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Commission canadienne de sûreté nucléaire

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Final submission from Kerry Rowe

Mémoire définitif de Kerry Rowe

In the Matter of the

À l'égard des

Canadian Nuclear Laboratories (CNL)

Laboratoires Nucléaires Canadiens (LNC)

Application from the CNL to amend its Chalk River Laboratories site licence to authorize the construction of a near surface disposal facility

Demande des LNC visant à modifier le permis du site des Laboratoires de Chalk River pour autoriser la construction d'une installation de gestion des déchets près de la surface

Commission Public Hearing
Part 2

Audience publique de la Commission
Partie 2

May and June 2022

Mai et juin 2022

2022 06 09

The Canadian Nuclear Safety Commission (CNSC)

Dear Commissioners,

RE: Supplemental submission regarding "Canadian Nuclear Laboratories' application to amend its Chalk River Laboratories site licence to authorize the construction of a near surface disposal facility" - **Long-term safety/design theme**

I would like to provide this supplemental written input, as a follow-up to my previous written submission and presentation. This document provides additional detail regarding several questions I was asked and some other interrelated issues that were raised at the hearing. Specifically, I would like to address the following five interrelated issues:

1. Is a containment mound safer in the long-term than containment in in-ground concrete vaults or shallow rock cavities?
2. Why will placing waste not damage the liner system?
3. Do liners leak?
4. Can waste be removed after placement?
5. What impact on groundwater and surface water (e.g., Ottawa River) outside the ECM can be expected throughout the contaminating lifespan of the facility?

1 Is a containment mound safer in the long-term than containment in in-ground concrete vaults or shallow rock cavities?

An intervenor opined[1] that there is a "*need for re-examining the environmental effects of the NSDF and safer and more secure alternatives, such as in-ground concrete vaults or shallow rock cavity facilities*". This statement reflects a perception that concrete vaults and shallow rock cavities are more secure than the proposed ECM containment mound. Based on my technical expertise, I strongly disagree for the following reasons.

Intact concrete and rock are much harder and stiffer than the proposed ECM liner system. However, that is not a real advantage. They are also both brittle and susceptible to cracking. I discussed concrete and its propensity to crack in my previous submission and in response to a question from the Commission. I refer the reader to those comments and will not repeat myself. However, I will add, based on my visits to the CNL facility and discussions with the highly trained individuals monitoring and containing existing on-site contaminant plumes, that part of CNLs present problem is the leakage of radionuclides from existing concrete structures used historically for temporary containment. This is not surprising. The design life for concrete structures is generally of the order of 50 to 100 years and while the containment of low-level waste in concrete may be useful as part of a disposal strategy (e.g., encapsulation of some waste for disposal in the ECM), there is no reasonable expectation concrete will remain impermeable for 100 years let alone for 550 years. Indeed, one of the

[1] Page 49 of the Hearing transcript of 31 May 2022

applications for GCLs similar to those to be used in the containment mound is to minimize leakage through cracks in concrete structures.

The biggest challenge with shallow rock cavities is finding a deposit that is unfractured and will not fracture during construction or a design earthquake. In addition to the work that I do on near-surface waste containment, I also conduct research into the bentonite being considered for use between the canisters and the rock to provide the "impermeable" seal in a deep high-level waste repository. The bentonite commonly considered (known as MX80) for high-level waste disposal is of a lower quality than that used in the geosynthetic clay liners (GCL) to be used in the NSDF ECM. This was confirmed by performing testing where we remove bentonite from GCLs and use it as a control for comparison with the performance of MX80.

As I previously pointed out concerning concrete, the proposed ECM liner system has the advantages of (i) being ductile, (ii) having withstood quite severe earthquakes in California, and (iii) capable of withstanding reasonable differential settlement and strains far greater (by orders of magnitude) than either concrete or rock without cracking.

Thus, based on over 40 years of professional experience in the containment of waste, I conclude that from a technical perspective, without any consideration of costs, CNL's proposed containment mound design is much safer in the long term than containment in in-ground concrete vaults or shallow rock cavities.

2 Why will placing waste not damage the liner system?

In response to Commissioner Maharaj's question: "*So why wouldn't the biggest risk of damage to the bottom liner be when you are actually putting the waste in*?" [page 190 of transcript], I indicated that the geomembrane was covered by a 200 mm thick sand protection layer (Figure 1), overlain by 300 mm of 19 mm clear stone (the leachate collection layer), overlain by a 300 mm-of Granular A (a term used for high-quality granular material often used as a road base). This provides 800 mm of protection. What I forgot to mention at the time was that in addition to this 800 mm protection, the first 1 m of waste would consist of homogeneous soil or soil-like waste or clean fill as indicated in CNL's safety case (232-03610-SAR-001 REV. 2; page 166):

> "*This layer will be free of large debris and relatively free-draining and is intended to protect the underlying LCS and base/sidewall liner. The select waste layer will be placed with equipment working from the perimeter to the centre, such that equipment is never directly on top of the LCS layer. Until this 1 m layer is in place, only low ground pressure equipment will be used for waste placement in the ECM.*
>
> *The maximum pressure over the base liner system geosynthetic materials is 35 kPa, and the placement of select waste over the base liner system (geosynthetics) shall meet the 35 kPa requirement. Low-ground pressure equipment for construction, operations, and maintenance may be used until the initial 1 m select waste lift is in place to meet the 35 kPa pressure requirement over the geosynthetic materials. The*

35 kPa maximum value is based on the actual ground pressure due to industry-standard equipment used for spreading granular materials over a geomembrane liner/geosynthetic materials (e.g., Caterpillar D6M LGP Dozer). Based on industry operational experience, the NSDF design uses this 35 kPa value as a constraint until the select waste layer is placed over the base liner system, at which point higher pressure can be applied."

This select fill brings the total thickness of soil or soil-like material above the geomembrane to 1.8 m and they should be more than sufficient to protect the geomembrane from damage during the placement of the general waste mass.

In short, the liner system is extremely well protected from damage during waste placement.

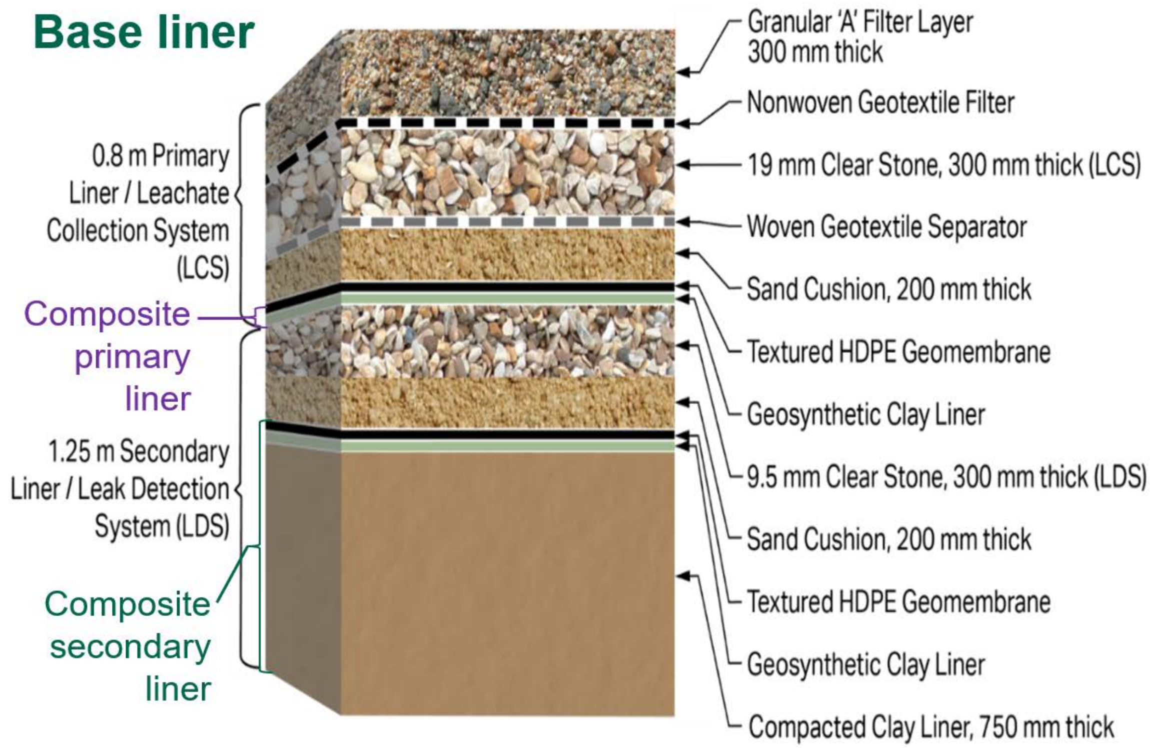

Figure 1: Proposed NSDF ECM bottom liner

3 Do liners leak?

I respond here to several submissions indicating that municipal solid waste liners "*can eventually leak*" or "*the proponent's own studies show that the mound will leak continually and disintegrate in a few hundred years*." "*It is designed to leak after closure when the mound deteriorates but more concerning it could very well leak during the 50 years of waste and placement...*" and many other similar comments. I appreciate that to the layperson, the language and the approaches taken in preparing the documentation for the hearing could be confusing if one does not appreciate the full context of what is being said. I will try and put some of these issues into an appropriate context.

As I indicated in my original submission, an intact geomembrane will not allow any leakage. So if the geomembrane is perfectly constructed there will be NO leaks. If we could guarantee perfect construction all of the time, then only the upper geomembrane would be required and the underlining components of the liner system for the base (Figure 1) could have been omitted.

However, designers recognize that while one can achieve zero holes, it is prudent to design assuming that there will be some holes and to ensure that the impact on the environment will be negligible despite the potential presence of some holes. Every reasonable effort will be taken to achieve zero holes in the geomembrane, but it is impossible to guarantee that any liner (be it a geomembrane, concrete, or rock) will have zero defects and zero leakage. It is for this reason that multiple actions are being taken to ensure that even if there were to be several small holes in the geomembrane, no significant leakage will escape to the environment. I presume the intervener's desire, as is mine, is that there be no escape of contaminants that could impact the environment. It is to achieve that objective that the following components of the system are provided:

(i) The geosynthetic clay liner (GCL) below the geomembrane will very substantially reduce any leakage that can occur through a hole in the primary geomembrane. As I indicated in my previous submission and presentation (Figure 2), twelve 100 mm long by 1 mm wide slits (area 100 mm²) would allow a very small amount of leakage (0.006 l/day) into the secondary leachate collection and leak detection system.

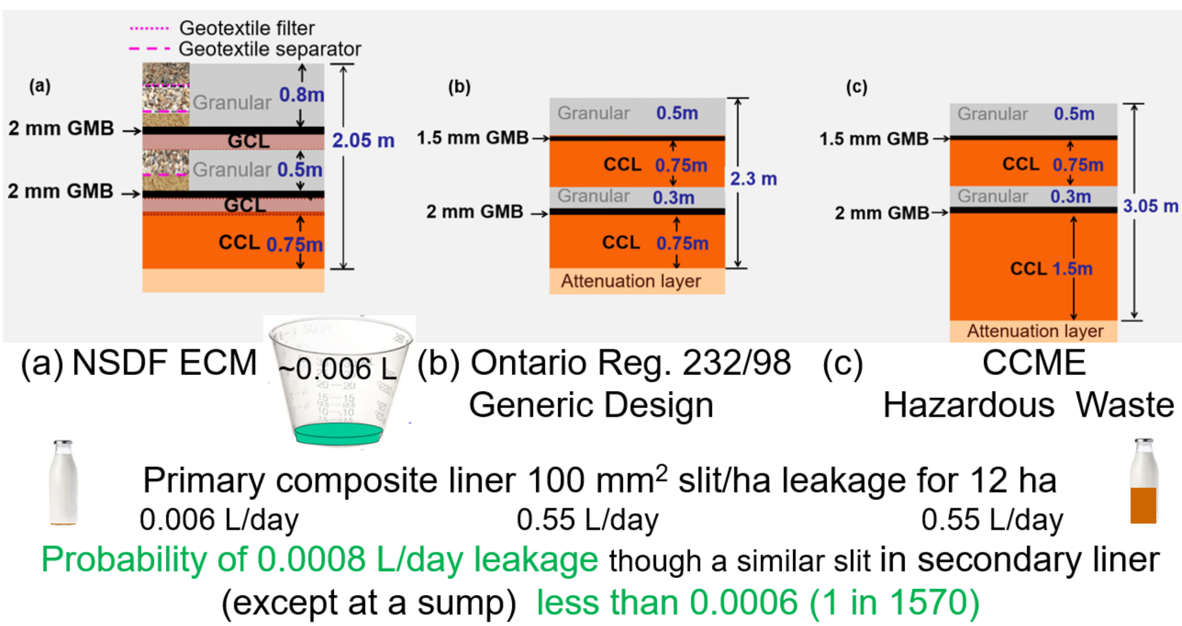

Figure 2: Calculated leakage through NSDF ECM design compared to Ontario reg 232/98 designed for light landfill and CCME generic design for hazardous waste landfill, assuming in each case 12 slits with each having an area of 100 mm^2 (the typical hole size used in design calculations).

(ii) The leak detection / secondary leachate collection system is designed to collect anything that leaks through the primary system and remove it before it can escape to the environment. To provide a high level of confidence that anything that does escape through the primary liner is collected, the secondary liner is even more robust than the primary liner with the geomembrane, a GCL, and a 750 mm thick compacted clay liner. As indicated in the example shown in Figure 2, the probability of a leak as high as 0.0008 L/day is less than 0.06%, and most likely, the leakage is so small that it cannot be measured.

(iii) A high level of quality assurance will be provided by an independent expert team to ensure that the liner is constructed in accordance with the design drawings and specifications and to minimize the potential for any holes.

(iv) As illustrated in my initial submission, the effect of a hole in the geomembrane can substantially increase if it occurs in a wrinkle (e.g., Figure 3) that is buried at the time of covering the geomembrane. To prevent this from becoming significant, wrinkles that are covered will be kept to an absolute minimum in terms of the total area, height, and length (e.g. targeting a situation as shown in Figure 4) by the construction quality assurance.

Figure 3: To minimize/prevent leakage, the geomembrane should not be covered with protection soil with the wrinkling shown. The contractor would be required by the CQA consultant to defer covering until wrinkling decreases to a negligible level (e.g., Figure 4)

Figure 4: No wrinkles. The geomembrane can be covered with protection soil at this time.

(v) An electrical leak location survey, which can detect holes in the geomembrane, will be conducted after the geomembrane is placed. It will also be repeated, using a second and different technique once the geomembrane has been covered by the soil protection layer.

This allows any defects that are detected to be repaired before the liner is completed and any waste is placed.

(vi) In addition to the independent CQA consultant checking the work of the contractor and their construction quality control, CNL will also have individuals with the knowledge of liner construction observing and checking on the CQA consultant, and CNL will have access to independent expert opinion from myself in the event of any questions arising regarding the suitability of what is being conducted.

(vii) All of the above are most critical during the 50-year operating period during which the waste is being placed and before the final cover is constructed. Once the final cover is placed, it becomes the primary defence against any escape of contaminants by controlling the infiltration of moisture into the facility. If there is no leachate being generated because no water can enter, then there can be no leakage even if there were no liner systems.

(viii) Notwithstanding the validity of the foregoing statement, the liners have a service life well above the 550-year design life requested by CNL and as indicated in my previous submission, these liner systems can be considered to have a service life well above 1000 years (indeed above 2000 years). Contrary to the statements made by interveners, the systems are not designed to fail after 50 years or even 550 years. Should they be needed, they should still be functional more than a thousand years from now.

The foregoing is background, I now address several specific statements.

(a) Municipal soil waste liners "*can eventually leak*". This statement raises two questions. (i) What is meant by eventually? and (ii) What is the implication of the leak? For example, small landfills in Ontario are allowed to have a single composite liner with a geomembrane having a service life of 150 years. By definition, the service life is the time at which the liner no longer controls the leakage to the design (negligible) value. When the service life is reached then the geomembrane may crack but it doesn't disappear. The leakage may increase but it will increase very slowly over time as cracking increases. The 150 Years in Ontario's regulations were selected based on the size of the landfill and the corresponding contaminating lifespan (the period during which the contaminants are at a concentration that they could harm the environment if they were to escape) of 150 years. Once the contaminating lifespan is reached then, by definition, the escape of "leachate" does not cause an impact on the environment. Hence, the liner is no longer needed and the fact that it will indeed eventually leak has no impact on the environment. Thus, I agree that municipal solid waste liners can eventually leak but provided the liner is appropriately designed and constructed to have a service life longer than the contaminating lifespan, eventual leakage at the end of the service life will have a negligible impact on the environment when it occurs. Conceptually, a similar situation applies to the NSDF ECM with the difference that the service life is estimated to exceed 1000 years (and likely 2000 years) and the contaminating lifespan is less than 550 years.

(b) "*the proponents and studies show that the mound will leak continuously and disintegrate in a few hundred years*." This is a misunderstanding of some of the scenarios examined and, as written, the statement is not true. The studies have NOT shown that the mound "*will leak continuously and disintegrate in a few hundred years*".

(i) Calculations have been performed by CNL for the unrealistically conservative assumption of a complete failure of the base liner at the time of closure simply so they could calculate what the impact be under those circumstances. It is not intended that the liner would fail; it is simply a sensitivity study asking the question: "what would happen if there was a complete failure?". Even with this unrealistically conservative assumption, CNL's Post-Closure Safety Assessment[2] gives a peak dose of 0.0057 mSv/y. This is fifty-fold lower than the target of 0.3 mSv/y. Thus, if a complete failure of the liner system has an impact that is fiftyfold smaller than an acceptable level, it logically follows that any realistic minor defects will have a negligible impact even immediately downgradient to the mound let alone more than a kilometre at the Ottawa River.

(ii) Even before the final cover is in place, it is unlikely that leakage through any holes that may exist would be continuous. Leakage would tend to be triggered by rainfall events and subsequently, there may be leakage through the primary liner if it has any hole and then be collected by the secondary system.

(iii) Thus, while calculations were performed assuming the system was not working before 550 years, this is not the same as showing that it will fail before 550 years. Indeed, as I indicated above, it is expected that the system will still be quite functional, if required, well beyond 550 years and indeed beyond a thousand years.

(c) *"It is designed to leak after closure when the mound deteriorates, but even more concerning it could very well leak during the 50 years of waste and placement*..." It is not true that the system is designed to leak after closure. Indeed, it is designed to control leakage to a negligible value (i.e., negligible impact on the environment) for the entire service life if needed.

(i) I agree that it is probable that there will be some leakage through the primary liner during the first 50 years of waste placement. All efforts will be made in terms of design and construction to control this leakage to a very small value. However, it is the recognition that indeed this is probable that motivates an entire secondary system (secondary collection layer, geomembrane + GCL + 750 mm of compacted clay liner; Figure 1) to collect what leaks through the primary liner.

(ii) In my opinion, based on extensive experience, it is extremely unlikely that there will be detectable leakage out of the containment mound during the first 50 years let alone have any impact on the environment immediately downgradient of the landfill.

4 Can waste be removed?

President Velshi's question: *'based on Dr. Bart's failure mechanism what is your thought about … the retrievability of waste … after closure: is that a feature that would be advisable for the NSDF'.* [this is what I think I heard since the draft transcript (page 194) was garbled]. This is a complex question because it can be viewed from several perspectives.

Having subsequently read some of the background comments from other interveners, I infer that the question is probably concerning the repairability of the liner. As indicated in my response to another question, the most likely time for damage within the service life of the system is during and immediately after the construction of the liner system and while additional layers in the liner are

[2] https://iaac-aeic.gc.ca/050/documents/p80122/142897E.pdf

being placed. I refer to Item 2 above. During the construction stage, it is relatively easy to both detect (with an electrical leak location survey) and repair any defects.

Should defects be detected (e.g., by excessive leakage through the primary liner) during the period of waste placement, the waste could be moved, and a repair initiated. I would expect any such leakage to be greatest before waste is placed over the damaged area since the increasing stress with increasing overlying waste will reduce the potential for leakage through any existing hole and not increase the potential for leakage as appears to be assumed by some intervenors. If detected before any waste is placed over the location of leakage, repairs can be easily initiated. The greater the mass of waste above a point of interest, the more challenging it will be to move the waste and such an undertaking would likely only be considered if the leakage was substantial. However, even if the leakage were substantial, it would be leakage through the primary liner and not out of the containment mound. Once the waste is placed in a cell, the final cover will minimize any leachate generation and consequently any leakage even if there was a defect in the underlying primary liner.

A second possible interpretation of the question is whether, after the closure of the facility, could waste be removed either to (a) recover resources or (b) repair a defect in the underlying liner system.

(a) It is certainly possible that the waste could be removed and moved elsewhere. This did happen for landfills containing PCB contaminated soil in London Ontario where after 22-25 years in the landfill, the waste was subsequently exhumed and incinerated[3]. However, I find this scenario highly unlikely for the NSDF ECM because the situation is quite dissimilar to that with the PCBs. PCBs are "forever chemicals" without a clear half-life and they would certainly be declared as long-lived in the context of radioactive waste. In contrast, radioactivity is one of the most predictable phenomena encountered in waste management. Once the radioactivity has decayed leaving soil and construction debris, I find it hard to imagine it would be worthwhile retrieving this material, but if that was desired it would be technically possible once there were no further controls on the site (see item 5 below).

(b) It is also possible that the waste could be removed to initiate repair in the liner system. However, this would be the last resort and is unlikely to ever be necessary. I say this for two reasons. Firstly, the design of the liner system is such that the scenario is extremely unlikely. Secondly, while not denying this scenario is possible, I considered it extremely unlikely that one would ever remove the waste to repair a defect in the geomembrane post closure. The most likely means of mitigating any such leakage would be to reduce the source of the leakage, namely the leakage through the cover. This could be far more readily achieved by either repairing the cover or adding additional cover elements to prevent the leakage.

5 What impact on groundwater and surface water outside the ECM can be expected throughout the contaminating lifespan of the facility?

In response to Commissioner Maharaj's question "*I would like to ask a short question to CNL about a statement that was made in the intervenor's written submission. In her submission, she referred to*

[3] An investigation by my team of the performance and condition of the liner for this facility 22-25 years after its installation show that it was still in excellent condition, had contained all the PCBs from any migration into the environment, and still had hundreds of years of service life remaining despite the fact it was manufactured in the early 1980s and not of the same quality as the geomembranes that I have recommended for the ECM.

a bathtub effect and that was addressing the question around the side wall design of the facility and whether or not it was high enough to prevent filling. I'm not sure I understand exactly what that means and I was wondering if you could provide some clarity."[page 96 of transcript] I have the following comments.

As alluded to earlier, modelling is conducted to consider worst-case scenarios and ultimately what could happen after the contaminating lifespan of the facility has been reached. These scenarios that considered the "bathtub effect" assumed that:

(i) the liner was still functional (otherwise it would leak out the bottom and not overflow the bath), and

(ii) the cover had failed and was letting in the excess amount of water that upon percolation through the waste generating leachate; and

(iii) there was no operation of the leachate collection system.

The bathtub effect may come into play once the contaminating lifespan of the facility has been reached (i.e., the radioactivity in the leachate is so low that it can be released into the environment without an environmental or health and safety impact). However, this is an issue of operations and not an issue of design. The design is such that the bathtub effect can be prevented for as long as needed. Even if the leachate collection system failed, the bathtub effect can be prevented by repairing or upgrading the final cover.

As discussed by CNL in the hearing, the operation of the leachate collection system cannot be terminated without approval (presumably by CNSC) and even when it is turned off that does not excuse CNL from continued monitoring and acting as needed if it appears likely that contaminants could escape and impact the environment. Even if the leachate collection system has been shut off, it can always be re-instigated. If the volume of leachate being generated is too high that implies a problem with the final cover. The final cover can be repaired or replaced if ever that is needed. In short, I see no scenario where the bathtub effect would be likely to be generated without prior approval once the contaminating lifespan of the facility has been exceeded and that any such bathtub effect would have a negligible impact on the environment.

Closing comments

In summary, I recognize that some of the concepts and terminology may be difficult for the layperson to appreciate. However, in my experience, the concerns that they raise about the impact on the environment are unreasonable in the context of the proposed design, construction, and operations. In saying this, I am anticipating that approval would require that:

(i) the design be constructed as proposed and that no substantial changes be made without approval by the engineer of record and CNSC; and

(ii) a high level of construction quality assurance be required along the lines outlined in my submission; and

(iii) there be an appropriate electrical leak location survey both following geomembrane placement and following placement of cover soils; and

(iv) the operation of the facility is such that there is no more than 0.3 m of head in the sump under typical operating conditions and that the facility not be used for storage of leachate.

Yours sincerely.

R. Kerry Rowe OC