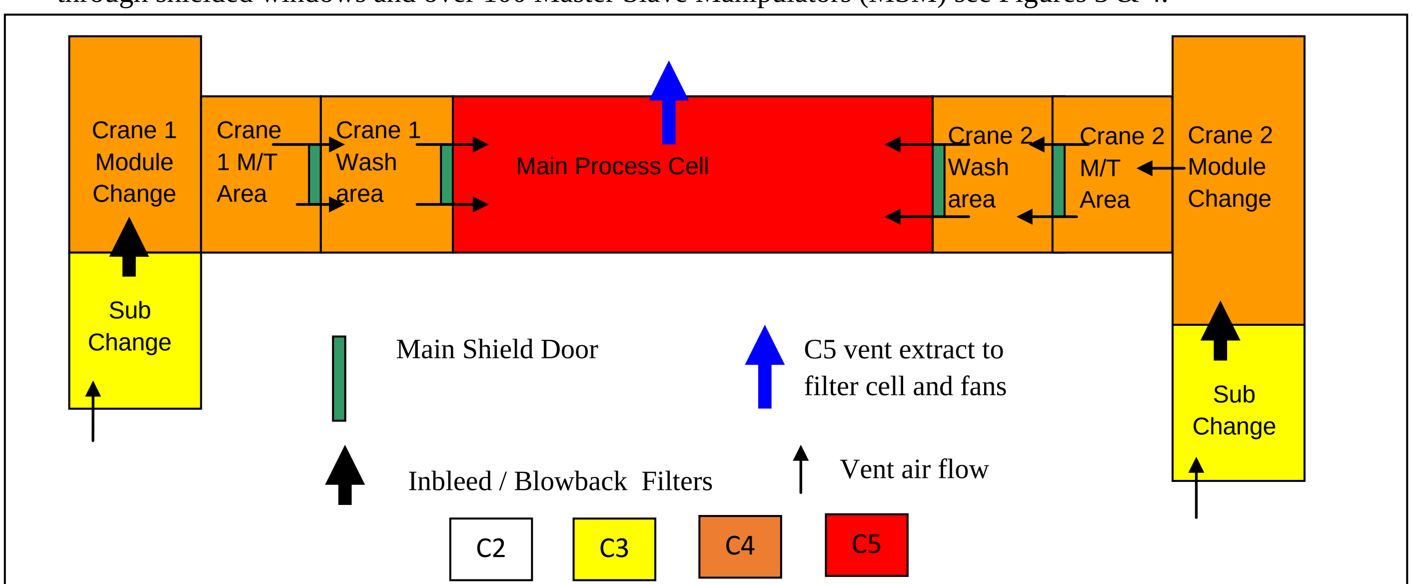

Figure 2 – cell layout

Table I – Description of zoned area contamination classifications.

Contamination Classification	Typical PPE / RPE Requirements*
C0	Open areas
C1	Risk of minor contamination
C2	Works clothing, Free breathing,
C3	Coveralls, full body suit, Full face respirator, gloves, boots.
C4	Full PVC suit, full face respirator, multiple gloves, boots,
C5	Air Fed Suit, entry / exit facility.

* The PPE / RPE requirements for any given classification can be upgraded to take into account the extent of loose contamination.

Figure 4 – Typical operator control console and MSM arrangement.

Figure 3 – Photograph showing the scale and complexity of a major workface.

Contamination event

Complications from a power disturbance in November 2013 gave rise to a reverse flow condition from the C5 cell areas in Figure 2 to the outer C2 man access areas, depositing ultra-fine particulate widespread contamination across several floors. (NB the root cause is not discussed in this paper.) As a consequence, these areas were nominally treated as C4, with minimal increases in radiation levels within the plant, the major issues being associated with contamination. The contamination appeared to have accumulated on horizontal surfaces as though a dust cloud had settled. The degree of contamination varies, but in coarse terms, reduces with distance from the C5 cell areas. The area of plant affected consists of several 100’s of square meters of floor area, with adjacent rooms up to 12 meters high. As indicated above and in Figure 3 & 4, the associated walls, cables, crane and MSMs were also contaminated.

Decontamination of these areas was necessary to enable recovery of the plant for restart. This paper considers only the recovery of the former C2 areas and C3 sub-change rooms and C4 areas normally used to access plant equipment in other cells for essential maintenance e.g. wash cells, to best restore normal practice. Access beyond these areas previously already controlled demanding higher levels of PPE & RPE.

PROCESS STEPS

As a consequence of the power disturbance, the plant was safely evacuated within established protocols and instructions. When normal power was restored, a series of controlled entries were made as per standard practice under the control of the Incident Control Centre (ICC). It became apparent in some areas of the plant loose contamination levels far exceeded normal levels, whilst other areas were contaminated to a lesser extent.

Engagement

Upon realizing the magnitude of the contamination, the ICC, supported by senior management had resources made available to directly support the ICC in gaining control of the situation, but also to support the concept of recovery. Various technical expertise attended the twice daily meetings in the ICC, with technical advice readily accepted and implemented. It was considered invaluable to have such internal skills and assets made available at the time of need who were based on the site. It was critical that such advice was internal, skilled and knowledgeable to define the most appropriate actions without any delay or bias. Cessation of traditional wet decontamination methods to a ‘contain and control’ approach is one example of non-plant based expert knowledge used to aid the response.

Strategic options and points of consideration

Apparent to all participants, site management and other stakeholders, recovery of the plant to normal operations was essential and any concept of barriers to this would have to be robustly justified. Use of prior plant knowledge, practical experience and technical data, concepts and considerations for the recovery of the plant were aired offline from, but parallel to the ICC. Whilst data, primarily HP&S surveys was incomplete, limited or unavailable; a coarse set of strategic and tactical options could be assessed to offer future direction.

The desired final outcome from the strategic options presented below was to enable determination of the decontamination methods, timescales, costs and resource requirements for recovery. Most decontamination processes are used either in enclosed plant, e.g. vessels and pipework; or used for decommissioning where function is no longer required. This requirement is a significant deviation from typical decontamination assessments both in terms of scale and need for re-use of all equipment and surfaces without damage. Of particular note is the need to keep electrical systems operational.

Strategic Options;-

1. Operate and control the whole plant as a C3/C4 operating area until decommissioning.
2. Gross removal of loose contamination on essential equipment only to enable a possible early restart of operations.
3. Gross removal of loose contamination on all surfaces to reduce contamination risk, but maintain plant as a C3 operating area.
4. Gross removal of loose contamination to enable further investigation of sub-changerooms and or restart with intent to deliver a Phase 2 decontamination to reach previous designated levels in parallel with normal operations and scheduled outages.
5. Global decontamination of all areas to reach previously designated level as a single phase of works prior to operations commencing in so far as practicable.

Mindful of any root cause investigation and remedial action, it was evident that several months of outage would ensue, hence time to implement a phase of planned decontamination. With this window of time, option 5 was selected.

Conversion of these options into a recovery plan had to consider several factors. Amongst the multitude of risks to future operation of the plant, was the potential for slow and prolonged leaching of contamination from porous surfaces and gaps / crevices. Very early guidance to cease the use of wet decontamination in favor of a contain and control approach with fixatives and strippable coatings eliminated or greatly reduced this risk, whilst reducing the RPE demands for further entry to the plant.

The factors considered included;-

- ALARP – What is an acceptable contamination risk for the future?
- Future operability of plant – Impact of slower operations at higher PPE levels vs effort to restore the plant in full (or part) including the outage period necessary to achieve recovery, within the context of remaining years of anticipated plant operations.
- Cost – Attempts should be made to limit the input of external / non plant resources, to balance cost of return to service is balanced against future return / benefit.
- Timescale – Re-establish as an operating plant was a primary objective. Phased recovery of various floor levels could permit gradual recovery of some areas of the plant alongside operations. However, a clearer understanding of the timing of revised Safety Case and or improvements to prevent future repeat events would determine the acceptability of longer but better recovery options.
- Resource demands – The envisaged manual nature of any recovery enables a plant led recovery, supported by others where necessary within a Technical / Expertise framework. The critical resource will be HP&S and an increase in numbers was a foregone conclusion. Past projects have shown the benefits of a dedicated, multi-disciplinary plant based project team to deliver objectives.
- Confidence of reaching the required post clean up contamination levels – The current understanding of the mode of contamination and behavior thereof made any assurance of reaching ‘normal’ C2 levels, or indeed historical pre-event radiological conditions very unlikely. Would there be a short lived C3 operating mode (~2-3 years for air sampling, floor swabs etc.) followed by an enhanced C2 measure using gloves and light duty RPE?
- Empowerment of plant personnel to recovery plant themselves – Creation of guiding and supporting framework with appropriate resources from the plant.

- Uncertainties / absences in radiological understanding - HP&S data initially limited to floor swabs to determine where could be accessed without restriction. The extent of contamination in C3 areas, on walls, doors etc. Note the installed radiometric monitoring equipment in the contaminated areas was no longer functioning due to contamination within the monitors.
- Access requirements and proportional decontamination effort – what value is there in cleaning ceilings and high wall areas that introduces significant issues vs instigating managerial controls?
- Future managerial, process, radiological operating constraints to operations - Electrical systems are often fitted with fans, have inaccessible areas and then there are cable trays etc that will demand a method of controlling access and intervention. This will make future operation and maintenance of the plant more complex.
- Political / Target / High Hazard Reduction Impacts – Plant will be offline for some time. The impact to buffer levels / capacity with respect to other reprocessing operations considered in a UK industry context.
- Demonstrable progress – aligned to the above point, being able to show early progress and maintain the morale of the plant teams.
- Sequencing – mostly to avoid in so far as practicable secondary contamination of areas / items.
- Verification and maintenance of other essential plant equipment status to maintain a safe status.

The resultant decontamination strategy consisted of following aspects, accepting in the first instances, there may be some secondary contamination as result;-

Phase 1 – Create Man Access

- Identify the critical items, decontaminate as required.
- Vacuum, survey and contain residual contamination on floors with strippable coatings.

Phase 2 – Improve Working Environment

- Vacuum, survey and wipe surfaces (including walls) up to head height to limit the spread of contamination and render the area C3.
- Use strippable coatings to contain residual contamination.
- Decontaminate cell windows, operator workstations.
- Construct scaffold access towers to the cranes and assess contamination levels and upper sections of walls, cable trays etc before moving any cranes.
- Use rope access from crane rails to decontaminate walls.

Phase 3 – Reduce Contamination In Higher Designated Areas

- Make progressive entry to C3 sub-changerooms and other essential areas.
- Employ similar method and principles as above, considering non-typical items by exception.

Required scope of recovery effort

Contamination collected on air sampler cards was described as a light very fine grey dust that was radiologically shown to be predominantly Caesium. Caesium is soluble in most aqueous systems and considered ‘mobile’ for absorption into paints and porous materials. It was important to avoid future leaching of contamination from traditional wet decontamination methods where possible. This became important in many areas of the plant, that whilst an ultrafine dust, it could not be completely removed by vacuuming and wiping.

The target was to create normal man access to the former C2 areas before determining contamination levels in sub-changerooms and higher classification cell areas. This fell into 3 distinct phases and applied sequentially to the logically bounded areas / rooms. Items requiring decontamination were a mixture of simple and complex geometry items, electrical systems with fans etc and operator control stations (see Figures 3 & 4).

Phase 1 – Create Access

Create reduced risk access by removing and or securing / fixing contamination with strippable coatings to prevent further spread of contamination to less or uncontaminated areas. It also reduces the PPE / RPE requirements from breathing apparatus used for re-entries to more conventional means. The primary goal was to establish the degree and extent of contamination for each given area. This further underpins the decontamination / recovery strategy.

Phase 2 – Improve Working Environment

The contamination by this time was shown to be not as mobile as first considered. A justification was made for decontaminating to head height, then immediately covering the cleaned area with PVC or cling film, making demonstrable progress with minimal risk of secondary contamination from hold-up above. This reduced further working restrictions and hence aided the recovery effort. The higher areas as shown in Figure 2 required scaffold etc. hence were not readily accessible.

Once upper area access was established, the care exhibited by the teams and the clean and cover approach, virtually avoided secondary contamination of the lower (below head height) areas.

Phase 3 – C3 Sub-Changerooms And Essential Maintenance Areas

Using the experience of Phase 2, the creation of multiple teams, enabled a concerted effort to be focused on phase 2 activities, whilst a smaller team was tasked to follow the principles of Phases 1 & 2 in the higher contamination areas.

The greatest challenges were the multiple crane and cable systems, on account of the unknown radiological condition and position at height as to prevent secondary contamination. A significant scaffold tower was erected to access the first crane, crane rails and cable systems before moving it. This served as valuable learning points for the remainder of the plant areas.

The cable trays and cables running through the plant would require significant effort to fully decontaminate them due to settling of contamination between cables. Coarse vacuuming of the cables was carried out, followed by wiping with long reach tools to avoid hand injuries from clips and ties. Any residual contamination was fixed where required using a strong fireproof paint. This will be monitored over time to check for any leaching. However, there is no direct man access that could give rise to contamination of personnel, and in keeping with many other aspects of the recovery, is now subject to managerial controls.

Using HP&S data for floor areas, it was reasonable to assume for contamination of similar levels to be prevalent on MSMs and other plant items with horizontal or sloping features.

The decontamination objectives were to recover as much of the plant in-situ as is possible, using plant operators, or those seconded from elsewhere within Sellafield Limited who were given the appropriate task specific training.

DECONTAMINATION

There are 4 main types of decontamination process types that can be considered at a high level, namely:-

- Water Jetting – High Pressure, Ultra High Pressure ((U)HPWJ), and non-water variants such as NiThrow™ / Nitrocision®.
- Chemical – Mild and aggressive chemicals, foams, gels, wipes etc.
- Abrasives – sand, shot, ice, dry ice blasting
- Physical – laser ablation, microwave scabbling, peening, needlegun etc.

The emphasis for recovery of the plant is to retain function and surface condition of the existing plant, i.e. leave paint, labels, signage etc undamaged. Therefore, most decontamination processes can be eliminated because of their aggressive nature and or any of the following principles.

- Liquids be avoided in so far as possible since this provides an absorption path and or means to leak into cracks, gaps in walls, floors etc that will become a future leach path for contamination over time into paints etc. This eliminates all *in-situ* water jetting and ice blasting, bulk chemicals (but not foam) of non-metallic items.
- Abrasives – Wet Abrasive Blasting (WAB) is discounted as above. Dry Abrasive Blasting (DAB) discounted due to potential damage to surfaces (except for Dry Ice), e.g. paint removal; and give rise to an additional solid waste form.
- All physical methods aggressively attack the surface and concern segregation rather than decontamination.

The preferred methods to support the recovery were:-

- Simple HEPA filtered vacuum systems and wiping with impregnated wipes.
- Strippable coatings to trap and entrain contamination in a solid wasteform.
- CO_2 blasting (low pressure) leaves no residues, considered for higher contamination areas and or inaccessible features such as the crane*.
- Foam followed by immediate vacuuming off provides large surface area coverage with minimal liquors*;

* Testing carried out, but found deployment was not required.

Only where necessary were wet processes considered. With the exception of Dry Ice blasting, these systems were selected because they can be deployed with minimal training by existing plant operators and other secondee’s as part of a “self-help” recovery effort. Whilst it is technically possible to achieve decontamination with more aggressive processes, these take time to implement, require capture systems and call upon a limited pool of skilled resources. Furthermore, the impact if they were to fail was felt intolerable given the circumstances of the contamination event.

Man access areas

The greatest challenges were the crane and cable systems as seen in Figure 3, on account of the unknown radiological condition and location at height. This served as a valuable learning point for the remainder of the plant areas. Not moving the crane prevented any entrainment of contamination into the wheels, tracks and working gear, and likewise any secondary contamination of the area below.

The phased methodology proposed above was followed without the need for more aggressive decontamination methods that would cause delay. The waste being generated required a verification exercise of suitable offsite disposal routes to minimise volumes of wastes going to the UK Low Level Waste Repository. Since much of this was combustible, waste segregation by the plant aided the management and transfer of wastes, whilst this route was made available.

MSMs being of stainless steel construction were bagged and removed for decontamination using UHPWJ as per normal practice using existing facilities. It was also prudent for the MSMs to be further maintained ahead of normal requirements in readiness for restart of operations. Key MSMs were removed first. MSM removal is a considerable task in its own right, the use of UHPWJ coupled with the dismantling of the item has historically been shown sufficient to access all areas of the intricate mechanisms.

A final floor cleaning phase after removal of the strippable coating was conducted using standard floor cleaning scrubber pads and mild wet decontamination reagents to remove in so far as practicable traces of contamination to C1 levels or better. Doing so reduced the risk of future loose contamination which when coupled with sealing and polishing of the floor using standard products, demonstrates ALARP with respect to any future contamination issues.

Sub-changerooms & higher designated areas

Where contamination levels demanded further consideration, dry Ice blasting was proposed. In reality, the careful operation in higher contamination areas and a backdrop of no personal contamination issues, the default wiping and vacuuming followed by strippable coatings was shown to be sufficient. Vacuuming would typically give a DF of 10 per pass, wiping was more variable with DFs of 2-50. Strippable coatings were used to contain areas afterwards. Where strippable coatings were applied directly, DFs of 50 or more were readily observed. It should be noted that these high DFs were associated with almost exclusively loose contamination and would not be representative of other situations.

Supporting works

Strippable coatings were deployed with appropriate training and used to reduce or prevent the risk of further spread of loose contamination on the various floors of the plant due to the increasing volumes of human traffic. The selection of specific products was done on the basis of large scale availability of product during the early Response phase. Once an appreciation of the scale of challenge was known, identifying more mechanically superior products (during peeling / removal) would offer a safer option. However such products contain chelating agents that are prohibited within the CFAs for the respective disposal routes. Removal of the chelating agents made them CFA compliant and hence was requested of the supplier. This offered very similar decontamination performance (<10% difference) whilst retaining the similar mechanical properties. This enabled a less restrictive use of the coatings in the recovery.

Contingency for higher contaminated items included the provision of CO_2 (Dry Ice) blasting used with local enclosures and extract systems. The implementation times required works to be undertaken in parallel to the Phase 1 operations because of the uncertainty at the time. The process was demonstrated inactively on similar equipment and progress made towards implementation, however was not required.

DISCUSSION

The creation of such a large work scope in such a short period of time was inevitably going to introduce conflicts and challenges. One such challenge was for the recovery was to consider the need to access and maintain existing safety devices against pre-defined schedules. Prompt identification of such systems and the means to access them was reviewed. Where possible contingency and substitution arrangements were employed to negate the heavy demand to what was truly essential, whilst maintaining re-assurance that systems function and or remain calibrated accordingly. This gave the recovery teams some of the resources needed to fulfill their remit.

Managing the work

From Day 1, it was assumed the whole plant would be contaminated until it could be demonstrated otherwise by HP&S data. HP&S surveys, access to plant to restart essential equipment and assessment of the overarching building position took 2-3 days, before first implementation of the Phase 1 works. The Recovery formally took over from Response at Day 6, although in reality was running offline in parallel with the Response activities. Formal declaration of Recovery released key plant operators to support the recovery and restore some normality to the plant. Key to defining the sequencing and delivery of work was a Programme Manager who had intimate knowledge of the plant whilst retaining a capacity to look at strategic and tactical issues. This knowledge was used to best effect in setting out the plant recovery priorities against the 300+ rooms in the building.

The plant recovery was broken into logical domain areas, rooms etc. Using the technical and physical knowledge of the plant, coupled with a growing depth of HP&S data, an estimate of time for recovery of each area could be made and hence create a total programme to estimate resource, equipment, time and costs. The Root Cause investigation and associated remedial actions where managed alongside the recovery, to establish a combined perspective of credible restart of operations (but do not form part of this paper). This information was used to inform site and external stakeholders, particularly in gaining the progressive support and or approvals of regulators in an open and transparent manner.

Resourcing

Delivery of the decontamination effort was through the creation of multi-disciplinary teams. Team members included plant operators, craft teams, HP&S and associated contractors. All team members were given basic decontamination training and were encouraged to work and support each other, with comfort that expert support was available if needed. For example, all personnel could decontaminate walls, items and cable trays during the construction of the scaffold towers regardless of demarcation to avoid an iterative and time consuming multiple entries. The training and multidisciplinary approach was not restricted to decontamination, but also the use of equipment to enable access to the higher areas, with rope access from crane beams and Mobile Elevating Work Platforms (MEWPs) to cover areas above head height.

Updating information

In accordance with standard practice, during the Response phase, all information came through the ICC. This was shared appropriately at the twice daily meetings, recorded on action sheets and HP&S data recorded on floor plans for the plant (see Figure 5). This visual aid gave an important impression of the real-time situation, whilst underpinned by traditional HP&S records.

Figure 5 – Typical Visual Contamination Map

As the Recovery phase commenced, the situation became less fluid enabling more formal record keeping, review and planning of work scopes. Plans were updated to show which areas were unchecked, clean, to be decontaminated, decontaminated, coated and or released back for re-occupation for each specific area and floor. Records and plant status for walls and other features is discussed below.

How to record & identify residual contamination levels

The decontamination of the plant being ‘in-progress’ at any given time, it was necessary to identify what items or areas had been decontaminated, to what levels and when, without reference to normal HP&S records. To implement such a concept, a simple grid system for each floor level was produced. Each grid was labeled with a label identifying its current status (see Figures 6 & 7). The label being color coded, identified clearly at distance the degree of any residual contamination.

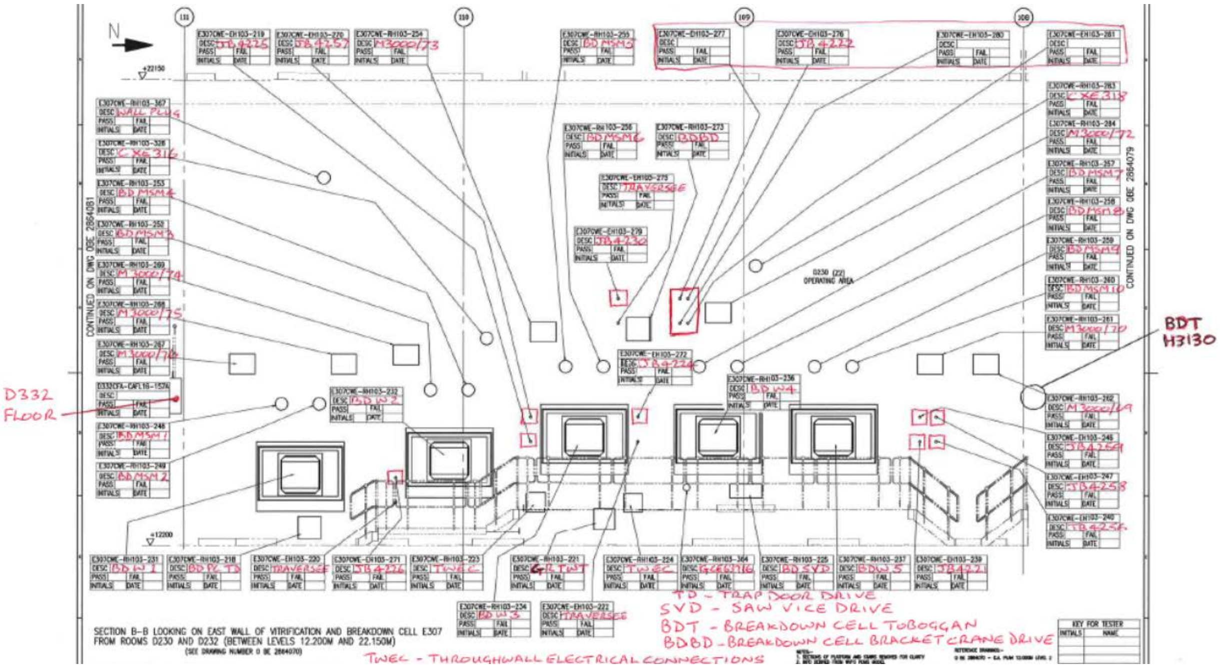

Figure 6 – Grid of HP&S data

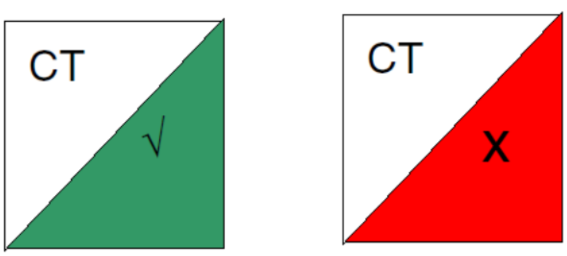

Figure 7 – On plant label showing current HP&S status.

Other items such as operator control consoles at the cell work faces often had fans etc that could harbor contamination. In order to achieve an operational plant condition in a timely manner, some of the enclosed systems have been labeled as ‘at risk’ items that should only be opened under special arrangements, e.g. temporary enclosure. This has brought about a change in the future working ethos of the plant, to expect contamination and cautious in the movement, opening or otherwise intrusion into items. Over time, there is an expectation that the number of such items will diminish and ultimately be removed in totality as on-going maintenance and repair of items occurs.

Reoccupation of the plant

The plant has several office areas for personnel who require regular or continuous plant access. Many of these personnel were unable to initially return to their offices until their respective offices / work areas had been checked and certified as suitable e.g. checking desk, PCs, monitors, chairs. As one of the many workfaces, a progressive manner to re-occupation was adopted, not least as a visible measure of demonstrable progress. In doing so, revised local instructions for emergency responses, e.g. fire alarms, were needed and revised contamination and radiation protection rules (Local Rules). Briefing sessions for those seeking re-occupation were arranged and registers of those briefed and plant access controls were maintained. It was important to note and install changes to signage because of the progress or otherwise dynamic nature of the recovery, bringing about changes to the working and emergency arrangements that had to briefed again.

Whilst works to re-occupy these office areas was on-going, many of those affected were supporting the recovery in any case. This reduced the demand to temporarily relocate personnel to other nearby office areas.

CONCLUSION

The early engagement of key technical resources at the ICC has prevented a legacy contamination issue. The creation of a multi-disciplinary recovery team free from demarcations and financial restrictions has been shown to be effective at restoring the plant within 12 months of the event. The success and speed of the recovery was in part due to the importance placed on the ownership of the recovery with plant operators and recovery teams. They were guided and directed by plant based knowledgeable managerial leaders who could inform and mold the recovery plan and manage stakeholders whilst, and in turn be supported by other non-plant based expertise.

Many factors were highlighted and considered in preparing a decontamination / recovery strategy that would be of universal benefit to any future contamination challenge at a nuclear facility. These must be coupled to a thorough plant knowledge in order to provide the earliest direction to plant and stakeholders.

Decontamination of the plant was achieved using plant based personnel and others seconded to the work area in mostly multi-disciplinary teams, giving each other mutual support to ‘self-help’. A framework of bounded simple decontamination guidance and methods for all team members, enabled visible and demonstrable progress for the teams, plant operators, managers and stakeholders alike. It is important that such teams are supported on by experts for those issues beyond the boundaries of the guidance and offer oversight of any need to amend the approach. Whilst more technical solutions could have been implemented, it is difficult to place a value on the ownership and delivery of the solution by the teams.

The challenges of working at height demanded multiple methods of access, including rope access, MEWPs and scaffold towers to accommodate the various physical restrictions within the plant. It was important for all recovery team members to be trained in these access methods to deliver their tasks.

Any recovery plan must also consider the maintenance and repair requirements of the systems needed to provide a safe environment to work within. These can be intelligently scaled back, mitigated and or substituted at times of need as part of an overall risk / hazard mitigation programme.

Having clear and dynamic methods for visualization of the radiological conditions and progress provided invaluable information to all stakeholders and delivery teams. The control and capture of data on a daily basis provided an excellent means of supporting learning from experience for controlling and reviewing a dynamic situation.

Disposal routes were opened up for wastestreams that supported the recovery. Alternative products for the higher activity streams were produced, assessed and implemented to support the recovery, making best use of the available skill base to deploy them.