CLYM

Project Report

TO:	Michael Cimis	DATE:	February 1, 2013
FROM:	Charles Watts		
SUBJECT:	Dartmouth College Rennie Farm Remediation: Phase One Summary		

Background

In early 2011, Dartmouth College (DC) initiated the remediation of a small low-level radioactive waste burial site at Rennie Farm (Rennie). The intent of this project was to release the property from radiological controls associated with its State of New Hampshire broadscope radioactive materials license. Clym Environmental Services, LLC (Clym) was asked to oversee the radiological remedial efforts. Clym agreed to work in a joint role with GZA GeoEnvironmental, Inc. (GZA) and its subcontractor ENPRO Services, Inc. (ENPRO) to manage environmental impacts and excavation.

Clym prepared an initial site Health and Safety Plan (HASP) that included a basic work plan for Phase One site operations. This plan was submitted to the State as an amendment to the DC radioactive materials license and was subsequently approved. All radiological work on this project was conducted under the authority of the DC radioactive materials license. The decision making process for site health and safety is included in the HASP, therefore this report serves as a summary of site operations and findings. All site work has simultaneously been communicated to and (where applicable) permitted by NH DES and EPA stormwater management authorities.

Site History

According to historical accounts in College records, DC operated a small, approximately one acre, burial site for radioactive animal waste from life sciences experiments conducted in the 1960s and 1970s. At the time of the remediation, limited information was available on the actual burial procedures at the Rennie site. Records revealed that a perimeter fence controlled access to the site, and that forty-three burial plots existed. The plots were reported to be approximately ten feet in length, three feet in width and have a soil cover of three to four feet. No details of the actual waste types deposited in each plot remained, except for a listing of radioactivity (by radionuclide and activity) for the final twenty-eight plots, and reference to the site as an animal burial site. This log shows that waste was infrequently buried at the site, often only a few times a year.

No indication of the volumes of waste deposited during each burial event was found. A limited inspection of one plot was conducted in 2007 revealing a bag labeled with radiation warnings and containing animal carcass waste. This investigation provided some confidence that the site was limited to radioactive animal waste.

With the passage of time, the original fence collapsed and trees overgrew much of the site. In conjunction with the 2007 investigation, the College installed groundwater monitoring wells around the site and periodically collected samples thereafter. These samples revealed no contaminants (either chemical or radiological) above associated reporting levels. A modest dirt driveway leads from the road to the upper field where the site is located.

Site Preparation

With the original perimeter fence no longer standing, and its placement not visually discernable, a ground-penetrating radar (GPR) survey was conducted at the site. It was hoped that this survey would identify the original site borders as well as confirm the depth of soil covering each plot. Complicating the GPR survey was the growth of more than one hundred trees of varying sizes on the site. When the survey was completed, the perimeter of the burial site was determined and no obvious shallow (less than three feet deep) anomalies were confirmed.

In early November 2011, the trees overgrowing the burial site were removed. Soil samples were collected at one and two-foot depths throughout the burial site area. Samples were collected over indentations in the ground that were believed to represent the settling of soil and the possible locations of the forty-three burial plots. The area associated with these indentations represented approximately three-quarters of the land set aside as the burial site. Forty-three soil samples were collected at a one-foot depth and forty-three additional samples were collected at a two-foot depth. Composites of each of these samples sets were sent for radioanalysis. Additional samples were collected in the remaining areas within the site at one and two foot depths. These samples sets were also composited. Soil samples were also collected outside of the burial site area to establish background levels of naturally occurring radioactive materials. In all, eight (8) composite samples were prepared and shipped for radioanalysis at GEL Labs in Charleston, SC.

Site preparations included the placement of a lab trailer to serve as an office for operations and a field lab. The trailer was equipped with a liquid scintillation counter and sample preparation area. A quality assurance procedure was put into effect once the instrument was installed and calibrated. Portable radiation detection instrumentation was also maintained in the trailer and subject to quality assurance procedures.

Given the remote location and limited access, significant site, road and stormwater improvements needed to be made to allow for the continued movement of equipment from staging areas to the remedial area. These improvements included a gravel access road, a packed stone staging area for refrigerated trailers, gravel pads for office trailers, sound dampening walls for the refrigerated trailers, site security and storm water management.

Once these infrastructure improvements were completed, the focus of pre-operations turned to radiation safety. On-site training on basic radiation safety concepts and the site work plan was conducted. Dosimetry was issued to all remedial site workers and a log was established to track the wear period of all badges (dosimeters were kept in the lab trailer along with controls when not worn). Site control was also established. The entrance to the farm was controlled with barricades and a campus security guard. All individuals entering the site were required to complete the access log. All personnel who were approved to approach the remedial area were required to wear appropriate personal protective equipment and were escorted by either Clym or Dartmouth College representatives at all times.

The next step involved clearing and securing the approximately one-acre remedial site. Trees on the site were removed, site control fencing was installed, and an approximate two-foot cover layer of soil was excavated. This excavated soil was above the buried wastes and was collected in piles at the site and termed "green" soil (as it was deemed highly unlikely that this soil would contain radioactive contaminants from the plots).

A second GPR survey was scheduled to rule out the potential for large volumes of waste and/or metal drums. It was expected that the efficiency of the GPR system would be increased by removing the top layer of soil and that any large metal objects would be more easily detected. The second GPR survey was conducted with no significant findings. In addition, the GPR survey did not detect, with any certainty, the location of the plots on the site.

With the GPR surveys completed, site radiological control zones were instituted based on the work plan. The area inside the original fence as well as a margin of at least ten feet on all sides was designated as the burial area. The exclusion zone was marked as to encompass the entire burial area, contamination reduction zones were established on either side of the exclusion zone and a support zone was marked. The perimeter fence secured all zones. Radiation workers (Clym personnel) would enter the site through a donning and doffing station. Support personnel operating excavation equipment, would enter the site on wooden walkways from the support zone to access their equipment. A viewing area for visitors was created outside the fence barrier.

Site operations were to be controlled from day to day by using Radiological Work Permits (RWPs). A permit was to be completed for each day of remedial operations and would be discussed with remedial site workers during a daily Job Safety Briefing. A copy of each RWP was to be posted outside of the donning and doffing station during each shift. Emergency equipment including first aid stations, portable fire suppression equipment, eyewash station and safety shower were strategically located.

On November 15, 2011 representatives from the State of New Hampshire Radiological Health Section inspected the site. These representatives were given a tour of the site and an overview of the operations plan. With site conditions and the plan of operations meeting the State's approval, remedial work began later that same day.

Planned Remedial Operations

Based on the types of procedures common with life sciences animal research, the work plan had predicted that there would be the potential for multiple waste streams at the site: radioactive-biological material, dry active waste, soil, liquid scintillation vials and possible mixed wastes (e.g. contaminated lead, hazardous liquid scintillation media, etc.). In order to support a future request for unrestricted use status for the site, the work plan called for the removal of all visible waste from the site.

Given the reported size of the plots, estimates for each waste type were made and these estimates were used to plan for initial site operations. It was expected that the primary waste stream would be radioactive-biological material, or waste generated from animal research. It was recognized that with the passage of time, waste may have moved from original containers into the surrounding soil and so one (1) foot of soil contiguous to each plot would be removed as a conservative safety margin. Lastly, the possibility existed that some liquid scintillation vials, lead or other waste exhibiting chemical hazards might be present. These wastes were not expected to be present in significant volume. Radioactive liquids were not expected at the site.

Site storm water run-on and run-off controls were instituted and work zones were to be established and approved prior to remedial operations. Stormwater run-on was prevented by the placement of a trench along the highest elevation of the site and site run-off was directed around the dig site and down gradient groundwater monitoring wells.

Each day a job safety briefing would be held to discuss the plan for the day and the requirements of the RWP. Quality assurance procedures would be conducted on all instruments to be used and dosimetry would be distributed. Each RWP provided a personal protective equipment (PPE) assessment for each work zone. The PPE requirements were discussed with all remedial personnel. The security staff was apprised of personnel approved for site access.

ENPRO personnel would operate excavation equipment and provide support as needed. GZA personnel would also provide support and monitor for chemical contaminants from the contamination reduction zone. Clym personnel would work in the exclusion zone.

Excavation equipment was to remove the top layer of soil over a suspected plot until visible waste was identified. This top layer of soil was to be piled in the controlled area and kept separate from soil containing waste or coming from the contiguous one-foot area around each plot. Top layer soil would be categorized as "yellow" and soil containing waste or coming from the contiguous one-foot perimeter would be categorized "red." "Yellow" soil was not expected to have any radioactive contamination, but was subject to sampling. "Red" soil was expected to contain some radioactive contamination and was segregated for shipment offsite.

Once waste in a plot was identified, it was to be removed by hand digging where possible and then the excavator would remove the remaining layer of contiguous soil. Waste items would be collected into totes, trays or buckets and visually inspected. Non-conforming waste would be segregated (e.g. markings of unexpected radionuclides, sharps, containerized liquids, lead, etc.). The waste would be surveyed with handheld radiation detectors (countrate meter, dose rate meter).

Samples of the soil from each remediated plot would be collected and the excavator would continue digging until the next plot in the row was revealed. The site dig was conducted such that the entire site, with the exception of the one corner containing known (non-radioactive) human remains, would be excavated and inspected.

As Found Conditions

The work plan, though addressing the expected site conditions, was written to allow flexibility in operations so that reaction to "as found" conditions could be made in real time and any necessary changes to health and safety requirements could be documented on RWPs. It was decided that the excavation would begin at the corner nearest the access trench at the plot labeled #2 on the historical site map and work would continue toward the rear of the site. This would allow for four plots (#2, 15, 23 and 28), representing burials from the beginning of the site up until 1970, to be investigated early in the operation and allow for a consideration of burial practices over time.

During the excavation of the first plot, a small number of bags containing lab and animal carcass waste were encountered at about the four-foot depth. Once the waste was unearthed, strong odors of biological decay and naphthalene were encountered. These odors would be present for the remainder of the plot remediation phase of the project. Some bags showed signs of root intrusion and waste including animal bones, plastic items and broken glass were found uncontained. Sealed bags were selected at random and opened. Labels and markings were legible, and some animal carcasses showed only limited signs of biological decay. Waste bags were removed until only loose, non-biological, items remained in the soil. The "red" soil, including loose waste items in significant number, was segregated as planned and the waste items that had been removed were field screened and packaged. After the "red" soil had been removed, the excavation equipment was surveyed and then digging would continue.

The excavator continued removing soil toward the next plot in line, identified as Plot #15 on the site map. Soil between each plot was visually inspected prior to being added to the "yellow" pile. Evidence of waste was found at five to six feet below grade. The waste in this plot was not fully contained in bags. Evidence of broken bottles, syringes and lab waste was included with bagged lab and animal waste. A bottle of liquid lying in the soil was recovered, still intact, that was labeled "Nitric Acid, Fuming." Intrusion of ground water was detected and covered the final one-two feet of waste items, at an approximate 8-9 foot depth. Soil appeared between waste items and may have been added during the disposal process. "Red" soil was again separated and the other waste items screened and packaged. The volume of waste recovered was so significantly increased from the first plot, that the decision was made to return to the first plot and dig deeper.

Indeed waste items were encountered about two feet below where the initial excavation had stopped in Plot #2. Waste items were similar to what was seen in Plot #15. After all visible waste was collected from this second plug, excavation continued to assure that no other waste was present. Again, approximately two feet deeper another plug of waste was identified (similar in condition and type to Plot #15). This "waste layering" would be found throughout the site. Digging continued until the excavator reached ledge. No ground water was encountered while excavating Plot #2.

The third plot that was excavated (identified as Plot #23) again revealed waste items outside of the original containers (e.g. broken glass bottles, liquid scintillation (LS) vials, syringes, rusted out metal cans, etc.) Waste was found in layers to an approximate six-foot depth. The last plot in the first row of excavation was Plot #28. Again, waste was found in layers to a depth of approximately nine feet with substantial ground water intrusion. Small waste items such as LS vials and syringe plungers were found in significant volume in the soil. More glass bottles containing liquids, most broken, but some unbroken, were recovered. Efforts were made to remove all loose waste items from the plot, but site conditions made this difficult. Though these items would represent a very small percentage of total waste at the site, it is likely that a number of small waste items remain in the ground.

Samples were collected from the "red" soil pile generated from these first four plots. Theses samples were collected so as to exclude any waste items, discolored soil or overly wet soil. The samples were intended to validate that no significant hazardous chemical constituents were present and that the one-foot margin of soil was sufficient to account for any radioactivity liberated from the original burial plot. Composites of these samples were shipped for analysis ("red" samples).

Field screening with handheld radiation detection instrumentation identified radioactivity on waste bags, waste items (such as vials, metals, glass, lab trash) as well as animal carcasses. Visual inspections of waste items also noted markings detailing long-lived radioactive constituents. Due to the expense of off-site radiochemical analysis, it was decided that field screening would be employed to qualify any unexpected radiation levels or radionuclides. Further, given that liquids recovered from the first plots were found to contain ^{3}H and ^{14}C and that many liquid containers may have lost integrity, all contiguous soil was designated for shipment as radioactive, rather than being subjected to further sampling.

The remaining plots at the site exhibited these same characteristics, some with ground water intrusion, others dry. In order to assure that all waste was identified, excavation continued until ledge was reached. The significant depth of plots required that all excavation be conducted by machine and personnel were forbidden access into trenches due to the resulting trenching and shoring hazard. During excavation, additional unexpected items were found including a 30-gallon metal drum, 5-gallon metal cans (containing residues of a purple liquid with solvent odor thus presumed liquid scintillation media) and a gas cylinder.

On November 19 a plug of metal cans was unearthed. These cans were badly rusted and leaking a purple colored liquid with strong solvent odor. The soil was discolored around the cans and the ground water was also discolored with a purple sheen. The metal cans were removed and packaged into 55-gallon drums. The soil was removed beyond the originally intended contiguous one-foot area so as to collect a majority of the discolored soil. This soil was segregated into a different pile, designated "purple". The excavation continued until all visible solid waste was removed. Site operations were suspended while DC personnel were notified.

DC personnel authorized the resumption of site operations as they prepared to notify the appropriate State authorities. Additional waste and soil coated with this purple sheen was located and segregated. Any soil with the hint of solvent odor (or including loose waste items with purple coloring) was segregated into the "purple" pile. Intermodal containers were delivered on December 1 and the purple soil was loaded into these containers for temporary, secure storage.

The remainder of the site was investigated and remediated as previously described. Negotiations with radioactive waste processing and disposal facilities had been ongoing for some time. DC personnel chose to have Clym broker all radioactive and radioactive-biological wastes to the EnergySolutions facility in Oak Ridge, TN for processing and disposal. This same facility would also receive soil waste bagged in "super sacks" for inspection, repackaging and transshipment to the EnergySolutions low-level radioactive waste disposal facility in Clive, UT. Due to limited storage space at the site, waste shipments began during plot excavation and continued through the site closure for winter.

With the onset of winter weather already at hand, waste shipments began on December 2, 2011. Due to space limitations and the significant depth and width of the burial plots, yellow soil piles were used as fill to allow for the movement of excavation equipment around the site and to reduce trenching hazards. It was surmised that if radiological contamination had spread past the one-foot contiguous soil barrier (collected as "red" soil), that the site would need to be reopened and a second remedial effort would be required guided by a more aggressive sampling strategy. This first effort therefore remained focused on the removal of plot waste and the contiguous "red soil".

Site Surveys and Contamination Control

During remedial operations and waste packaging and movement, equipment surveys were conducted to allow movement of equipment into and out of the remedial area. Direct monitoring and wipe surveys were conducted on personnel and equipment to control the migration of contamination. Workers in the exclusion zone "surveyed out" with portable radiation detection instruments after each shift and stored reusable PPE in poly liners in the donning and doffing station. The donning and doffing station was surveyed after each use.

Dose rate surveys were conducted daily in the exclusion zone to properly characterize site exposure conditions. The lab trailer was surveyed each day for radioactive contamination. Each container of waste was surveyed for dose rate and a wipe sample was collected on the exterior of the package. Throughout the project, no site survey sample was found to have radioactive contamination in excess of established limits (220 $dpm/100cm^2$).

Personal Exposure Monitoring

Personal dosimeters provided to all remedial site workers were collected and returned to a NVLAP accredited dosimetry provider (Landauer, Inc.). All dosimeters registered no exposure in excess of background levels.

Air samples collected within the exclusion zone (breathing zone and area) revealed no airborne contaminants.

Waste Inspection and Packaging

This site inventory provided a tally of radioactive materials and associated activities for the majority of the plots. Based on this inventory, a list of long-lived radionuclides, or those with a half-life allowing activity to remain at the time of remedial actions, was created. Four radionuclides of interest were identified: tritium (^{3}H), carbon-14 (^{14}C), lead-210 (^{210}Pb) and nickel-63 (^{63}Ni). The other radioactive materials listed on the inventory would have decayed to background levels given the passage of time. Because the data provided in the inventory was direct generator knowledge and the plots without an inventory reportedly contained similar wastes from similar protocols, this inventory was used as a basis for establishing waste activity characteristics. In order to account for underestimated activities in the plots listed on the inventory, and to account for the plots with no radioactive material inventory, a conservative multiplier was applied to establish a range of total activity for the site. A multiplier of ten (10) was applied to the reported activity to establish a profile range for radioactivity in wastes. This range was used to establish waste processing and disposal options.

Field screening techniques, as previously outlined, were employed to assure that the established activity range was not exceeded and to provide a means of detecting radionuclides not listed on the inventory. Given that wastes would be sampled and screened by any subsequent processing and disposal facility, the primary intent was to identify any non-conforming material in the field that might affect waste acceptance or pricing.

By examining original source vial markings, other labels, dose and countrate meter readings, and on-site field lab results, ^{3}H, ^{14}C and ^{210}Pb were confirmed. In addition, three small, sealed ampules of cesium-137 (^{137}Cs) was located during the screening. The presence of cesium-137 was not expected, as it was not included in the site inventory. The identification of these small ampule stands as evidence of the effectiveness of the field screening procedure that was employed.

Biological waste was packaged into double-lined fiberboard containers. The containers were placed in a secured refrigerated trailer for storage on site and kept frozen to limit the extent of the associated odor. Dry active wastes (DAW) consisting of broken glass, metal cans and sharps were packaged in fifty-five gallon steel drums and stored on site. Small DAW items present in significant number (vials, syringe plungers, plastic pipette tips, etc.) were left commingled in the "red" soil. This soil was packed into lined 1.6 cubic yard "super sacks" and placed on pallets at the site for storage until shipment. A number of intact containers of liquid were recovered at the site. Some of the containers still had legible marking, while others were unlabeled or illegible. Liquids were field screened for visible phase separation and pH. Like liquids were bulked together while any liquid exhibiting a potentially hazardous constituent was overpacked into pails for further analysis. The "purple" soil remained secured in locked intermodal containers pending analysis of initial samples.

Waste Shipment

The off-site shipment of waste began on December 2 and continued, depending on the availability of transport vehicles until December 19, 2011. Containers were moved from the burial site and transported to one of the staging areas. Super sacks were individually lifted and placed onto a trailer and carefully transported down to the loading area. Here the sacks were surveyed for dose rate and external contamination and loaded onto a transport vehicle. Once shipment paperwork had been completed and signed, the transport vehicle was sent to a nearby, certified scale to assure that the weights over each axle were acceptable. All loads reported acceptable axle and total weight levels.

Boxes of radioactive-biological waste were weighed, marked, labeled and surveyed for dose rate and external contamination. These containers were stored in a refrigerated trailer until a refrigerated transport vehicle arrived. The containers were reloaded into the transport vehicle and shipment paperwork was completed. Drums containing DAW were included on transport vehicles as space and weight restrictions allowed.

The site was closed for the winter on December 22, 2011 with the intermodals, liquid mixed waste and waste from the field lab remaining on site. The wastes shipped off-site during remedial operations were shipped to the EnergySolutions facility in Oak Ridge, TN for processing and subsequent final disposal at the EnergySolutions site in Clive, UT.

The solvent contaminated soil ("purple" soil) was sampled and based on the sample analysis results, the RHS was petitioned to allow DC to classify the soil as non-radioactive. With the State's approval of this request, the profiling and disposal was left to GZA. The purple soil was removed from the intermodal containers and shipped for disposal. The empty intermodal containers were surveyed (direct monitoring and wipe sample) and shipped back to EnergySolutions.

The remaining mixed wastes were profiled and shipped for disposal at NSSI (Houston, TX) on December 3, 2012. As of this date, no radioactive waste remained on the site.

All waste that was shipped for off-site processing and disposal arrived safely, was accepted and passed additional screening tests required by the receiving facilities. No variance in expected activities or nuclides, weights or waste types or the physical properties of the waste were reported. No exception with waste acceptance guidelines or Department of Transportation regulations was registered.

Site Sampling

Composites of the soil from each plot were prepared and shipped off-site for analysis. These samples ("yellow" soil) were intended to characterize the chemical and radiological condition of the soil at the site, post-remedial operations. Ground water samples from monitoring wells were collected and analyzed for chemical contaminants and radioactivity (as water levels allowed) by GZA.

Due to the variation in some sample results, additional background samples have been collected to better understand the levels of naturally occurring radioactive materials at the site. Ground water sampling continues at the direction of the Department of Environmental Services (DES).

Conclusion of Phase One Operations

Phase One operations were recently concluded with the shipment of all remaining wastes at the site. Dartmouth College in submitting this summary report is anticipating a dialog with the RHS to identify the requirements for Phase Two of this project.

In all, the remedial efforts, though identifying more waste and different waste types than originally expected, did identify forty-three plots and revealed no cause for suspicion that other plots exist. In addition, though the vast majority of waste from the plots was removed and shipped off-site, it is probable that small waste items (vials, vial caps, needle plungers, pipet tips, etc.) remain at the site. The soil samples collected after the removal of the waste and contiguous soil revealed levels of radioactivity commensurate with background readings. Ground water samples taken after remedial operations also reveal no radioactivity above background levels.

Despite the difficulties encountered during site investigation and remediation, we now believe - with the principal waste and an ample margin of soil removed, and favorable sample analysis data to date - that the site is ready for final status survey.