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REMEDIATION OF HISTORIC DUMP #2 AT CHALK RIVER LABORATORIES

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Abstract

Dump #2 is a 0.2 hectare (3,400 m^3 volume) landfill at Chalk River Laboratories (CRL) on the Ottawa River shoreline. In operation between 1960 and 1972, the site was used for the then-accepted practice of open burning of non-radioactive trash. Over the course of the landfill's operation, and its use as an electrical equipment storage yard, some contamination incidents have occurred. Characterization studies have revealed local hotspots of soil radiological contamination (Cs-137 and refined natural U) and chemical contamination (heavy metals typical of ash). As Uranium levels at hotspots are in excess of the CNSC published unconditional clearance level for soil, the current long-term remediation strategy is to excavate the landfill and transfer the contents to a suitable waste disposal facility. In the interim, the plan is to stabilize the slope and protect it from potential damage in the event of extreme flooding. This will be accomplished by treating eroded channels and placing a rock revetment below the 100-year flood line. Deciding the proper final remediation strategy is a challenge due to uncertainty in when disposal facilities will be available, uncertainty regarding hazards in the landfill, differing perceptions of risk, and end-state criteria still under development. Collaboration with internal groups at CRL and benchmarking to other site clean-up agreements are being used to establish the framework for remedial measures that are in keeping with the (low) level of risk.

1. Introduction

The Chalk River Laboratories' Dump #2 is a legacy landfill site that originated in the early 1960s. The dump can be seen in the lower, central portion of Figure 1. The site was intended as a non-radioactive landfill, but some dumping of radiologically contaminated wastes did occur on occasion. Several historical documents mention the contamination incidents at Dump #2, but there are few records of waste emplacements to the dump or the number of contamination incidents that occurred. Dump #2 was used as a burning site where refuse was reduced to ash by incineration. This practice is likely the reason that the waste demonstrates a notable concentration of dioxins and furans.

Dump #2 is located beside the Ottawa River and the lower portion lies within the 100-year flood plain. As a result, leaving the waste in-situ that is above the clean-up criteria is not a viable option for the long term since under flood conditions the there is potential for waste and associated radiological and chemical contamination to be washed into the river. The current strategy is to monitor the site and the long term solution may require excavating the waste and move it to an approved disposal facility.

Figure 1: 1960s photo of CRL site, showing Dump #2 at the riverbank

Some characterization and several surface cleanups have taken place at Dump #2 between 2005 and 2015, and a number of radiologically contaminated 'hot spots' have been identified along the eastern bank. Some remediation has been carried out, but complete removal of the 'hot spots' was unsuccessful because of interference from rock and tree roots combined with the depth of contamination. A Remedial Options Evaluation prepared in 2013 suggested that the best course of action is to stabilize the bank to prevent erosion in the interim, and to complete full scale remediation when suitable waste facilities are available. The CRL site decommissioning strategy has since changed (i.e., schedule compressed), however, and Dump #2 is now a candidate for full-scale remediation at an earlier date (2021). In the mean time, interim activities are planned for summer of 2016. This paper will outline characterization data to date, discuss remedial options, outline the plans for the chosen interim strategy, and describe the challenges along the way.

2. Site location and description

The site is approximately 0.6 acres (0.2 ha) and stretches 100 m along the Ottawa River shoreline. The intended use was to incinerate non-radioactive trash; however, there were a number of contamination incidents over the period of operation which prompted the closure of Dump #2 in 1972. After closure, the waste was covered with clean fill and the surface was graded flat to facilitate the storage of large electrical equipment and hardware. Dump #2 is estimated to contain 3,400 m^3 of waste with a maximum depth of 5 m (Figure 2).

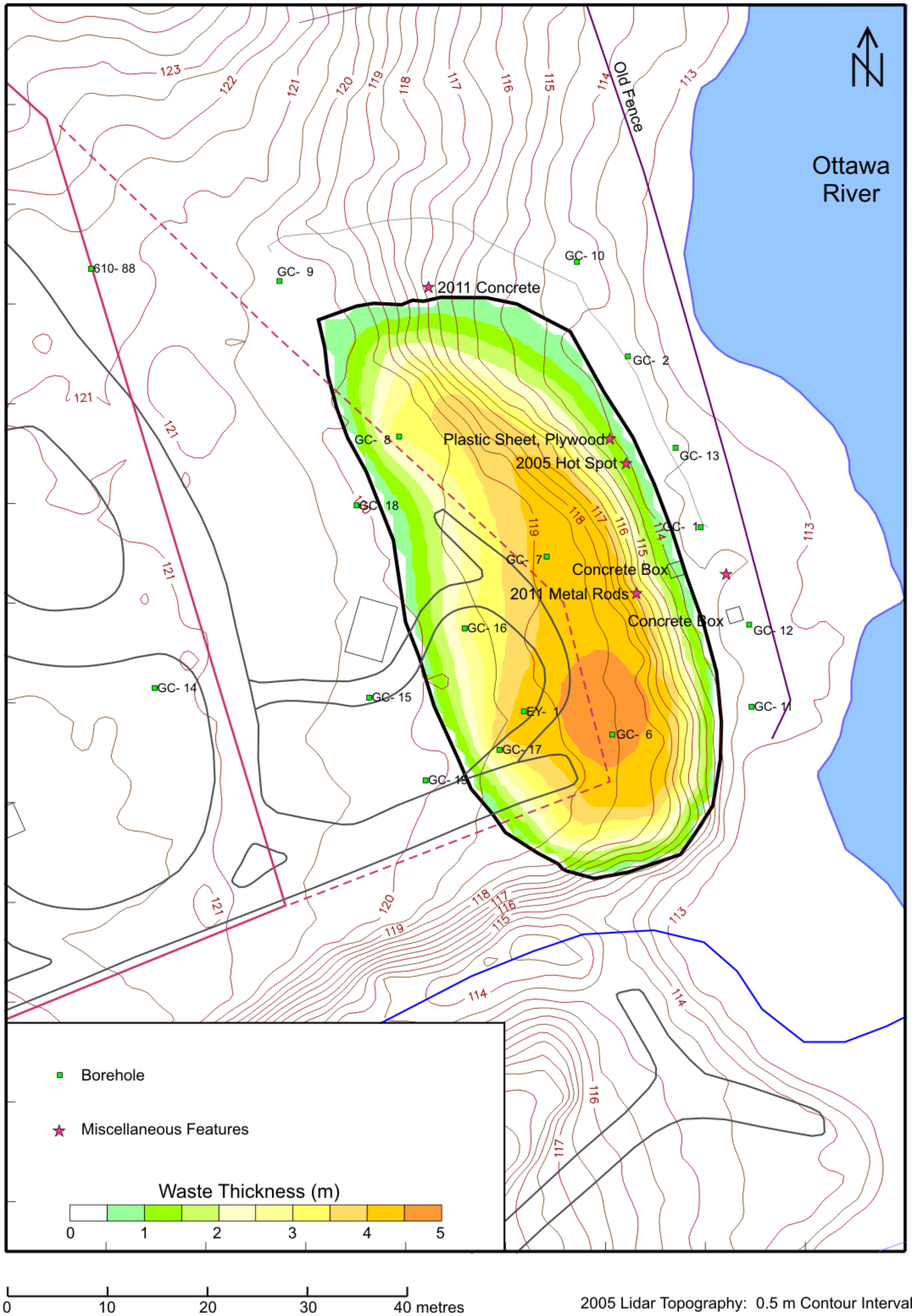

Figure 2: Depth of waste and topography of Dump #2

The east and south faces of the site consists of a steep bank sloping towards the River to a flattened access road along the toe of the bank (Figure 3 to Figure 5). A series of monitoring wells have been installed along the centre line of the access trail (Figure 4). Although the steep faces of the dump have grown over with trees and brush, they exhibit obvious signs of erosion from seasonal flooding.

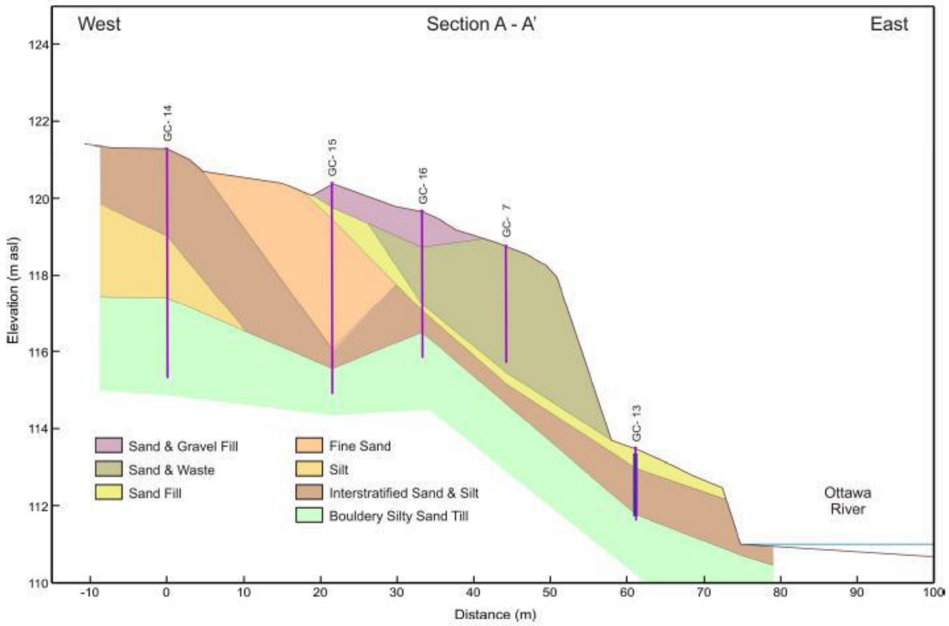

Figure 3: Cross Section of Dump #2 showing the waste thickness, borehole locations, and elevations

Figure 4: East side of Dump #2 as it appeared in 2005 December

Figure 5: South side of Dump #2 as it appeared in 2013 April

Figure 6 shows the water levels of the Ottawa River since construction of an upstream hydroelectric dam in 1950. In the past 65 years, the average annual mean level was 111.5 m above sea level (asl); the maximum recorded on one day level was 113.7 m asl in 1960, which would have reached the toe of the landfill slope. The calculated conservative estimate of the 100-year flood elevation for this reach of the Ottawa River is 115 m, or about one third of the way up the slope.

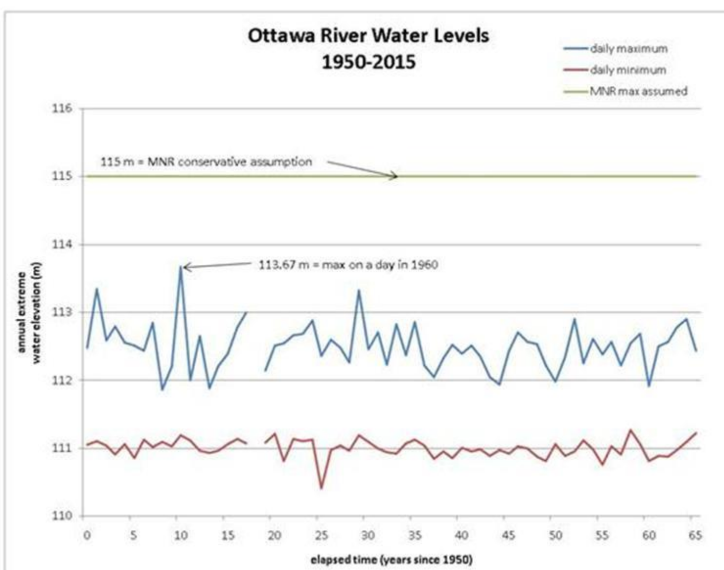

Figure 6: Ottawa River water levels at CRL over time

3. Characterization to date

In 2005, a cleanup exercise was undertaken to remove surface debris; during this time, a small section of metal pipe was discovered with significantly contaminated soil surrounding it. The identification of alpha and beta contamination and the progeny of refined uranium led to the realization that the site was more complex than originally thought and that a better understanding of the contaminants was needed.

In 2006, the site underwent a major cleanup in which surface stored equipment and materials were removed and a CRL perimeter fence was relocated to make the surface of the landfill more accessible for characterization. Multiple investigations were conducted at Dump #2 in the 2005 to 2015 time period. Radiological surface surveys, soil sampling, groundwater monitoring, and vegetation sampling described below were undertaken by the CRL's Environmental Technologies Branch (ETB).

3.1 Radiological surface surveys

Ambient surface radiation surveys were completed in 2005, 2011 (Figure 7), and 2012.

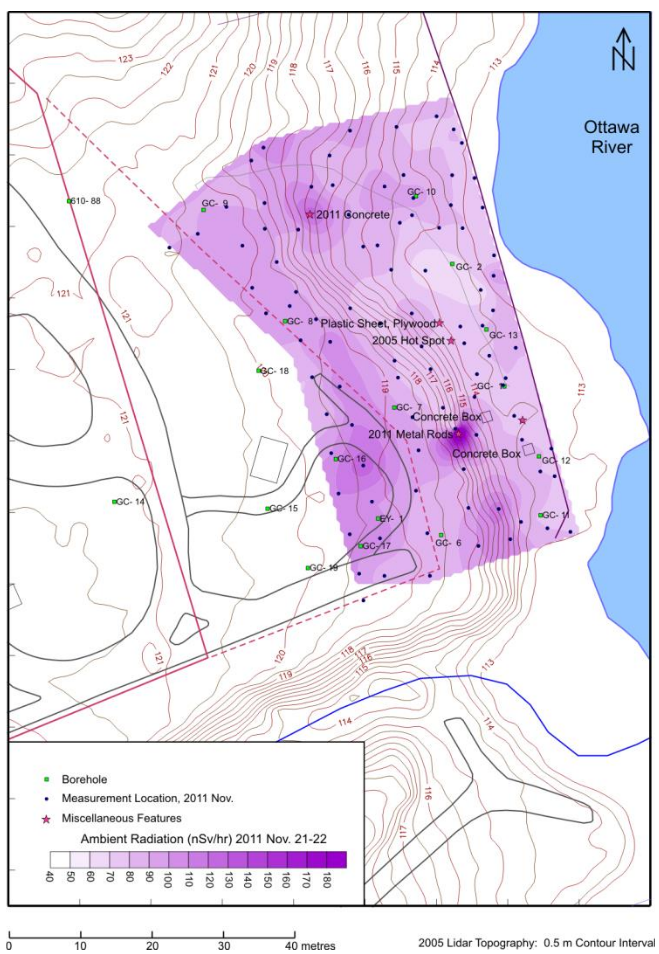

Figure 7: Ambient radiation point measurement locations and contours collected in 2011 November

These surveys showed that there is little in the way of elevated radiation fields in the area. Ambient radiation fields in portions of the CRL site that are unaffected by CRL activities range from 0.05 to 0.12 µSv/hr (5 to 12 µrem/hr). A large portion of the ambient radiations fields recorded during the survey of Dump #2 fell toward the low end of this range with the highest recorded reading in 2011 falling slightly above the background at 0.28 µSv/hr (28 µrem/hr). The average was 0.089 µSv/h (8.9 µrem/hr).

Two 'hot spots' were identified; one called '2005 hot spot' was remediated through removal of contaminated soil and a metal pipe at the surface. Contaminated soil and metal at this hot spot exhibited a count rate of 50,000 cpm beta gamma. Laboratory analysis of samples from this location confirmed contamination as high as 840 Bq/g gross alpha and 860 Bq/g gross beta, and up to 500 Bq/g U-238 from refined natural Uranium. This was a factor of 500 higher than the Canadian Nuclear Safety Commission (CNSC) unconditional clearance level for U-238 of 1 Bq/g [1]. The second 'hot spot' exhibited a count rate of 30,000 cpm beta gamma over the plastic sheet covering the area, with 3,000 cpm beta gamma being measured within one square meter surrounding the 'hot spot'. This area will be remediated during the field season of 2016.

A radiological survey in 2012 identified two patches of elevated Cs-137 with levels at approximately 1 Bq/g, but potentially as high as 100 Bq/g depending on the distribution in the soil. Contaminants were identified as natural uranium and Cs-137 but there could have been other contaminants that were not identified.

The radiological surveys indicated pockets of contamination through the fill but it is not fully understood where or to what extent. Aside from the pockets, the surface surveys have shown no dramatic levels of contamination on or around Dump #2. Survey results have been somewhat inconsistent, since they show few common features between surveys performed in different years; however, none of the anomalies have been large enough to pose a radiation dose rate hazard for workers at the site.

3.2 Groundwater sampling

Owing to the absence of an infiltration barrier over this landfill, there is the potential for leaching of both radiological and non-radiological contamination from the wastes, however, groundwater monitoring has shown minimal evidence of leaching to date. Semi-annual groundwater monitoring has been conducted since 2005 at two locations downgradient of Dump #2. Low concentrations of total beta activity were measured in samples from 2006 and 2007 (up to 21 Bq/L), but beta activity has been detected only once since then (0.9 Bq/L in the fall of 2010). With the exception of the anomalous gross beta concentrations measured in 2006 and 2007, groundwater concentrations have met Canada Drinking Water Guidelines for radiological parameters [2].

Groundwater monitoring results have shown trace quantities of dioxins and furans (pq/L range) expected to be the result of burning operations at the landfill. The data show that a number of trace elements are also present in somewhat elevated concentrations, but these most likely arise from Dump #2 itself; notable among the trace elements are: Cu, Mo, Ni, Se, Sn, U, and Zn. For these metals, the average concentrations in groundwater are less than CCME guidelines [3] for protection of aquatic life with the exception of Se which exceeds the guideline of 1 µg/L by a factor of 25.

3.3 Borehole soil samples

Borehole drilling was completed in 2005 to determine the areal extent of the landfill and the extent of contamination in the waste fill and surrounding geologic materials. Samples were collected at 0.75 m depth intervals at the borehole locations shown in Figure 2. Samples of waste from Dump #2 showed a large variation: wire, machine shop turnings, glass, fragments of charred wood, melted plastic and an amorphous black material.

Radiological analyses revealed all soil samples to have total beta concentrations ≤ 1 Bq/g. Metal contaminants were more of a concern; over half of the samples submitted for metal analysis by X-ray fluorescence (XRF) had concentrations above the CCME industrial soil quality guidelines for the protection of environmental and human health [4]. Metals with sample results over the CCME guideline include: Se, Cd, Sn, Sb, Cr, Co, Ni, Cu, Zn, and Pb. Maximum concentrations measured in a sample taken from the waste for Pb, Cu, and Zn were approximately 125, 115 and 24 times higher than the CCME guidelines, respectively. In general, the highest concentrations of metals in borehole samples were from borehole GC-16 (Figure 3).

3.4 Vegetation sampling

A survey of contamination in vegetation at the landfill was completed in 2005. The survey provided results of gross beta, gross alpha, and tritium from 12 trees on the eastern (river) side of the hill. Tritium and alpha levels in vegetation were reflective of background and were not a concern. The average gross beta concentration in the tree samples was 40 Bq/kg and was within the range of normal background. Only one tree had a total elevated beta concentration of 340 Bq/kg dry weight, which is slightly above the CRL gross beta release criterion for vegetation of 300 Bq/kg.

4. Remedial Options Evaluation and interim strategy

In 2013, a Remedial Options Evaluation of Dump #2 concluded that the best option was to place the landfill in a safe state in the interim and to defer final clean-up until a suitable disposal facility would be available. The interim plan consisted of removing surface debris, placing clean cover over the landfill, stabilizing the slope and continuing to monitor and check for remediation. Environmental Protection played a large role in the Remedial Options Evaluation and ultimately the current Remedial Action Plan.

The first Remedial Action Plan for Dump #2 was completed in March 2015. The plan included removal and chipping of the majority of the trees along the eastern bank of the landfill, slope contouring, and erosion repair with the addition of new fill material. A geotextile membrane and riprap were to be laid down over the face of the eastern bank to help curtail erosion. Finally, a gabion wall (metal mesh gabion baskets filled with coarse stone) along the toe of the slope was proposed as protection against flooding.

Some stakeholders felt that the initial Remedial Action Plan did not match the level of risk that was discussed in the Remedial Options Evaluation. The removal of trees and the placement of riprap and gabion wall were felt to be excessive. A revised Remedial Action Plan completed in 2015 November is less invasive. The new Plan includes leaving trees in place along the slope, repairing and stabilizing eroded ruts, relying on vegetation to anchor the slope instead of covering the slope with riprap, and using natural rock instead of gabions as an unobtrusive flood barrier over the bottom third of the slope.

Figure 8 depicts the revised interim remedial strategy. This more natural approach will minimize disturbance and capitalize on the existing vegetation.

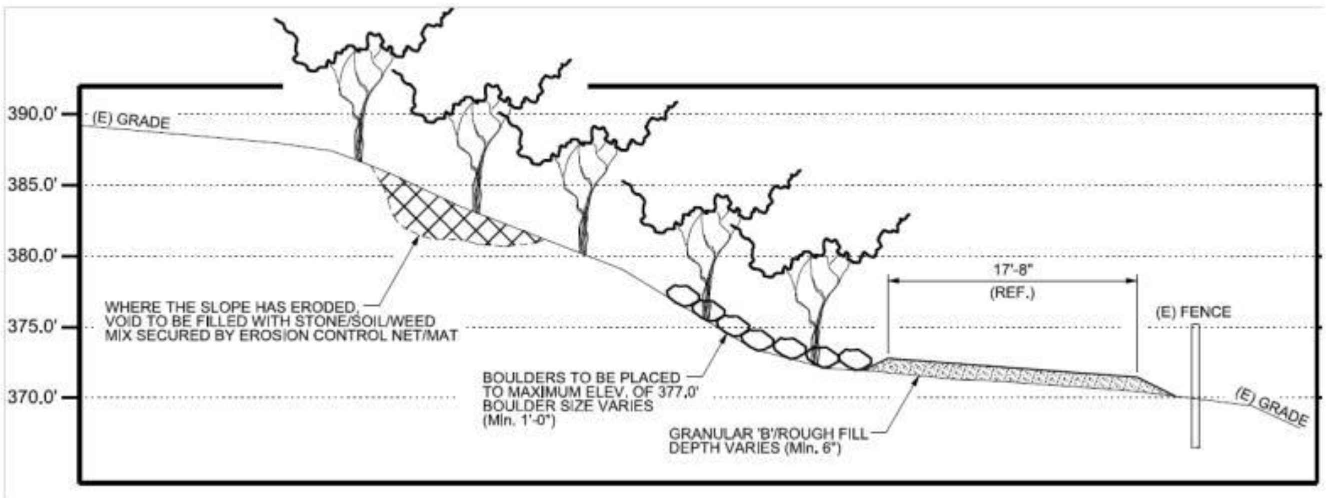

Figure 8: Planned placement of materials on slope

Implementation is planned for mid-2016. In 2015, preparations were undertaken consisting of: brushing of vegetation to widen the access trail, radiological ground surveys of the slope, removal of surface trash, installation of a turtle/silt barrier at the waterfront, and stockpiling of natural rock boulders to serve as rock revetment.

5. Long term remediation strategy

The original long term remediation strategy was to remove all the waste material but only when proper disposal facilities would be available in approximately 2035. A recent change in the CRL site decommissioning strategy will make a proper disposal facility available in approximately 2021.

To develop an appropriate long term strategy for Dump #2, the gaps in characterization data need to be evaluated. The possibility of radiological ‘hot spots’ within the waste and soil metal concentrations well above the CCME Soil Quality guidelines will likely drive the final remediation strategy. In collaboration with a consultant, a characterization plan will be developed to better understand the landfill waste. Furthermore, a defined end-state plan for the CRL site and explicit cleanup criteria will contribute to the final long term remedial strategy.

6. Challenges

There have been several challenges associated with coming to a consensus for a Remedial Action Plan for Dump #2. Changes to the decommissioning strategy for the CRL site (i.e., acceleration) have affected the time frame for remediation at Dump #2 as well as the type of remedial activities planned. Full remediation was halted in 2006 and deferred to 2035; now such remediation could proceed as early as 2021 when disposal facilities are anticipated to be available.

In this instance it is not clear that all waste in Dump #2 need to be excavated. There is concern that not enough characterization has been done within the waste materials. ERP engaged a consultant to examine the existing data and develop a characterization plan by mid-2016.

Another challenge has been differing perceptions of risk and hence differing opinions on remediation. While consensus was achieved in 2013 with respect to the Remedial Options Evaluation – place the site in an interim safe state and defer large-scale remediation – different approaches for the interim work were proposed. On the one hand, tree-clearing and installation of a riprap cover would offer good slope stabilization but would be very invasive. On the other hand, keeping the trees and installing a non-obtrusive barrier would be less invasive but would require monitoring and occasional erosion repairs. The balance has tipped in favour of the less invasive approach based on: the low risk established during the Remedial Options Evaluation, preference by the Environmental Protection group, and the shortened time period to large-scale remediation.

Finally, end-state criteria and explicit cleanup criteria are currently being developed for various affected lands, including Dump #2. These need to be in place prior to final remediation.

7. Conclusion

A review of the available characterization data of Dump #2 has revealed gaps in our knowledge specifically with respect to the distribution of contaminants within the landfill. Overall, there is no evidence of widespread radiological contamination, but 'hot spots' are likely to exist within the landfill, and some metals are found in concentrations above the CCME soil quality guidelines.

Dump #2 is being placed in safe state with erosion repairs and construction of an unobtrusive flood barrier. Final remediation is deferred until a proper disposal facility is available in approximately 2021. Deciding the proper final remediation strategy is a challenge due to changes in time frames for disposal facilities, uncertainty regarding hazards in the landfill, and site end-state criteria still under development. Collaboration with a consultant on an intrusive characterization plan will provide information to support development of the final remediation strategy at Dump #2.

8. Acknowledgements

We would like to thank the Environmental Technologies Branch for their characterization surveys and analysis work, and Environmental Protection for their significant input to the Remedial Options Evaluation.

9. References

[1] Nuclear Substances and Radiation Devices Regulations, SOR/2000-207, Schedule 2, Unconditional Clearance Levels. Current to 2016 March 16. Last amended 2015 March 13. Minister of Justice, Department of Justice Canada, Ottawa, Ontario.

[2] *Guidelines for Canadian Drinking Water Quality – Summary Table.* Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. 2014 October.

[3] *Canadian Water Quality Guidelines for the Protection of Aquatic Lif*e, In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, ISBN 1-896997-34-1, 1999.

[4] *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*, In: Canadian Environmental Quality Guidelines, Canadian Council of the Ministers of the Environment, ISBN 1-896997-34-1, 1999.