

# **Port Hope Area Initiative Clean-up Criteria**

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Revision 5**

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**Prepared for:**

Low-Level Radioactive Waste Management Office  
5 Mill Street South  
Port Hope, ON  
L1A 2S6

**Prepared by:**

EcoMetrix Incorporated  
14 Abacus Road  
Brampton, Ontario  
L6T 5B7

## **EXECUTIVE SUMMARY**

This document presents a selection of clean-up criteria for the Port Hope Area Initiative (PHAI), for discussion purposes. Criteria are proposed for radioactive and non-radioactive contaminants or constituents of potential concern (COPCs) in low-level radioactive waste (LLRW) and soil, in harbour sediments, in water and groundwater, and in air including radon (Rn) levels in houses. The COPCs present in LLRW are all natural elements in soils, but which occur at relatively high concentrations in historic LLRW associated with former Eldorado operations.

This document references the work presented in three technical support documents prepared under separate cover by SENES-Golder and Stantec Consulting Ltd., and consolidates and builds upon their findings for discussion. These reference documents identified and prioritized COPCs associated with LLRW, and developed candidate clean-up criteria for LLRW in the municipalities of Port Hope and Clarington. Also, COPCs were identified and candidate criteria proposed for the four industrial waste-contaminated sites to be addressed by the PHAI – the Port Hope Harbour Centre Pier, Lions Recreation Centre Park, John Street former Coal Gasification Plant and Chemetron Lagoon sites.

The COPCs were identified and prioritized based on their potential to contribute to ecological and human health effects, as presented in Table ES-1 for historic LLRW. Radon gas was also identified as a COPC in the context of indoor air. Using a similar process, COPCs in soils and waste at the four industrial waste-contaminated sites were identified, as summarized in Table ES-2. Many of the non-radioactive COPCs identified in Port Hope are common contaminants in urban soils in general. Remedial work will focus only on the LLRW and associated contaminated soil, and will incorporate some measure of remediation of four former industrial waste-contaminated properties known to be contaminated by other past industrial activity. The influence of LLRW can be identified using chemical, radiological and physical signatures that distinguish it from any other soil contamination known to exist in Port Hope. Based on examination of a large number of analyses of LLRW and contaminated soil samples from Port Granby, Welcome, Port Hope-Ward 1 and Port Hope Harbour, soil contaminated with LLRW is known to invariably contain concentrations of radium-226 ( $^{226}\text{Ra}$ ) and/or thorium-230 ( $^{230}\text{Th}$ ) above background concentrations in combination with elevated concentrations of arsenic and uranium. The only other contamination known in the study area that may contain modestly elevated concentrations of  $^{226}\text{Ra}$  and  $^{230}\text{Th}$  is coal ash, which is distinguished by the presence of ash and cinders. There are no deposits of historic wastes from Eldorado operations that do not contain Ra-226 and/or Th-230 at elevated concentrations.

Candidate clean-up criteria for soils were developed following protocols, guidance and regulatory practice set by the Canadian Nuclear Safety Commission (CNSC), the Ontario Ministry of the Environment (MOE) and Environment Canada. International practice was also considered. In cases where established clean-up criteria did not exist, candidate criteria were created specifically for the PHAI. These criteria were specifically developed by the LLRWMO in consultation with public stakeholders, the Port Hope and Clarington Municipal Peer Review

teams, and provincial and federal authorities to guide the remediation process in Port Hope and Clarington in a manner intended to be consistent with the “Clean-up Principles”.

**Table ES-1: Contaminants/Constituents of Potential Concern Associated with Low-Level Radioactive Waste-Contaminated Sites**

	Primary <sup>1</sup>	Secondary <sup>1</sup>
Radium-226 (and decay products)	√	
Thorium-230	√	
Thorium-232 (and decay products)	√	
Uranium	√	
Antimony	√	
Arsenic	√	
Barium		√
Boron		√
Cadmium		√
Cobalt	√	
Copper	√	
Fluoride <sup>2</sup>	√	
Lead	√	
Mercury		√
Molybdenum		√
Nickel	√	
Selenium		√
Silver		√
Vanadium		√
Zinc		√

<sup>1</sup> Primary COPCs collectively account for great majority of potential hazard. Secondary COPCs are also present, but at low concentrations that contribute little to potential hazard.

<sup>2</sup> Fluoride is a COPC at Port Granby only.

**Table ES-2: Contaminants/Constituents of Potential Concern Associated with Four Former Industrial Waste-Contaminated Sites<sup>1,2</sup>**

	<b>Primary<sup>3</sup></b>	<b>Secondary<sup>3</sup></b>
<b>Inorganic COPCs</b>		
Antimony	LRC/CnP	
Arsenic	CnP	LRC
Barium		LRC/CnP
Beryllium		CnP
Boron	LRC/CnP	
Chromium	CLSo	
Cobalt		CnP
Copper	CnP/CLSI	LC/CGP
Lead	LRC/CnP	CLSo/CGP
Mercury		CLSo
Molybdenum		CLSI
Nickel		LRC
Selenium	CLSo	
Silver	CLSo	CGP
Vanadium		CLSo
Zinc	LRC/CnP	CGP
<b>Organic COPCs</b>		
Petroleum hydrocarbons	CnP/CGP	CLSo/CLSI
Oil and grease		CLSI
Benzene		CLSI
Chlorobenzene	CLSI	
1,3-dichlorobenzene		CLSI
1,4-dichlorobenzene	CLSI	
1,2,4-trichlorobenzene	CLSI	
3,3-dichlorobenzidine	CLSI	
Polychlorinated biphenyls		CLSo/CLSI
Polycyclic aromatic hydrocarbons	CGP	CnP

<sup>1</sup> COPCs exclude radioactive elements associated with LLRW deposited at a portion of the Centre Pier site.

<sup>2</sup> LRC = Lions Recreation Centre Park.

CnP = Port Hope Harbour Centre Pier.

CLSo = Chemetron Lagoon site soil.

CLSI = Chemetron Lagoon site sludge.

CGP = John Street former Coal Gasification Plant site.

Note: Non-LLRW wastes from the Water Pollution Control Plant to be removed from storage facility; cleanup criteria are not applicable.

<sup>3</sup> Primary COPCs collectively account for great majority of potential hazard. Secondary COPCs are also present, but at low concentrations that contribute little to potential hazard.

For radioactive COPCs in soils, criteria are presented for residential and non-residential land use conditions, based on a project-applied dose constraint of 0.3 mSv/a above background. This dose constraint is protective in that it represents 30% of the 1 mSv/a dose limit set for protection of members of the general public. It also represents a smaller fraction of the ~1.4 mSv/a received on average in Port Hope and Clarington from natural background sources. Criteria are presented for  $^{226}\text{Ra}$  and daughters in soil through all pathways potentially present. Criteria for  $^{230}\text{Th}$  are presented which conservatively account for 500 years of ingrowth of  $^{226}\text{Ra}$  and daughter products, to accommodate conditions where  $^{230}\text{Th}$  activities are in excess of  $^{226}\text{Ra}$  activities. The criterion for  $^{232}\text{Th}$  includes all members of the  $^{232}\text{Th}$  decay series. A summation rule is also provided, which ensures that total doses from all uranium-238 ( $^{238}\text{U}$ ) and thorium-232 ( $^{232}\text{Th}$ ) and uranium-235 ( $^{235}\text{U}$ ) decay series radionuclides present will not exceed 0.3 mSv/a within 500 years. The proposed criteria for total individual radionuclide concentrations, inclusive of natural background, are 0.29 Bq/g for  $^{226}\text{Ra}$ , 1.16 Bq/g for  $^{230}\text{Th}$  and 0.158 Bq/g for  $^{232}\text{Th}$  for current and foreseeable unrestricted land use. For sites with over-riding development constraints (e.g. the Welcome Waste Management Facility), the corresponding proposed total concentration criteria are 0.97 Bq/g, 4.67 Bq/g and 0.40 Bq/g, respectively. The summation rule is also applicable, so that if all of these radionuclides are present at elevated concentrations, the criteria are reduced according to the specific concentrations of each present at a site.

The 0.3 mSv/a dose constraint provides a target for deriving radionuclide concentration criteria for soil. Clean-up of soils to meet the derived criteria will almost certainly result in incremental doses that are much below 0.3 mSv/a for all age classes and members of the public, and will generally approach zero because the excavated soils will be replaced with clean fill which will shield any residual radioactivity in underlying soil where concentrations remain above natural background but below criteria. Also, the presence of excess  $^{230}\text{Th}$  relative to  $^{226}\text{Ra}$ , combined with the summation rule results in criteria which will constrain short-term doses (over timeframes of <500 years) to levels significantly less than 0.3 mSv/a, while natural weathering processes in soil over hundreds of years will tend to counteract the effect of  $^{226}\text{Ra}$  in-growth over the same timeframe so that a 0.3 mSv/a condition is never reached. Furthermore, the criteria are sufficient to ensure that even after complete in-growth of  $^{226}\text{Ra}$  from  $^{230}\text{Th}$  (requiring about 8,000 years) doses are never likely to approach 1 mSv/a. In addition to the above criteria, which protect against incremental doses in excess of 0.3 mSv/a, ALARA measures will also be applied to further reduce doses to levels that are “As Low As Reasonably Achievable (social and economic factors being taken into consideration)”.

For non-radioactive COPCs, the recommended criteria for soils affected by LLRW are generally the MOE generic soil standards for residential land use or, in locations where constraints will prevent residential development (e.g., the long-term waste management facilities (WMFs), the MOE generic standards for industrial/ commercial land use. There are small deposits of contaminated soil outside of the Welcome WMF property where the lower of MOE generic residential or agricultural criteria should apply.

Chemical and toxicological testing was conducted to develop possible site-specific soil clean-up criteria for arsenic (As), antimony (Sb), lead (Pb) and uranium (U). These elements were targeted for site-specific criteria development for various reasons. For As, Sb and possibly Pb, historical sampling data indicate that large volumes of historic LLRW affected soil may have one or more of these COPCs present at concentrations that are slightly greater than the generic provincial criteria. Site-specific criteria for these COPCs were of interest as possible alternatives to generic criteria if judged appropriate. For As, Sb and Pb, these alternate criteria should be considered by the proponent, the regulators and the municipality if, for example minor but widespread exceedances of the generic criteria occur. For U, the site-specific approach was necessary to develop clean-up criteria because no approved or generally accepted generic criteria exist. The site-specific criteria for U only are proposed here for routine application in the PHAI. Site-specific criteria for other COPCs will be applied only if situations arise where they may be more appropriate and there is agreement with key stakeholders (municipalities, regulatory agencies and the project proponent) providing oversight to the clean-up process.

At the four industrial waste-contaminated sites, the total volume of contaminated material present is substantial. Discussions on the management of wastes at these sites are currently underway between the Municipality of Port Hope and Natural Resources Canada. It is recommended that all material containing LLRW at the Centre Pier site be remediated to meet the proposed residential land use criteria for all COPCs. At the industrial waste-contaminated sites, it is recommended that the non-LLRW contaminated surficial soils be remediated to meet applicable generic provincial land use criteria for commercial/industrial/community land use or the site-specific criteria developed here for As, Sb and Pb. Risk management procedures should be applied to limit any risk from contamination in underlying soils, assuming soil criteria cannot be applied to full depth. It may be appropriate to apply generic provincial residential use criteria for the former Coal Gasification Plant site on John Street due to its location in a residential area.

The proposed soil criteria for radioactive and non-radioactive COPCs are considered protective of both human and ecological receptors. For radioactive constituents in soil, a screening-level ecological risk assessment (ERA) was completed to confirm that criteria derived for the protection of human health would also be protective of ecological receptors, including mammals, birds and soil invertebrates. Site-specific testing was used to assess potential ecological effects of uranium and non-radioactive COPCs. The screening assessment completed here was carried out as a series of calculation checks and did not take the form of a conventional ERA, as ERAs are incorporated into the Environmental Effects Assessments under the PHAI. Based on these determinations, the recommended criteria were judged to pose little or no ecological risk.

For harbour sediments, the Port Hope Project provides for removal of all harbour sediments down to native till or bedrock. Thus, criteria are required only for identifying the lakeward extent of excavation along the approach channel and elsewhere remediation will extend to natural background material. Site-specific criteria are recommended for sediments in the approach channel are based on benthic invertebrate sampling and sediment toxicity testing. To accommodate the possibility that residual sediments may be dredged in future after completion of the PHAI, recommended criteria for U,  $^{226}\text{Ra}$ ,  $^{230}\text{Th}$  and  $^{232}\text{Th}$  correspond with those recommended for residential soils, to ensure that such sediments would be acceptable for

disposal without special management for its radioactivity content. This approach will result in clean-up of non-radioactive COPCs, such as arsenic, lead and copper, to concentrations below the Ontario “severe effect level” sediment quality guidelines

The proposed criterion for  $^{222}\text{Rn}$  is  $125 \text{ Bq/m}^3$  (total) in Port Hope homes. The application of a total rather than an incremental criterion for  $^{222}\text{Rn}$  is based on the fact that it is generally not possible to reliably distinguish incremental from background radon indoors. This criterion is more conservative than the recently proposed Health Canada guideline of  $200 \text{ Bq/m}^3$  for residential dwellings, as it is based upon representative indoor radon concentrations determined through testing of homes in southern Ontario. If this criterion is exceeded, then the source(s) should be determined. Any soils containing  $^{226}\text{Ra}$  at concentrations greater than the cleanup criteria will have been removed prior to addressing an exceedance of the indoor radon criterion. If it is found that soil  $^{226}\text{Ra}$  at concentrations above background, but below the clean-up criteria, and a pathway is shown to exist from radon entry into the home from the adjacent soil, clean-up of this soil should be completed so as to eliminate the pathway.

Criteria are recommended for surface water and groundwater to cover a variety of situations. In general, there are no known situations where groundwater has been contaminated by LLRW and has resulted in contamination of existing potable water supplies. There are small localized situations where groundwater quality has affected the quality of surface waters in small local drainages in Ward 1 of Port Hope, such as in the Alexander Ravine Creek and in the Highland Drive South Ravine Creek. It is reasonable to assume that Ward 1 of Port Hope will remain on a municipal supply for domestic water, and that remediation of any groundwater contamination in Port Hope can generally be accomplished by source removal and natural attenuation. Where development of domestic supply wells is possible down-gradient of existing or proposed waste management facilities (WMFs), such as in Port Hope Ward 2 or Clarington, provincial standards for drinking water quality should apply at the site boundary. If these criteria cannot be met, mitigation by means such as provision of an alternate supply may be necessary in future.

Criteria are also recommended for other materials and objects which may have radioactive surface contamination. These materials may be commingled with LLRW and contaminated soil and may also occur in structures that remain in current use. These criteria correspond with the generic criteria recommended by Health Canada for similar materials, and are based on protection against annual doses in excess of  $0.3 \text{ mSv}$  in an individual that may be exposed to these materials.

This document represents the culmination of the cooperative efforts of the Low-Level Radioactive Waste Management Office (LLRWMO), the Municipalities of Clarington and Port Hope, members of the public, the Ontario Ministry of the Environment, Natural Resources Canada, Health Canada, and the Canadian Nuclear Safety Commission, and was supported by the assistance of many other provincial and federal agencies.