Practical Experience with Remediation of a Former Active Handling Building Site in the United Kingdom - 9058

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ABSTRACT

Since the year 2000, Nuvia has been contracted to carry out the decommissioning of a former Active Handling Building A59 on the United Kingdom Atomic Energy Authority (UKAEA) site at Winfrith in Dorset. This is in support of UKAEA's mission, which is to carry out environmental restoration of its nuclear sites and to put them to alternative uses wherever possible. Latterly, a new body, the Nuclear Decommissioning Authority (NDA), has become responsible for managing the UK decommissioning legacy and since 2004 UKAEA has been contracted to the NDA to deliver decommissioning work at Winfrith and other UK sites.

The earlier operations concentrated mainly upon the clearance and decontamination of two heavily shielded suites of caves, originally used to carry out remote examination of irradiated nuclear fuel elements, together with a range of within-building support facilities. In 2006 the main containment building structure was demolished as well as the two suites of caves, leaving the base slab for final removal.

The demolition contract with UKAEA required removal of the base slab and recovery for disposal of a quantity of encast, internally contaminated items such as secondary active drain pipes, active ventilation ducting and more than 100 steel mortuary tubes set up to 6.6m deep into the slab. The scope of the work also required the underlying soil to be carefully monitored for the presence of radioactive contamination and, if detected, its remediation to an end state suitable for un-restricted use without planning or nuclear regulatory controls.

These latter operations form the basis of this paper, which reviews some of the significant tasks undertaken during the process and also sets out the development of a robust waste monitoring strategy for the recovered concrete debris ahead of its disposal. This has enabled more than four thousand tons of debris to be classified as SOLA (Substance of Low Activity), allowing disposal to landfill. This will include details of the development of a system, including a bag monitoring procedure, used to support the classification of some concrete debris as SOLA material.

Currently, the base slab has been completely demolished and all encast items recovered for disposal, including the deep mortuary tubes. This was only achievable by the installation of a dewatering system which enabled safe excavation. These latter operations were challenging owing to the significant depth of some of the items to be removed and the unconsolidated sediments underlying the site.

The paper will discuss the main issues involved with the remediation of features within the concrete slab and the underlying soils. These will include comments on the ground conditions, soil structures, groundwater levels and problems associated with provision of waste storage areas and their various impacts upon project progress. Several challenging areas of the slab such as the original decontamination bay and pressurised suit area sump have been removed and the paper will describe how the underlying soils were monitored using a Groundhog™ based system ahead of final remediation and waste sentencing.

One area of particular significance to the remediation process has been the use of office-based contaminated land assessment tools including ReCLAIM, a Microsoft Excel spreadsheet based tool used to assess current and future impacts of radiological contamination at nuclear licensed sites. Finally, during these operations, evidence of ground contamination has been detected by routine monitoring and the methods taken to remove and remediate the underlying soils will be described together with details of the surveillance systems utilised. Some examples of the problems encountered during the remediation will be described, potentially of value to others working in a similar field.

INTRODUCTION

In several earlier papers, (References 1-5), the construction in the 1960s and subsequent utilization of a former Active Handling Building at the UKAEA nuclear research establishment at Winfrith has been described. This facility contained two large concrete shielded suites of ‘caves’, often referred to as ‘hot cells’, together with other supporting facilities such as an equipment decontamination bay, active workshop, active facilities ventilation plant and health physics department. Over the following 30+ years the caves were used to carry out destructive studies on a wide range of nuclear fuel materials as well as other highly active non-fissile items. As such the two cave lines were highly contaminated at the start of decommissioning operations.

The A59 facilities were declared redundant in the mid 1990s and in the year 2000 following a commercial tendering process, Nuvia was awarded the contract by UKAEA to decommission and demolish the whole building. This was in support of UKAEA's mission, which is to carry out environmental restoration of its nuclear sites and to put them to alternative uses wherever possible. Since 2004 UKAEA has been contracted to the Nuclear Decommissioning Authority (NDA) to deliver decommissioning work at Winfrith and other UK sites.

The decommissioning operations are now well advanced with all the above-ground facilities demolished and this paper will concentrate upon those phases of the work carried out over the past year concerning removal of the base slab and remediation of the underlying soil. These latter operations have been challenging and during the process of removal of encast items such as filter pits, active drain pipes and steel mortuary tubes extending to a depth of more than 6.6m, significant evidence of land contamination has been detected. The methods used to remove the base slab and to monitor and remediate the underlying soil will form the basis of this document.

The process of remediation of the site is now at an advanced stage and at the time of writing, the process of final infilling of the large cavity with soil and final grading and monitoring is about 75% complete.

BASE SLAB REMOVAL & ASSOCIATED OPERATIONS

In previous papers (References 1-5,) the lead up to Building A59 demolition operations has been described in some detail. The building structure was demolished first as the walls of the two cave lines each provided significant structural support to the roof. The demolition of the cave lines then followed after installing a powerful air mover system at one end of each unit to produce an air flow into the facility and away from the demolition position at the opposite end. The air mover discharges were drawn through a double HEPA filter into a new horizontal discharge stack fitted with an isokinetic sampling system to ensure that radioactive discharges to atmosphere were minimal and below agreed site-based limits.

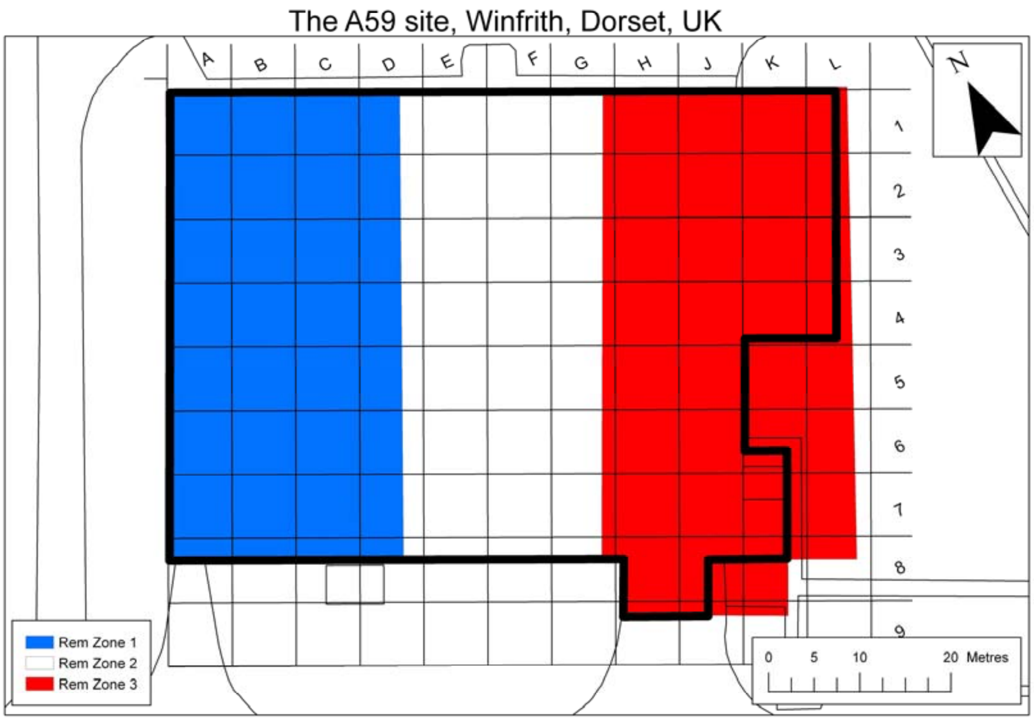

Figure 1: Diagram of the A59 Base Slab with outline showing three Demolition Areas and the alpha-numeric key used for location of specific positions.

Once all the cave line demolition materials had been monitored and cleared, (References 6 & 8), work commenced on the roughly 70m x 45m concrete base slab. The slab was generally constructed with a 30mm high density concrete surface layer on top of a 90mm layer of low density concrete. Within the slab were encast ventilation filter pits, active drain pipes/pits and more than 100 mortuary tubes up to 6.6m deep. All these items were located at different depths in the slab and were surrounded by more low density concrete. Some of the active drain pipes led outside the slab to five external drainage pits which formed part of the liquid effluent disposal system for the site. A variety of techniques were then used to remove these contaminated items and to progress the steady demolition of the slab itself. These operations were undertaken in accordance with an overall plan that allowed the progressive removal of the slab from west to east, noting that the first third of this large area contained the least amount of encast items, (Figure 1). An area along the northern perimeter of the slab was also demolished in this phase having been the site of the main two-storey office block.

A diamond sawing technique was used to section the concrete slab on each side of all the active drain pipe runs to ease their removal when required. A range of hydraulic breaker units was used to demolish the slab ranging from small machines of around a 5te capacity used on pipework runs and around filter pits to much larger 20te breakers for the main slab areas and where thicker concrete was present.

Figure 2: Ventilated Enclosures over NCL and Decontamination Bay Sump Areas
also showing the Zone 1 area cleared of concrete to left side. Note also
the presence of groundwater in puddles after rain due to clay content of the soil

These machines were also provided with a standard excavation bucket so that spoil could be lifted out to expose items as required. An additional requirement for some excavations was to carry out the work inside a ventilated enclosure. This was necessary due to the high levels of potentially loose contamination encountered in some cases, particularly the ventilation filter pits, the decontamination bay sump and the base of the former pressurised suit area (PSA), (Figure 2). The use of excavators inside a ventilated enclosure was very restrictive and work progress dropped significantly. The piping of the machine's exhaust outside the enclosure was challenging and operatives also had to wear filtered respirators, further hampering progress. An additional problem concerned the need to place the recovered material into LLW drums if it was contaminated, and the monitoring of these materials before sentencing further slowed progress.

The active drain secondary pipework was generally located at a depth of around 1m below the top of the slab with gentle falls to ensure adequate liquid flows during operations. A small excavator was used to remove the overburden and expose the pipe lengths which appeared to have been secured within a low density concrete matrix upon a fairly firm base. In a few locations evidence of pipe fracture and leakage into the surrounding concrete and soil was detected and these sites were carefully marked for future reference during remediation operations. The leakage appeared to have been caused by fracture of the surrounding concrete used to secure the pipework, almost certainly due to ground movements over the lifetime of the facilities. Following removal of the pipework, the trenches were for convenience temporarily infilled to allow for removal of the adjacent slab. In another site external to the slab, a pipe connection to the site active effluent system was found to be missing at a joint such that there had been significant local leakage over many years. In this case some evidence of contamination was detected and as this area was external to the slab, some local soil removal and monitoring was undertaken to eliminate the bulk of this contamination.

The requirement to expose, recover and dispose of the 124 steel mortuary tubes located at up to 6.6m below the slab surface was challenging in both gaining safe access to these features as well as providing a dry site for monitoring purposes. As a result, an integrated slab excavation and demolition plan was devised, supported by a site dewatering system to enable deeper structures beneath the slab to be removed under dry conditions. The installation and operation of these dewatering wells and the disposal of the recovered ground water has been described before (Reference 7) and is not repeated here. Suffice to note that water was recovered from the north east side of the base slab from four wells drilled to a depth of about 20m below the surface of the slab. Water recovery rates reached about 12 litres/sec during a period of around 9 months during which the local water table was steadily reduced from about 2m to about 7m below slab surface at which level it was then maintained.

There was considerable discussion about the excavation design, particularly where recovery of the mortuary tubes in the 4.5 – 6.6m depth were concerned. Due to the sandy nature of the soil with a high clay particulate and flinty inclusions, tests were made on samples from around the proposed excavations to determine the natural angle of repose of

Figure 3: Recovery of deep mortuary tubes from base slab close to dewatering well

these materials. This was undertaken to establish a safe angle of attack for the excavations such that the sides would remain stable during recovery operations. Following these tests and subsequent discussions with experts, a safe but more practical means of the recovery of these tubes was devised, minimising the quantities of soil that were required to be removed. Figure 3 shows a typical view of one of these excavations.

DEMOLITION MATERIALS RECOVERY & HANDLING

The slab demolition commenced on a 25m x 45m section at the western side where there were relatively few encast items. Here the slab was demolished using a 20te hydraulic excavator using a breaker unit and bucket in series. The upper 300mm of high density concrete was broken across a substantial area and the bucket then applied to recover the broken concrete into a large local pile. The low density concrete and soil were then locally excavated around four 3.3m deep mortuary tubes which had been originally provided for a cave line extension that had never been utilised. As a result these tubes were only very slightly contaminated internally and their removal was undertaken with minimal excavation by pulling them out sideways with the excavator. No contamination was detected on the outer surfaces of these tubes and this allowed the exposed cavity to be temporarily infilled ahead of any subsequent land monitoring and remediation. As the active drain pipes had already been removed from this whole area, only a small section of the Pressurised Suit Area (PSA) base slab remained to be demolished. This allowed the rest to be monitored using a sensitive Groundhog™ system based upon a 3" (76mm) sodium iodide (NaI) scintillation detector and ratemeter, which when coupled with a GPS system allowed a map of the residual activity across this section of the site to be produced.

The materials recovered from the base slab demolition mainly comprised broken high and low density concrete and contaminated steel items such as the mortuary tubes. However some clean steel materials were also recovered, mainly the reinforcing bars used in the upper layers of concrete and various foundation materials. These latter materials were recovered and set aside for monitoring and, if appropriate, recycling. The concrete was initially pulverised using another hydraulic breaker to a 75mm cube or smaller. In many cases a concrete crushing machine was also used for this purpose and all size-reduced materials placed into 1te builders' bags for temporary on-ground storage. The excavator was used to recover all concrete materials from this first area of the base slab such that only the underlying soil remained, Figure 2.

Subsequently the central and finally the eastern areas of the base slab (Figure 1) were demolished but not without some problems as have already been described concerning the need to erect ventilated enclosures over some contaminated areas. The demolition process was undertaken without particular difficulty, except where space was restricted within the enclosed ventilated areas. The heavy excavator successfully recovered over 100 large concrete blocks that formed the solid bases for the main building stanchions. These varied in size from about 1-6te, the largest items being associated with supports for the main building cranes. After monitoring, these bases were broken up with the largest excavator and the debris crushed for treatment as for the slab base.

Recovery of the deepest batch of mortuary tubes was actually completed without incident, despite concerns for ground stability that had delayed the operations. Here an excavator stripped away the low density concrete to a sufficient depth to allow their recovery by pulling them out sideways from the steel retaining structure, (Figure 3). After local monitoring had revealed no external contamination, these items were taken to the on site ventilated waste processing enclosure (HAKI tent) for size reduction and disposal as LLW. This facility was introduced at an early stage of the demolition process and its ventilation was provided by an air-mover connected to the site discharge stack used to support the cave line demolition. Here mechanical saws and standard gas cutting techniques were used to section larger items for disposal as LLW, there being little opportunity to effect sufficient decontamination to permit disposal to any lesser waste category.

MONITORING OF DEMOLITION DEBRIS

The concrete monitoring procedure has previously been described (References 6 & 8), but in outline comprises two separate but complementary procedures. Firstly, the materials in the bags, having already been crushed to <75mm cube, were emptied out and 'trough monitored' in a low radiation background area of the demolition site. Four concrete lined troughs 2.5m wide, 15m long and 0.1m deep had been constructed upon a section of the demolition site for this purpose, (Figure 4).

Figure 4: Monitoring of concrete debris in the external troughs with LLW drums ready for removed materials with dewatering tanks in the background.

The monitoring process, which uses a 3" (76mm) NaI detector and count rate meter to identify and assist with removal of any materials above an agreed background count rate, identifies bulk concrete that may be suitable for disposal to landfill as exempt waste. Some of the material was set aside in the Winfrith rubble store for use as infilling when various large structures on site are demolished at some time in the future. However, the majority of this material was sent for disposal at a local landfill.

As noted above, the 'trough' monitoring was intended to demonstrate that bulk concrete contained less than the limit set in the SOLA Exemption Order to permit landfill disposal. Since the base slab materials were found to contain small but variable amounts of residual radioactive contamination, a second process based upon a developed bag monitoring protocol was introduced This was carried out using a calibrated high resolution gamma spectrometer, a bag rotation turntable and a gamma counting procedure based upon the main isotopes present in the A59 'fingerprint'. The gamma spectrometer is calibrated against a reference source each day with a regular background check made by counting a reference bag available for the purpose.

Bags of materials that lay below 0.4Bq/g were then set aside and subsequently disposed of to landfill under the UK SOLA Exemption Order. More than 4000te of such materials have been disposed from this project to date under these arrangements. Residual materials which contain activity levels above 0.4Bq/g have been set aside for disposal as LLW.

It should be remarked that the on-site storage a large quantities of crushed concrete and some soil in builders' bags has presented considerable difficulty. Much of the site is in the advanced stages of remediation and there are piles of soil and some crushed concrete awaiting bag monitoring. For a project with a base slab so large, it would have been of great benefit if access to a much larger area for interim storage of bags had been available.

GROUNDHOG MONITORING AND SITE REMEDIATION

As noted earlier, the base slab was demolished in three roughly equal sized zones from west to east across the site. One reason for this was because the flow of groundwater followed a roughly south west to north east direction so that regions that had been cleared first lay upstream from the areas awaiting attention. However, many of the sub-surface features removed were recovered without any requirement for dewatering owing to the ~2m deep water table and the presence of considerable amounts of low density concrete.

A Graphical Information System (GIS) was developed for the life-cycle of the A59 remediation project where it was found to be invaluable for recording baseline conditions and remediation progress. The system was used to store details of the site such as historical plans, site extent and boundaries and subsurface features (drains, storage tubes, ducts etc.)

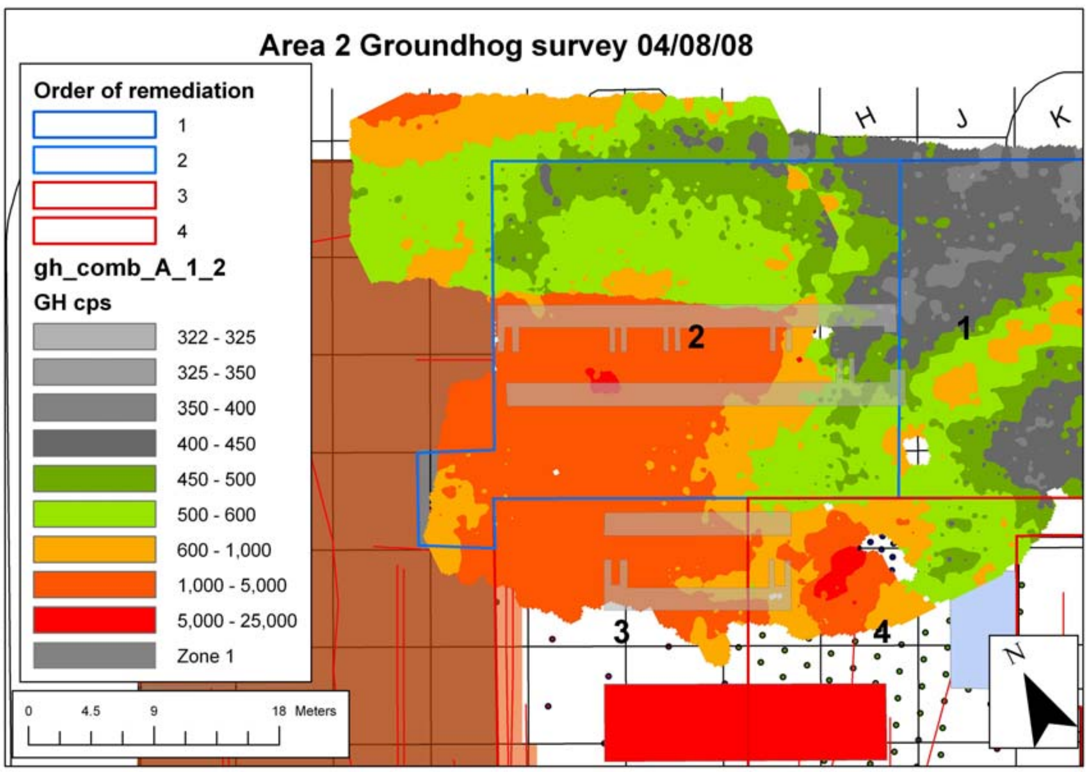

Figure 5: Groundhog™ survey of an area of A59 base slab after demolition showing variation in activity levels ahead of remediation

As the remediation progressed, regular remediation progress drawings were generated to show areas of concrete removed, features removed i.e. concrete stanchion bases, pipework, or where soils had been remediated and verification samples collected, (e.g. Figure 5). One of the key features of this system is the ability to electronically switch on and off any of the layers of data so that specific examinations can quickly be made of almost any feature in the slab without the intrusion of any unwanted data. The system also has a capability to provide for the rapid completion of area and volume calculations when producing site statistics.

In each of the three main areas, after removal of the concrete and exposure of the underlying soils, Nuvia utilised the Groundhog™ gamma radiation monitoring system as well as the more traditional hand-held instruments for surveys on the site. The Groundhog™ system comprises a sensitive 76mm NaI scintillation detector coupled with a data logger and global positioning system (GPS). Accessible areas were surveyed on foot by a man traversing the survey area at a velocity 1m/s on lines spaced 1 m apart.

Radiation readings are automatically collected by the system at one-second intervals, which produces a survey resolution of one reading per square metre. This highly accurate and sensitive survey ensures contaminated areas are detected and their location recorded with sub-metre accuracy, and enables the spatial extent of any contamination to be determined. The data are used to plot a contour map of contamination (e.g. Figure 5) which can be displayed on a Geographical Information System (GIS). Analysis of the survey data using the GIS allows the results to be assessed in detail, and enables even minor deviations from the site's natural background radiation level to be identified and investigated.

Figure 6: Bucket Monitoring of Soils using Table & Sodium Iodide Detector

The process of Groundhog surveying was made more challenging by the difficult ground conditions. Heavy and prolonged rainfall, coupled with the significant level of clay particles within the soil, resulted in the site being very difficult to traverse on foot. Additionally, there were safety implications over surveying deeper excavations and steep slopes. In some periods of poor weather surface water ran into excavations to form pools, further hampering remediation operations. Finally, the site would have benefited from the establishment of a series of fixed marker posts around the perimeter against which all soil sample locations could have been referenced.

The radiation contour map was then used to demonstrate the efficacy of the remediation in a progressive manner. This involved scanning of surfaces, derivation of an action plan and then using an excavator bucket to remove progressive layers of soil for checking for activity using a well-established bucket-monitoring process. Here the ~0.5m^3 bucket of the machine, Figure 6, is loaded with soils and placed upon a reference table set over a NaI 76mm detector system. This system is set up and calibrated to give a go/no-go response so that the soil can be set aside for reuse or bagged for more detailed monitoring if contamination is suspected ahead of any disposal considerations.

A predetermined sampling grid was used for the collection of soil samples from remediated areas, a proportion being sent off-site to a laboratory for radiochemical analysis. From the results a significant proportion showed that levels of residual activity in the soil were acceptably low, allowing some back-filling with available clean soil to be undertaken. In a few cases the results showed that further remediation actions were required followed by fresh sampling of the soil until the required conditions were met. The intention is finally to in-fill the cavity with non-calcareous soil from an on-site stockpile, to return the site to a condition close to that which originally existed. The final operation will be to monitor the remediated ground with a 'Groundhog™' system to provide confirmation that work on the site is complete.

DOSE BASED ASSESSMENT TOOLS

Two radioactive exposure assessment tools are commonly used in the United Kingdom: the Radioactive Contaminated Land Exposure Assessment, RCLEA, (Reference 9), and NRPB W36, (Reference 10). Both techniques were used with a spreadsheet tool (RECLAIM) developed on behalf of the Nuclear Decommissioning Authority (NDA) by Nexia Solutions Limited (Reference 11).

This tool, based on a Microsoft Excel spreadsheet, enables the user to input data on the radionuclides (including activity), dose targets and site occupancy to run a number of different scenarios in which dose uptake is calculated. This figure can be compared with a user defined dose target in order to assess the remediation activities. The ReCLAIM package was used on areas where identifiable contamination exists to calculate the risks to future site users.

In order to make up-front assessments, models were run using pre-defined gross activity levels (0.1, 0.2, 0.5, 1.3 and 5Bq/g) using the previously agreed radiological fingerprint. The results of these tests were used as a guide to the acceptability of residual soil contamination.

LESSONS LEARNED

During the latter stages of this project concerning the removal of the base slab and remediation of the underlying soils, some further lessons have been learned that may be of value to others.

1. The rate of removal of slab concrete was much greater than could be accomplished during crushing and monitoring of the debris using two independent systems to establish disposal options. As a consequence, much more storage area was required to hold the 1te bags than was actually available. As a result, mounds of concrete built up awaiting crushing and available storage space was not ergonomically convenient for the subsequent monitoring operations. In any large project of this nature, account needs to be taken at an early stage to provide sufficient waste storage space to allow the monitoring to be undertaken in an efficient manner.
2. The demolition operations involving recovery and disposal of heavily contaminated materials from the slab such as the ventilation filter pits required use of a ventilated tent to provide a suitable containment. The working conditions inside the tent were sufficiently difficult to significantly reduce the rate of progress. In any project of this nature it will be useful to identify areas of significant residual contamination at an early stage so that the necessary resources of time and manpower can be allocated within the overall programme at the planning stage.

3. A more realistic approach to excavation plans would have assisted during the development of a procedure for recovery of the deeper mortuary tubes. The attendant risks were generally clear but greater reliance might have been given to the experience of demolition contractors who were well versed in such operations. The application of purely theoretical approaches to this work greatly increased the uncertainties and lost a few weeks of programme time. In the end a more practical approach was adopted and the operations proceeded without any difficulty.
4. All waste data would benefit from creation of a dedicated database. Here the waste data was divided between multiple users, computers, networks and formats which made compilation of reports a time consuming and difficult process. Collaboration with the client at an early stage and joint development of a common database would have improved efficiency.
5. One final point in any contract of this nature is to recognise the conflict between carrying out operations against a technically driven programme rather than commercially driven imperatives.

CONCLUSIONS

The work associated with the decommissioning and demolition of the former A59 Active Handling Building at Winfrith has progressed steadily since 2000. Over the past year operations to remove the A59 building slab have been completed together with most of the site remediation. These operations, based upon a coherent slab demolition plan, have been undertaken under a variety of conditions during which a range of challenges have been met and overcome. One of the biggest challenges concerned the need to undertake significant excavations within a ventilated enclosure, which significantly extended the anticipated working time. However, the various items within the slab that were heavily contaminated were successfully recovered without incident during this process.

The removal of the base slab was generally accomplished without incident creating huge quantities of low and high density concrete for crushing and monitoring ahead of disposal. More than 4000te of materials have been disposed of to landfill, supported by a calibrated gamma spectrometry monitoring regime for the 1te builders' bags that hold the debris. This has had a major impact upon the reduction of volumes of materials sent for disposal as Low Level Waste (LLW).

The use of Nuvia's Groundhog™ system together with a well defined sampling grid enabled the footprint of the base slab to be surveyed and subsequently remediated to an agreed standard to allow infilling with non-calcareous soil ahead of final leveling and grassing as the final step for completion of the project. The use of exposure assessment tools has greatly assisted in closing out the remediation operations and its use is commended to others.

The project is now approaching a successful conclusion and the co-operative working established between all parties has greatly assisted in progressing the operations in a safe, business-like manner.

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