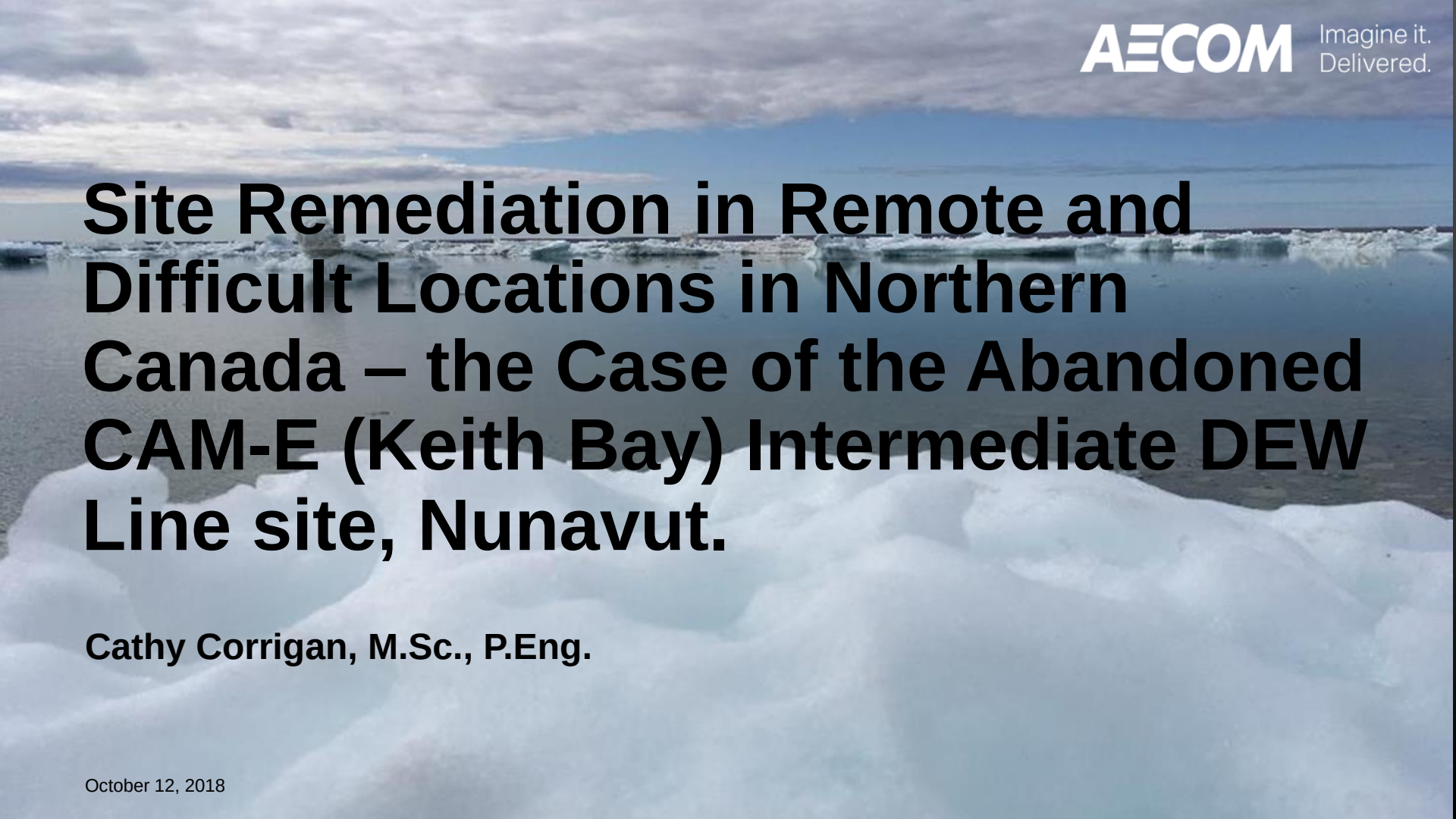


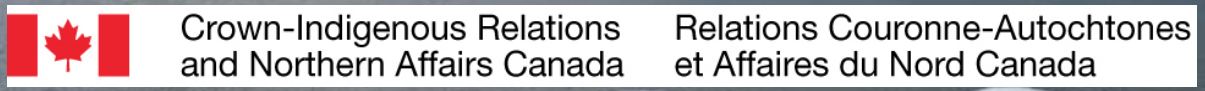
Site Remediation in Remote and Difficult Locations in Northern Canada – the Case of the Abandoned CAM-E (Keith Bay) Intermediate DEW Line site, Nunavut.

Cathy Corrigan, M.Sc., P.Eng.

October 12, 2018

In Collaboration With

François Bourassa, P.Eng.

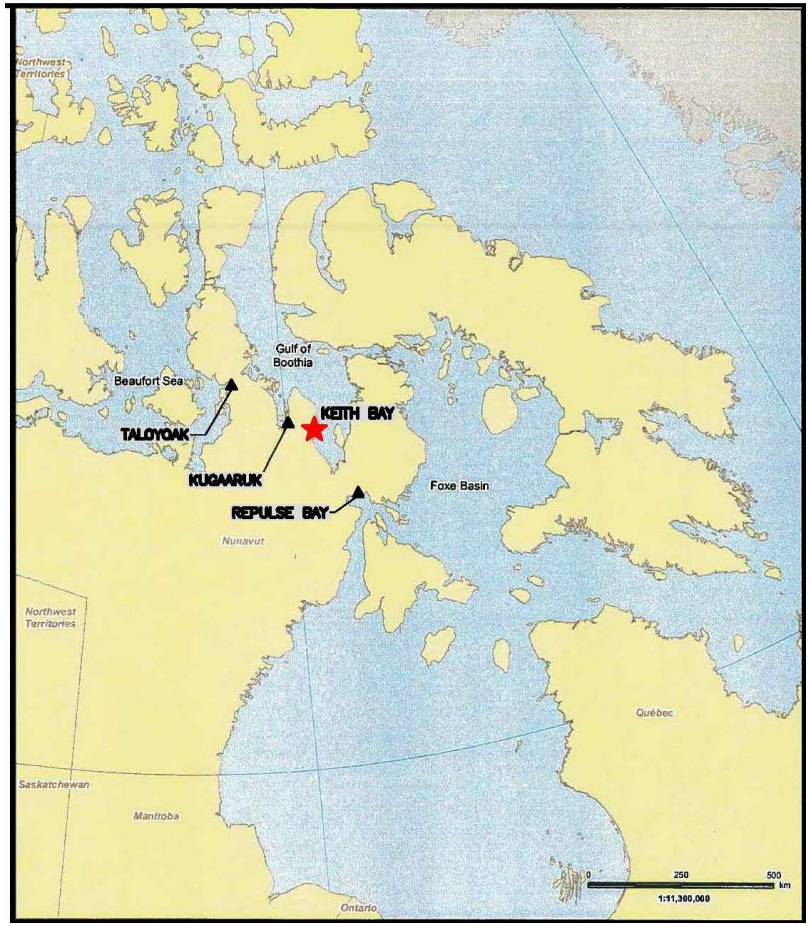


Dele Morakinyo, PhD., P.Eng.

Michael Bernardin, B.Env.D
Matthew Irvine, B.Env.St. C.E.T.
Matthew McElwaine, P.Eng.

October 12, 2018

CAM-E Keith Bay Location



AECOM

CAM-E Keith Bay Background Information

Distant Early Warning (DEW)
Line Sites in North America

Remediation Scope of Work
Contaminated Soil

- Soil impacted with moderate levels of metals and PCBs – “Tier II soil” = 3700 m^3
  - For disposal on-site in a new, purposely constructed landfill (“Tier II Facility”).

- Soil impacted with low levels of lead, PCBs (“Tier I soil”), and heavy-end petroleum hydrocarbons (“Type A PHCs”) = 1300 m^3
  - For disposal on-site in a newly constructed non-hazardous waste landfill.

- Soil impacted with lighter-end PHCs – “Type B PHCs” = 1900 m^3
  - For on-site treatment in a constructed landfarm.

Remediation Scope of Work
Buried Debris Areas

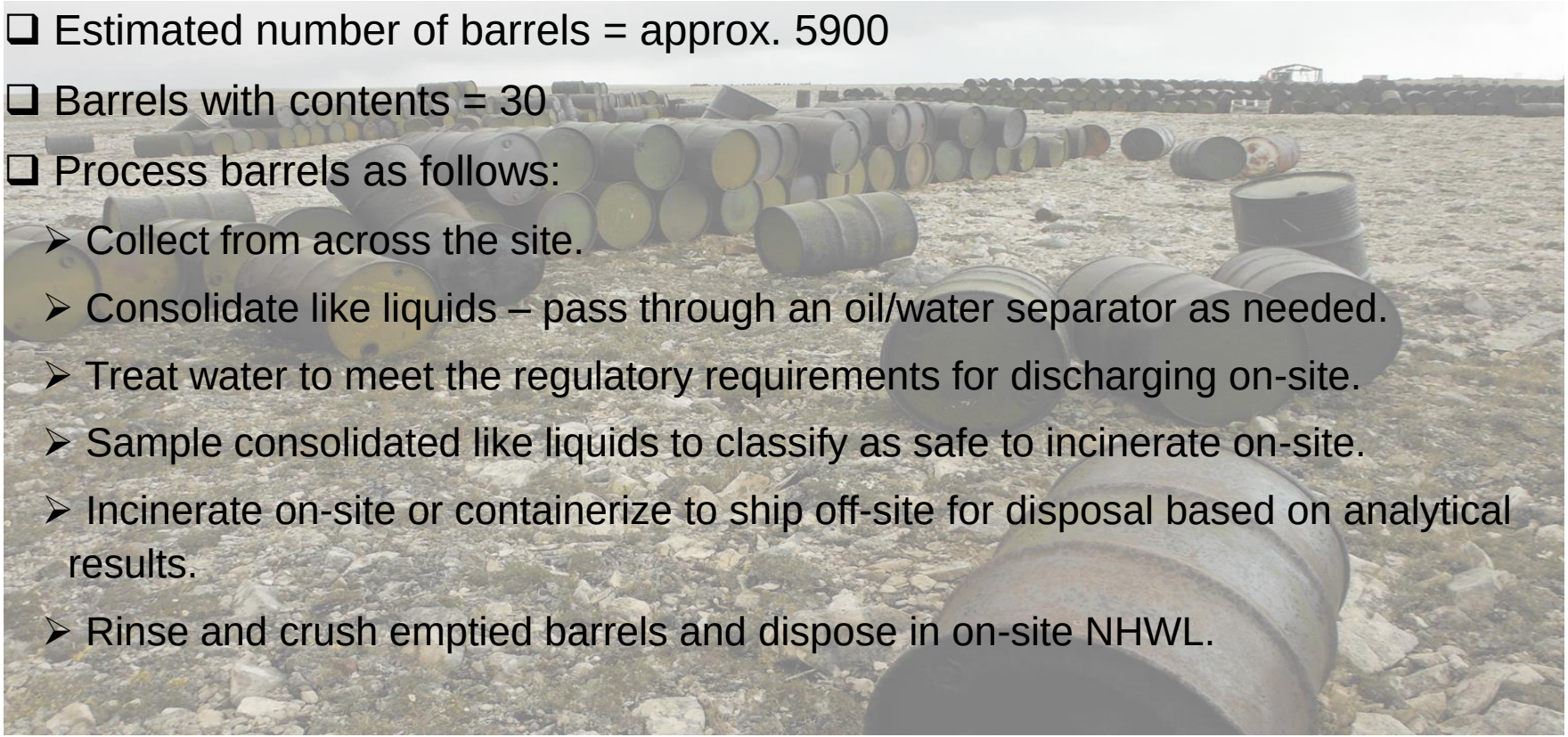
- ❑ Buried Debris Areas with evidence of contaminant migration:
  - ➢ Excavate, segregate waste from soil, classify soil contaminant levels, classify waste types (hazardous vs non-hazardous), dispose accordingly = 3200 m^3 to excavate and process.

- ❑ Buried Debris Areas with no evidence of contaminant migration
  - ➢ Cap with placement of compacted granular fill = 1600 m^3 of fill for placement.

Remediation Scope of Work
Infrastructure & Surface Debris

- Structure Demolition = 52 m^3
  - Complete hazardous waste abatement (asbestos, PCB and lead paint) and dispose of remaining non-hazardous waste in on-site NHWL.
- Debris Removal = 1800 m^3
  - Segregate hazardous from non-hazardous items (complete abatement as required), dispose of non-hazardous waste in on-site NHWL.
- Hazardous Waste = 6 m^3
  - Containerize and ship off-site for disposal at a licenced facility.

Remediation Scope of Work
Barrel Processing



- Estimated number of barrels = approx. 5900
- Barrels with contents = 30
- Process barrels as follows:
  - Collect from across the site.
  - Consolidate like liquids – pass through an oil/water separator as needed.
  - Treat water to meet the regulatory requirements for discharging on-site.
  - Sample consolidated like liquids to classify as safe to incinerate on-site.
  - Incinerate on-site or containerize to ship off-site for disposal based on analytical results.
  - Rinse and crush emptied barrels and dispose in on-site NHWL.

Remediation Scope of Work
New Infrastructure Construction

- Non-Hazardous Waste Landfill (NHWL) – Capacity = 3200 m^3
  - Slight sub-grade excavation, construction of compacted granular berms, intermediate fill placement between waste lifts, compacted granular cap, side-slope armouring with rip rap.

- Tier II Facility (Contaminated Soil Landfill) – Capacity = 5590 m^3
  - Constructed at grade, with low-permeability saturated containment berms keyed into underlying permafrost, a geosynthetic liner installed along the base, extending up the inside of the side slopes, and along the base of the final cap, and sufficient thickness of granular fill placed over the berms and in the cap to aggrade permafrost into the landfill contents and saturated berms.

- Landfarm – Capacity = 1900 m^3
  - Compacted granular berms with a geosynthetic liner along the base and up the side slopes.

Remediation Project Planning – CIRNAC and PSPC

- A “Class B” (indicative) cost estimate is typically prepared as part of the Remedial Action Plan and Preliminary Design immediately following the site assessment.
- A “Class A” (substantive) cost estimate is prepared with the detailed design and tender package. At this stage, PSPC develops a risk management plan to address information gaps and potential funding implications. The typical contingency carried is approx. 20% of the Class A estimate value. CIRNAC secures project funding at this stage.
  - Cost estimate and contingency for this project: $30,860,000 and ~$6M.
- Due to the length of time for the federal procurement process, contractor planning and the timing window for mobilization, the detailed design and tender package for this job were finalized approximately a year prior to award.
  - This provided opportunity for a pre-tender bidders’ tour of the site in the summer.
- The tender period for the project started December 17, 2015 and the contract was awarded April 16, 2016.

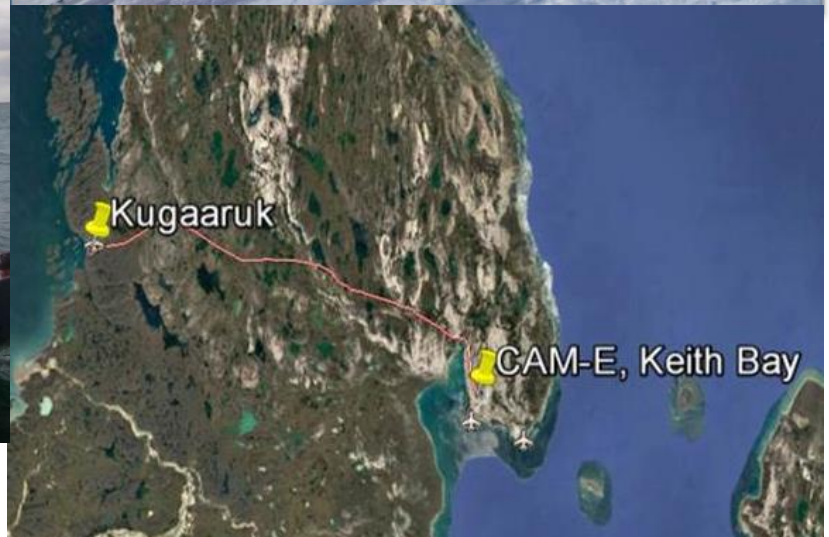
Remediation Project Planning – Contractor

- Selecting the number and type of equipment, the amount of fuel, and the size of camp required to complete the work is a delicate balance of carrying some contingency to cover scope increases but at the same time, not be overly costly.
  - The contractor must do their own evaluation of potential information gaps in the design and tender package and plan accordingly.
  - Having experience with other similar sites is a significant advantage.
- The type of equipment, size/type of camp, and other infrastructure are largely selected during the tender process.
  - Having equipment already staged elsewhere in the Arctic is a big advantage.
  - Kudlik had a large selection of heavy equipment and vehicles in different Nunavut communities and needed to evaluate the costs of hauling equipment from one community to another versus hauling from the south to price out their sealift mobilization costs during bid preparation.

Remediation Project Planning – Contractor

- For this particular ice-blocked site, mobilization was doubly challenging: it had to be done partly by sealift and partly by overland “cat train”.
  - Two options were considered and scoped out: sealift to Kugaaruk (with needed Coast Guard icebreaker accompaniment at high cost) then cat train for 85 km or sealift to Repulse Bay then cat train for approx. 300 km.
  - Despite the doubled sealift cost to Kugaaruk, it was identified to be the best option, in consideration of the need to travel over problematic ice in Committee Bay for the Repulse Bay route.

Contractor Mobilization



Remediation Operational Constraints

Gap Assessment

- ❑ Upon contract award for remediation oversight, AECOM reviewed additional information and identified information gaps to be assessed at the remediation start.
- ❑ Approx. 295 test-pits were completed for added soil delineation and buried debris confirmation of remedial design (evidence of contaminant migration).
- ❑ To complete the assessment work required two extra field technicians for two weeks in 2017 to work along side normal operations and Kudlik provided an excavator and operator for 115 hours.
- ❑ 34 paint or painted substrate samples were collected to identify hazardous waste classification of infrastructure and debris.
- ➢ At the end of the 2017 season, a significant amount of scope changes had been identified.

Addressing Scope Changes – General Operations

AECOM

Addressing Scope Changes – PHC Contaminated Soil

- Approx. 5000 m^3 additional Type B PHC soil was identified for treatment.
  - A second landfarm cell built.
  - A second screener was brought to site on the winter cat train.
  - Approval was sought and obtained from the regulator to leave the liner in place to provide for a longer treatment period.

AECOM

Addressing Scope Changes – Barrels

- Barrel Numbers and Content Volume:
  - The number of barrels identified on-site was found to be fairly accurate but the number with contents was ~90x the amount originally identified: 2737 drums.
  - The final tally from content consolidation:
    - 3800 L of diesel
    - 2200 L of sludge
    - 600 Kg of grease
    - 17 000 L of various oils
    - 30 000 L of water (includes rinsing)
  - All of the organics required off-site shipping. Lined shipping containers as well as some overpacks were used for containment.
  - Existing tanks on-site and two collapsible pools were used to hold the water for treatment.

AECOM

Addressing Scope Changes – On-Site Disposal Facilities

- Tier II Facility:
  - Lessening of the Tier II soil quantities required redesigning the facility for lower capacity.
  - Soil from buried debris area excavation was conservatively all as Tier II to help fill it.

- NHWL:
  - Because of uncertainty regarding barrels for disposal and late surface debris removal, insufficient capacity was a concern.
  - Had a modified design with change order ready to go if needed in a hurry.

Addressing Scope Changes – Hazardous Materials

- Hazardous Materials – Lead and PCB painted items:
  - The specifications had called for removing paint from structures but this was not feasible due to the climate (very windy, low temperature) and the overall timeline for the site remediation.
  - The contractor utilized shipping containers that had mobilized in supplies to provide containment (with added interior liner and bracing) for off-site disposal of larger painted items.
  - Other light items that could be mobilized by plane (small lined wooden containers that got assembled or lined heavy-duty cubic metre bags) were also brought to site.

Scope Changes: Summary of Significant Items

Item	Original Scope of Work	Final Scope of Work
Tier II Soil Volumes (m^3)	3700	1600
Type B PHC Soil Volumes (m^3)	1900	6600
Buried Debris Area Regrades (m^3)	1620	4450
Buried Debris Area Excavation (m^3)	3200	1550
Barrels for Content Processing (each)	30	2737
Landfarm Capacity (m^3)	1900 (cell 1)	4080 (cells 1 & 2)
Leachable Pb Hazardous Waste (m^3)	Not clearly defined (mixed with PCB amended paint items)	- 115

- 15 change orders were issued and more will be needed to reconcile hazardous waste for off-site shipment and disposal and unit rate prices for items where contract quantities ended up being significantly less.

AECOM

Recommendations – Better Scope Definition

- Recognizing challenges of site assessment at a remote site, detailed planning is key:
  - Use historical air photos to identify buried debris areas (they are typically very evident), staining, past land uses (for sites where the original infrastructure may not be present).
  - Using historical air photos with stereo pairs also allows for planning assessment locations – both environmental and geotechnical in advance so that field work progresses more efficiently. More recent satellite imagery over remote sites typically does not have the same level of resolution as historical air photos.
  - Consider what tools will give "most bang for the buck":
    - Drone surveys are extremely valuable for such sites that are spread out and where logistics may not allow for everywhere to be reached.
    - Small, portable, powered soil coring or test pitting equipment are particularly valuable for collecting soil samples through the depth of the active layer (typically only 1.5 m at these sites).

Recommendations – Better Scope Definition

- ❑ Recognizing challenges of site assessment at a remote site, prioritizing is also key.
- ❑ It is critical to complete the assessment thinking ahead to how remediation will proceed – what are the costly or time-consuming items? Focus on these if time becomes limited. Examples:
  - ➢ Type B PHC impacted soil will always be treated on-site and can be risk-managed to some extent = not super high priority. In contrast, Tier II soil (which is generally surficial and easily assessed without equipment) gets either shipped off-site or has its own disposal facility built on-site. It's critical to assess this properly.
  - ➢ Asbestos containing items are generally visually identifiable and asbestos is disposed of on-site in the NHWL. In contrast, leachable Pb or PCB painted items must all go off-site for disposal (paint abatement is generally not viable for these sites) at a licenced waste facility. Painted waste is the important item to sample, not asbestos.

Recommendations – Contractual Mechanisms to Better Address Uncertainty

- When doing detailed design and tender package prep, it is valuable to PSPC and CIRNAC to have specific remedial elements with information gaps clearly identified and with appropriately conservative contingency percentages carried for each item.
  - Contaminated soil areas with incomplete delineation are one common example whereby one area might warrant 50% contingency while another only 15%.
  - Carrying those contingency percentages into contract quantities lessens the potential need for a change order during progress of work.
- Creative payment item ideas that allow for some uncertainty:
  - Use a provisional cost sum for items that are poorly defined – such as barrel contents – by coming up with a conservative estimate.
  - Set up payment items that group in remediation items into a shared work element – for example placement of a specific granular type that is used for multiple purposes.

Conclusions

- Remote site remediation – particularly those with multi-faceted remediation requirements – require a high level of planning and contingency allowance on the part of designers, the owner and contracting authority, and the contractor.

- Ideally, site assessment work and tender package preparation are done in consideration of remediation implementation and use methods that lessen the contractual challenges of dealing with scope changes during the short remediation season.

- CAM-E Keith Bay was a particular challenge because of the difficult site access and having to address considerable scope changes. Despite the challenges, the project was completed on-time thanks to a concerted effort by an experienced team.