Ministry of the Environment, Conservation and Parks
Drinking Water and Environmental Compliance Division
West Central Region
Niagara District Office

Ministère de l'Environnement de la Protection de la nature et des Parcs
Division de la conformité en matière d'eau potable et d'environnement
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August 10, 2018

Mrs. Maria Bellantino Perco
Senior Specialist, Environment
Vale, Port Colborne Refinery
187 Davis Street, Box 250
Port Colborne, On L3K 5V2
E-Mail: Maria.BellantinoPerco@vale.com

Dear Mrs. Bellantino Perco:

Please find attached the ministry's comments from the review of the document, "*A Proposed Framework for the Port Colborne Community Based Action Plan (PCCAP)*", prepared by Vale dated March 2017. There were no changes made to the draft versions previously provided to you and the Regional Municipality of Niagara's Public Health Unit.

The ministry agrees in concept to the proposed PCCAP and I ask that Vale proceed with scheduling consultation with the municipality and stakeholders to obtain additional feedback for consideration along with the ministry's comments while finalizing the action plan details.

The ministry will be happy to attend the consultation meetings and we look forward to reviewing the finalized plan.

Sincerely,

Kim Groombridge
District Manager, Niagara District

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MEMORANDUM

August 10, 2018

TO: **Kim Groombridge**
District Manager
Niagara District Office, West Central Region

CC: **Linda Gabriele, Issues Project Coordinator, Niagara District**

FROM: **Greg Washuta, P. Eng., M. Eng., F.E.C.**
District Engineer
Niagara District Office, West Central Region

RE: **Review of Vale's Community Based Action Plan dated March 2017**

I have reviewed the following report:

- *"A Proposed Framework for the Port Colborne Community Based Action Plan (PCCAP)",* prepared by Vale, dated March 2017.

I am delighted to provide the following comments.

1. Page 3 – Vale has indicated that there were historical emissions of nickel, copper and cobalt. However, the Port Colborne Community Based Risk Assessment 2014 Update Report indicates that Vale accepts accountability for the contamination of soil with nickel, copper, cobalt and arsenic. Therefore, arsenic should be included in the statement regarding historical emissions.

2. Table 4, Prior to talking to the public, clarification on the bracketed numbers in the table will be required.

3. On page 12, various Risk Management Measures (RMMs) are proposed including the following:
   - Establishment of vegetation on bare soil areas;

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- an "*engineered permanent barrier*" in high foot traffic areas that would be used predominantly by children;
- top soil and the application of a vegetative cover;
- indoor air cleaning activities; and
- removal of soil to a depth of 30 cm.

As part of the public consultation process during the plan development and refinement, additional details on each of the above RMMs will need to be supplied.

Furthermore, Vale should be aware that some type of monitoring program of the RMMs will need to be implemented in order to validate that the RMM is performing as desired.

4. Page 15, Section 2.2.1 – With regards to woodlots, there will need to be a registration on title with a restriction on residential development so that nickel contaminated areas are remediated prior to residential development being established, if applicable.

5. The action plan does not address ornamental trees and shrubs that may be grown by residents and methods that residents can take to ensure that they grow effectively.

6. For sites that are subject to the requirements of Ontario Regulation 153/04, this has not been addressed. Consideration should be given to having discussions with the development community about this issue.

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August 10, 2018

MEMORANDUM

TO: Kim Groombridge, District Manager, Niagara District Office

FROM: Paul Welsh, Research Scientist, Ecological Standards Section, SDB
James Gilmore, Coordinator of Air Standards and Risk Assessment, Human Toxicology and Air Standards Section, SDB
Andrew McDonough, Terrestrial Effects Scientist, Terrestrial Assessment and Field Services Unit, Environmental Monitoring and Reporting Branch (EMRB)

CC: Craig Kinch, Manager, Ecological Standards Section, SDB
Julie Schroeder, Manager, Human Toxicology and Air Standards Section, SDB
Chris Charron, Manager Air Quality Monitoring and Transboundary Air Sciences Section, EMRB
Aaron Todd, Supervisor, Terrestrial Assessment and Field Services Unit, EMRB
Linda Gabriele, Senior Environmental Officer, Niagara District Office
Greg Washuta, District Engineer, Niagara District Office

RE: Port Colborne Community Based Risk Assessment Action Plan Proposed by Vale

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As requested, we have reviewed the most recent submissions from Vale Canada Limited (Vale) on the Port Colborne Community Based Risk Assessment (CBRA) and the proposed Port Colborne CBRA Action Plan. Specifically, we reviewed the following:

- A Proposed Framework for the Port Colborne Community-Based Action Plan (Action Plan) prepared by Vale dated March 2017.
- "Port Colborne CBRA Update Report Response to MOECC Comments" prepared by Vale dated May 11, 2017.
- Email dated July 13, 2017 that provides Vale's responses to select comments on a previous ministry memo titled "Comments on Vale's Responses to Previous MOECC Comments on the Port Colborne Community Based Risk Assessment" (original memo dated May 19, 2016).

The purpose of this memorandum is to provide review comments on Vale's Action Plan, focusing on the underlying science, to ensure potential human health and environmental risks are identified and addressed. We also identify additional concerns that should be incorporated in the next version of this Action Plan arising from previous ministry comments on Vale's CBRA reports. As noted by Vale, this proposed Action Plan was developed based on the results of the CBRA and feedback provided by the ministry. Part of ministry feedback included discussions regarding outstanding ministry concerns with all three CBRA reports (Crops, Natural Environment, and Human Health Risk Assessments) and with the CBRA Update Report. In this memorandum, we do not repeat these concerns as the ministry's science position has already been clearly articulated in our previous comments on these CBRA reports (location of ministry comments and Vale's responses provided below)[1]. Overall, the ministry agrees with Vale that risks to the natural environment and crops are present in soils with elevated Ni concentrations in Port Colborne, although they likely occur at lower soil Ni concentrations than the proposed Site Specific Soil Thresholds (SSTL) reported in the CBRA. However, the ministry does not agree with Vale that there are no potential human health risks associated with elevated Ni in soil (especially at the extremely high estimate of 48,000 mg/kg Ni proposed by Vale for fill soils for the Rodney Street Community).

As with previous ministry comments, the focus of our review is on Ni since it is the most significantly elevated metal above background levels and the main metal of concern for this community. We support risk management measures based on reducing Ni exposure and risks to the toddler as these measures should also be protective of other age categories and exposure scenarios[2]. In addition, our comments typically focus on fill soil for proposed actions associated with reducing human health risks whereas comments related to the natural environment or crops typically focus on organic and clay soils.

Overall, this memorandum is organized as follows:

- Section 1: Comments on Vale's Proposed Port Colborne CBRA Action Plan
- Section 2: Outstanding Ministry Concerns That Are Not Addressed in Vale's Action Plan

Section 1 - Comments on Vale's Proposed Port Colborne CBRA Action Plan

It is our understanding that the primary goal of this Action Plan is to propose specific risk management measures to reduce toddlers' Ni exposure to Ni contaminated soil in the Port Colborne community and that other risk management measures to address other concerns will be incorporated in subsequent versions of this plan.

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[1] Stantec Consulting Ltd. Port Colborne Community Based Risk Assessment 2014 Update Report. September 12, 2014

- Appendix 1A provides ministry review comments on the previous CBRA reports in a memorandum titled "Ministry Comments on Vale Port Colborne Community Based Risk Assessment" dated May 11, 2011.
- Appendix 3A provides Vale's responses to ministry comments on the Human Health Risk Assessment component of the CBRA.
- Appendix 4A provides Vale's responses to ministry comments on the Natural Environment Risk Assessment component of the CBRA.
- Appendix 5A provides Vale's responses to ministry comments on the Crops Risk Assessment component of the CBRA.

Ministry memorandum dated May 17, 2016 titled "Review Comments on the Revised Port Colborne Community Based Risk Assessment". Responses from Vale provided in "Port Colborne CBRA Update Report Response to MOECC Comments" dated May 11 2017.

Ministry memorandum dated May 19, 2016 titled "Comments on Vale's Responses to previous MOECC comments on the Port Colborne Community Based Risk Assessment". Responses to select comments provided by Vale in an email from Mrs. Maria Bellantino Perco (Superintendent, Environmental and Occupational Health Department, Vale) dated July 13, 2017.

[2] Potential health risks from Ni exposure are lower for adults and pregnant females than for toddlers since background dietary Ni exposure is much lower for adults (approximately 4 μg/kg-bw/day) than for toddlers (approximately 11 μg/kg-bw/day) (Health Canada Total Diet Survey, 2000-2007), and both incidental soil ingestion and Ni absorption across the gastrointestinal tract is lower for adults than toddlers.

Section 1.1 - Proposed Actions to Address Risks to Human Health

To address concerns with Ni exposure to the toddler, Vale has developed a series of Ni soil concentration thresholds (referred to as concentration bands) for fill, clay and organic soils in Port Colborne. Our comments focus on fill soils but apply to all three types of soil.

Overall, we support the concept of using a tiered framework to identify various risk management actions to reduce exposure and risks to toddlers living in the Port Colborne community. This approach results in a graded risk management response where higher concentration bands require more intense risk management measures to limit soil exposure. Ideally, the goal should be to reduce Ni exposure so that after risk management measures are implemented, the soil exposure will be at or below the proposed Ni concentration associated with the first concentration band (e.g., the Risk Based Screening Concentration (RBSC) of 1,800 mg/kg for fill soil).

For the human health aspects of this Action Plan, the focus of our review was to:

- evaluate the scientific rationale used to determine the proposed soil Ni RBSC and the other soil Ni concentration bands.
- determine the percent increase in exposure over background exposure at these Ni concentrations.
- determine the potential risk to toddlers associated with these Ni concentrations.

For fill soils, Vale has calculated the first concentration band of 1,800 mg/kg Ni based on an approach consistent with a method suggested by the ministry[3]. This threshold is much lower than the proposed RBSC for fill soil in the CBRA as it was developed using input parameters that address several ministry concerns with the current CBRA. Vale also proposed additional Ni concentration bands to represent increasing amounts of Ni exposure from soil by varying the estimated soil ingestion rate between 110, 155, and 200 mg/day. These concentration bands were derived using a Ni oral Toxicity Reference Value (TRV) that is not supported by the ministry. Instead of revisiting the Ni oral TRV, Vale is encouraged to estimate these concentration bands as a function of the variability in the background Ni exposure from the Canadian Total Dietary Survey. For example, between 2000 and 2007, the estimated Ni exposure from this survey was 11.14 ± 4.28 µg/kg-bw/day.

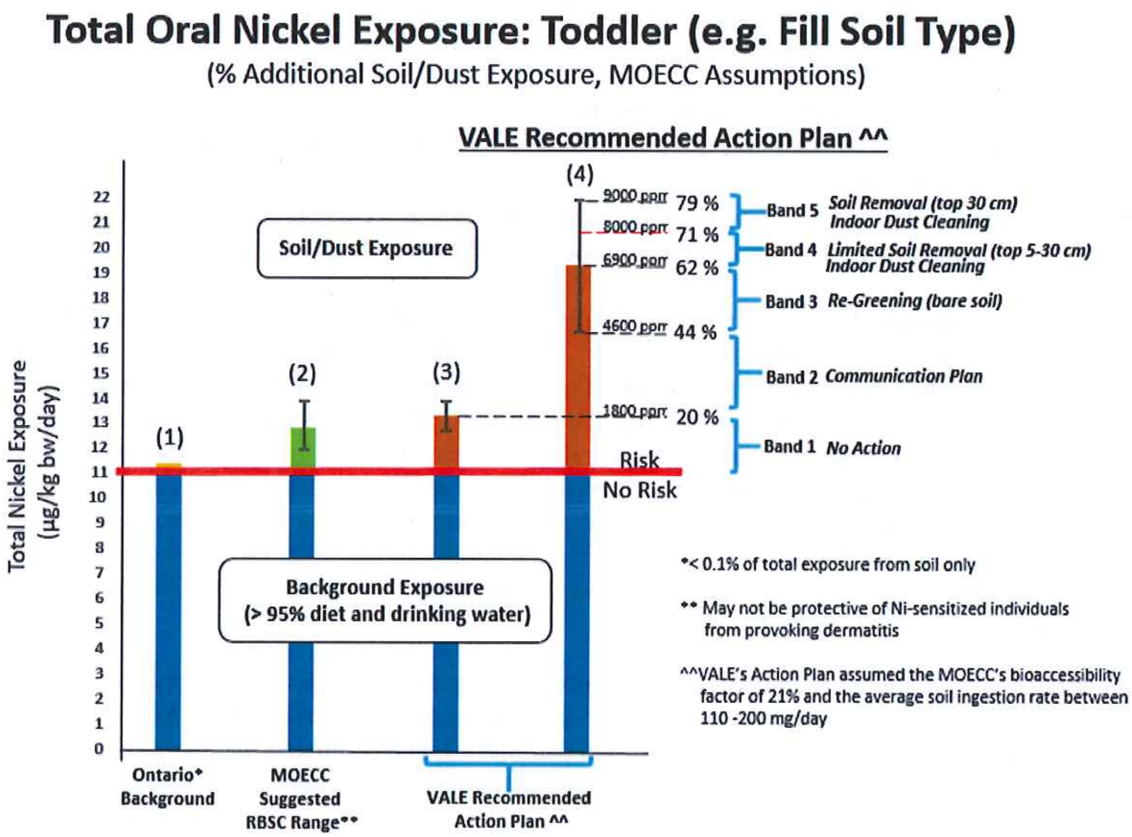
Regardless of the fact that the scientific rationale underpinning these additional Ni concentration bands is not supported by the ministry, we calculated the net increase in exposure (above total background exposure) using ministry preferred assumptions and parameters, and estimated the potential risk associated with these soil Ni concentrations by comparing estimated exposure to the ministry's recommended TRV.

[3] Only summary information has been provided by Vale in this Action Plan of the suggested ministry approach (see Table 1a and 1b of the Action Plan); additional information on this approach is provided in Attachment #1 of this memorandum.

MOECC Figure 1 summarizes the different exposure scenarios by plotting total Ni exposure (in µg/kg-bw/day) under 4 different scenarios:

- Typical Ontario background exposure.
- MOECC suggested RBSC range.
- Estimated exposure using Vale's proposed RBSC.
- Estimated exposure using Vale's proposed Ni concentration bands with different soil ingestion rates.

MOECC Figure 1



As can be seen, total Ni exposure under background exposures (primarily due to Ni in diet) is equal to the current risk threshold of 11 µg/kg-bw/day (blue bars). When background exposure equals or exceeds a risk threshold, then a risk management approach is needed to reduce exposure levels to a reasonably acceptable risk range. This approach is used when a health protective limit for soil preventing the exceedance of a health based benchmark (i.e. the TRV) is not possible.

In Ontario, typical soil conditions (Ni < 82 ppm) represent less than 0.1% of total Ni exposure (1) and this was used for context in establishing the MOECC suggested RBSC range. For fill soils, the ministry estimated a suggested range of RBSCs to reflect a reasonably acceptable risk range as part of a risk management approach. The derivation of these values is provided in Attachment #1 and summarized in Tables 1a and 1b of Vale's Action Plan. The average RBSC from this range represents a 15% increase in exposure (2). Vale has proposed a RBSC of 1,800 mg/kg, which falls within the range of these potential

RBSCs, and represents a 20% increase in exposure (3). The total Ni exposure predicted at the Ni soil concentration bands for fill soil proposed by Vale range from 44% to 79% over background exposures (4).

Using ministry recommended parameters, the predicted risk at these exposure estimates, based on hazard quotients[4] (HQ), is 1.2 at Vale's proposed RBSC and ranges between 1.4 and 1.8 at Vale's proposed concentration bands. A hazard quotient greater than 1.0 indicates a potential risk to toddlers from elevated Ni in soils in Port Colborne. Specifically, the estimated exposure and risk for each concentration band for fill soils is as follows:

- Concentration Band 1: Ni ≤ 1,800 mg/kg. This concentration band represents up to a 20% increase over background exposures and was calculated using input parameters that address ministry concerns with the CBRA (see Attachment #1).

- Concentration Band 2: Ni > 1,800 mg/kg but ≤ 4,600 mg/kg. This concentration band represents between 20 and 44% increase in total exposure (HQ ranges from 1.2 to 1.4). Vale has proposed a communication plan for any property with soil Ni concentrations exceeding 1,800 ppm. However, they were unable to provide evidence in their Action Plan that public health communication plans that promote individual efforts to reduce exposure are effective as a long term or demonstrable solution to reduce exposure to contaminated soils.

- Concentration Band 3: Ni > 4,600 mg/kg but ≤ 6,900 mg/kg. This concentration band represents between 44 and 62% increase in total exposure (HQ ranges from 1.4 to 1.6). In addition to the communication plan, Vale has proposed a re-greening of bare native soil if soil Ni concentrations exceed 4,600 mg/kg. As with public health communication plans, Vale was unable to provide evidence in their Action Plan that re-greening is effective as a long term or demonstrable solution to reduce exposure to contaminated soils.

- Concentration Band 4: Ni > 6,900 mg/kg but ≤ 8,000 mg/kg. This concentration band represents between 62 and 71% increase in total exposure (HQ ranges from 1.6 to 1.7). In addition to the communication plan and re-greening, Vale has proposed limited soil removal (within top 5-30 cm) and possible removal and cleaning of in-house dust.

- Concentration Band 5: ≥ 8,000 mg/kg. This concentration band represents a 71% increase in background exposure with a HQ of 1.7. Vale has proposed full soil removal (30 cm) for any soil that exceeds 8,000 mg/kg consistent with the previous limit where full soil removal was undertaken.

Finally, we support the proposed woodlot study to examine human interactions with the woodlot (to determine if fencing is required to limit access) and/or if registration on title is required. Ni concentrations in the woodlots can be as high as 33,000 mg/kg and evaluating a trespasser scenario and other potential human interactions is appropriate.

[4] Hazard Quotient = predicted Exposure divided by the Toxicity Reference Value

Section 1.2 - Proposed Actions to Address Risks to Crops

Vale has identified several risk management measures that could be considered to reduce the risk associated with elevated Ni exposure to terrestrial plants used in local agriculture. These include adding lime, phytoremediation with *Alyssum*, and deep tilling. These remediation options, and the results of ongoing research conducted by the University of Guelph under Dr. Beverly Hale, were discussed at a recent meeting between Vale, the ministry, and other stakeholders on Oct 26, 2017.

In Section 2.3 of the Action Plan, Vale highlights that the ministry continues to have concerns with the proposed SSTL for the Crops ERA but Vale does not provide an alternative SSTL. Attachment #2 of this memorandum provides a weight of evidence analysis conducted by the ministry using the site-specific crops toxicity data summarized in the CBRA Update report. This weight of evidence analysis is provided to allow Vale to develop a revised SSTL for crops that addresses ministry concerns with the CBRA. All agricultural lands that exceed the SSTL need to be identified in order to determine where, and what type of remediation is required.

Since the results of some of the remediation studies are still ongoing, our comments focus on the specific actions recommended by Vale in Section 2.3.1 of this Action Plan.

- Additional information on the results of liming at the 3 levels evaluated in Port Colborne soils (i.e., 10, 50 and 80 tonnes per hectare) should be provided in this Action Plan. While not a permanent solution (since Ni remains in the soil), liming should continue to be considered as a suitable remediation option since it is effective at reducing Ni bioavailability to crop species and it is already done in the area as part of normal agricultural practices.

- Additional information should be added to this Action Plan to support the concern expressed by Vale that Alyssum could become an invasive weed (a problem in the Pacific southwest but unclear if a problem in Port Colborne) and that phytoremediation would not be effective within a "reasonable time period".

- Deep tilling to a depth of 30 cm would need to be evaluated based on the type of soil as mixing upper layers of fertile soil with deeper layers of clay/unfertile soil is not recommended as a preferred remediation option. However, this approach may be acceptable for organic soils. The overall effect of deep tilling would be to dilute the contaminated upper layer of soil (e.g., the top 15 cm) with the uncontaminated deeper layer of soil (15-30cm). While this approach does not remove the Ni from the soil, it would result in a net reduction in the amount of Ni available for uptake by the plants (assuming their root systems are concentrated in the upper soil layer).

- Another remediation option that could be considered is to remove soils from specific areas if discrete hotspots of contamination are identified. A soil threshold to identify hotspots would need to be developed by Vale if this approach was considered as part of this Action Plan.

- Note: Agricultural activities that contribute to soil/dust re-entrainment should be considered in light of potential inhalation health risks.

Section 1.3 - Proposed Actions to Address Risks to the Natural Environment

Vale has not identified any risk management measures to reduce the risk associated with elevated Ni exposure to terrestrial plants and to aquatic and terrestrial organisms that reside in the Port Colborne area. Instead, future studies have been proposed for the aquatic environment (specifically the Wignell and Beaverdams drains) and for the woodlot areas (e.g., the Reuter Road woodlot).

In Section 2.2 of the Action Plan, Vale highlights that the ministry continues to have concerns with the proposed SSTL for the Natural Environment ERA but Vale does not provide an alternative SSTL. As noted above, Attachment #2 of this memorandum provides a weight of evidence analysis conducted by the ministry using the site-specific crops toxicity data to allow Vale to develop a revised SSTL for crops that addresses ministry concerns with the CBRA. This dataset can also be used to develop an alternative SSTL for the natural environment (see Attachment #3). All non-agricultural lands that exceed the SSTL (woodlots, non-agricultural fields, and residential areas) need to be identified in order to determine where, and what type of remediation is required.

Our comments on the risk management measures for the natural environment are limited to the two studies proposed by Vale.

- Vale has proposed conducting a survey of the aquatic environment focusing on better characterizing the risks from elevated Ni levels in municipal drains east of the refinery. The proposed study should consider surface water and sediment as both could be impacted by elevated Ni from Ni contaminated soils (e.g., via erosion of soil or from leaching of Ni from soil to groundwater and then discharge into surface water). However, the proposed study focuses only on the Wignell and Beaverdam Drains due to concern of elevated total Ni in surface water. This study needs to be expanded to address vernal ponds and ditches as they represent critical habitat for amphibians and concentrations of Ni were measured at much higher concentrations (within the primary study area) than measured in the agricultural drains (see Appendix B, Tables B3 and B4 of the CBRA Update Report).
- Vale has also proposed further study in the woodlot areas to identify more sophisticated risk management options (versus simply removing the contaminated soil and destroying the woodlot in the process). Limited information is provided in this Action Plan on what the woodlot study would entail and if it would include other contaminated woodlots in addition to the Reuter's road woodlot. However, Vale has indicated this study will include an assessment of the herbaceous plant community (see footnote #1, email from Vale dated July 13, 2017). We support evaluating selective silviculture and/or hot-spot clean-up of the woodlots to determine if they could be an effective remediation option. However, an upper soil threshold to identify hotspots would need to be developed by Vale if this approach was considered as part of this Action Plan.
- Vale also identifies that one potential remediation option for the contaminated woodlots is to do nothing recognizing that while impairment due to elevated Ni is occurring, "the woodlots appear to be more or less normal to those without specialized knowledge of ecological processes". This approach would not address the elevated Ni in soil and it is unclear how long it would take for these woodlots to naturally recover (if at all). This approach could be considered as long as current environmental risks are acceptable. An upper soil threshold for where this remediation option could be considered would also need to be developed; possibly based on a Modified Ecological Protection approach (as proposed in the CBRA Update Report) but developed to ensure that potential risks to terrestrial vegetation, soil invertebrates, amphibians, mammals and birds are acceptable.

Section 2: Outstanding Ministry Concerns That Are Not Addressed in Vale's Action Plan

There are several comments that the ministry provided on the various CBRA reports that are not currently addressed in Vale's proposed Action Plan. Several of these outstanding ministry concerns have implications for subsequent risk management measures.

Section 2.1 - Additional Actions to Address Risks to Human Health

Vale has not proposed any risk management measures to address several exposure pathways or sensitive receptors. Additional actions that need to be incorporated into this Action Plan include measures to address:

- Elevated Ni in garden produce grown on Ni contaminated soils (results from the CBRA clearly demonstrate elevated Ni in garden produce grown in soils with average soil Ni concentrations between 353 and 705 mg/kg).
- Lack of current information on Ni concentrations in soils in residential areas and for soils around schools, playgrounds, daycares and other playground areas that toddler-aged children frequent.
- Provocation of dermatitis in Ni sensitized individuals, through either oral exposure or direct contact.
- Ni exposure to a pica child.
- Ni exposure associated with agricultural, as well as remediation and other activities, which could result in soil and/or dust re-entrainment and subsequent soil and/or dust inhalation. Note: Ni in soil when re-entrained can be an acute inhalation risk as well as contribute to a potential chronic increase in cancer risk.
- Measures to block off-site transport of Ni from Vale's industrial lands.

Section 2.2 - Additional Actions to Address Risks to Crops

Vale has proposed several risk management measures to address ministry concerns. Additional actions that need to be incorporated into this Action Plan include measures to address:

- Lack of current information on Ni concentrations in soils for all potentially impacted agricultural fields.

Section 2.3 - Additional Actions to Address Risks to the Natural Environment

Vale has not provided any risk management measures to address potential environmental risks for other types of contaminated natural lands (e.g., non-agricultural fields and for residential properties). The fact that the human influenced environment was not part of the CBRA does not mean that risk management measures are not needed to address potential impacts to terrestrial vegetation on residential properties that exceed the SSTL.

Additional actions that need to be incorporated into this Action Plan include measures to address:

- Lack of current information on Ni concentrations in all potentially impacted woodlot soils and non-agricultural fields. As noted in ministry comments on the CBRA, some non-agricultural fields and woodlots do not have enough data to properly characterize the soils and will need additional confirmatory sampling.

- Potential for tree diseases to dramatically alter the composition of these woodlots.

- Potential risks to sheep and other ungulates due to elevated Cu in soil. Note: risks were identified for sheep but no SSTL was proposed and risks were calculated in the CBRA Update report using the Modified Ecological Protection Option only.

- Biodiversity offsetting or other improvements elsewhere in the Port Colborne area to compensate for the adverse impacts in woodlots (especially if proposed remediation options may result in more environmental harm than benefit). For example, specific actions could be provided that will protect the habitat and existing population of the Fowler's Toad.

Attachment #1 - Details on Suggested Ministry Approach to Derive RBSCs

Vale has calculated revised risk based soil concentrations (RBSCs) for Ni in Port Colborne soils based on an approach suggested by the Ministry (Table 2 of Vale's Action Plan). Based on predicted risks to the toddler, the proposed soil Ni concentration for Concentration Band #1 is 1,800 mg/kg for fill soil, 2,500 mg/kg for clay soil, and 1,200 mg/kg for organic soil. These soil Ni concentrations proposed by Vale fall within the upper range of soil Ni concentrations estimated by the ministry to be a reasonable estimate of an appropriate RBSC. While summary information has been provided by Vale on the suggested ministry approach in this Action Plan (see Tables 1a and 1b), in this attachment, we provide some additional rationale supporting the parameter values used to estimate exposure and toxicity.

Consistent with the approach taken by Stantec (2014) in the CBRA Update Report, the overall approach taken by the ministry to estimate an acceptable RBSC included both direct exposure to Ni contaminated soil as well as indirect exposure to Ni contaminated soil-dependent dust. The estimated RBSCs derived using this approach are similar to the values presented in Table 1a of Vale's Action Plan. Specifically, the ministry incorporated:

- a 10 and 20% allocation of the Toxicity Reference Value (TRV) to represent a lower and upper bound exposure limit as part of a risk management approach.
- a range of incidental soil and dust ingestion rates (from 110 to 200 mg/day) for the toddler.
- an estimated ratio of outdoor soil to indoor dust as a function of total Ni concentrations in soil.
- Ni bioaccessibility estimates of 21, 15, or 32% for fill, clay and organic soil types respectively.

Given the state of current risk assessment models/risk assessment science and the variability and uncertainties in the background Ni exposure estimates, the Ni TRV, and exposure parameters used in this CBRA, the ministry was unable to determine a point estimate as a preferred RBSC. Instead, we identified a range of acceptable RBSCs as part of a risk management approach that could be considered by Vale instead of the proposed RBSC in the CBRA. Though RBSCs have been developed based on a consideration of adverse effects for the toddlers, there is also the recognition that some individuals who have Ni sensitivities may not be fully protected at these RBSCs.

The ministry has identified several parameters that are important for estimating these RBSC. These included the oral Ni TRV, the estimate for bioaccessibility/bioavailability, the ratio for outdoor soil to indoor dust, the soil ingestion rate for the toddler, and the background exposure estimate (essentially all from diet). The following summarizes these key parameters. For a more detailed discussion, see Appendixes A through E in the ministry's comments on the updated CBRA report[5].

Nickel Toxicity Reference Value: Based on current up-to-date scientific information (CCME 2015, EFSA 2015), the ministry has identified that the most appropriate TRV for evaluating oral exposure to Ni is 11 µg/kg-bw/day for the toddler. A TRV is the benchmark used in risk assessment as an indicator of the maximum acceptable daily dose to which a person may be exposed without adverse effects. The oral Ni TRV of 20 µg/kg-bw/day used by Vale in the CBRA and to calculate the Ni Concentration Bands in this Action Plan is based on adverse changes in body weight and organ weight observed in exposed test animals (rodents). The TRV of 20 µg/kg-bw/day was originally supported by the ministry. However, based on the most up-to-date scientific information, changes in weight are no longer the most sensitive endpoint to use in assessing oral Ni exposure. Instead, the MOECC supports a TRV of 11 µg/kg-bw/day based on adverse reproductive and developmental effects observed in rodents. This TRV is appropriate

[5] Ministry memorandum provided to Vale dated May 17, 2016 titled "Review Comments on the Revised Port Colborne Community Based Risk Assessment". Responses from Vale provided in "Port Colborne CBRA Update Report Response to MOECC Comments" dated May 11 2017.

for the protection of Ni-associated reproductive and developmental adverse effects including the potential toxicity of Ni in developing male reproductive organs. However, this TRV may not be fully protective of Ni-sensitized individuals from dermatitis. Finally, this TRV of 11 µg/kg-bw/day is supported by Health Canada (2010), the World Health Organization (WHO, 2007) and the Office of the Environmental Health Hazard Assessment, California Environmental Protection Agency (OEHHA, 2012) and the analysis by the European Food and Safety Authority (EFSA , 2015). It represents the most up-to-date value to use in risk assessment as an indicator of the maximum acceptable daily dose to which a person may be exposed without adverse effects. Vale did not use this TRV in their Action Plan to estimate the Ni Concentration Bands.

Bioavailability/Bioaccessibility of Ni: In general, the ministry recognizes that not all Ni in soil in Port Colborne is biologically available. That is, if a person consumes soil containing Ni, not all the Ni would be available for absorption from the soil in the gastrointestinal tract (i.e., bioaccessible) and the resulting absorption of Ni into the bloodstream would be less than 100% (i.e., bioavailable). However, the ministry believes that the estimates used in the CBRA are too low and underestimate Ni exposure from soil and the risk resulting from incidental ingestion. Instead of using the *in-vivo* bioaccessibility estimates developed with experiments with rats (as done in the CBRA), the ministry supports using the *in-vitro* estimates developed with experiments that mimic the conditions of the human gastrointestinal tract. The ministry reviewed the Ni *in-vitro* bioaccessibility estimates made for the three soil types: fill, clay and organic soil, and recalculated the Ni bioaccessibility using all of the fill data (including the 2002 Exponent data for the fill soil that was omitted by Stantec) and using the 95th upper confidence limit of the mean (95th UCLM) rather than the mean. Based on the ministry's recalculations, the estimated bioaccessibility of Ni is 21% in fill soil, 15% in clay soil, and 32% in organic soil. These bioaccessibility estimates were used by Vale in their Action Plan to estimate the Ni Concentration Bands.

Outdoor Soil to Indoor Dust Ratio for Ni Exposure: Based on a limited number of samples, the ratio between Ni in indoor dust and Ni in soil was estimated in this CBRA to be 0.2 (i.e., dust contains 20% of the total Ni that is found in soil from the Port Colborne community). This ratio was used in the CBRA to estimate the Ni concentration of indoor dust from measured Ni concentrations in soil. The ministry agrees that given the uncertainty associated with the limited data available, a ratio of 0.2 is an acceptable qualitative value for characterizing soil with Ni concentrations greater than 2,000 mg/kg. However, the ministry calculated a ratio of Ni in indoor dust to Ni in outdoor soil of 0.56 for Ni concentrations < 2,000 mg/kg using a modified dataset of the CBRA's dust and soil data. Vale used a ratio of 0.56 in their Action Plan to estimate the Ni Concentration Bands.

Ni Soil Ingestion Rate (SIR) for the Toddler: The incidental SIR is the key exposure assumption used in the CBRA in estimating the combined soil and dust pathways. The ministry agrees with the alternative incidental SIR of 110 mg/day for the toddler receptor (as used in the CBRA) but notes that this is considered by the MOECC as a Central Tendency Exposure estimate in the calculation of exposure from the soil and dust pathways. The ministry also considered a SIR of 200 mg/day as a Reasonable Maximum Exposure estimate. A SIR of 200 mg/day is also used as an upper bound estimate for residential child soil ingestion rate for Superfund sites in the U.S. (OSWER Directive 9200.1-120; 2014). As the SIR does not distinguish between soil and dust, the ministry assumed for a 45:55 ratio (soil to dust) as done in the US EPA's Integrated Exposure and Uptake Biokinetic (IEUBK) model for estimating lead exposure in children (US EPA, 2002). In addition, as done in the CBRA, the soil pathway was also pro-rated for winter snow cover, where exposure to soil outdoors is considered to be negligible or zero. Both 110 and 200 mg/kg were used by the ministry. Vale used a SIR of 110, 155, and 200 in their Action Plan to estimate the Ni Concentration Bands.

Background Nickel Exposures from Diet: The ministry recognizes that dietary sources of Ni is a major contributor to the baseline or background Ni exposure and recent findings from CCME (2015) and other regulatory sources have determined that dietary exposure alone may approach or exceed the recommended total daily intake of Ni from all sources. However, the ministry also acknowledges that there is variability and uncertainty associated with these estimates. As such, dietary estimates based on larger sampling of food such as the Health Canada Total Diet Survey are considered to be more reliable than the relatively limited information on Ni concentrations in garden produce and supermarket foods that were developed for evaluating dietary Ni exposure in the CBRA. Supermarket exposure should be similar throughout Canada and given that the available data from the CBRA update report clearly indicate that Ni is elevated in local garden produce (i.e., locally grown fruits and vegetables), dietary exposure to residents of Port Colborne should be higher than the Canadian average; not lower as indicated in the CBRA. The overall average Health Canada estimated dietary exposure of Ni in food is 183.4 µg Ni/day or 11.14 µg/kg-bw/day for the toddler based on the 2000-2007 surveys (CCME 2015, Appendix 9). Vale also used a background Ni exposure of 11.14 µg/kg-bw/day for the toddler in their Action Plan to estimate the Ni Concentration Bands.

Absence additional site-specific information, the ministry used the Canadian average estimate of 11.14 µg/kg-bw/day developed by CCME, based on Health Canada Total Diet Survey (2000-2007) of total dietary intake, for the toddler resident in the CBRA and in calculation of the RBSC. While the CCME's (2015) total dietary estimate does not consider the contribution of Ni from local produce, MOECC considers it to be an upper bound estimate of the mean for the following reason: CCME calculated the average Ni concentrations in food by including non-detect samples at the method detection limit concentration instead of using ½ of the detection limit as was done in the CBRA and as recommended by the Country Foods Guidance of Health Canada (2010)[6]. The ministry recognises that there is some uncertainty with this approach as it assumes that the contribution of Ni from local produce may be accounted for if the total dietary Ni exposure based on Health Canada Total Diet Survey (2000-2007) of total dietary intake is an upper bound estimate of the mean instead of the average estimate.

Range of Allocation Factors: Allocation Factors (also referred to as Source Allocation Factors; SAFs) are applied to TRVs and used to account for concurrent exposures via other media. The range of RBSCs considered by the ministry to be *reasonably acceptable* is based on a 10 to 20% allocation of the TRV (or background exposure since the TRV and background are equivalent for Ni). This range is considered to represent a lower and upper bound estimate of acceptable RBSCs and translates to an incremental Hazard Quotient (HQ) of 0.1 to 0.2; an expression of the ratio of potential exposure of Ni to the level at which no adverse effects are expected. Note: the incremental HQ would be added to the background HQ to determine overall risk (i.e., the total HQ would be 1.1 or 1.2 as the background HQ is 1.0).

The rationale for considering 10 or 20% allocation is as follows:

- 10% allocation of the estimated background exposure is similar to the approach used by CCME (2015) to establish soil criteria when the background exposures are within 90%, or when background exposures exceed the TRV.
- 20% allocation of the estimated background exposure follows the approach used in Ontario for developing health based soil criteria or Site Condition Standards. This approach assumes that one-fifth of the TRV (i.e., 20%) can be allocated to soil exposures, while assuming that exposures to other media (e.g. diet, drinking water, inhalation, and consumer products) can contribute up to

[6] The importance of how samples with Ni concentration below detection limits are treated can be illustrated by the analysis conducted by EFSA (2015, Table 9). They found that the estimated median exposure from Ni in diet for the toddler can range between 7.4 to 10.3 µg/kg-bw/day (a difference of 2.9 µg/kg-bw/day), depending on if samples below detection limits were treated as zero or as the detection limit.

80% of the TRV.

- 10 to 20% allocation range falls within the variability in the background dietary exposure estimates from the Canadian Total Dietary Survey (2000 and 2007).

Additional details supporting the use of 10 and 20% allocation is provided below:

- The Canadian Council of Minister of the Environment (CCME) protocol for determining Canadian Soil Quality Guidelines refers to background exposure as the Estimated Daily Intake (EDI) and the TRV as the Total Daily Intake (TDI). Typically, CCME allocates 20% of the residual exposure (i.e., the TDI minus the EDI times 0.2) then adds back the background soil concentration to the calculated soil concentration to derive the soil quality guideline. For Ni, CCME (2015) developed a human health based soil Ni criterion of 200 mg/kg (for residential /parkland use) based on 10% of the EDI. This guideline was developed recognizing that background Ni exposures for the toddler receptor was within 90% of the TRV. The approach used by CCME also recognized that a 10% increase in the EDI was equivalent to the variability observed in the data from various studies measuring Ni in diet. As a consequence, CCME concluded that a 10% increase in exposure does not represent a biologically significant increase in exposure. Previously, in situations when non-soil exposures to a contaminant exceed a TRV, CCME (2006) have either considered not setting a soil quality criteria or setting it to be the background soil concentration. Typically background soil levels are determined based on soil sampling from localized area that are not influenced from anthropogenic sources of exposure. For Ni, the 98th percentile of the Ontario soil background level taken from agriculture and residential areas are 37 and 50 mg/kg respectively (MOE 2011). However, in addition to recognizing that using a soil background may not be practical or feasible, CCME recognizes that setting a soil quality guideline at background concentrations may not offer a significant reduction in health risk. As the EDI for Ni is approximately equal to the TRV for Ni, the ministry considered that allocating 10% of the TRV to the soil exposure pathway was supportable as a reasonable lower bound limit.

- The ministry has established generic health based soil criteria, under the Brownfields program (O. Reg. 153/04), typically by allocating 20% of the TRV to the soil exposure pathway. This considers that one-fifth of the TRV is allocated to the soil exposure pathway and that 80% of the TRV is allocated to exposure from other media (e.g. diet, drinking water, inhalation, and consumer products). Allocating 20% of the TRV to soil translates to a target Hazard Quotient of 0.2 for the soil pathway. Different allocation factors can be used if there is strong evidence to support allocating more (or less) of the TRV to the soil pathway. For Ni, most of the exposure comes from food and drinking water and less than 1% of the total Ni exposure comes from soil (based on the 98th percentile of the Ontario soil background level of 50 mg/kg (MOE, 2011)). Overall, the generic approach to source allocation is best applied in situations where total exposures levels are less than the TRV. As background Ni exposures are equivalent to the TRV, and background soil Ni exposures for Ontario are typically less than 1% of total Ni exposure, the ministry considers a 20% allocation of the TRV of 11 µg/kg-bw/day (or 20% of the estimated background exposure since they are equivalent) as a reasonable upper bound limit.

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Attachment #2 - Suggested Ministry Approach to Derive SSTLs for the Crops ERA and the Natural Environment ERA

As outlined in our comments on the various CBRA reports, the ministry believes the proposed SSTL's based on the 2001 greenhouse study with oats is too high to be protective of crops growing in the Port Colborne soils. To support Vale in developing an alternative SSRL, the ministry proposes the following approach which we believe are more likely to be protective of most crops grown in the Port Colborne area where accepted agricultural practices are used. This approach is based on a reanalysis of all of the site-specific crops toxicity studies that were summarized in the Update CBRA report.

The following table (MOECC Table 1) is taken from Appendix 5B-2 in the CBRA Update Report. This table lists the scientific papers used (source), the crop, the endpoint, the 25% effect concentration (EC_{25}), and the weighted EC_{25} developed by Stantec for the meta-analysis of the crop studies. As pointed out in the CBRA Update Report, Stantec calculated EC_{25} values for these studies, even though the toxicity data presented in some of these papers was not necessarily ideal for the development of EC_{25}'s. The ministry appreciates Stantec efforts in this regard and acknowledges the challenges in developing these values. The scoring system (i.e., the rating system for the papers) was developed because the ministry wanted to include data from other Port Colborne based studies in the development of SSTLs and Stantec was concerned that not all of these studies contained the depth of soil and plant information that was available in the 2001 greenhouse study. In response, the ministry agreed that the studies should be scored in some way to take into consideration the varying degrees of confidence in the data from the various studies. As noted in our review comments, although the ministry was involved in developing the scoring system and the selection of the key studies, we were not involved with the meta-analysis or how the EC_{25}'s were weighted.

It is understood that there are many ways to approach this data. Stantec selected the original CBRA SSTLs (based on PNEC values) and used the EC_{25} or weighted EC_{25} values from these other studies simply as support for their values. This means that the SSTL values proposed by Stantec do not actually incorporate data from other studies, which the ministry understood would be done. Instead, the ministry recommends a meta-analysis approach that examines all of the toxicity data, including data from the Crops Study conducted by Jacques Whitford as well as the other key studies for the Port Colborne community (summarized in MOECC Table 1). There are various ways to develop SSTLs using this approach. One method is to simply rank the data (smallest to largest EC_{25} value) using a species sensitivity type approach and select a percentile effect from the overall distribution. For example, the 25^{th} percentile results in an EC_{25} of 1,073 mg/kg nickel in soil and a weighted EC_{25} value of 965 mg/kg nickel in soil.

Another approach would be to calculate the geometric mean of the EC_{25} (or weighted EC_{25} values) and add an uncertainty factor to account for uncertainties in the underlying dataset. The ministry considers there to be uncertainty in all of the Port Colborne studies, including the 2001 greenhouse study, and believes applying an uncertainty factor is appropriate. Areas of uncertainty include:

- Data from some of the studies was not ideally suited to the development of EC_{25} values
- Limited data for a wide range of crop species. Although data from nine different crop species is included in the meta-analysis, most of the data (79%) is for only three crops (celery, lettuce and wheat)
- Toxicity can range more than an order of magnitude even within the same crop species (EC_{25}'s for celery range from 260 mg/kg nickel to 6,930 mg/kg nickel).
- The pH and nutrient status of the soils was not reported in all studies
- Endpoints were not always highly relevant to the agricultural community (e.g., reduction in biomass versus reduction in yield).

MOECC Table 1: Rating (score), calculated EC_{25} values, and weighted EC_{25} values of studies conducted to determine the effect of metal contaminated organic soils in the Port Colborne area of Ontario on agricultural crops

Source	**Crop**	**Endpoint**	**Score**	**EC_{25} (mg/kg)**	**Weighted EC_{25}[1] (mg/kg)**
Frank et al. 1982 (1980)	Celery	Top Weight	0.76	260	198
Frank et al. 1982 (1981 head)	Lettuce	Top Weight	0.76	370	281
Frank et al. 1982 (1981)	Celery	Top Weight	0.76	380	289
Frank et al. 1982	Beet To	Top and Root	0.72	410	295
Frank et al. 1982 (1980 escarole)	Lettuce	Top Weight	0.76	450	342
Bisessar 1991	Wheat	Grain Weight	0.93	970	902
Bisessar 1991	Wheat	Shoot Height	0.9	1030	927
Bisessar 1991	Wheat	Stem Weight	0.9	1050	945
Bisessar 1991	Wheat	Leaf Weight	0.9	1080	972
Bisessar 1991	Wheat	Root Weight	0.93	1320	1228
Bisessar & Palmer	Celery	Root Weight	0.86	1960	1686
Frank et al. 1982	Radish	Root Weight	0.72	1960	1411
Bisessar et al. 1983	Celery	Shoot Weight	0.69	2310	1594
JW 2001 (GH)	Oat	Shoot biomass	0.86	2400	2064
Temple & Bisessar 1981	Onion	Leaf Weight	0.69	2530	1746
Temple & Bisessar 1981	Onion	Root Weight	0.69	2960	2042
Bisessar & Palmer	Lettuce	Leaf Weight	0.86	3080	2649
Bisessar & Palmer	Celery	Stalk Weight	0.86	3230	2778
Rinne 1984	Celery	Shoot height	0.76	3380	2569
Frank et al. 1982 (1980 head)	Lettuce	Top Weight	0.76	3410	2592
JW 2000 (GH)	Soybean	Shoot biomass	0.76	3470	2637
Bisessar & Palmer	Celery	Leaf Weight	0.86	3580	3079
Temple & Bisessar 1981	Lettuce	Root Weight	0.69	3780	2608
Frank et al. 1982	Cabbage	Top Weight	0.76	4040	3070
Bisessar & Palmer	Lettuce	Root Weight	0.83	4320	3586
Temple & Bisessar 1981	Celery	Stalk Weight	0.72	4630	3334
Temple & Bisessar 1981	Lettuce	Leaf Weight	0.72	5090	3665
Bisessar et al. 1983	Celery	Shoot Height	0.66	5120	3379
Bisessar 1989	Celery	Shoot Height	0.79	5200	4108
Bisessar 1989	Celery	Shoot Weight	0.83	5250	4358
Temple & Bisessar 1981	Celery	Leaf Weight	0.69	6010	4147
Bisessar 1989	Celery	Root Weight	0.79	6930	5475
5th Percentile				**376**	**285**
25th Percentile				**1073**	**965**
50th Percentile				**3020**	**2316**
75th Percentile				**4110**	**3143**
Geometric mean				***2101***	***1644***

[1] Weighted EC_{25} = Score x EC_{25} (mg/kg)

In addition, while the use of a 25% effect concentration (EC_{25}) may be an accepted toxicity endpoint in risk assessment and applicable to ecosystems in general, it is unlikely that a farmer would accept a 25% reduction in their crops every year due to elevated Ni in the soil. Finally, the study by Frank et al., 1982, was the only study where the saleability of the crop was tested (i.e., could the crops be sold at market). In other studies where the crop yield was not given, it is not clear that the crop would be marketable at all.

Given these uncertainties, an uncertainty factor of 1 is not warranted (i.e., taking the geometric mean of the EC_{25} values as given is not supported) and an uncertainty factor of 2 is suggested. Using an uncertainty factor of 2 results in an SSTL for the muck soils as follows:

- Geometric mean of the EC_{25} is 2,101 ÷ 2 = 1,050 mg/kg.
- Geometric mean of the weighted EC_{25} values is 1,644 ÷ 2 = 822 mg/kg.

The EC_{25} values given by Stantec for sand, till clay and Welland clay soils are 1,350, 1,950 and 1,880 mg/kg nickel, respectively (Jacques Whitford, 2004). When the uncertainty factor of two (2) is applied to these EC_{25} values, the proposed SSTL values are 675 mg/kg nickel for sand, 975 mg/kg nickel for till clay and 940 mg/kg nickel for Welland clay. Although the same scoring and weighting of EC_{25} values could have been conducted on the mineral soil data as was conducted on the muck soil data, the ministry recognizes that this was not necessary since there was only one study that reported information on mineral soil in the literature and it was for only one crop (wheat) (Bisessar, 1991); apart from the Jacques Whitford studies (JW 2000 and JW 2001).

The ministry understands that Stantec proposed SSTLs are based primarily on the probable no effect concentration (PNEC) values from the 2001 greenhouse study. The ministry recognizes that Stantec and their consultant are concerned that studies conducted when the refinery was in operation may be biased because of concern that deposition of nickel and other metals on the leaves could be responsible for the toxic effects documented. Also, Stantec and their consultant have argued that the form of nickel in the soil would have been different and more toxic to plants in the 1970s compared to the 2000s. We have already provided a rebuttal to these arguments as part of our review comments on the CBRA Update report.

However, apart from JW 2000 and JW 2001, one study was conducted in 1989, well after the nickel refinery was shut in 1984 and the overwhelming majority of nickel in the soil tested in this study had had at least 30 years to equilibrate with the soil. This study (Bisessar, 1991) also had the highest score (0.90) and consequently the highest weighting of the EC_{25} values developed for the muck soil (MOECC Table 1). This study not only included plant toxicity information on agricultural muck soil but also agricultural clay soil. The ministry understands that Stantec had concerns with the pH range in soils used in this study, but the ministry does not agree since this only occurred in the most contaminated mineral soil and the pH was only slightly below the OMAFRA acceptable pH level (see MOECC Table 2). In the Bisessar (1991) study, a 22% reduction in grain weight was determined at 955 µg/g Ni in organic soil and a 31% reduction in grain weight was determined at 600 µg/g Ni in mineral soil. In the same study, phytotoxicity (longitudinal chlorosis and necrosis on the leaves) in wheat was observed at 955 µg/g in organic (muck) soil and 975 mg/kg in mineral soil (Bisessar, 1991). These concentrations are consistent with and close to the proposed SSTL's from the meta-analysis discussed previously. MOECC Table 3 summarizes these potential alternative SSTLs and includes phytotoxicity values from Bisessar 1991 (the highest scored paper on examining the toxicity of Nickel to Port Colborne crops).

MOECC Table 2: Soil pH at which Lime is Recommended for Ontario Crops

Crops	Soil pH Below Which Lime is Recommended	Target Soil pH[1]	Bisessar, 1991
Fine-textured mineral soils (clays and clay loams)			
Alfalfa, cole crops, rutabagas	6.1	6.5	
Other perennial legumes, oat, barley, wheat, triticale, soybeans, beans, peas, canola, flax, tomatoes, raspberries, all other crops not listed above or below	5.6	6	5.49 to 6.70
Corn, rye, grass hay, pasture	5.1	5.5	
Organic soils (peats and mucks)			
All field and vegetable crops	5.1	5.5	5.37 to 6.27

[1]where a crop is grown in rotation with other crops requiring a higher pH (for example, corn in rotation with wheat or alfalfa), lime the soil to the higher pH.
*soil pH below which lime is recommended and target soil pH values are from Table 9-2: Soil pH at which Lime is Recommended for Ontario Crops (OMAFRA, 2015)

MOECC Table #3: Potential Alternative SSTL's and Phytotoxicity values from Bisessar 1991.

Proposed SSTLs for Nickel (mg/kg)	Sand	Organic Muck Soil	Till (Shallow) Clay	Welland (Heavy) Clay
From Crops Report (based on PNEC/2)[1]	375	1,175	700	825
From Crops Report (based on $EC_{25}/2$)	675	1,200[2]	975	940
From Meta-Analysis (based on 25th percentile of EC_{25})	--	1073	--	--
From Meta-Analysis (based on 25th percentile of weighed EC_{25})	--	965	--	--
From Meta-Analysis (based on geometric mean $EC_{25}/2$)	--	1050	--	--
From Meta-Analysis (based on geometric mean of weighed $EC_{25}/2$)	--	822	--	--
From Bisessar 1991		955	600	

[1] From JW 2004 report: PNEC = 750 mg/kg for Sand, 2,350 mg/kg for Organic Muck Soil, 1,400 mg/kg for Till (Shallow) Clay, and 1,650 mg/kg for Welland (Heavy) Clay
[2] From Table 1 (JW2001 EC_{25} value = 2,400 mg/kg)

Based on our review comments on the CBRA Update report and this analysis, the ministry is unable to accept the SSTLs proposed by Stantec as being sufficient to protect agricultural crop species. Given the uncertainty in all of the agricultural studies that have been conducted for Port Colborne soils, it appears that an appropriate SSTL would fall between 600 and 1,200 mg/kg for organic muck, till (shallow) clay, and welland (heavy) clay soils and between 400 and 700 mg/kg for sandy soils.

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Attachment #3 - Suggested Ministry Approach to Derive SSTLs for the Natural Environment ERA

While there are a number of outstanding concerns with the ERA-NE, the ministry believes there is enough information available to complete the risk assessment for the natural environment. It is clear that a revised risk assessment that addresses remaining ministry comments (conducted under the "worse-case" scenario that examines risks in the most contaminated soils nearest to the refinery), will identify adverse impacts in the fields and woodlots close to the refinery. It also is likely that plants and soil invertebrates will be the most sensitive receptors. The risks to other organisms (e.g., amphibians, mammals and birds) still need to be quantified as that information will be important for informing risk management activities. However, proposed SSTL's based on plants and soil invertebrates will likely be acceptable and protective of these other receptors.

As discussed in our comments on the CBRA report, it is acceptable to use the information from the Crops ERA to establish the SSTL for non-agricultural fields and woodlots. While the use of a 25% effect concentration (EC_{25}) may be unacceptable for an agricultural setting (see Attachment #2), it is an appropriate toxicity endpoint to use for the natural environment risk assessment.

An appropriate SSTL to protect sensitive crop species was estimated to be between 600 and 1,200 mg/kg for organic muck, till (shallow) clay, and welland (heavy) clay soils and between 400 and 700 mg/kg for sandy soils. These SSTL's could have been developed by several different approaches; including applying an uncertainty factor of 2 to the SSTL's proposed by Stantec in the CBRA (based on PNECs) or to the estimated EC_{25} values from the meta-analysis. For the natural environment ERA, this uncertainty factor would not be needed. Based on the estimated SSTL's proposed for the Crops ERA by the ministry and removing the uncertainty factor of 2, an appropriate SSTL for the natural environment would be between 1,200 and 2,400 mg/kg for organic muck, till (shallow) clay, and welland (heavy) clay soils and between 800 and 1,400 mg/kg for sandy soils. Based on the available information on earthworms (e.g., laboratory toxicity tests and field assessment data), it appears that these SSTL's would also be protective of soil invertebrates as well.