AECL EACL

ENVIRONMENTAL RISK ASSESSMENT OF CHALK RIVER LABORATORIES 2012

Chalk River Site (includes NLBU Administrative Records)

ENVP-509220-REPT-001

Revision 0

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EXECUTIVE SUMMARY

An Ecological Effects Review (EER) for the Chalk River Laboratories (CRL) site [81] conducted in 2005 was required by the CNSC in order to demonstrate, based on environmental monitoring data, that provisions taken by AECL to protect the environment are adequate. It was a preliminary quantitative Ecological Risk Assessment (EcoRA). The Canadian Standards Association (CSA) has recently completed its N288.6 standard on Environmental Risk Assessment (ERA) for Class I nuclear facilities, based on environmental monitoring data [37]. The standard calls for both EcoRA and human health risk assessment (HHRA), for radiological and non-radiological contaminants and physical stressors. It also calls for regular review and update of the ERA, which becomes a living document, serving to focus the facility's environmental monitoring programs and to inform risk management strategies.

This ERA report updates the 2005 EER, using more recent environmental data, including data from EER follow-up studies, and following the recent CSA N288.6 standard. Specific objectives, consistent with the standard, are: (1) To evaluate the risk to relevant human and non-human biota receptors resulting from exposure to contaminants and stressors related to the CRL site and its activities; and (2) To recommend further monitoring or assessment as needed based on the results, to clarify risks or reduce uncertainties in the assessment.

The scope of the ERA encompasses current operations (short-term), and human health and ecological effects potentially arising from these operations. The next ERA update (scheduled for 2018) will also encompass end-of-state considerations (long-term). All current releases of contaminants, and potential impacts of other stressors to the natural environment, are considered. Past practices or events outside of operational facilities are considered where they may be resulting in a contaminant release or receptor exposure today. Proposed future operations are not considered here, but have been addressed in Environmental Assessments. Similarly, risk management is not discussed here, but is addressed in the Nuclear Legacy Liabilities Program. There is no other requirement for risk management since future projects will not have any unacceptable risks associated with them as determined through Environmental Assessments.

The natural environment considered in this ERA includes all locations outside operational areas, both on-site and off-site, that may be subject to adverse impacts arising from CRL site operations. This includes atmospheric, groundwater or surface water plumes leaving the operational areas. Operational areas include WMA-B, CA-2, and CA-1. Former operational areas that are currently non-operational (e.g., WMA-A, WMA-C, WMA-F) are considered.

An updated Site Description is presented, including a description of the engineered site, facilities, and systems; a description of effluents from the facilities and environmental monitoring activities; and descriptions of the natural and physical environments.

Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) begins with an identification of the human receptors of interest, the radiological and non-radiological contaminants of potential concern (COPCs), locations of exposure to COPCs, and relevant exposure pathways.

Workers on the CRL site are potentially exposed to environmental contaminants, both chemical and radiological, but these exposures are considered and controlled through the Occupational Health and Safety Program (OHSP) and the Radiation Protection Program (RPP). Because worker and visitor exposures on the site are kept within safe levels through the OHSP and RPP, on-site receptors are not addressed further in the HHRA.

Off-site members of the public are potentially exposed to low levels of airborne or waterborne contaminants. All potential critical groups were considered in the calculation of Derived

Release Limits (DRLs) for the site, where bounding critical groups were identified [41]. This HHRA focuses on the radionuclides that have the potential to be present in CRL's airborne and liquid effluents in significant quantities. The receptors for the HHRA are those off-site groups that were identified as potentially receiving the highest radionuclide exposures, as determined by the DRL model for the site [41].

The receptors that receive the highest total dose from airborne contaminants from CRL (based on % of DRL and results of environmental monitoring) are residents located at Balmer Bay, 6.8 km northwest and upstream of the site. Chalk River residents are slightly closer to the CRL site, but less exposed since they are not in the predominant NW-SE wind directions. The most exposed farm residents are at the Sheenboro farm, approximately 10.5 km southeast of the CRL site, downriver on the Québec side. Several farms are closer to CRL, but less exposed based on predominant wind directions. Balmer Bay residential and Sheenboro farm receptors were considered as receptors for assessment in the HHRA.

The receptors that receive the highest total dose from waterborne contaminants from CRL (based on % of DRL and results of environmental monitoring) are riverside residents at Harrington Bay, 8.6 km downriver on the Québec side, and residents at Petawawa and Pembroke, 17.9 and 30.1 km downriver, respectively. Residents in these communities were considered as receptors for assessment in the HHRA.

For releases to air, Ar-41, noble gases, and tritium at Balmer Bay, as well as I-131 at Sheenboro Farm, were identified as COPCs based on releases exceeding 0.1% of DRL. The Ar-41 and tritium are due mainly to releases from NRU, noble gases are due mainly to releases from the Mo-99 facility, and I-131 is due mainly to releases from tile hole arrays located in WMA-B. These four radionuclides are addressed in the HHRA.

For releases to water, no radionuclides exceeded the 0.1% of DRL criterion. 0.1 % of the DRL represents a dose of 1 µSv and is a small fraction of the 10 µSv dose level considered negligible. These radionuclide releases were not addressed further in the HHRA.

Non-radionuclide releases to air were also considered from a human health perspective. Acid gases NO_x and SO_2, and particulate matter (PM_{10}, $PM_{2.5}$), from various sources on site, have near-source concentrations exceeding Ontario Ambient Air Quality Criteria [158]. However, concentrations estimated for Balmer Bay, the most exposed off-site location, were far below Ontario Ambient Air Quality Criteria. These substances were not considered further in the HHRA.

Radionuclide exposures and resulting radiation doses were estimated by Ingram [89] for a composite of the Balmer Bay and Sheenboro Farm receptors. The air immersion, inhalation and ingestion of garden produce pathways were assessed based on measurements at Balmer Bay. The ingestion of milk pathway was assessed based on measurements of milk from a Deep River dairy. The ingestion of meat pathway was assessed based on measurements in pork and beef at a farm in nearby Chapeau, Québec. All measurements were background corrected so that doses calculated would represent incremental doses arising from CRL operations.

The public dose estimates for the Balmer Bay / Sheenboro receptors (adult and infant) were more than an order of magnitude below the public dose limit of 1 mSv/yr. Therefore, public health is presumed to be protected at these low levels of exposure to radioactivity from CRL. The dose estimates represent a fraction of natural background dose (Canadian average is 1.8 mSv/yr) [30].

Since the Balmer Bay / Sheenboro receptors receive the highest doses from the CRL site, the demonstration that they are protected implies that other population groups near CRL are also protected. Nevertheless, the ALARA (As Low as Reasonably Achievable) principle is applied at CRL to reduce emissions as much as is reasonably achievable.

Ecological Risk Assessment

The Ecological Risk Assessment (EcoRA) begins with an identification of the ecological receptors of interest, the radiological and non-radiological contaminants of potential ecological concern (COPECs), stressors of potential concern (SOPC), locations of exposure to COPECs, and relevant exposure pathways.

Selected ecological receptors represent a cross-section of taxonomic groups, habitats, feeding habits, and trophic levels so that effects can be extrapolated to ecologically similar species. They include both species that are common and widespread, because they perform important ecological functions in the ecosystem, and species that are rare and/or declining, because they have a higher perceived social value and may be particularly sensitive to human activity. All major species groups are represented, including fish, mammals, birds, amphibians and reptiles, vascular plants, and invertebrates. Selected species represent aquatic, terrestrial and wetland habitats, and different feeding strategies such as herbivore and insectivore.

The receptor list was discussed with stakeholders during the 2005 EER to ensure that local knowledge was adequately represented, and that species of special importance to the community and to local naturalists, conservation and government groups were considered. The chimney swift (a Committee On the Status of Endangered Wildlife In Canada (COSEWIC) Threatened species) was added for this ERA based on concerns about chimney swifts roosting in the Mo-99 Production Facility (MPF) stack. The air velocity of the MPF stack is low enough to let the birds in, whereas the velocity is too high for birds to enter the NRU stack.

Concentrations of contaminants were gathered from recent available site monitoring data (air and liquid effluents, site surface water, groundwater, sediments, and soils). Both measured and estimated concentrations were compared to screening criteria, which included applicable federal and provincial guidelines for environmental quality, and toxicological data from the literature. Effluent concentrations were compared to surface water quality guidelines, without dilution. Radionuclide concentrations in water, sediment and soil were compared to screening criteria developed by the U.S. Department of Energy [58], and to screening criteria that were derived using the methods of Chouhan et al. [43] [42]. Radionuclides in air were screened against criteria based on Holford [87] and other sources.

Any chemical contaminants or radionuclides that exceeded screening criteria at any location were assessed further in the EcoRA as COPECs at that location, unless shown to be below an upper limit of background. Local background concentrations of metals in surface water and sediment were available from follow-up studies to the 2005 EER. For radionuclides, in addition to those identified as COPECs, other radionuclides considered to contribute appreciably to dose at each location were included in dose calculations to obtain a close to total radiation dose.

The exposure assessment at each location used a combination of measured COPEC concentrations, and estimated concentrations for media that were not measured. Estimates involved calculation of partitioning between sediment and water, and calculation of uptake from environmental media to organism tissues. Uptake factors were based on site data if available.

Doses were calculated from media concentrations for all biota for radionuclides, and for birds and mammals for non-radionuclides, in order to compare with dose benchmarks. For other biota and non-radiological contaminants, exposure concentrations are compared directly with applicable concentration benchmarks. At most locations it was possible to estimate both average and maximum exposure values (concentrations or doses, as appropriate). These exposure values were used in risk estimation.

Risk estimation involved dividing exposure values by benchmark values to calculate risk quotients (RQ) for each relevant receptor at each assessment location. Benchmark values for radiation dose were taken from UNSCEAR [197] as recommended by CSA N288.6.

Benchmark values for non-radiological COPECs were taken from various literature sources. An RQ above 1 indicates a potential for adverse effects, particularly if based on average exposure at the assessment location. RQs based on maximum concentrations may overestimate risk for birds and mammals which may average their exposure through their movements. Fish at discharge points have been represented as residing in an area near the end of the pipe.

Groundwater within a source area was not considered as an exposure medium. However, screening of groundwater around the perimeter of a WMA was used to identify contaminants that might be of concern in downgradient surface waters. There is one exception to this in the ERA; exposure to groundwater was considered for soil biota in the zone of groundwater discharge to the Ottawa River.

A number of physical stressors were considered in the EcoRA, including potential for thermal effects due to cooling water discharge at the Process Outfall, entrainment / impingement effects at the cooling water intake, roadkill of wildlife, and ongoing habitat alterations.

Radiation Doses

At most locations around the CRL site, radiation doses are below the benchmark values of 100 µGy/h and 400 µGy/h for terrestrial animals and aquatic biota, respectively (2,400 and 9,600 µGy/d). A few locations exceed these benchmarks, in particular the wetlands affected by radiostrontium groundwater plumes.

Doses above the generic benchmark values do not necessarily produce adverse effects. However, doses well above benchmarks indicate a potential for adverse effects and suggest candidate locations for effects monitoring or risk management. Note that conservative assumptions were used in dose assessments.

Aquatic Sites

The highest average aquatic dose is estimated to occur in Spring B Forest (52,643 µGy/d for the snail and 5,066 µGy/d for the water shrew). Doses are due to Sr-90, which originates from WMA-B.

The highest average estimated doses for South Swamp are 16,900 µGy/d for the snail. Doses are due to Sr-90, which originates from WMA-A and/or Reactor Pit 2 in the LDA.

The highest average estimated dose for East Swamp is 10,200 µGy/d for the snail. Doses are mainly from Sr-90, which originates from the Liquid Dispersal Area.

At maximum exposure levels, calculated radiation doses at each location are greater by 2 to 4 times for snail and alder. These biota both have limited mobility, and some individuals could experience the maximum exposures. None of the doses received above benchmarks affect more than a small portion of the Perch Lake watershed, and are therefore unlikely to be important at the population level.

Doses were calculated to fall below benchmark values for all other inland aquatic site locations, including Perch Lake and inlets, Perch Creek, Main Stream, West Swamp, Duke/Bulk Stream, Bulk Storage Stream and the riverfront streams. Doses were also below benchmark values for aquatic biota in the Ottawa River nearshore mixing zone areas for all liquid effluent discharges.

Terrestrial Sites

In WMA-A the highest average estimated dose was for the masked shrew (67,136 µGy/d); however, actual doses to birds and mammals may be much lower based on home range and habitat considerations. Plant dose estimates were lower, but vegetation growth is controlled, thereby eliminating suitable habitat for robins and minimizing suitable habitat for shrews. Soil invertebrate dose was estimated at 49,000 µGy/d. WMA-A doses are mainly due to Cs-137.

In WMA-F, which contains historical waste soil from Port Hope, the woodchuck is predicted to receive an average dose of 6,180 µGy/d due to radon inhalation in the burrow. This dose is above 2,400 µGy/d; however, the literature suggests that doses for burrowing mammals in uncontaminated areas may routinely exceed 2,000 µGy/d.

In the LDA Chemical Pit (CP: 23,905 µGy/d) and Reactor Pit 2 (RP2: 43,892 µGy/d), the highest average estimated dose was for the masked shrew; however, actual doses to birds and mammals are probably much lower based on home range and habitat considerations. Soil invertebrate dose was 19,400 (CP), 9,390 (Laundry Pit, LP) and 34,100 (RP2) µGy/d. Doses in LDA are mainly due to Cs-137.

In the LDA/NRX pipeline location, the highest average estimated dose was for soil invertebrates (106,210 µGy/d, mainly due to Cs-137). Masked shrew had the highest average vertebrate dose (87,400 µGy/d, mainly due to Cs-137). Actual bird and mammal doses would probably be much lower if home range and habitat were considered.

In all other cases, doses in terrestrial biota within or adjacent to Waste Management Areas were predicted to be below 2,400 µGy/d. Doses marginally above this level, due to tritium in groundwater and vegetation, were estimated for alder growing on the Ottawa River shoreline near groundwater discharge areas for the NRU plume.

Radiation doses in white-tail deer (based on measured radionuclides in deer tissue) and in eastern wolf (based on calculation of radionuclides in wolf tissue) remain well below 2,400 µGy/d. The doses are mainly from Cs-137 in tissue (above background), and Ar-41 in air.

Radiation doses to terrestrial biota resident at the maximum concentration locations for atmospheric emissions are generally well below 2,400 µGy/d. The highest ground level doses are estimated at 1,434 µGy/d (based on effluent maximum with dilution factor), or 8.4 µGy/d as an annual average (based on air modeling), from Ar-41 around NRU. The terrestrial biota receiving doses above 2,400 µGy/d represent a few individuals within the confines of small waste management facilities. These doses are unlikely to lead to significant effects at the population level.

Chimney swifts roosting in the MPF stack receive higher doses, likely dominated by noble gas exposure. Dose from Xe-133 to a swift at this location was estimated at 2,900 µGy/d averaged over a 10-wk period of occupancy in the stack, marginally above the dose benchmark [48]. The air velocity of the MPF stack is low enough to let the birds in, whereas the velocity is too high for birds to enter the NRU stack.

Chemical Effects

Aquatic Sites

At aquatic receptor locations, some aquatic biota are predicted to receive chemical exposures above benchmarks (i.e., guideline or elevated background), principally for copper and iron. In most cases, the risk quotients are marginal (in the 1-2 range). Locations with risk quotients (RQ) greater than 2 include Spring B Forest (Fe), Perch Creek (Fe, TCDF, B(a)p), Duke Stream (Fe, Pb, Cd), Perch Lake Inlet 2 (Fe, TCDF), East Swamp (Se, PCB, TCDF), West Swamp (Fe, Se), and South Swamp (Se, Fe).

The risk quotients for Cd in Duke Stream are based on a water grab sample collected by Environment Canada, and have not been verified by CRL monitoring. The risk quotient for benzo(a)pyrene in Perch Creek is based on a sediment grab sample from the same survey.

The risk quotient for PCB (total) and TCDF (total) in East Swamp (RQ = 18 and 24 for benthos, respectively) is based on measured sediment values in excess of the CCME [28] guideline. Polychlorinated biphenyls (PCBs) and tetrachlordibenzofurans (TCDFs) originate historical releases from the Chemical Pit.

The risk quotients for Se in soil in West Swamp and South Swamp (RQs = 19.7 and 20.9, for alder) are based on measured values exceeding the CCME [28] soil guideline in these locations. Se is present in concentrations above background based on limited data.

Riparian birds and mammals at the inland aquatic sites have risk quotients below 1 for most chemical COPECs. An exception is Se; quotients are in the 1-2 range for average East, West and South Swamp soil concentrations.

Aquatic biota in the Ottawa River nearshore are exposed to discharge from shoreline outfalls and groundwater migration in the Ottawa River nearshore. Nearshore water RQs were < 1, based on calculated concentrations of COPECs.

Calculated concentrations of chlorine in the discharge zone of the Process Outfall produce a risk quotient of 1.8 relative to the benchmark concentration for invertebrates; however, the benchmark for fish is not exceeded. Calculated concentrations in the discharge zone of the Sanitary Outfall, where chlorination also occurs, do not exceed chlorine benchmark values.

Chloride is discharged via groundwater to the nearshore zone, resulting in sediment porewater concentrations above the Canadian Council of Ministers of the Environment (CCME) water quality guideline; however, maximum measured river water concentrations (under ice) do not exceed the guideline. Chloride in groundwater reflects the influence of road salt use around the CRL site.

The Ottawa River Remediation (ORR) project [184] has characterized sediments in the vicinity of the Process Outfall and has completed a preliminary identification of COPECs for further assessment of ecological risk. Identified COPECs include mercury and various radionuclides. Studies of sediment toxicity have been completed [188] [183]. A separate Ecological Risk Assessment is underway and expected to be completed in 2014 (175-121240-REPT-002, *in preparation*). The next ERA iteration in 2018 will summarize the results (Recommendation #4).

Terrestrial Sites

Limited data on chemical concentrations in surface soils within the Waste Management Areas, do not suggest adverse chemical effects on terrestrial biota within the WMAs.

A small area (less than 10 m^2) of soil contamination by natural uranium at the Electrical Storage Yard produces high risk quotients for soil invertebrates that reside there (RQ = 6.7 (Riverbank A & B average)). Risks to birds and mammals are expected to be much smaller due to their use of much larger foraging areas (RQ = 1.2 for masked shrew).

Soil invertebrates and alder trees residing on riverfront lands near groundwater discharge locations may be exposed to contamination as a result of occasional rise in the water table and contamination of root zone soils. Estimates of this exposure suggest that Cd, Cu and Zn may marginally exceed soil benchmarks by this mechanism (RQs in the 1-2 range). A higher RQ of 26.2 was estimated for iron (note: maximum concentrations were used to calculate RQs, as averages were not available).

Annual average air concentrations resulting from powerhouse emissions, calculated for the worst-case point of impingement location, were below the applicable benchmark for NO_x and above the benchmark for SO_2 (RQ = 4.8). No other atmospheric COPECs were identified.

Thermal, Entrainment and Impingement Effects

Thermal effects of the discharge of reactor cooling water are predicted to be very minor, as the temperature rise measurable in the river is very small and the size of the thermal plume is small. The model predicted zone in which temperature rise may exceed 3°C extends less than 200 m downstream of the Process Outfall.

Thermal surveys around the Process Outfall indicate that the area of thermal increment above 1°C in surface water is maximal in November for an area of 2,600 m^2. Aquatic life is protected where temperatures are less than 3°C above ambient. The area of thermal increment exceeding 3°C is generally zero and does not exceed 140 m^2. Thus, the area where aquatic life may be adversely affected is a very small fraction of the river.

The maximum measured water temperatures in the surveys occurred in August, with a maximum value of 22.5°C. This maximum is below the range of summer MWATs for warm water fish species (25 to 32°C). The lake herring (cisco) has a lower summer MWAT of 17°C; it would likely avoid the plume, as it would avoid other parts of the river with natural summer temperatures of 19 to 22°C. From the period of November to March, water temperatures were consistently below 10°C, with a maximum value of 9.8°C in November. The winter temperatures are below the range considered to potentially affect winter survival of warm water fish species. For lake herring the winter MWAT may be as low as 5°C in mid-winter, which is not exceeded in the plume. Thus, temperatures in and around the thermal plume are unlikely to impair growth or survival of fish in the area.

Impingement of fish at the NRU and NRX intakes (mainly NRU) is approximately 5,349 fish per year (2012). The key species are trout-perch and rainbow smelt, which represented 49% and 46% of the total in 2001 and 2004 studies respectively. Similar trends were observed in 2012. The total mass of fish taken is approximately 40 kg/yr (2012 data). The loss is roughly equivalent to the estimated total fish biomass productivity for less than 1 ha of river area. The loss appears to be modest, but may be of local significance to the population abundance of the most affected species. For lake sturgeon, an identified species at risk, NRU fish impingement varied from two in 2001, to ten in 2004, and one in 2012.

Fish eggs and larvae were not found in biweekly samples collected at the Powerhouse, although live zooplankton were identified. Fish eggs have been observed in NRX in the past but flows through NRX are small at present and this loss is not significant to fish populations, which is supported by the low numbers and biomass of fish impinged and recent hydro-acoustic data on fish abundance (see Recommendation #6, in progress). An evaluation of the habitat surrounding the intakes as well as literature on the impinged species, suggest it is unlikely that fish use these areas for spawning. Both trout-perch and rainbow smelt, which represent dominant species impinged at the NRU intake, typically spawn in streams as opposed to the open water of the Ottawa River.

Road Kill of Wildlife

Low numbers of large mammals (deer, moose, bear) are killed in traffic accidents along the CRL access road. The rate of mortality is small relative to annual production in the local populations and is expected to be of no consequence at the population level.

Monitoring of reptile road kills began in 2009. Thirteen turtles were killed on Plant Road from the end of May 2010 through to mid-July 2011. Two turtle crossing areas were identified and turtle crossing signs were installed at those locations. Additionally, silt fences were installed along the shoulders of the road preventing turtles from accessing the roadway. Re-routing strategies to assist with turtle movements on site are planned for 2014.

As a turtle conservation measure, road grading during the spring nesting season has been curtailed. In addition, a nest management program has been implemented. This involves locating nests and placing covers over them for protection from predation. Covers are removed the day of hatching.

Road Salt

Substantial quantities of road salt are used in winter on CRL roads, and may lead to localized effects in wildlife (attraction of large mammals to roads where traffic hazards exist; ingestion poisoning in birds). These effects are unlikely to be any more significant than road salt effects along other regional roadways or in small urban areas in Ontario. The CRL Salt Management Plan identifies actions that will be taken to use and store road salt responsibly, minimizing accidental losses and related effects.

Greenhouse Gases

Greenhouse gases are of greater concern at a regional or global scale than at the local scale. CRL releases greenhouse gases such as CO_2 from combustion of fuel at the Power House and halocarbons which may contribute to global warming. Total greenhouse gas emissions from CRL, assessed relative to national emissions, represent 0.0049% of the national total. Thus, the CRL contribution to the problem is insignificant.

Other Habitat Factors

Other habitat manipulations at CRL, such as the installation of fencing and creation of fire breaks, may produce local effects on wildlife movements and distributions. These effects are likely to be minor and comparable to the effects of similar activities throughout the region.

Recommendations for the Monitoring Program

A set of recommendations have been developed resolving data gaps, addressing uncertainty and increasing transparency of ERA inputs and results prior to the next scheduled update in 2018. Closure criteria have been agreed upon between AECL and the CNSC (2013 April, see Section 5.2).

Further details concerning these recommendations, including descriptions, task managers, work that needs to be completed, deliverables, timelines, and feedback into environmental monitoring program are discussed in the 2012 ERA 5-yr workplan (ENVP-509220-PLA-001, in progress).

1. A) In the 23 instances where radiation doses or chemical exposure (concentration or dose) were predicted to exceed benchmarks it is recommended that AECL confirm exposure conditions (concentrations in biota for radioactivity, concentrations in the environment for chemicals), confirm the presence of ecological receptors similar to those assessed (including Species at Risk), and proceed to ongoing monitoring, where possible for the effects relevant to benchmark exceedance (e.g., woodchuck dose for Rn-222 in WMA-F; soil invertebrate, grass and sweet fern combined radiological dose in WMA-A).

   In the areas where benchmarks are exceeded, these confirmatory concentration measurements may be used to further refine relevant site-specific transfer parameters, such as partition coefficients (Kds) and bioaccumulation factors (BAFs).

   B) Assess background concentrations for the other non-radiological contaminants that are measured routinely as part of CRL Environmental Monitoring Program, but do not currently have any guidelines or limits to screen against (i.e., so that we’ll know in the future whether we’re significantly above background).

In some cases where chemical benchmarks are exceeded, there is uncertainty regarding local background.

C) For the instances where groundwater was found to exceed benchmarks, check whether there is no surface water data to confirm exposure conditions. If/where data is missing, it is recommended that AECL measure surface water at point of discharge (note that groundwater was screened, but not evaluated in the ERA since it is not considered to be an exposure medium for biota).

2. Monitoring to show the effectiveness of the new plume capture technology that is to be implemented in South Swamp focusing on post implementation recovery of the wetland. There should also be a follow-up to determine if risk quotients (RQ) for COPECs have dropped below one.
3. Vegetation control programs should be maintained in most Waste Management Areas (CRL Significant Environmental Aspect (SEA)), as this will discourage colonization of biota and minimize the potential for doses such as those estimated for organisms assumed to inhabit the Chemical Pit and Reactor Pit 2. There should consist of routine vegetation inspections to ensure the control program is effective. The ERA assumes that no vegetation other than grass cover will be allowed to inhabit the WMAs. Manual and/or chemical vegetation control methods may be used as required to maintain the program.
4. The ecological risk assessment of sediments in the Ottawa River, currently in progress, should be completed as scheduled in 2014, and updated results should be incorporated into the next ERA iteration (Section 4.4.2.2).
5. Further assessment of radiation dose and effects on the Chimney Swift population using the Mo-99 facility stack for nesting and roosting should be undertaken (Section 4.2.4.4) because this species has been identified as a species at risk.
6. Fish entrainment and impingement (E/I) monitoring for Lake Sturgeon should be continued in 2014, focused on the NRU intake. For other fish species, the relationships between E/I, intake flow, season, temperature and other relevant variables could be explored to possibly develop predictive relationships. If validated, a predictive model might be used to estimate E/I in lieu of routine monitoring. The program should follow advice in clause 7.8.2 of the CSA N288.6-12 standard, and the cited EPRI technical guidance documents. Entrainment monitoring should include fish eggs and larvae as well as aquatic macroinvertebrates. Impingement monitoring will include fish captured on the debris screen.
7. Currently, NPRI commitments are met with regards to particulates (road dust) as fugitive emissions from transportation, especially from the gravel roads. Planned project activities in the next three years involve many soil excavations and these soil excavations and open / cleared areas are also potential sources of particulates, not currently assessed, that need to be assessed for NPRI reporting.
8. Environmental risk assessment and measurement endpoints need to be clearly defined for the environmental values that AECL has previously determined (VECs). These are typically related to the attributes of populations and communities (e.g., to protect “game fishing”, measurement endpoint could be “percent mortality of game fish in exposed habitats”).
9. There is no information or estimation method available to evaluate chlorine concentration in either Storm Outfall 03 or 04, yet chlorinated water is entering each from process, fire and service water used on-site (on occasion a chlorine “smell” has also been observed from Storm Outfall 04) (Appendix 1, Table A1.14). These locations need to be assessed.

10. Once RQs for each area of concern in the ERA (TABLE 5. 3) have been confirmed, results will be sent to CRL Risk Managers for inclusion in the remediation plans for CRL.