18th Floor, 4730 Kingsway
Burnaby, BC V5H 0C6
T: 604.669.0424
F: 604.669.0430
hemmera.com

March 6th, 2015
File: 1382-002.02

CanZinco
Nyrstar Canada (Holdings) Ltd.
2840 – 650 West Georgia Street
PO Box #11552. Vancouver, British Columbia, Canada
V6B 4N8

Attn: Johan Skoglund, Group Manager Environment
e-mail Johan.skoglund@nyrstar.com

Dear Johan;

Re: Soil Toxicity Testing and the Derivation of Site Specific Soil Remediation Objectives (SSROs) for the Nanisivik docksite

This report, along with the appended Stantec (October 15, 2014) report entitled *Ecotoxicity Assessment of Nanisivik Stockpiled Glacial Tills Contaminated Predominantly with F2* (Appendix A), is provided to assist with risk management decisions about petroleum hydrocarbon contaminated soils at the Nanisivik, NU, docksite. This report also provides follow-up information to the Bright and Stephenson letter report of September 4th, 2014, regarding the "*methodology/approach for developing Site Specific Soil Remediation Objectives (SSROs) for pre-determined project areas of the Nanisivik docksite".* Finally, I have attempted to address revised Nunavut Water License Renewal conditions in the context of the soils as referenced in Part D, Item 11 and Part F, Item 12[1].

[1] Nunavut Water Board Water License No: 1AR-NAN1419 and accompanying cover letter (re: Type "A" Water Licence No. 1AR-NAN1419 Renewal, CanZinco Minerals Ltd.: Former Nanisivik Mine Site), dated December 23rd, 2014.

SUMMARY

The Soil Toxicity Testing and the Derivation of Site Specific Soil Remediation Objectives for the Nanisivik docksite report is provided to assist with risk management decisions about petroleum hydrocarbon contaminated soils at the site. The report is submitted to address Nunavut Water License 1AR-NAN1419 conditions in the context of the soils as referenced in Part D, Item 11 and Part F, Item 12.

This report provides our interpretations of field sampling and laboratory-based scientific studies completed to develop a better understanding of the levels of residual hydrocarbons in docksite soils that could lead to unacceptably high risks to living organisms at the site.

Based on comparisons with generic soil quality guidelines, current concentrations of petroleum hydrocarbons in soils originating from the Nanisivik docksite tank farm area are sufficiently low to preclude risks to humans or living organisms other than soil invertebrates and plants. The sampling program and laboratory toxicity tests were intended to show the response of plants and soil invertebrates in soils with a range of concentrations of petroleum hydrocarbons in the diesel range, measured as Canada-Wide Standards Fraction 2 (F2). Because the approach and laboratory toxicity testing methods used strongly parallel those used to derive the generic Canada-Wide Standards for soil invertebrate and plant protection in 1999 (and in the 2008 updates), we felt that the approach would be useful for developing a credible site specific soil remediation objective for F2.

In spite of much lower performance of the test organisms in the site soils in comparison with optimal laboratory control soils, the site soil samples with the higher F2 concentrations actually resulted in better plant growth and soil invertebrate reproduction than the soils with F2 concentrations far lower than the generic Canada-Wide Standards for the protection of plants and soil invertebrates.

Based on my interpretations of the laboratory soil toxicity tests results for Nanisivik docksite soils, I provide the following conclusions:

1. Stockpile concentrations of F2 of up to 410 mg/kg should not inhibit the growth and success of plants and soil invertebrates relative to their growth and success in equivalent nutrient poor site soil samples deemed to be uncontaminated (or minimally contaminated) by reference to the generic Canada-Wide Standard F2 value of 260 mg/kg. Rather, the low organics, nutrient content, and water holding capacity of these soils appears to be the greatest impediment to re-vegetation with native arctic plants.

2. Based on findings herein, soils that contain **<410 mg/kg F2** are deemed to pose a low risk to plants and soil invertebrates based on direct contact pathways, and do not require special risk management considerations during site remediation.

1.0 PROJECT UNDERSTANDING

The Water Licence Renewal for the Former Nanisivik Mine Site provides a management framework for the use of water and disposition of waste in support of the "continued closure and reclamation, and post-closure monitoring activities at the former Nanisivik Mine site"[1]. A portion of the authorizations in the Water Licence Renewal is focussed on soils at the former Nanisivik Mine docksite area that became contaminated as a result of the historical handling and loss of refined petroleum hydrocarbon products from above-ground storage tanks within the docksite tankfarm.

Recent efforts on behalf of CanZinco to investigate, remediate and manage the environmental risks from hydrocarbon-affected soils are documented in other reports and communications, including those submitted in support of CanZinco's Water Licence Renewal application. This report provides our interpretations of field sampling and laboratory-based scientific studies completed to develop a better understanding of the levels of residual hydrocarbons in docksite soils that could lead to unacceptably high risks to living organisms at the site.

Soil remedial efforts for hydrocarbon contaminated soils at the Nanisivik docksite have focussed on reducing the levels of petroleum hydrocarbons (**PHCs**) to less than threshold of effects levels for soil invertebrates and plants as defined by the Canada-Wide Standards (**CWS**) for PHCs, also known as the Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for petroleum hydrocarbons. The average and maximum concentrations of petroleum hydrocarbons in site soils are currently lower that the above-described PHC CWS threshold-of-effects values for lighter end petroleum distillates [CWS Fraction 1 (**F1**)], and for heavier hydrocarbons within the range of **CWS fractions F3 and F4**.

A portion of the soils excavated from the former tank farm area at the docksite, however, contain petroleum hydrocarbons in the predominantly diesel range (**CWS F2 fraction**). The highest observed concentrations of diesel-range hydrocarbons in excavated stockpiles currently exceed the PHC **CWS F2 generic soil quality guideline for the protection of soil invertebrates and plants of 260 mg/kg** (parts-per-million) for a commercial land use.

Part D of the Water Licence Renewal (Conditions Applying to Construction and Operations), Item 11 states –

> "*The Licensee is allowed to conduct studies designed to develop Tier 3 soil remediation objectives based on the Canadian Council of Ministers of the Environmental (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (2006) or other relevant guidelines as long as the studies involved are within the scope of the Licence's terms and*

conditions with respect to Water use, Waste generated and potential impact on the Receiving Environment."

The referenced studies are discussed herein.

The sampling program for soils originating from the Nanisivik docksite tank farm area and laboratory toxicity tests, as described in Appendix A, were intended to show the response of plants and soil invertebrates in soils with a range of concentrations of petroleum hydrocarbons in the diesel range, measured as Canada-Wide Standards (CWS) Fraction 2 (F2). In particular, the sampling design for derivation of Site Specific Soil Remediation Objectives (**SSROs**) for the Nanisivik docksite tankfarm remediation was based on a comparison of the toxicological responses of soil invertebrates and plants in:

(i) Soil samples that had been collected from the subsurface areas of the docksite in the former tank farm area and remediated to F2 concentrations below the Canada Wide Standard for protection of plants and soil fauna (**reference**), and

(ii) Soil samples representing the highest onsite F2 concentrations in excavated soils as of early September 2013.

The evaluation of biological responses in soil samples with F2 concentrations spanning the range from reference to the highest concentration in onsite stockpiles was intended to support the development of mathematical dose-response relationships that – in turn - would lend themselves to identifying a threshold of effect concentration for F2. Such a threshold would be nominated as an SSRO. Such an SSRO would form the basis for site risk management approaches as an alternative to use of the generic PHC CWS F2 guideline.

We focussed our studies on soil invertebrate and plant survival and growth responses, since the lowest generic soil quality guideline for F2 within the PHC CWS that is applicable to a commercial land use (260 mg/kg) is derived to protect soil invertebrates and plants. The PHC CWS F2 generic soil quality guidelines associated with the protection of other living things such as humans or aquatic life in the adjacent marine environment are higher than for soil invertebrates and plants as shown in **Table 1**.

The existing concentrations of F2 in docksite stockpiles are less than 1,290 mg/kg F2 (Table 4: Remediation Confirmation Soil Samples, *Nanisivik Mine Contaminated Soil Remediation 2014 Progress Report* (SRK 2015) which is sufficiently low to preclude risks to humans or living organisms other than soil invertebrates and plants. This conclusion is based on comparison with the larger set of generic PHC CWS (Table 1), and is further discussed in Section 3 below.

The sampling design for the SSRO study also recognized the possibility that the responses of plants and invertebrates in laboratory toxicity tests to the soils with the highest F2 concentrations would not be significantly different from the adequately remediated reference soils, in which case a reasonable

conclusion is that the highest on-site excavated soil concentrations are lower than the threshold of effects for this particular soil type, hydrocarbon mixture, and test biota.

Table 1: Summary of the Petroleum Hydrocarbon Canada-Wide Standards (CCME) Soil Quality Guidelines for Fraction F2 - Industrial Land-use with Coarse-textured Soil

Exposure Scenario	F2 soil concentration (mg/kg)	Notes
Humans		
Direct contact (incidental ingestion, skin contact, dust inhalation)	>30,000	The estimated soil concentration for unacceptable exposure levels exceeded the solubility limit for PHCs, and could only occur in the presence of free-phase hydrocarbons.
Vapour inhalation (indoor environment)	1,700	Not applicable to site since there are no buildings above or near the contaminated soils.
Potable groundwater	320	Not applicable to site since there is no viable groundwater supply that could support use as drinking water.
Other Living Things (Ecological Receptors)		
Aquatic life based on groundwater mediated transport	380	Not applicable to site since direct testing of groundwater at the site shows that risks to aquatic life are acceptably low. Surface water bodies (Twin Lakes Creek and Strathcona Sound) are more than 10 m from any impacted soil. and groundwater quality data are available to more directly assess this exposure scenario.
Protection of soil invertebrates and plants	**260**	"Eco Soil Contact"
Management Limit	1,000	Accounts for additional considerations such as presence of free-phase hydrocarbon, protection of buried infrastructure, and explosive hazards.

Because the approach and laboratory toxicity testing methods used in the Stantec (2014) study strongly parallel those used to derive the generic Canada-Wide Standards for soil invertebrate and plant protection in 1999 (and in the 2008 updates), we felt that the approach would be useful for developing a credible SSRO. Northern wheatgrass was included among the suite of plants used in the ecotoxicity testing based on prior observations that this species is among the most sensitive of plant species evaluated to the present time to petroleum hydrocarbons, and data for this species strongly influences the value of the generic Canada-Wide Standards based on toxicity to soil invertebrates and plants.

2.0 SUMMARY OF LABORATORY TOXICITY TEST RESULTS

This section provides a synopsis of the results obtained from trials in response to Part F of the Water Licence Renewal (Conditions Applying to Waste Disposal and Management), Item 12(a), which requests that the update to the September 4th letter report include the following:

"Details on the results obtained from transplant trials to determine petroleum hydrocarbon, F2 toxicity as well as information on associated evaluation of ecological risk to Arctic plants from residual petroleum hydrocarbon concentration in soils as determined from trials"

Detailed methods and results are presented in Appendix A. Briefly, soil samples were collected from docksite stockpiles and shipped to Stantec's laboratory in Guelph, ON. The influence on plant survival and growth of the different soils samples was examined. The soil samples included a laboratory control, site reference soil samples with low CWS F2 concentrations, and soil samples reflective of the highest known stockpile F2 concentrations. The SSRO study also included the assessment of survival and reproductive output of a soil invertebrate (springtail or collembolan): *Folsomia candida*).

The three plant (alfalfa: *Medicago sativa*; blue grama grass: *Bouteloua gracilis*; northern wheatgrass: *Elymus lanceolatus*) and one springtail species used as surrogates for docksite soil flora and fauna did not perform as well [survive, grow, produce young in the case of the springtails] in any of the soil samples collected from the Nanisivik docksite stockpiles as they did in the organic rich control Artificial Soil (Appendix A). This is as expected, since the docksite soils originate from the subsurface environment, from glacial tills and marine uplift sediments, without having had the benefit of experiencing soil forming processes that occur at the surface in arctic and other environments. As such, the docksite stockpile soils have very low organic content and nutrients, beyond nitrogen and phosphorus nutrients added to increase bacterial hydrocarbon breakdown (called "biostimulation" or "bioremediation"). The soil characteristics are discussed further in Section 3, below.

In spite of the much lower performance of the test organisms in the site soils in comparison with optimal laboratory control soils, the site soil samples with the higher PHC F2 concentrations actually resulted in better plant growth and springtail reproduction than the soils with F2 concentrations far lower than the PHC CWS generic standards for the protection of plants and soil invertebrates (**Table 2**). This is further illustrated in Figures 1 through 4.

Table 2: Summary of laboratory toxicity test results

		PHC CWS F2 Concentration in Soil Sample (mg/kg)					
[F2] at time of collection		**100**	**100**	**360**	**360**	**610**	**610**
[F2] in test units at initiation of toxicity testing (t=0)		**63**	**63**	**240**	**207**	**223**	**407**
Alfalfa	[1]Shoot Length (mm)	12	18	19	26	31	30
	Root Length (mm)	[2]na	na	13	25	96	81
	shoot mass (g)	1.4	0.8	3.3	6.0	10.8	6.8
	root mass (g)	na	na	0.7	0.9	5.1	2.1
Blue Grama	Shoot Length (mm)	15	9	20	29	23	18
	Root Length (mm)	4.0	3.0	11	21	23	15
	shoot mass (g)	0.4	0.2	0.7	1.2	0.9	0.6
	root mass (g)	0.1	0.0	0.1	0.4	0.2	0.1
N. Wheatgrass	Shoot Length (mm)	85	61	97	94	102	98
	Root Length (mm)	49	32	72	72	81	70
	shoot mass (g)	4.8	2.6	5.0	4.9	5.9	4.6
	root mass (g)	0.8	0.5	2.0	1.6	2.3	2.1
F. candida	survival	87	80	97	97	90	77
	No. of progeny	81	1	315	1030	578	1294

Notes: (1) average values for all test replicates; (2) na: not applicable. No root tissue development was observed and no measurements were possible therefore.

2.1 MAJOR INTERPRETATIONS OF TOXICITY TESTING RESULTS

The observed responses of one soil invertebrate and three plant species to petroleum hydrocarbon contamination (as F2) in Nanisivik docksite soils suggests an enhanced soil productivity as a result of the enhanced organic carbon concentrations associated with the PHC inputs. The improved biological response with increased (not decreased) F2 concentration can be explained by the fact that various petroleum hydrocarbon mixtures have been shown to serve as an additional or *sole carbon source* (i.e. a new source of energy-containing fixed carbon that is a useable food source) for soil bacteria involved in decomposition reactions[2,3,4].

[2] Hino, S., Watanabe, K and Takahashi, N. 1997. Isolation and characterization of slime-producing bacteria capable of utilizing petroleum hydrocarbons as a sole carbon source. Journal of Fermentation and Bioengineering 84(6): 528-531.

[3] Yan, W.J., Minqquan, G.A. et al., 2008. Study of plugging microbial consortium using crude oil as sole carbon source. Petroleum Science 5(4): 367-374.

[4] Banks, M.K., Mallede, H. and Rathbone, K., 2010. Rhizosphere microbial characterization in petroleum-contaminated soil. Soil and Sediment Contamination: An International Journal 12(3), 371-385.

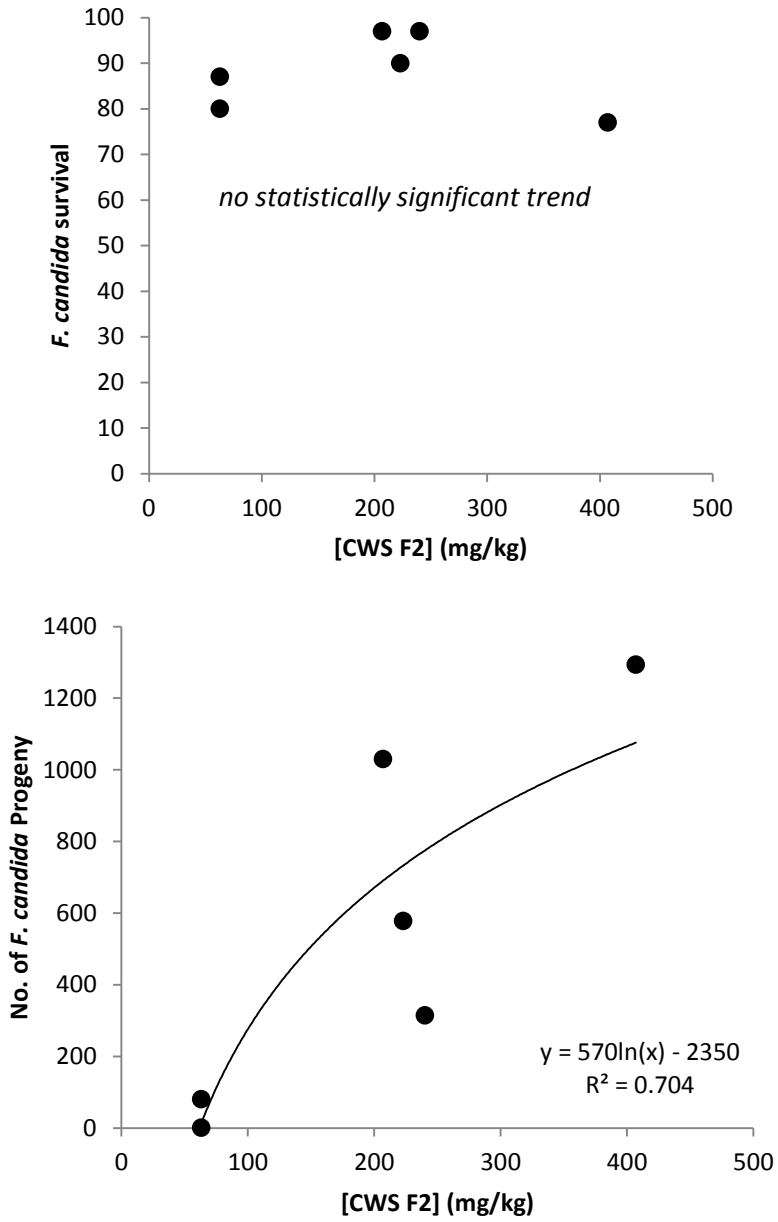

Figure 1: Response of springtails (*F. candida*) in excavated soil samples as a function of measured CWS F2 concentration: (a) survival; (b) reproduction

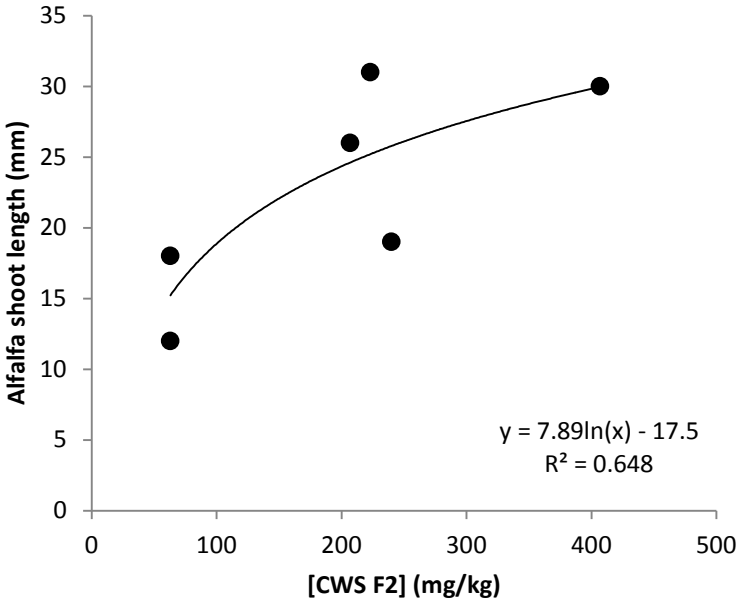

Figure 2: Alfalfa shoot length as a function of CWS F2 concentration

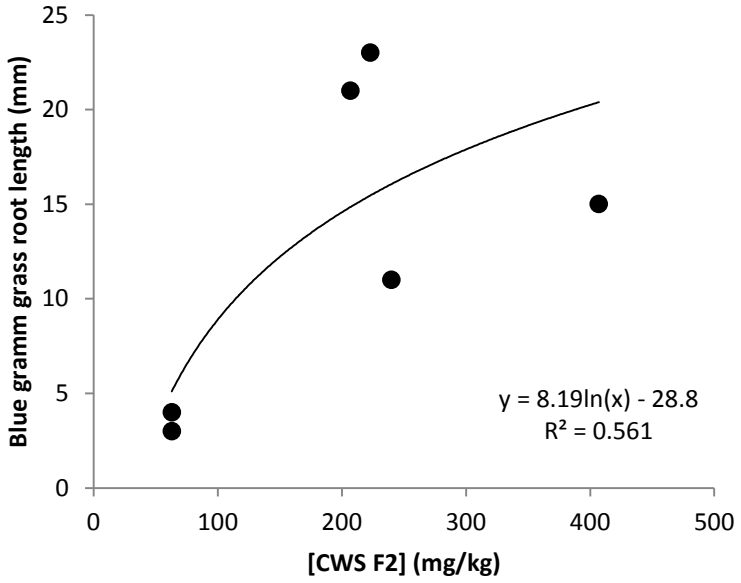

Figure 3: Blue grama grass root length as a function of CWS F2 concentration

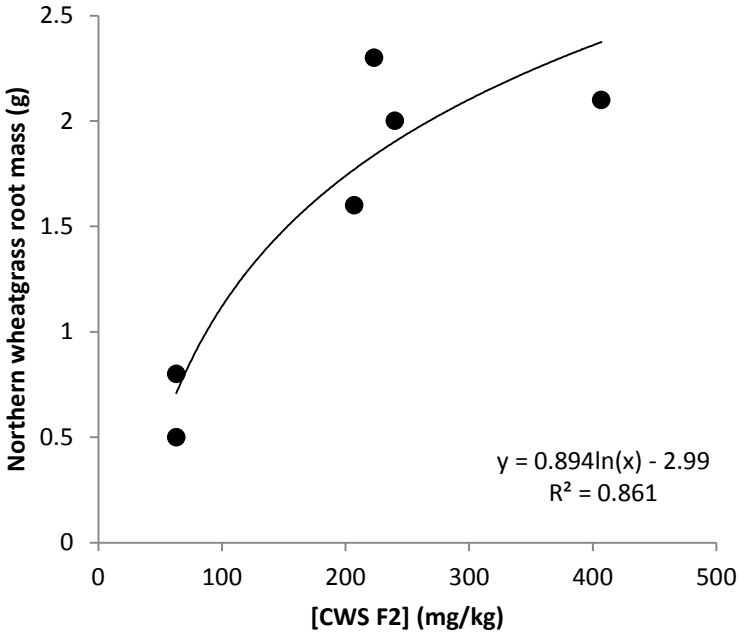

Figure 4: Northern wheatgrass root biomass as a function of CWS F2 concentration

The subsurface soils excavated from the area beneath the former tank farm are virtually devoid of measurable concentrations of natural organic matter (e.g. measured as total organic carbon: TOC), and the presence of aged diesel and its breakdown products at the concentrations currently found in the soils probably increases soil microbial productivity.

Several researchers have demonstrated that addition of petroleum products to soils can result in an increased amount of both total and hydrocarbon degrading bacteria[5,6]. While there are anecdotal accounts of enhanced plant productivity in cold climates that have been affected by petroleum product releases, in addition to enhanced microbial productivity, few published scientific studies exist.

2.2 DEVELOPMENT OF A SITE-SPECIFIC REMEDIAL OBJECTIVE (SSRO)

Since plant growth or springtail (collembolan) survival and reproduction were not reduced with increasing F2 concentration in the soils tested, it is not possible to derive estimates of soil F2 concentrations that would result in a reduction in fitness (for example, by 10%, 20%, 50%), as survival, growth or reproduction or a similar set to ecotoxicological thresholds. The data did not lend itself to F2 concentration-biological relationships that could be used to establish an upper limit for an SSRO. Rather,

[5] Atlas RM (1986). Fate of petroleum pollutants in Arctic ecosystems. Water Sci Technol 18:59–67
[6] Aislabie JM, Balks, MR, Foght JM, and Waterhouse EJ (2004). Hydrocarbon spills on Antarctic soils: effects and management. Environ Sci Technol 38:1265–1274

improved fitness was observed for the maximum soil concentration tested. The highest tested concentration was based on the maximum concentration available in the samples collected on site in July of 2014.

The most contaminated soil collected from the site exhibited an initial F2 concentration at the time of collection of 610 mg/kg, in comparison with the PHC CWS F2 guideline of 260 mg/kg, while the minimally contaminated reference soil samples had an initial F2 at the time of collection of 100 mg/kg. The soil samples lost an appreciable portion of their F2 concentration from the time of collection in the field to the introduction into ecotoxicity test units in the laboratory at the initiation of testing (Table 1) in spite of best efforts to prevent such losses. The laboratory to field decrease in F2 concentration was from 33% to 63% of the initial concentration. This suggests that the F2 hydrocarbons in stockpile soils are amenable to further natural attenuation given the right environmental conditions (especially temperature and soil moisture).

The sample with an initial F2 concentration of 610 mg/kg was observed to have an F2 concentration at the initiation of laboratory experiments of 407 mg/kg. This was the highest soil concentration tested. From a practical perspective, it is reasonable to set the SSRO as the highest F2 concentration in soils used in laboratory toxicity testing; i.e. **recommended SSRO = 410 mg/kg** (rounded to two significant figures). Higher F2 concentrations were not tested, and while increased plant growth was observed through the available range of F2 concentrations, it is conceivable that increased toxicity and decreasing performance could occur at progressively higher F2 concentrations existing on site.

2.3 POTENTIAL LIMITING FACTORS FOR BIODEGRADATION RATES AND SITE PLANT PRODUCTIVITY

The major limitation to the success of the laboratory test species appeared to be either water or nitrogen availability, since performance in all site soils – including the reference – was much lower than in an organic rich, artificial laboratory control sample that is more representative of organic-rich temperate agricultural soils. Further examination of nutrient availability at the docksite and of treatments that could further accelerate soil forming processes of relevance to this particular coastal arctic environment will help with site re-vegetation and ecological restoration. Since the site will continue to support a commercial activity (high arctic port), ecological restoration of areas with previously disturbed and excavated soils may or may not be part of site management goals for future operators.

Over the shorter term (i.e. for the summer of 2015) the laboratory toxicity testing results suggest that attenuation of CWS F2 hydrocarbons from stockpile soils may occur not just by volatilization, but also via microbial biodegradation. Since available nitrogen may be a limited factor for biodegradation (along with seasonal temperatures) it may be possible to further enhance biodegradation rates during the 2015 active growing season through additional applications of high nitrogen fertilizer to soil that exceeds the

recommended SSRO. Given the low water-holding capacity of the site soils, however, excess nitrogen and/or phosphorus could result in osmotic stress for site plants.

2.4 CONCLUSIONS AND RECOMMENDATIONS

Based on my interpretations of the laboratory ecotoxicity tests results for Nanisivik docksite soils (Appendix A), I provide the following conclusions and recommendations:

1. Stockpile concentrations of CWS F2 of up to 610 mg/kg, as measured from field collected samples in the early fall of 2013, should not inhibit the growth and success of plants and soil invertebrates relative to their growth and success in equivalent nutrient poor site soil samples deemed to be uncontaminated (or minimally contaminated) by reference to the generic PHC CWS F2 value of 260 mg/kg. Rather, the low organics and nutrient content of these sub-soils appears to be the greatest impediment to re-vegetation with native arctic plants. The presence of native vegetation covering the major portion of the soil surface during the active growing season at the site to the immediate south of the Upper Treatment Area (UTA) attests to the potential for establishment of productive soils and native plant communities on the uplifted glaciomarine soils that occur within the active zone at the site (and comprise the stockpile soils) given adequate water supply (the highly vegetated area is fed by seeps from the saturated active layer, supported by sub-permafrost groundwater or taliks that emerge near the base of the slope).

2. Based on findings herein, soils that contain **<410 mg/kg F2** are deemed to pose a low risk to ecological receptors based on direct contact pathways, and do not require special risk management considerations as part of site re-development.

3. Field plots were set up on site in July 2014 as a supplement to the laboratory-based ecotoxicity tests, as described in the Bright and Stephenson letter report of September 4th, 2014. These will likely not provide additional insights about petroleum hydrocarbon soil concentration – plant response relationships since it was possible to set up plots for only a few different soil concentrations, and the field responses of native transplanted vegetation are likely to be more variably than under controlled laboratory conditions based on other hard-to-control influences such as localized soil temperature and soil moisture. It is conceivable that the field plots will provide direct field evidence of enhanced plant productivity in cold climates that have been affected by petroleum product releases. Documentation of the field plots will be provided in the contaminated soil remediation 2014 progress report.

4. CanZinco should review stockpile soil amendments for the early season in 2015 toward further maximizing the rates of biodegradation in 2015. While an earlier study was completed to support nutrient amendments for the stockpiles (based on addition of urea and DAP), the soil nutrient data suggest that the desired C:N:P ratios have not been achieved. In addition, some published

studies suggest that in soils in arid regions such as the polar desert, limited soil water can result in an inhibition to the growth of petroleum degrading bacteria as a result of osmotic shock for excessive N or P additions.

5. I recommend that CanZinco work with federal government entities with an interest in the site to develop a longer term plan to promote ecological restoration, based on re-vegetation potential of the excavated subsoils, to the extent that this is not contrary to DND's future site plans. Application of a site-specific CWS F2 soil remediation guideline for soil invertebrates and plants to the tankfarm area and Nanisivik docksite in general is relevant to the extent that hydrocarbon contamination should not impede the viability and productivity of native arctic soil invertebrate and plant communities, it instead augments it at the concentrations tested. This, in turn, is a relevant management goal to the extent that ongoing physical disturbance or site developments do not impose a greater barrier to ecological restoration.

3.0 RESPONSE TO WATER LICENCE RENEWAL REQUESTS FOR ADDITIONAL INFORMATION

Part F of the Water Licence Renewal (Conditions Applying to Waste Disposal and Management), Item 12(b) requests additional information on the following:

- **"Details related to the physical and chemical description of soil types used to conduct toxicity testing and rationale for using sweet crude oil as an acceptable indicator for gasoline/diesel contaminants"**

Chemical and physical characteristics of the soils used for laboratory toxicity testing are provided in the appended report, as well as other hydrocarbon contaminated soil remediation progress reports. The pH of soil samples tests was slightly alkaline (pH 8.08 to 8.26) at the initiation of testing, with an electrical conductivity (EC) in the range of 365 to 541 µS/cm (Appendix, Table A.5.). This is a conductivity range that is conducive to the growth of plant species that are sensitive to soil salinization (i.e., EC less than 2,000 µS/cm: Alberta Salt Contamination and Remediation Guidelines). Levels of soil salinity in this arctic coastal setting, and in uplifted marine deposits, should not be an impediment to plant growth, therefore.

The plant and soil invertebrate toxicity test soils initially exhibited a percent moisture (percent of water holding capacity) in the range of 28% to 37% (Appendix, Table A.5.). The stockpile soil samples exhibited a relatively low water holding capacity (Appendix, Table A.6.) of only 27 to 29%. This lower water holding capacity is due to the fact that the stockpile soils are mostly sandy textured (59% to 63% sand: particles > 0.063 mm), with a low silt content (26 to 30%) and clay content (10% to 13%). As discussed previously, the stockpile soils have a low organic carbon content (<0.1 to 0.83% by mass). The artificial laboratory control soil, in contrast, had an organic carbon content of 2.8%.

Fractionated fresh sweet crude oil was used in the development of the PHC CWS for the protection of soil invertebrates and plants, using similar experimental procedures as used in this SSRO study. Fractionated crude oil was not used in this SSRO study. Rather, the hydrocarbon contaminated soil as it currently exists in docksite stockpiles was used to develop an SSRO.

- **"Explanation of consideration given to the most recent analytical result (from petroleum hydrocarbon contaminated soil samples received by the laboratory on September 3, 2014) in determining the basis for the proposed approach"**

Documentation of stockpile soil and confirmatory testing results will be provided under separate cover in the contaminated soil remediation 2014 progress report. The average and maximum concentrations of F2 in docksite stockpile soils are lower than previously formally documented (SRK 2015). No new data were received in 2014 that suggest anomalously high concentrations in on site soils relative to the site conditions for which the SSRO was developed.

- **"Details on potential bioaccumulation of contaminants in biota relying on plants that may be impacted"**

The major portion of diesel-range petroleum hydrocarbons are aliphatic hydrocarbons (straight chain and branched carbon chains), such as the alkanes decane, dodecane, and hexadecane. A very minor portion of such hydrocarbons are comprised of aromatic hydrocarbons such as polycyclic aromatic hydrocarbons (PAHs). The observed concentrations of PAHs in soil are not a concern at the docksite. The strong hydrophobicity of both aliphatic and aromatic hydrocarbons means that they are sparingly soluble and are predominantly found attached to soil particles as opposed to in soil interstitial water. Plants do not tend to accumulate appreciable amounts of CWS F2 range or higher molecular weight petroleum hydrocarbons, therefore, based on uptake from soil interstitial water in the rhizosphere followed by translocation to above-ground plant tissue[7].

Few scientific studies have focussed on the uptake into plants of aliphatic hydrocarbons, in part because many of the aliphatic hydrocarbons that are detected using the PHC CWS analytical approach or similar approaches occur naturally within plants, and it is challenging to confidently differentiate between naturally occurring (biological origin or "biogenic") and petroleum based aliphatic hydrocarbons in plant tissues. A limited number of studies have demonstrated the uptake of PAHs in both below-ground and above-ground portions of plants; however, the tissue concentrations are invariably orders of magnitude lower than in the soil in which the plants are growing. Meudec et al (2006)[8], for example, demonstrated the uptake of PAHs into the shoot tissues of a salt marsh plant

[7] Kipopoulou, A.M., Manoli, E., Samara, C., (1999). Bioconcentration of polycyclic aromatic hydrocarbons in vegetables grown in an industrial area. Environ. Pollut. 106, 369–380.
[8] Meudec, A., Dussauze, J., Deslandes, E. and Poupart, N. (2006). Evidence for bioaccumulation of PAHs within internal shoot tissues by a halophytic plant artificially exposed to petroleum-polluted sediments. Chemosphere 65: 474–481

(*Salicornia fragilis*) from experimentally oiled sediments; however, the total PAH concentrations in the plant tissues was in the range of 3.5 to 10 µg/kg (parts-per-billion) while the total PAH concentration in the sediment was in the range of 30 to 550 mg/kg (parts-per-million). The bioaccumulated concentrations were 10,000 fold or more lower in the plant tissue than the spiked sediment. PAH concentrations obtained from docksite stockpile soils and the tankfarm area are an order of magnitude below CCME soil quality guidelines (SRK 2015).

In general, the physicochemical properties of petroleum hydrocarbons preclude their uptake into plant above-ground or below-ground tissues at levels that could result in risks to herbivores. The exposures associated with incidental soil or sediment ingestion are likely to be much greater than hydrocarbon exposures associated with plant ingestion.

As discussed above and presented in Table 1, expected soil concentrations above which there may be risks to humans for CWS F2 hydrocarbons exceed 30,000 mg/kg. This attests to the relatively low toxicological sensitivity of humans and other mammals to petroleum hydrocarbons in general, with some exceptions. Uptake via plant ingest, based on root uptake from soil, is not a viable exposure pathway, therefore.

- **"Details of insect response to potential contaminants in the approach being considered"**

The laboratory toxicity testing included a small-bodied soil invertebrate: the springtail (collembolan) *Folsomia candida.* As shown in Figure 1, the soil invertebrate had higher reproductive output in the more highly contaminated stockpile soils tested.

Responses of springtails to soil contamination should generally reflect much greater sensitivity than for larger bodied insects. This is because springtails, and similar small-bodied mesofauna, inhabit the small spaces between soil particle, and are generally intimately associated with soil interstitial water, as well as the contaminants it contains. Larger insect are covered by an chitinized exoskeleton that may be less permeable to hydrophilic and lipiphilic contaminants. Finally, many of the insects of interest at the Nanisivik docksite are more mobile than soil mesofauna, at least through part of their life cycle, and less likely to bioaccumulate petroleum hydrocarbon constituents from the more contaminated stockpile area throughout their life cycle.

Overall, it is expected that the responses of the invertebrate *Folsomia candida* to petroleum hydrocarbon contaminated will adequately reflect responses of sensitive, resident insects. It is highly improbably, therefore, that insects or their consumers at the Nanisivik docksite have an unacceptable risk potential.

4.0 CLOSURE

We have appreciated the opportunity of working with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

Report prepared by:
Hemmera

Doug A. Bright, Ph.D.
Practice Lead – Environmental Risk Assessment
250.388.3584 (ext. 606)/
dbright@hemmera.com

5.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera, based on fieldwork conducted by Hemmera, for the sole benefit and exclusive use of Canzinco. The material in it reflects Hemmera's best judgment in light of the information available to it at the time of preparing this Report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. Hemmera accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this Report.

Hemmera has performed the work as described above and made the findings and conclusions set out in this Report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This Report represents a reasonable review of the information available to Hemmera within the established Scope, work schedule and budgetary constraints. It is possible that the levels of contamination or hazardous materials may vary across the Site, and hence currently unrecognised contamination or potentially hazardous materials may exist at the Site. No warranty, expressed or implied, is given concerning the presence or level of contamination on the Site, except as specifically noted in this Report. The conclusions and recommendations contained in this Report are based upon applicable legislation existing at the time the Report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the Report. Regulatory implications discussed in this Report were based on the applicable legislation existing at the time this Report was written.

In preparing this Report, Hemmera has relied in good faith on information provided by others as noted in this Report, and has assumed that the information provided by those individuals is both factual and accurate. Hemmera accepts no responsibility for any deficiency, misstatement or inaccuracy in this Report resulting from the information provided by those individuals.

The liability of Hemmera to Canzinco shall be limited to injury or loss caused by the negligent acts of Hemmera. The total aggregate liability of Hemmera related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of Hemmera for services rendered on this project.

APPENDIX A

Ecotoxicity Assessment of Nanisivik Stockpiled Glacial Tills Contaminated Predominantly with F2

Stantec, 2014

Ecotoxicity Assessment of Nanisivik Stockpiled Glacial Tills Contaminated Predominantly with F2

Prepared for:
CanZinco Mines Ltd.
c/o Nyrstar
Tessinerplaz 7
CH-8002 Zürich
Switzerland

On behalf of:
SRK Consulting (Canada) Inc
Suite 202, 5204 - 50th Avenue,
Yellowknife, NT X1A 1E2
Canada

Prepared by:
Stantec Consulting Ltd.
1-70 Southgate Drive
Guelph ON N1G 4P5
Canada

File No. 122160084
October 15, 2014

Sign-off Sheet

This document entitled Ecotoxicity Assessment of Nanisivik Stockpiled Glacial Tills Contaminated Predominantly with F2 was prepared by Stantec Consulting Ltd. for the account of CanZinco Mines Ltd.. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Prepared by Emma Shrive
(signature)

Emma Shrive, Project Manager

Reviewed by Gladys L Stephenson
(signature)

Gladys Stephenson, Director of Laboratory Services

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was contracted by CanZinco Mines Ltd. (CanZinco) in collaboration with SRK Consulting Ltd. (SRK), to provide an ecotoxicity assessment of land-farmed, stockpiled glacial tills contaminated predominantly with F2, originating from fuel storage facilities in Nanisivik, Nunavut, using one collembola and three surrogate plant species.

The purpose of the ecotoxicity assessment was to provide site-specific toxicological data that could be used to inform the applicability of the site-specific remedial objective (SSRO) developed for the site and to provide insight into the efficacy of bioremediation methods applied to these soils. As mentioned above, site soils were contaminated with petroleum hydrocarbons, predominantly F2 (**Appendix F**).

The toxicity test methods and procedures used for the ecotoxicity assessment are those described in the Environment Canada test method series for terrestrial organisms (EC, 2005a; 2007).

This ecotoxicity assessment was performed using methods and procedures very similar to those used in support of the derivation of the Tier 1 PHC CWS (Canada-wide Standards) for the protection of ecological receptors exposed to PHCs via the soil contact exposure pathway (CCME 2000). Stantec's CALA[1]-accredited Soils Laboratory also performed the testing that was completed for the derivation of the Tier 1 PHC CWS; the testing was done in 1998-2000 and supervised by the same senior research scientist that directed the testing completed herein for this initiative.

1.1 SCOPE OF REPORT

This report contains an introduction (Section 1) and a brief summary of the methods and procedures used to prepare the test soils and conduct the tests (Section 2), as well as a summary of the test results (e.g., Section 3 and the test reports in **Appendices A-D**). The test methods are described in greater detail in each of the Environment Canada test protocols for plants and collembola (EC, 2005a and 2007, respectively). The discussions of the test results and their regulatory implications are included in Section 4 of the report.

[1] Canadian Association for Laboratory Accreditation Inc.

2.0 Materials and Methods

2.1 TEST SOILS

2.1.1 Site Soils

The site soils used for this assessment were stockpiled site soils historically contaminated with petroleum hydrocarbons (diesel) that, for the past several years, have undergone remediation via classic "land-farming" methodologies (e.g., amendment with fertilizer, aeration, spreading, and turning etc.). Site soils were collected by SRK throughout June and July. These soils were shipped in labeled, 20-L, high-density polyethylene buckets to Stantec's Soils Ecotoxicology Laboratory at 70 Southgate Dr., Guelph ON. Seven buckets arrived on July 3, 2014, two buckets arrived on July 8, 2014, and two more buckets arrived on July 29, 2014 (**Appendix E**). The samples were assigned unique identification numbers (**Table 1**) and logged into the Quality Management System at the laboratory and the appropriate observations and measurements recorded. Soil temperature and condition were assessed and documented upon arrival.

The soils selected for testing were chosen based on analytical results obtained from soil samples that had been collected in the field by SRK and submitted to Exova (Ottawa, ON) for analyses. The site soils chosen for testing were soil 14431 (100 mg F2/kg soil), soil 14432 (360 mg F2/kg soil), and soil 14433 (610 mg F2/kg soil). The strategy was to collect soil samples with a gradient of F2 concentrations comprising low, medium and high concentrations relative to the existing applicable site-specific criterion of 260 mg F2/kg soil for commercial/industrial land uses (CCME, 2008). Each bucket of soil was treated as an independent field replicate. The negative reference control soil (or experimental control soil) was Site Soil 14431.

Table 1: Description of the site soil samples received at the Stantec Consulting Ltd. Soils Laboratory (Guelph)

Soil Sample Descriptor	Date Received	Number of Samples	Unique Sample IDs
14431	July 3, 2014	3 x 20-L bucket	1457_14431_01, 1457_14431_02, 1457_14431_03
14432	July 3, 2014	2 x 20-L bucket	1458_14432_01, 1458_14432_02
14433	July 3, 2014	2 x 20-L bucket	1459_14433_01, 1459_14433_02
14434	July 8, 2014	2 x 20-L bucket	1460_14431_01, 1460_14434_02
14947	July 29, 2014	1 x 20-L bucket	1493_14947
14948	July 29, 2014	1 x 20-L bucket	1494_14948

2.1.2 Artificial Soil

Artificial control soil was included in the experimental design of each toxicity test. The artificial soil (AS) is characterized as a sandy-loam soil and served as a negative control soil to evaluate the health of the test organisms, the influence of the experimental conditions on test organism performance (e.g., survival and/or reproduction), technical proficiency, and the acceptability of the test (i.e., performance is measured and compared to the validity criteria outlined in the test methods). The negative control soil used for the toxicity assessment was formulated from natural ingredients of silica sand, kaolinite clay, and Sphagnum peat, and buffered to a neutral pH range (6.0 – 7.5) with $CaCO_3$. The soil characteristics are described in **Appendices A to D**.

2.2 TEST SOIL PREPARATION

Soils were prepared on day 0 for the plant tests and day -1 for the collembola test.

Soils were manipulated prior to testing (**Table 2**). Each set of site soil buckets were logged into the Stantec Southgate Laboratory as field replicates. The contents of each of the 20-L buckets were homogenized separately. Homogenization of soils occurred on July 28, 2014. Rocks and debris were removed with washed, gloved hands from the soils prior to testing; this took approximately 20 minutes for each soil sample. Soils were stored in the main laboratory with a mean temperature of 21.6 ± 0.4oC until used for testing.

The soil moisture content and water-holding capacity were determined for each soil. Water-holding capacity was measured on September 8, 2014. A sample from each homogenized site soil was sent to the University of Guelph's Soil and Nutrient Laboratory for characterization on August 26, 2014, in accordance with the Environment Canada biological test methods. Results were received September 17, 2014. All characterization results from the University of Guelph's Laboratory Services are presented in **Appendix G**.

Soils for all tests were hydrated and the water incorporated on July 31, 2014 prior to testing; plant tests were initiated on July 31, 2014 and invertebrate tests began on August 1, 2014. Moisture content, soil pH, and electrical conductivity were measured at the start of each plant test and at the start and end of the collembolan test. Soil pH and electrical conductivity were measured at the end of each plant test.

All three plant tests (alfalfa, blue grama grass, and northern wheatgrass) ended with processing on August 21, 2014. The collembolan test was processed on August 29, 2014.

Table 2: Description of the site soil samples homogenized at the Stantec Consulting Ltd. Soils Laboratory (Guelph).

Soil Sample Descriptor	Date Homogenized	Number of Samples	Soil Condition	Sample ID
14431_1	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1457_14431_01
14431_2	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1457_14431_02
14432_1	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1458_14432_01
14432_2	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1458_14432_02
14433_1	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1459_14433_01
14433_2	July 28, 2014	1 x 20-L bucket	Moist; clay/sandy with rocks	1459_14433_02

2.2.1 Physical and Chemical Characterization of Test Soils

The pedological characteristics of the artificial and site soils were measured to satisfy the requirements of the Environment Canada biological test methods (EC, 2005a and 2007). Subsamples of all test soils were collected and submitted to Laboratory Services at the University of Guelph (Soils and Nutrient Laboratory, Guelph, ON) for physical and chemical characterization (**Tables A.6, B.6, C.6, D.4, Appendices A to D**, respectively). The analytical reports are provided in **Appendix G**. The Environment Canada biological test methods also require that soil pH, electrical conductivity, moisture content and water-holding capacity be measured for all test soils; these parameters were measured at the Stantec Soils Laboratory and are reported in the test reports (**Tables A.5, A.6, B.5, B.6, C.5, C.6, D.3, D.4, Appendices A to D**, respectively).

2.3 TOXICITY TESTS

Definitive (plant) and chronic (collembola) screening tests were conducted with artificial negative control soil and the three site soil samples (2 field replicates each). The test methods and species were those recommended by Environment Canada (2005a and 2007). The test species battery included three plant species (Alfalfa – *Medicago sativa*, Blue Grama Grass - *Bouteloua gracilis*, and Northern Wheatgrass – *Elymus lanceolatus*), and one soil invertebrate species, the soil arthropod (Springtail or Collembola – *Folsomia candida*). The test species are surrogate species for the Arctic Bay ecoregion in which the site resides. The test organisms were exposed to each of the site soils, one of which served as the experimental control and a negative control soil (AS – artificial soil) that was formulated in the laboratory. The negative control soil was included for QA/QC purposes to assess test organism performance and the assurance of the test procedures and conditions. The purpose of the longer-term plant and

chronic invertebrate tests was to examine the effects of prolonged exposure to the site soils on the survival, and reproduction of collembola and the emergence and growth of plants relative to test organism performance in the experimental control soil (e.g., reference soil with physico-chemical characteristics similar to those in the site soils).

The measurement endpoints for the 28-day collembola test were adult survival and mean number of progeny produced. The measurement endpoints for each plant test included seedling emergence, shoot and root length, and shoot and root dry mass. Plant test durations were 21 days for all three plant species.

2.3.1 Test Species Selection

The test species are representative of two major groups of soil organisms, plants and soil invertebrates. They are functional surrogate species for the plant species growing in the "riparian" areas of the site where water is present; for the most part, the site constitutes a polar desert (Doug Bright, pers. commun). Blue Grama Grass (*Bouteloua gracilis*) and Northern Wheatgrass (*Elymus lanceolatus*) are monocotyledonous plant species and Alfalfa (*Medicago sativa*) is the dicotyledonous plant species. *Folsomia candida* is a parthenogenic soil arthropod.

The plant species were selected because:

- they include di- and monocotyledonous species;
- they include annual and perennial species;
- they include a nitrogen-fixing species;
- reliable seed sources are available;
- performance criteria are available;
- they include forage crops;
- they are considered to be relatively sensitive to PHCs in soil; and,
- they are species recommended for ecotoxicity assessments by Environment Canada.

The invertebrate species were selected because:

- they have a relatively short life cycle that make it possible to conduct reproduction tests in the laboratory;
- they are easily cultured in the laboratory;
- they are commonly used invertebrate toxicity test species;
- they are considered to be relatively sensitive to PHCs in soil;
- performance criteria are available;
- reliable cultures are available;
- toxicity data generated from tests with this species are reproducible and sensitive; and,
- standardized test methods exist for the test species (EC, 2007).

The test species are considered to be functional surrogates for the plant and invertebrate species that might inhabit the site. A list of common plants recorded at the port of Nanisivik is provided in **Table 3**. Northern wheatgrass belongs to the same genera as Lyme grass and Alfalfa is a nitrogen-fixing legume. More importantly, these species are recommended for use with the Environment Canada biological test methods with developed performance criteria for test acceptability.

Table 3: List of common plant species at the port of Nanisivik (courtesy of Arlene Laudrum, SRK Consulting Ltd.)

Shrubs	Sedge	Fern	Grasses	Flowering Angiosperms
Arctic willow (*Salix arctica*) Net-veined willow (*Salix reticulate*) Green alder (*Alnus crispa*) Dwarf birch (*Betula glandulosa*)	Arctic cotton (*Eriophorum* sp.)	Fragile fern (*Crystopteris fragilis*)	Lyme grass (*Elymus arenarius*)	Arctic bladderpod (*Lesquerella arctica*) Arctic dryad or Mountain avens (*Drya integrifolia*) Snow cinquefoil (*Potentilla nivea*) Mountain sorrel (*Oxyria digyna*) Purple mountain saxifrage (*Saxifrage oppositifilic*) Yellow oxytrope (*Oxytropis maydelliana*) Purple bladder campion (*Melandrium apetalum*) Arctic poppy (*Papaver radicatum*) Capitate lousewort (*Pedicularius capitata*) Arctic lousewort (*Pedicularius arctica*)

The experimental design and test conditions for each test species are summarized in **Table 4**, and in the test reports comprising **Appendices A, B, C, and D**. The test reports summarize the results of the definitive and chronic tests and any modifications to, or deviations from, the procedures and conditions recommended in the test methods.

Table 4: Experimental design and conditions of definitive plant and chronic invertebrate toxicity tests.

Test	Plant	Collembola
Test type	Definitive Screening	Chronic Screening
Test duration (d)	21	28
Test unit (chamber)	1-L polypropylene container	Glass 125-mL mason jar
Amount of soil	600 g wet wt.	40 g wet wt.
Temperature (day/night)	24/15 ± 3°C	20 ± 2°C
Photoperiod (h)	16 light : 8 dark	16 light : 8 dark
Treatments	Artificial soil (AS) 3 Site Soils (2 field replicates each)	Artificial soil (AS) 3 Site Soils (2 field replicates each)
Number of replicate test units per treatment	6 for AS 6 (3 per field replicate)	6 for AS 6 (3 per field replicate)
Number of organisms per test unit	10 – Alfalfa 10 – Blue Grama Grass 5 – Northern Wheatgrass	10
Lighting (Type & Intensity)	Full spectrum Durotest or Vita Lights 200-400 µmoles/(m^2·s)	Fluorescent 400-800 Lux
Physicochemical measurements	Conductivity, pH, % moisture	Conductivity, pH, % moisture
Biological endpoint measurements	Emergence, shoot and root length and shoot and root dry mass	Adult survival, number of progeny produced
Statistical endpoints	Significant difference among treatments	Significant difference among treatments
Description of methods	EC 2005a	EC 2007

2.3.2 Reference Toxicity Tests

Reference toxicity tests with boric acid and each test species were also conducted in artificial soil concurrently with each test to comply with the test protocols of Environment Canada; they are also a mandatory requirement for QA/QC purposes for CALA accredited laboratories. The results of the reference toxicant testing have been included in each test report. Organisms used for the reference toxicity tests were from the same batch as those used in the ecotoxicity assessment. The results from the reference toxicity tests are reported in **Appendices A to D**.

2.3.3 Statistical Analyses

Analysis of variance (ANOVA) procedures were applied to the data, followed by Fisher's protected Least Significant Difference (LSD) test, to determine if there were significant differences ($P < 0.05$) among the experimental reference control and site soil treatments. Statistical tests for assumptions of normality (Shapiro-Wilk normality test) and heteroscedasticity (i.e., application of ANOVA procedures to the residuals of the mean values) were conducted in order to satisfy the requirements of the ANOVA. In cases where the data did not meet the necessary assumptions, the data were examined for outliers and then transformed using the natural logarithm + 1 or the square-root transformations. If the transformed data did not satisfy the applicable parametric assumptions, non-parametric procedures (i.e., Kruskal-Wallis One-way Analysis of Variance test, followed by a Mann-Whitney U-test when significant differences existed) were applied. All analyses were performed with Systat 12 (SSI, 2007) and complied with recommendations in the Environment Canada guidance document (EC, 2005b).

2.4 ANALYTICAL CHEMISTRY

Samples of all site soils were collected in the field by SRK and submitted to Exova in Ottawa, ON for analyses prior to testing to determine which soils would be used for the assessment.

At the beginning of the testing, triplicate samples for each field replicate chosen for testing were collected by Stantec at test initiation and submitted to Exova for analyses. Single composite (among test unit replicates) samples for each field replicate were collected at the end of the plant tests by Stantec and submitted to Exova for analyses. Analytical reports are provided in **Appendix F**.

3.0 Results

The test reports for the tests with alfalfa, blue grama grass, northern wheatgrass, and collembola are presented in **Appendices A, B, C, and D**, respectively; the results of the soil physico-chemical characterization are presented in **Appendix G**. The analytical results for the soil samples collected and submitted by SKR prior to testing, and those collected and submitted at the beginning and end of testing by Stantec are summarized in **Appendix F**. Photographs taken during testing can be found in **Appendix H**.

3.1 CHEMICAL ANALYSES OF TEST SOILS

3.1.1 Petroleum Hydrocarbons

A sample of each soil was collected in the field and submitted for analyses before samples were shipped to Stantec (**Table 5**); triplicate samples from each field replicate were collected and submitted for analyses at the start of toxicity testing (**Table 6**); and, a single composite sample for each field replicate was collected at the end of the plant toxicity testing and submitted to Exova (Ottawa, ON) for analyses (**Table 7**). The Exova analytical reports can be found in **Appendix F**.

PHC concentrations of the test soils were compared to the Tier 1 standards for coarse-grained surface soil presented in the Canadian Council of Ministers of the Environment (CCME) Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, (CCME, 2008). F3 and F4 concentrations in all soil samples collected in the field were below the CCME standards for coarse-grained surface soil (**Table 5**); therefore, F2 concentrations were considered to be the contaminant of concern for these soils in this assessment. The concentration of F2 in soil 14431 was below the Tier 1 standards, so this soil was used as the reference control soil for the site. Both soil 14432 and soil 14433 had F2 concentrations that exceeded the Tier 1 Standards Value.

Table 5: PHC concentrations of soil samples collected in the field.

Standard Values	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)
Commercial/Industrial Land Use Coarse-grained surface soil (CCME, 2008)	260	1700	3300
Soil Type	**F2 (mg/kg) n = 1**	**F3 (mg/kg) n = 1**	**F4 (mg/kg) n = 1**
14431	100	30	< 20
14432	360	20	< 20
14433	610	40	< 20

The second set of samples was collected by Stantec and submitted for analyses at the start of the toxicity tests (**Table 6**). Soils were divided into independent field replicates (2 for each soil). Prior to samples being collected, soils were homogenized for approximately 20 minutes each on July 28, 2014 at which time a subsample of soil was collected and dried in the drying oven to determine the dry weight of each soil. At the start of the plant tests (2014-07-31), all soils were hydrated with de-ionized water and mixed using a hand-held electric mixer until the ideal moisture content for testing for each soil was reached. Analytical samples were collected in triplicate as the soils were being dispensed into their respective test units.

The analytical results from the start of testing show that mixing the soils to prepare them for testing resulted in F2 concentrations being reduced by 37% in soil 14431, 33 to 42% in soil 14432, and 33 to 63% in soil 14433. According to the analytical results in **Table 5**, concentrations of F2 in soil 14432 were reduced to below the Tier 1 Standards Value.

Table 6: PHC concentrations of soil samples at the start of the tests.

Standard Values	F2 (mg/kg)
Commercial/Industrial Land Use Coarse-grained surface soil (CCME, 2008)	260
Soil Type	**F2 (mg/kg) n=3, mean (SD)**
14431-01 (A)	63 (25)
14431-02 (B)	63 (6)
14432-01 (C)	240 (20)
14432-02 (D)	207 (25)
14433-01 (E)	223 (161)
14433-02 (F)	407 (31)

End of test samples were collected at the end of the 21 day plant tests. Soil from each field replicate was pooled from all three plant tests and a single sample from each was submitted for chemical analyses (**Table 7**).

Table 7: PHC concentrations of soil samples at the end of the tests.

Standard Values	F2 (mg/kg)
Commercial/Industrial Land Use Coarse-grained surface soil (CCME, 2008)	260
Soil Type	**F2 (mg/kg) n = 1**
14431-01 (A)	70
14431-02 (B)	50
14432-01 (C)	180
14432-02 (D)	180
14433-01 (E)	290
14433-02 (F)	280

Only soil 14433 (E and F) had F2 concentrations marginally above the Tier 1 Standard value at the end of the test.

3.2 TOXICITY TEST

3.2.1 Alfalfa

Detailed descriptions of the experimental design, conditions, and test results are provided in **Table 4** (see subsection 2.3.1) and in the test report for alfalfa (**Appendix A**). End-of-test photographs are provided in **Appendix H**.

All test performance acceptability criteria were met for seedling emergence and growth of alfalfa in AS and the reference toxicant test results were within the historical range; however, seedling emergence and growth of alfalfa in all site soils including the reference control soils was poor (**Table A.2, Figure A.1; Appendix A**). Alfalfa seedlings that emerged in the reference control soils grew poorly and although above-ground biomass was measureable, the shoots that emerged had no roots. The growth of alfalfa in the reference control soils failed to satisfy the acceptability criteria (with the exception of survival) established by Environment Canada.

Soil pH, electrical conductivity and moisture content were within the tolerance range for alfalfa (**Table A.5; Appendix A**). Alfalfa prefers a deep, well-drained loam, silt loam, or clay loam soils with a pH between 6.2 and 7.5. Sandy soils are suitable if properly irrigated and fertilized. Alfalfa is grown in saline soils with alkaline soil pH (e.g., soil pH 7.5-8.5) but fertilization and soil amendments are common (ASA, 2011). It is noted that the influence of soil fertility is likely a factor influencing the performance of alfalfa in these site soils; the nitrogen levels were below the detection limits and suboptimal for alfalfa growth.

There were no deviations to report for this test; however, there was a deviation to report for the reference toxicant test conducted concurrently with this test. At the end of the reference toxicant test, the average nighttime temperature and the maximum nighttime temperature were 21°C and 24°C, respectively which are higher than the maximum nighttime temperature required by the Environment Canada Test Method (EPS 1/RM/45, February 2005, with June 2007 amendments) (18°C). After reviewing the test results, procedures, and conditions, we concluded that the temperature deviation did not affect the test results (see **Appendix A** for additional details of the deviation).

3.2.2 Blue Grama Grass

Detailed descriptions of the experimental design, conditions, and test results are provided in **Table 4** and in the test report for blue grama grass (**Appendix B**). End-of-test photographs are provided in **Appendix H**.

All test performance acceptability criteria were met (**Table B.1; Appendix B**) for seedling emergence and growth of blue grama grass in AS and the reference toxicant test results were within the historical ranges. The criteria for test acceptability were not met by the performance of blue grama grass in the two reference control soils (e.g., site soils A and B). Seedling emergence was poor in the two reference control soils and seedling emergence was significantly greater in all site soils relative to the reference controls soils (**Figure B.1; Appendix B**). Growth of shoots and roots was poor for plants grown in all site soils.

The soil pH, electrical conductivity and moisture content were within the acceptable tolerance range for blue grama grass (**Table B.5; Appendix B**).

There were no deviations to report for this test; however, there was a deviation to report for the reference toxicant test conducted concurrently with this test (see subsection 3.2.1 for details). After reviewing the test results, procedures, and conditions, we concluded that the temperature deviation did not affect the test results (see **Appendix B** for a full description of the deviation).

3.2.3 Northern Wheatgrass

Detailed descriptions of the experimental design, conditions, and test results are provided in **Table 4** and in the test report for northern wheatgrass (**Appendix C**). End-of-test photographs are provided in **Appendix H**.

All test performance acceptability criteria were met (**Table C.1; Appendix C**) for northern wheatgrass grown in AS and the results of the reference toxicant test conducted with AS were within the historical ranges. There were no adverse effects observed in the test soils relative to the experimental control soils; however, it is critical to note that the reference control soils met only the test validity criterion for survival and seedling emergence and failed to meet the growth or phytotoxicity validity criterion. Seedling emergence and above ground biomass (shoot length and biomass) were comparable across treatments and growth of roots (length and mass) appears enhanced relative to that in the reference control soils (**Figure C.1; Appendix C**).

The soil pH, electrical conductivity and moisture content were within the acceptable tolerance range for northern wheatgrass (**Table C.5; Appendix C**).

There were no deviations to report for this test; however, there were two deviations to report for the reference toxicant test conducted concurrently with this test. The first deviation was that as described above regarding the average and maximum nighttime temperatures. After reviewing the test results, procedures, and conditions, we concluded that the temperature deviation did not affect the test results.

The second deviation related to the reference toxicant test conducted concurrently with this test was that five consecutive EC50 data points have fallen above the historical mean value of the reference toxicant warning chart for emergence. A review of the test system, organisms and technical performance did not reveal any specific problems or anomalies. All validity criteria were met for the test. There were no evident errors in preparation of the stock or test dilutions. Test chemistry such as pH and conductivity are comparable to historical data. The EC50 trends on the warning chart for this species will be monitored. The data point from this reference toxicant test (NW_1_2014) was included in the control charting and subsequent tests will be monitored for unusual outcomes and/or further trends (see **Appendix C** for detailed descriptions of the deviations).

3.2.4 Folsomia candida

Detailed descriptions of the experimental design, conditions, and test results are provided in **Table 4** (see subsection 2.3.1) and in the test report for collembola (**Appendix D**).

All test performance acceptability criteria were met (**Table D.1; Appendix D**) for survival and progeny production for *F. candida* in AS, and the reference toxicant test results were within the historical range. The test acceptability criterion for survival of *F. candida* in the reference control soil was met; however, that for progeny production was not. Although collembolan survival was unaffected (**Figure D.1; Appendix D**), progeny production was impaired in all site soils with the greatest impacts occurring in the site soils with concentrations of F2 below the Tier 1 CWS for F2 in soil.

The soil pH, electrical conductivity and moisture content were within the acceptable tolerance ranges for northern wheatgrass (**Table D.3; Appendix D**).

There was one deviation that occurred for this test. According to the Environment Canada test method for conducting collembola survival and reproduction tests (EPS 1/RM/47), test units must be set up by adding 30 g wet weight soil to each test unit. For this test, 40 g of soil was added to the test units for the site soil treatments. Because of the bulk densities of the site soils, more site soil was required in each test unit to match the volume of soil in the AS treatment test units. This deviation did not affect the test in any way (see **Appendix D** for a full description of the deviation).

4.0 Discussion

The performance of alfalfa and blue grama grass in glacial till soil was suboptimal; the reasons for this suboptimal performance in soils with F2 concentrations below the Tier 1 CWS for soils were not clearly established although the fertility requirements were likely lacking for these species. The potential influence of the physical chemical characteristics of the test substrates themselves (i.e., non-contaminant variables) or the presence of co-contaminants (e.g., metals) on the test organisms were identified as potential explanatory variables. These hypotheses are supported to some extent by the fact that: 1) despite no-observed effects on seedling emergence, northern wheatgrass grew less well in the reference control soils; and, 2) although *F. candida* survived in all test soils equally, production of progeny was low to non-existent in the two reference control soils.

Examination of the potential influence of metals (Cd, Pb and Zn) as co-contaminants revealed that generally the metal/metalloid concentrations in the test soils were either lower than the CCME values or below the site-specific remedial objectives developed for the site (Jacques Whitford Ltd., 2003). The levels for these three metals in the soils are not surprising in light of the local lead-zinc mineralization. The concentrations observed, in concert with the slight alkalinity of the soils, indicate that toxicological effects on plants are unlikely. Therefore, the hypothesis that sub-optimal growth is related to absence of available nitrogen is more likely, and fits with the observation of augmented growth in the soils with higher amounts of CWS F2 contamination. Since much of the scientific literature suggests that diesel in soil strongly inhibits nitrogen mineralization (and thus the formation of NH_3 or NO_3), the application of N-fertilizer would likely be required to enhance degradation by microbial organisms. However, diesel would serve as a good sole carbon source for various heterotrophic microbial consortia.

The exposure concentrations of F2 are summarized in **Tables 6 and 7** and for the most part the highest exposure concentrations do not equate to the most severe impacts; therefore, factors other than F2 concentrations are influencing the biological responses and confounding the interpretation of the test results. An examination of the physical and chemical characteristics of the glacial till suggest that the predominantly sandy silt soil was low in organic carbon, organic matter content and nitrogen so fertility and hence growth of plants would be adversely affected regardless of the type of contamination present in the substrates. Although only alfalfa has a relatively high plant-available phosphate demand, the phosphorus levels in the soils were particularly compromised in site soils E and F. There was consistency among the site soils and the reference control soils in terms of the particle size distributions, the organic matter content, and the nitrogen levels. These potentially confounding factors often influence the performance of the test organisms in soils when they vary significantly. Soil pH was also relatively consistent across soils and ranged between 8.08 and 8.58 which is higher than the optimal range for most of the test species but within their tolerance thresholds.

None of the measured non-contaminant variables (i.e., pH, OM, particle size distribution, texture, structure, magnesium, potassium, phosphorus, calcium, metal levels, etc.) explains the poor performance of the test species in the reference controls soils. Performance of the standardized toxicity test species in all site soils was relatively poor overall, in comparison with more optimal growth media for these temperate agronomic species such as the Artificial Soil. That said, various plant endpoints and the collembolan reproduction endpoint indicate that the presence of hydrocarbons in the soils provides some degree of "bioaugmentation", which may in part offset the very low TOC and plant available nitrogen in the soil samples. In particular, the following data clearly support a positive as opposed to negative concentration response relationship between growth or reproduction and the F2 concentrations:

- Alfalfa shoot length
- Alfalfa root length
- Alfalfa shoot biomass (dry)
- Blue grama root length
- Northern wheatgrass shoot length
- Northern wheatgrass root length
- Northern wheatgrass root mass (dry)
- Collembolan progeny

The following figures (**Figure 1 and 2**) contain examples to allow visualization of the "bioaugmentation effects" with the caveat that there are relatively few data to describe the relationships between the exposure concentrations and the biological responses. Non-linear regression procedures were used to describe these relationships.

The reduction in F2 concentrations in the glacial tills from the time of collection to both the start and end of the tests suggests that the F2 is readily mobilized from soil particles and can volatilize relatively rapidly when temperate conditions are present. Mixing procedures applied to the soils at room temperature during test soil preparation could contribute to the loss of volatile compounds from soils. Further losses can occur during the test from the activity of the organisms in the test units and during collection of subsamples for submission to the analytical laboratory.

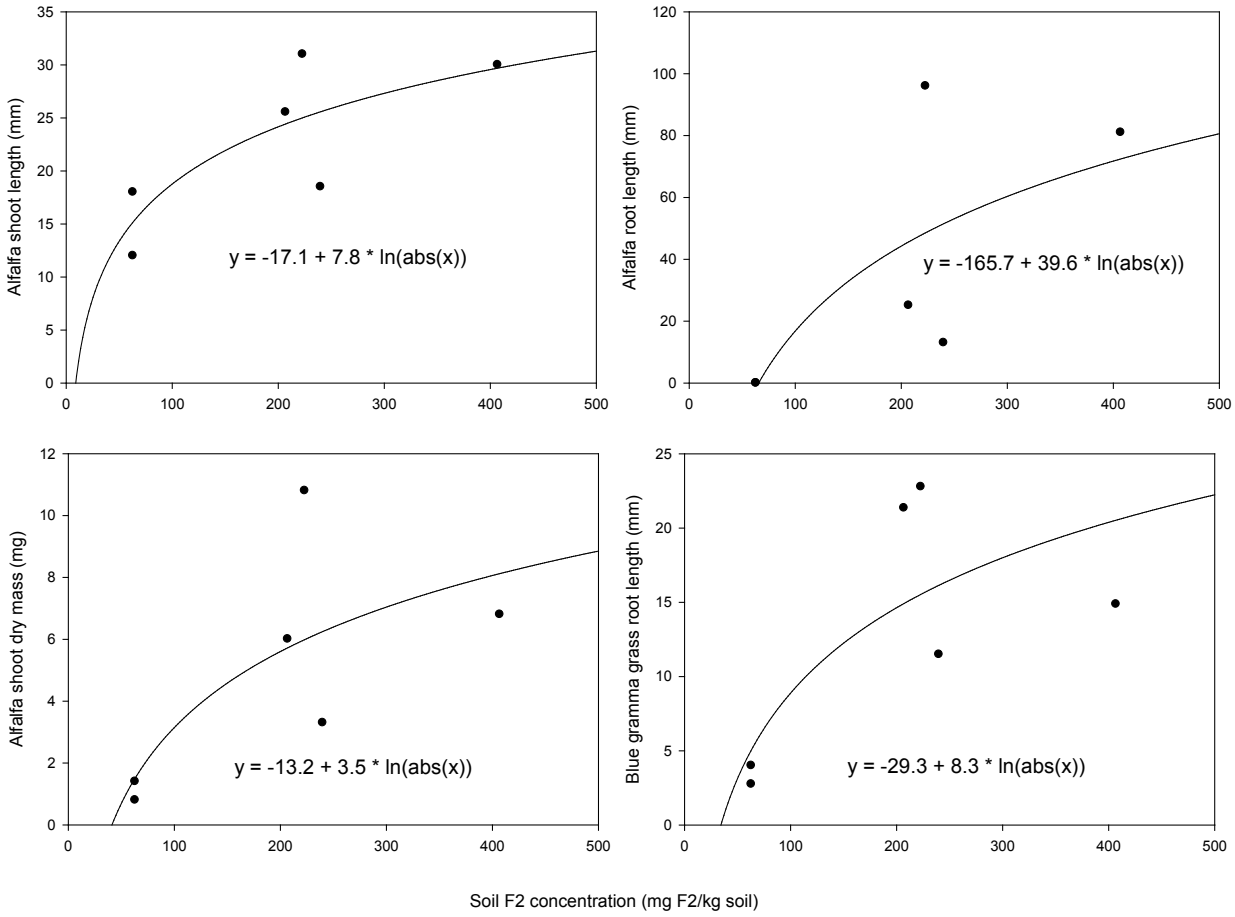

Figure 1: Exposure concentration response relationships illustrating the apparent "bioaugmentation effect" of the presence of petroleum hydrocarbons as predominantly F2 in the site soils.

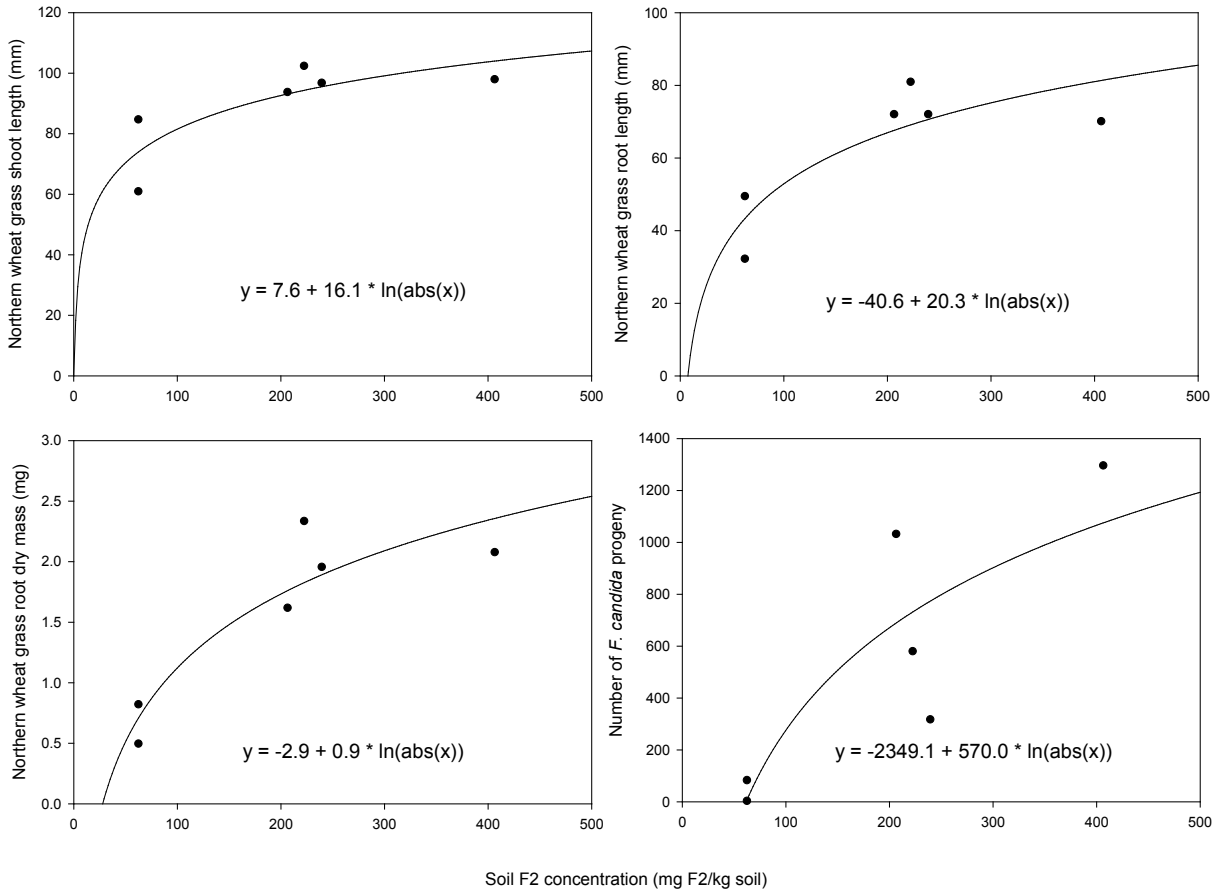

Figure 2: Exposure concentration response relationships illustrating the apparent "bioaugmentation effect" of the presence of petroleum hydrocarbons as predominantly F2 in the site soils. Note: units include mm for lengths, mg for weight.

4.1 TOXICITY TESTS

4.1.1 Plants

Plant growth responses to contaminants can be soil specific, contaminant specific, species specific, and endpoint specific. Seedling emergence is typically an insensitive endpoint relative to growth (length and mass metrics); however, for this study seedling emergence of alfalfa was adversely affected in all site soils except Soil D and, for blue grama grass, the greatest impacts were observed for plants grown in the reference control soils (soils A and B). Because seedling emergence of northern wheatgrass was comparable in all site soils relative to the AS, neither the F2 concentrations nor the measured edaphic characteristics for these site soils adversely affected emergence. Likewise, for growth of northern wheatgrass, when significant differences

existed among treatments, growth was consistently greater for all endpoints in the site soils with the highest F2 concentrations.

Alfalfa prefers a deep, well-drained loam, silt loam, or clay loam soils with a pH between 6.2 and 7.5. Sandy soils are suitable if properly irrigated and fertilized. In addition, alfalfa is grown in saline soils with alkaline pH values; however, critical to growth is sufficient nitrogen (2.50 to 4.00%), phosphorus (0.25 to 0.45%), potassium (2.25 to 3.40%), calcium (0.70 to 2.50%), magnesium (0.25 to 0.70%) and sulfur (0.25 to 0.50%). Soil fertility was likely compromised for both blue grama grass and alfalfa in these test soils. Conversely, petroleum hydrocarbons at the concentrations present in these site soils appear to actually enhance plant growth rather than hinder when plant performance is compared to that observed for plants grown in the reference control soils. That said, there is no consistent pattern to growth within or among species as a result of exposure to these site soils.

The poor performance of the three plant test species in the reference control soils precludes application of the applicable Alberta Tier 2 pass/fail criteria (Alberta Environment, 2007 and 2010). Although the reference soils were well matched to the site soil in terms of the measured critical influencing pedological parameters, characteristics that were not measured might have been responsible for the poor performance.

4.1.2 Soil Invertebrates

Invertebrate survival is an insensitive endpoint relative to progeny production and biomass. Progeny production responses are specific to both physico-chemical characteristics and soil contamination; therefore, differences between test soils were expected. Overall, progeny production by *F. candida* was significantly reduced in the reference soils (soils A and B) compared to the other site soils. No observable trend was present with respect to progeny production; no exposure concentration-response relationships were discernable and effects did not correlate with the F2 exposure concentrations in soil (**Figure D.1**, **Appendix D**).

The pH values of soils being tested ranged from 8.30 to 8.43 at the start of the collembola test, and from 8.08 to 8.36 at the end of the collembola test (**Table D.3**, **Appendix D**). *F. candida* is able to tolerate a wide range of soil pH values (3.2 to 7.65), although they prefer a pH of 6.0 (Jänsch et al., 2005). Optimal fecundity of *F. candida* has been reported in soils with pH values that range between 5.2 and 6.2 (Kaneda and Kaneko, 2002), while pH values between 5.4 and 6.6 were found to be optimal for production of progeny (Jänsch et al., 2005). All of the site soils had pH values higher than the tolerable range for *F. candida*; however, there was no observable trend between elevated pH and adult survival and progeny production in the site soils.

Initial soil moisture of the test soils ranged from 31 to 36 % WHC on a dry basis for the collembola test, while final soil moisture ranged from 38 to 81 % WHC on a dry basis. *F. candida* is able to tolerate a wide range of soil moisture contents (EC, 2007; Jänsch et al., 2005). The moisture content of the soil in the collembola test units at the end of the collembola reproduction test

was good for all test soils; therefore, soil moisture content did not adversely affect collembola survival or reproduction.

F. candida thrives in soils with high organic matter contents (EC, 2007; Jänsch et al., 2005). The organic matter content of the test soils was very low which might have adversely affected collembolan survival or reproduction in this assessment.

4.2 CONCLUSIONS

The species used in this assessment were surrogate species for the plant and invertebrate species that might occupy the soils on site. However, the site for the most part was bereft of plants and soil invertebrates (Photographs 7 to 10; **Appendix H**) and the area is thought to comprise lands in a polar desert with the exception of the zones within the site that are naturally wetted during the active growing season as a result of the emergence of shallow groundwater seeps. The results of the ecotoxicity assessment indicate that the test organism performance in soils without F2 concentrations (i.e., the reference control soils) was suboptimal independent of F2 contamination; conversely, performance of the test species was as good as or actually better in soils with F2 contamination. Some exposure concentration-effect relationships were discernable indicating positive effects but causality is uncertain. We hypothesize that nutrient availability might be a limiting factor despite the nutrient amendments that were undertaken with the site soils during the remediation process.

The results of the ecotoxicity assessment clearly demonstrated that the F2 is labile in these soils and readily dissipates (likely via volatilization) upon mixing at room temperature. Therefore, it is probable that the F2 will dissipate from soils if the soils are brought to the surface and turned over during a period of time when temperatures are above 20 °C. Microbial degradation likely contributes to the dissipation of F2 from the soils during the test and weeks available for bioremediation *in situ*. The test soil with the highest percent decrease in concentration from the time collected at the site to the time of initiation of the lab test (14433-1: E; decrease from 610 to 223 mg/kg F2) also supported the highest alfalfa shoot and root growth, and highest northern wheatgrass root and shoot growth. This could suggest that either bacterial biomass or metabolites of F2 augment plant growth, and further suggest that attenuation of F2 in the soils was not based on volatilization alone.

The ecotoxicity assessment results preclude derivation of a SSRO using either SSD (species sensitivity distribution) or Tier 2 pass/fail approaches (CCME, 2008; Alberta Environment, 2007 and 2010). The PHC concentrations in soil resulting in the best plant growth as a result of the "bioaugmentation" phenomenon, could be used to support a value higher than the current Tier 1 standard of 260 mg F2/Kg soil. The highest exposure concentration of F2 in soil, at which enhanced performance of collembolan and no-observable-adverse effects to plants were observed, was 407 mg/kg soil dry weight.

5.0 References

Alberta Environment (AENV). 2007. Tier 2 Eco-contact Guideline Derivation Protocol. July 13 2007 Draft. ISBN: 978-0-7785-6753-0 (On-line Version).

Alberta Environment (AENV). 2010. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. December 2010 ISBN: 0-7785-6306-8 (On-line Version).

ASA (American Society of Agronomy). 2011. Alfalfa Management Guide. American Society of Agronomy, Madison, WI.

CCME (Canadian Council of Ministers of the Environment), 2008. Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) In Soil: Update to the Scientific Rationale Supporting Technical Document. December 2000.

CCME (Canadian Council of Ministers of the Environment), 2000. Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) In Soil: Scientific Rationale Supporting Technical Document. December 2000.

Environment Canada (EC). 2005a. Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.

Environment Canada (EC). 2005b. Guidance Document on Statistical Methods for Environmental Toxicity Tests. Report EPS 1/RM/46, with June 2007 amendments. Method Development and Applications Section, Environmental Science and Technology Centre, Science and Technology Branch, Environment Canada, Ottawa, ON.

Environment Canada (EC). 2007. Biological Test Method: Test for Measuring Survival and Reproduction of Springtails Exposed to Contaminants in Soil. Report EPS 1/RM/47, September 2007. Method Development and Applications Section, Environmental Science and Technology Centre, Environment Canada, Ottawa, Ontario.

Hendershot, W.H., H. Lalonde, and M. Duquette. 1993. Soil reaction and exchangeable acidity. P 141-145 in: Soil Sampling and Methods of Analysis, M.R. Carter, ed., Canadian Society of Soil Science, Lewis Publishers, Boca Raton, Florida.

Jänsch, S., Amorim, M.J. and Römbke, J. 2005 Identification of the ecological requirements of important terrestrial ecotoxicological test species. Environmental Review, 13:51-83.

References
October 15, 2014

Jacques Whitford Ltd. 2003. Nanisivik Mine Human Health and Ecological Risk Assessment. Final report prepared for CanZinco Ltd. October 2003.

Kaneda, S. and Kaneko, N. 2002. Influence of soil quality on the growth of Folsomia candida (Willem) (Collembola). Pedobiologia, 46 (428-439).

McKeague, J.A. ed. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Ottawa, Ontario.

Microsoft® Office Professional Plus 2010. 2010. Version 14.0.5112.5000 (32-bit). Copyright 2010 Microsoft Corporation.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Soil Analysis Handbook. 1992. Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc., Georgia University Station, Athens, Georgia, 202 p.

SSI (Systat Software Inc.). 2007. SYSTAT© 12 for Windows. Version 12.00.08. Systat Software Inc., USA.

Appendix A:

Test Conditions, Experimental Design, Data Summaries, and Results of the Alfalfa Definitive Plant

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Sample Identification

Client:	Johan Skoglund (Canzinco Ltd.)
Sample(s) description:	Field-collected site soils contaminated with PHCs (contaminant of concern - F2) Artificial soil (AS) used as an experimental control.
Sample(s) identification:	See below

Bucket Label	Sample Login ID	Figure and Table ID***
Artificial Soils	AS mixed 2014-07-21-1	AS
14431 1/6	1457_14431_01	A
14431 2/6	1457_14431_02	B
14432 1/4	1458_14432_01	C
14432 2/4	1458_14432_02	D
14433 1/3	1459_14433_01	E
14433 2/3	1459_14433_02	F

***AS is the negative control soil, A and B are reference control soils

Date collected/formulated:	2014-06-30; AS formulated 2014-07-21
Method of soil collection:	Composite
Date sample(s) received:	2014-07-03
Time sample(s) received:	09:30
Temperature on arrival:	25 °C
Soil storage temperature:	21.6 ± 0.4 °C
Date sample(s) tested:	2014-07-31 to 2014-08-21
Technician(s):	Timothy Clemens, Alvin Leung, Kelly Olaveson, Wai Ma, Emma Shrive, and Jessica Sosa-Campos
Analyst(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
QA/QC:	Gladys Stephenson

Test Organism

Test organism:	Alfalfa (*Medicago sativa*) Common No. 1
Organism source:	OSC Seeds, Waterloo, Ontario
Stantec seed batch number:	Alf_2011_OSC

Test Conditions and Procedures

Test type:	Static, definitive
Location of testing:	Test setup and process: Stantec Southgate Laboratory Duration of test: University of Guelph, Growth Room 27A
Test duration:	21 days
Number of treatments:	3 (2 buckets of each soil), plus 1 experimental control (AS)
Temperature:	24.7 ± 0.3 °C (day), 17.6 ± 0.1 °C (night)
Light intensity:	330 ± 29 µmol/(m²•s)
Photoperiod:	16 h light; 8 h dark
Watering regime:	Artificial soil treatment watered with nutrient solution, site soil treatments watered with de-chlorinated municipal tap water, as required
Test unit description:	1-L clear polypropylene container covered with lid (until Day 7 or earlier if plants touched lid)
Soil volume/test unit:	600 g soil wet weight
No. organisms/test unit:	10
No. field samples/treatment:	2
No. replicate test units/treatment:	6 (3 per bucket), 6 replicates for AS
Measured soil chemistry parameters:	Initial soil pH, electrical conductivity, and percent moisture content, final soil pH and electrical conductivity
Measured endpoint(s):	Day 21: Seedling emergence, shoot and root lengths, shoot and root dry masses
Test protocol:	Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.
Statistical analyses:	Mean, SD – Microsoft Excel (2010) Non-Parametric (Kruskal-Wallis One-way Analysis of Variance) - Emergence - Shoot length - Root Length - Shoot Dry Mass - Root Dry Mass (Systat Version 12.0, SSI, 2007)

Test acceptability criteria met? Yes
See Table A.1.

Table A.1. Performance of plants (Alfalfa) in negative control soil treatment relative to test method validity criteria.

Criterion in Negative Control Soil		Negative Control Soil	Criteria Met?	Positive Control Soil	Solvent Control Soil
Measurement	Criterion				
Mean % survival of emerged seedlings (d 21)	≥ 90%	100%	Yes	NA	NA
Mean % seedlings with phytotoxicity symptoms/developmental anomalies (d 21)	≤ 10%	0%	Yes	NA	NA
Mean % emergence (d 21)	≥ 70%	82%	Yes	NA	NA
Mean shoot length (mm) (d 21)	≥ 40	107 mm	Yes	NA	NA
Mean root length (mm) (d 21)	≥ 120	146 mm	Yes	NA	NA

NA = not applicable

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Boric Acid Reference Toxicant Data for Artificial Soil

Type of test:	Seedling emergence and shoot growth
Test duration:	7 days
Date tested:	2014-08-05 to 2014-08-12
Stantec seed batch number:	Alf_1_2014
EC50 (Emergence):	1535.7 mg/kg
95% CL:	1277.7 to 1793.7 mg/kg
IC50 (Shoot length):	1415.8 mg/kg
95% CL:	1216.2 to 1648.2 mg/kg
Statistical analyses:	Emergence – Logit (R, 2013) IC50, 95% CL - Gompertz (SSI, 2007)
Historical geomean EC50:	993.2 mg/kg
Warning limits (± 2 SD):	395.2 to 1692.9 mg/kg
Historical geomean IC50:	1205.1mg/kg
Warning limits (± 2 SD):	739.7 to 1719.7 mg/kg
Technician(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
Analyst(s):	Timothy Clemens and Emma Shrive

Results

Table A.2. Effects on seedling (Alfalfa) emergence (Day 21) following exposure to the test soils. Results reported are number of seedlings in each test unit, as observed at the end of the test.

Soil Treatment	Number of Seedlings (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	9	7	6	9	9	9
A	0	0	1	NA	NA	NA
B	0	0	1	NA	NA	NA
C	0	0	2	NA	NA	NA
D	5	8	9	NA	NA	NA
E	0	0	1	NA	NA	NA
F	0	1	0	NA	NA	NA

NA = not applicable

Table A.3. Effects on seedling (Alfalfa) condition (Day 21) following exposure to the test soils. Results reported are seedling condition in each test unit, as observed at the end of the test.

Soil Treatment	Seedling Condition[1] (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	N	N	N	N	N	N
A	NA	NA	Di	NA	NA	NA
B	NA	NA	Di	NA	NA	NA
C	NA	NA	Di/Cl	NA	NA	NA
D	S/Cl/Di	Di	N/Cl	NA	NA	NA
E	NA	NA	G	NA	NA	NA
F	NA	Di	NA	NA	NA	NA

[1] Condition of seedlings indicates a visual assessment of seedling health and vigour, relative to those in negative control soil. Normal seedlings are green, robust, and without deformities or discolouration. "Non-normal" seedlings are seedlings that exhibit symptoms of suboptimal health such as chlorosis or necrosis, or those that are wilted, desiccated, discoloured, etc. These signs can result from the phytotoxic effect of the contaminant. Explanations of codes are provided below.

N Normal Cl Chlorotic G Green but not healthy
Di Discoloured S Stunted
NA = not applicable (e.g., uneven replicate test design or no plants emerged).

Stantec

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Table A.4. Effect on seedling (Alfalfa) emergence and growth (Day 21) following exposure to the test soils. Results are reported as treatment means (n = 3 replicates for site soils, 6 replicates for artificial soil) with one standard deviation of the mean in brackets.

Soil Treatment	Percent Emergence (n = 10 seeds)	Shoot Length (mm)	Root Length (mm)	Individual Shoot Dry Mass (mg)	Individual Root Dry Mass (mg)
Artificial Soil	82 (13)	107 (17)	146 (15)	33.2 (11.0)	9.5 (2.4)
A	3 (6)	12 (NA)	NA	1.4 (NA)	NA
B	3 (6)	18 (NA)	NA	0.8 (NA)	NA
C	7 (12)	19 (NA)	13 (NA)	3.3 (NA)	0.7 (NA)
D	73 (21)	26 (2)	25 (1)	6.0 (1.4)	0.9 (0.2)
E	3 (6)	31 (NA)	96 (NA)	10.8 (NA)	5.1 (NA)
F	3 (6)	30 (NA)	81 (NA)	6.8 (NA)	2.1 (NA)

NA = not applicable

The results reported relate only to the sample(s) tested

Date: October 8, 2014 Approved by: Gladys L Stephenson
Director of Laboratory Services

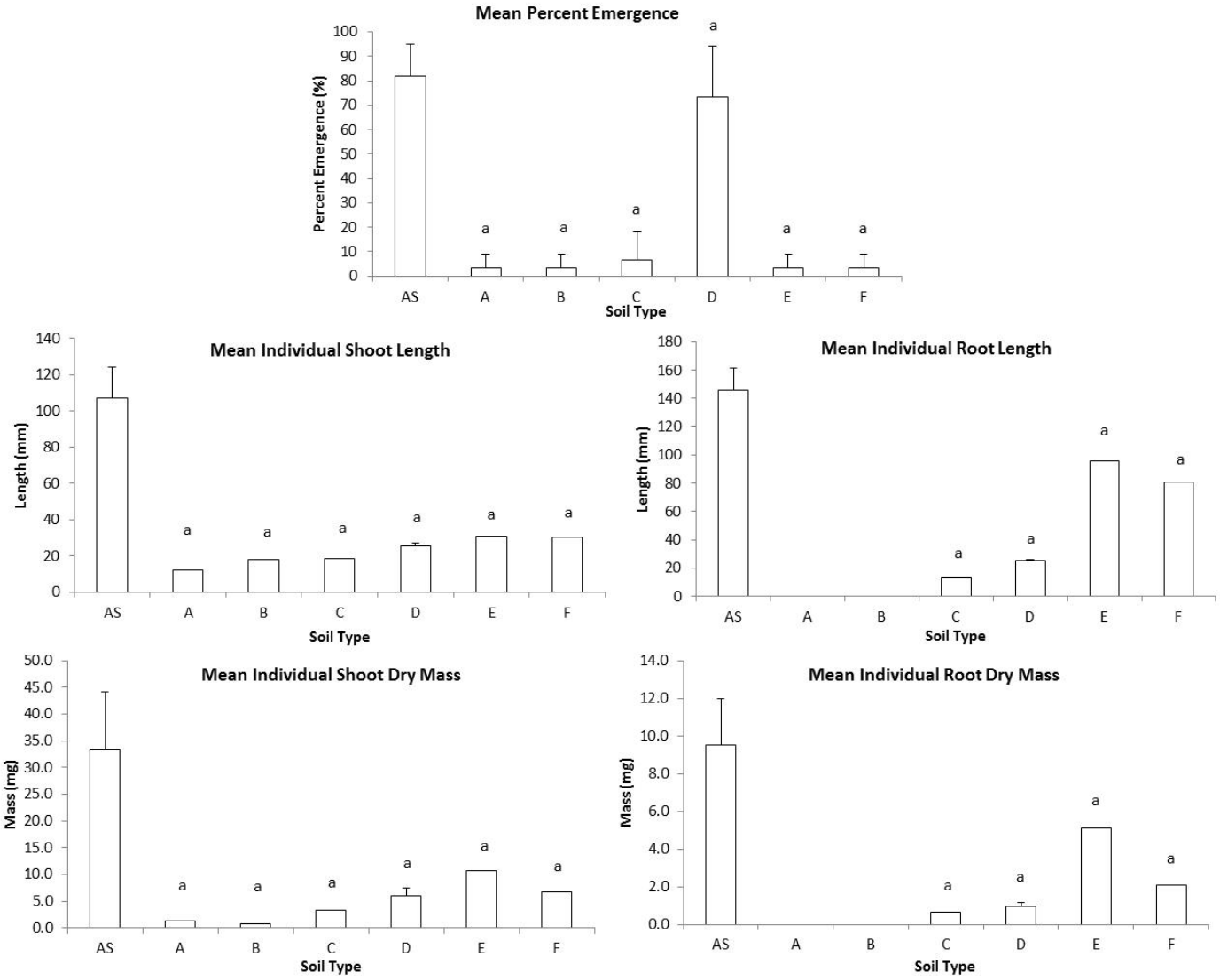

Figure A.1. Seedling (Alfalfa) emergence and growth (Day 21) following exposure to the test soils. Columns indicate treatment means. Bars above the columns represent one standard deviation of the mean. Letters above the columns that are different indicate a significant difference ($p < 0.05$) among means. Site soils A and B are reference control soils.

Soil Characteristics

Table A.5. pH, conductivity, and moisture content of test soils at the beginning (Day 0) and end (Day 21) of the test.

Soil Treatment	Initial pH[1]	Final pH[1]	Initial Conductivity[1] (µS/cm)	Final Conductivity[1] (µS/cm)	Initial Soil Moisture[2] (% WHC)
Artificial Soil	7.51	7.62	236	568	67
A	8.22	8.27	518	607	33
B	8.26	8.29	541	582	33
C	8.10	8.35	415	469	32
D	8.25	8.37	345	420	37
E	8.08	8.58	392	312	28
F	8.12	8.54	365	362	30

[1] pH and conductivity were measured using a 2:1 water:soil slurry
[2] % WHC - percent of water-holding capacity of the soil
NA = not applicable

Table A.6. Texture, organic matter content, carbon content, fertility, and water-holding capacity of test soils.

Soil	Parameter[1]							
	Sand (%)	Silt (%)	Clay (%)	Organic Matter (% dry)	Organic Carbon (% dry)	Nitrogen (% dry)	Plant Available Phosphorus (mg/kg dry)	Water-holding Capacity (%)
Artificial Soil	78.4	5.8	15.8	6.8	2.81	< 0.05	5.48	80
A	62.6	25.7	11.7	0.6	0.83	<0.05	6.96	27
B	59.4	29.1	11.5	0.8	0.52	<0.05	7.16	27
C	60.2	28.4	11.4	0.8	0.33	<0.05	8.27	27
D	59.4	29.6	11.0	0.7	0.69	<0.05	10.2	27
E	62.6	27.2	10.2	0.9	<0.1	<0.05	3.60	29
F	59.8	27.6	12.6	0.8	0.77	<0.05	5.01	29

[1] Analyses conducted by the University of Guelph, Laboratory Services – Agriculture and Food Laboratory (AS collected: 2014-05-28; report date: 2014-06-10; Site soil collected: 2014-08-26; report date: 2104-09-17, except for water-holding capacity which was determined by the Stantec Southgate Laboratory.

Comments

No seeds exhibiting unusual appearance or undergoing unusual treatment were used in this test.

Test Method Modifications

1. Soil pH was measured using a soil-water slurry, which represents our normal practices and is a method modified from the Soil Analysis Handbook (1992), instead of using a $CaCl_2$ slurry, as recommended by the method for pH. This had no impact on the results of the test. The method of using $CaCl_2$ was developed for soil scientists who were comparing the pH of different soils, and wished to minimize the variability of the different pHs (McKeague, 1978). As a result, the $CaCl_2$ method will, by design, minimize the variability of the soil pH among soil samples, and will be less sensitive to differences in pH. In addition, soil pH measured in water is considered to be the pH closest to the pH of soil solution in the field (Hendershot et al., 1993).

Test Method Deviations

1. There was a deviation related to the reference toxicant test conducted concurrently with this test. At the end of the reference toxicant test, the average nighttime temperature and the maximum nighttime temperature were 21°C and 24°C, respectively which are higher than the maximum nighttime temperature required by the Environment Canada Test Method (EPS 1/RM/45, February 2005, with June 2007 amendments) (18°C). After reviewing the test results, procedures, and conditions, it appears that the data logger used to monitor temperatures was set to record temperatures approximately 15-20 minutes later than usual which captured temperatures at 6:20 am when the lights were on in the growth room, instead of 6:00 am when lights were still off. We concluded that the temperature deviation did not affect the test results. All test validity criteria for emergence and growth were met for Alfalfa. The plants appeared to be healthy and showed no signs of stress. The reference toxicant test results were added to the warning charts and all results fit within the warning limits.

References

Environment Canada (EC). 2005. Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.

Hendershot W.H., H. Lalonde, and M. Duquette. 1993. Soil reaction and exchangeable acidity. P 141-145 in: Soil Sampling and Methods of Analysis, M.R. Carter, ed., Canadian Society of Soil Science, Lewis Publishers, Boca Raton, Florida.

McKeague, J.A. ed. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Ottawa, Ontario.

Microsoft® Office Professional Plus 2010. 2010. Version 14.0.5112.5000 (32-bit). Copyright 2010 Microsoft Corporation.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Soil Analysis Handbook. 1992. Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc., Georgia University Station, Athens, Georgia, 202 p.

Systat Software Inc. (SSI). 2007. SYSTAT© 12 for Windows. Version 12.00.08. Systat Software Inc., Chicago, IL.

Appendix B:

Test Conditions, Experimental Design, Data Summaries, and Results of the Blue Grama Grass Definitive Plant Test

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Sample Identification

Client:	Johan Skoglund (Canzinco Ltd.)
Sample(s) description:	Field-collected site soils contaminated with PHCs (contaminant of concern - F2) Artificial soil (AS) used as an experimental control.
Sample(s) identification:	See below

Bucket Label	Sample Login ID	Figure and Table ID***
Artificial Soils	AS mixed 2014-07-21-1	AS
14431 1/6	1457_14431_01	A
14431 2/6	1457_14431_02	B
14432 1/4	1458_14432_01	C
14432 2/4	1458_14432_02	D
14433 1/3	1459_14433_01	E
14433 2/3	1459_14433_02	F

***AS is the negative control soil, A and B are reference control soils

Date collected/formulated:	2014-06-30; AS formulated 2014-07-21
Method of soil collection:	Composite
Date sample(s) received:	2014-07-03
Time sample(s) received:	09:30
Temperature on arrival:	25 °C
Soil storage temperature:	21.6 ± 0.4 °C
Date sample(s) tested:	2014-07-31 to 2014-08-21
Technician(s):	Timothy Clemens, Alvin Leung, Kelly Olaveson, Wai Ma, Emma Shrive, and Jessica Sosa-Campos
Analyst(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
QA/QC:	Gladys Stephenson

Test Organism

Test organism:	Blue Grama Grass (*Bouteloua gracilis*) Unspecified variety
Organism source:	Hannas Seeds, Lacombe, Alberta
Stantec seed batch number:	BGG_2007

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Test Conditions and Procedures

Test type:	Static, definitive
Location of testing:	Test setup and process: Stantec Southgate Laboratory Duration of test: University of Guelph, Growth Room 27A
Test duration:	21 days
Number of treatments:	3 (2 buckets of each soil), plus 1 experimental control (AS)
Temperature:	24.7 ± 0.3 °C (day), 17.6 ± 0.1 °C (night)
Light intensity:	330 ± 29 µmol/(m²•s)
Photoperiod:	16 h light; 8 h dark
Watering regime:	Artificial soil treatment watered with nutrient solution, site soil treatments watered with de-chlorinated municipal tap water, as required
Test unit description:	1-L clear polypropylene container covered with lid (until Day 7 or earlier if plants touched lid)
Soil volume/test unit:	600 g soil wet weight
No. organisms/test unit:	10
No. field samples/treatment:	2
No. replicate test units/treatment:	6 (3 per bucket), 6 replicates for AS
Measured soil chemistry parameters:	Initial soil pH, electrical conductivity, and percent moisture content, final soil pH and electrical conductivity
Measured endpoint(s):	Day 21: Seedling emergence, shoot and root lengths, shoot and root dry masses
Test protocol:	Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.
Statistical analyses:	Mean, SD – Microsoft Excel (2010) ANOVA (note with Fisher's LSD test, Shapiro-Wilk test for normality, and ANOVA for homogeneity) - Emergence - Shoot Length (data was log transformed) - Shoot Dry Mass (data was log transformed) - Root Dry Mass (Systat Version 12.0, SSI, 2007) ANOVA (without Fisher's LSD test, Shapiro-Wilk test for normality, and ANOVA for homogeneity)

- Root Length

(Systat Version 12.0, SSI, 2007)

Test acceptability criteria met? Yes
See Table B.1.

Table B.1. Performance of plants (Blue Grama Grass) in negative control soil treatment relative to test method validity criteria.

Criterion in Negative Control Soil		Negative Control Soil	Criteria Met?	Positive Control Soil	Solvent Control Soil
Measurement	Criterion				
Mean % survival of emerged seedlings (d 21)	≥ 90%	100%	Yes	NA	NA
Mean % seedlings with phytotoxicity symptoms/developmental anomalies (d 21)	≤ 10%	3%	Yes	NA	NA
Mean % emergence (d 21)	≥ 70%	88%	Yes	NA	NA
Mean shoot length (mm) (d 21)	≥ 50	121 mm	Yes	NA	NA
Mean root length (mm) (d 21)	≥ 70	109 mm	Yes	NA	NA

NA = not applicable

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Boric Acid Reference Toxicant Data for Artificial Soil

Type of test:	Seedling emergence and shoot growth
Test duration:	10 days
Date tested:	2014-08-05 to 2014-08-15
Stantec seed batch number:	BGG_1_2014
EC50 (Emergence):	1077.6 mg/kg
95% CL:	783.9 to 1371.2 mg/kg
IC50 (Shoot length):	595.7 mg/kg
95% CL:	518.8 to 683.9 mg/kg
Statistical analyses:	Emergence - Logit (R, 2013) IC50, 95% CL - Linear and non-linear regression (Logistic), (SSI, 2007)
Historical geomean EC50:	718.1 mg/kg
Warning limits (± 2 SD):	341.5 to 1148.1 mg/kg
Historical geomean IC50:	526.8 mg/kg
Warning limits (± 2 SD):	354.7 to 711.1 mg/kg
Technician(s):	Timothy Clemens, Kelly Olaveson, Emma Shrive, and Jessica Sosa-Campos
Analyst(s):	Timothy Clemens and Emma Shrive

Results

Table B.2. Effects on seedling (Blue Grama Grass) emergence (Day 21) following exposure to the test soils. Results reported are number of seedlings in each test unit, as observed at the end of the test.

Soil Treatment	Number of Seedlings (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	8	9	9	9	9	9
A	2	0	1	NA	NA	NA
B	2	4	1	NA	NA	NA
C	8	5	8	NA	NA	NA
D	8	8	10	NA	NA	NA
E	5	5	6	NA	NA	NA
F	3	4	5	NA	NA	NA

NA = not applicable

Table B.3. Effects on seedling (Blue Grama Grass) condition (Day 21) following exposure to the test soils. Results reported are seedling condition in each test unit, as observed at the end of the test.

Soil Treatment	Seedling Condition[1] (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	N	N/ClT	N	N	N	N
A	BT	NA	Di/NcT	NA	NA	NA
B	Cl	Nc	Cl	NA	NA	NA
C	Nc	Di/ClT	NcT	NA	NA	NA
D	NA	Cl	Nc	NA	NA	NA
E	N/Cl	G	N/Cl	NA	NA	NA
F	ClT	G/BT	Nc/CLT	NA	NA	NA

[1] Condition of seedlings indicates a visual assessment of seedling health and vigour, relative to those in negative control soil. Normal seedlings are green, robust, and without deformities or discolouration. "Non-normal" seedlings are seedlings that exhibit symptoms of suboptimal health such as chlorosis or necrosis, or those that are wilted, desiccated, discoloured, etc. These signs can result from the phytotoxic effect of the contaminant. Explanations of codes are provided below.

N	Normal	Nc	Necrotic	Di	Discoloured
BT	Brown Tips	Cl	Chlorotic	G	Green but not healthy
NcT	Necrotic Tips	ClT	Chlorotic Tips		

NA = not applicable (e.g., uneven replicate test design or no plants emerged).

Stantec

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Table B.4. Effect on seedling (Blue Grama Grass) emergence and growth (Day 21) following exposure to the test soils. Results are reported as treatment means (n = 3 replicates for site soils, 6 replicates for artificial soil) with one standard deviation of the mean in brackets.

Soil Treatment	Percent Emergence (n = 10 seeds)	Shoot Length (mm)	Root Length (mm)	Individual Shoot Dry Mass (mg)	Individual Root Dry Mass (mg)
Artificial Soil	88 (4)	121 (10)	109 (13)	9.2 (0.9)	2.5 (0.2)
A	10 (10)	15 (1)	4 (3)	0.4 (0.2)	0.1 (0.1)
B	23 (15)	9 (3)	3 (0)	0.2 (0.0)	0.0 (NA)
C	70 (17)	20 (3)	11 (10)	0.7 (0.3)	0.1 (0.1)
D	87 (12)	29 (5)	21 (9)	1.2 (0.3)	0.4 (0.1)
E	53 (6)	23 (8)	23 (17)	0.9 (0.4)	0.2 (0.1)
F	40 (10)	18 (1)	15 (10)	0.6 (0.1)	0.1 (0.1)

The results reported relate only to the sample(s) tested

Date: October 8, 2014 Approved by: Gladys L Stephenson
Director of Laboratory Services

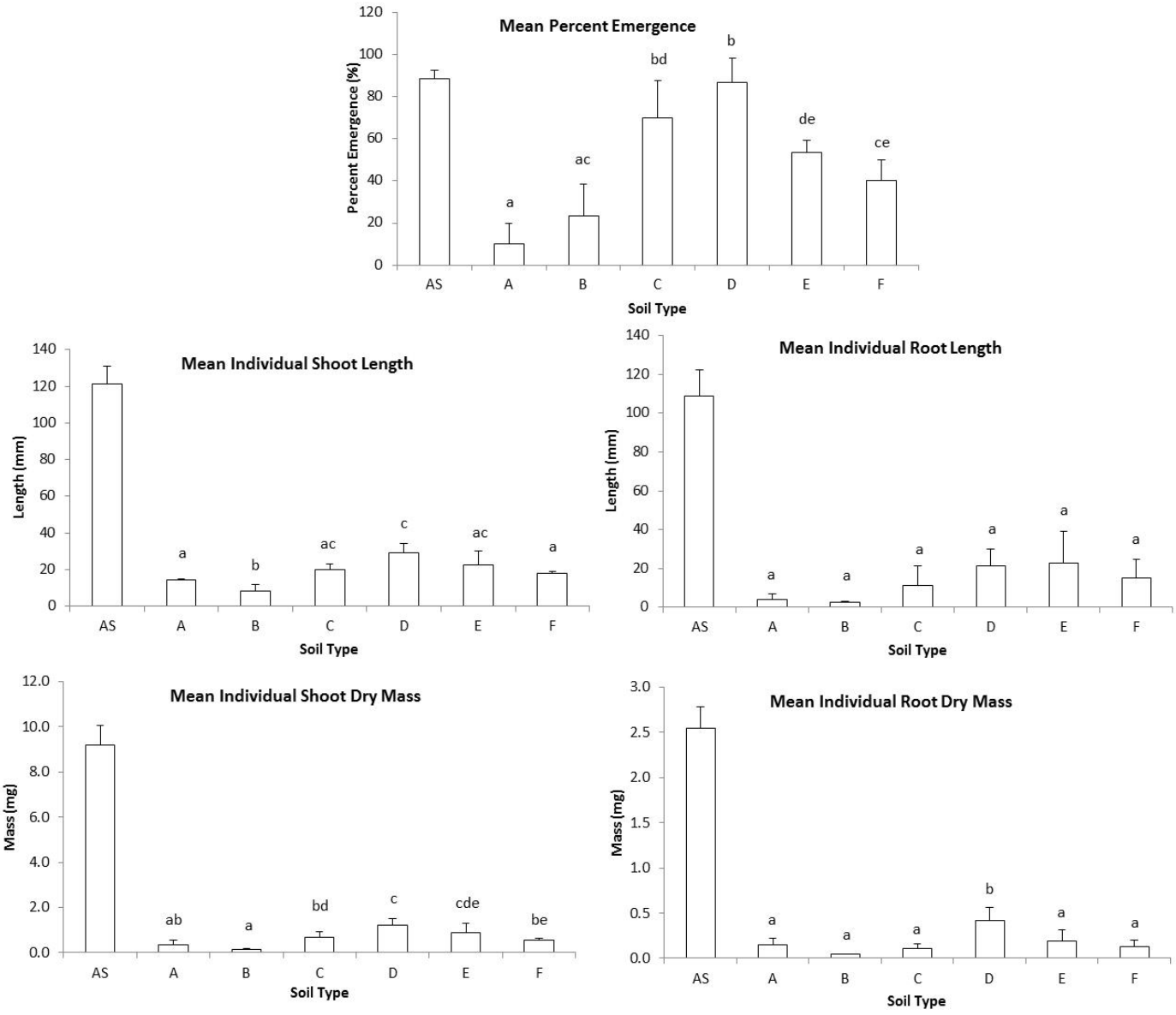

Figure B.1. Seedling (Blue Grama Grass) emergence and growth (Day 21) following exposure to the test soils. Columns indicate treatment means. Bars above the columns represent one standard deviation of the mean. Letters above the columns that are different indicate a significant difference ($p < 0.05$) among means. Site soils A and B are reference control soils.

Soil Characteristics

Table B.5. pH, conductivity, and moisture content of test soils at the beginning (Day 0) and end (Day 21) of the test.

Soil Treatment	Initial pH[1]	Final pH[1]	Initial Conductivity[1] (µS/cm)	Final Conductivity[1] (µS/cm)	Initial Soil Moisture[2] (% WHC)
Artificial Soil	7.51	7.71	236	493	67
A	8.22	8.24	518	663	33
B	8.26	8.22	541	761	33
C	8.10	8.39	415	500	32
D	8.25	8.37	345	449	37
E	8.08	8.50	392	368	28
F	8.12	8.45	365	390	30

[1] pH and conductivity were measured using a 2:1 water:soil slurry
[2] % WHC - percent of water-holding capacity of the soil
NA = not applicable

Table B.6. Texture, organic matter content, carbon content, fertility, and water-holding capacity of test soils.

Soil	Parameter[1]							
	Sand (%)	Silt (%)	Clay (%)	Organic Matter (% dry)	Organic Carbon (% dry)	Nitrogen (% dry)	Plant Available Phosphorus (mg/kg dry)	Water-holding Capacity (%)
Artificial Soil	78.4	5.8	15.8	6.8	2.81	< 0.05	5.48	80
A	62.6	25.7	11.7	0.6	0.83	<0.05	6.96	27
B	59.4	29.1	11.5	0.8	0.52	<0.05	7.16	27
C	60.2	28.4	11.4	0.8	0.33	<0.05	8.27	27
D	59.4	29.6	11.0	0.7	0.69	<0.05	10.2	27
E	62.6	27.2	10.2	0.9	<0.1	<0.05	3.60	29
F	59.8	27.6	12.6	0.8	0.77	<0.05	5.01	29

[1] Analyses conducted by the University of Guelph, Laboratory Services – Agriculture and Food Laboratory (AS collected: 2014-05-28; report date: 2014-06-10; Site soil collected: 2014-08-26; report date: 2104-09-17, except for water-holding capacity which was determined by the Stantec Southgate Laboratory.

Comments

No seeds exhibiting unusual appearance or undergoing unusual treatment were used in this test.

Test Method Modifications

1. Soil pH was measured using a soil-water slurry, which represents our normal practices and is a method modified from the Soil Analysis Handbook (1992), instead of using a $CaCl_2$ slurry, as recommended by the method for pH. This had no impact on the results of the test. The method of using $CaCl_2$ was developed for soil scientists who were comparing the pH of different soils, and wished to minimize the variability of the different pHs (McKeague, 1978). As a result, the $CaCl_2$ method will, by design, minimize the variability of the soil pH among soil samples, and will be less sensitive to differences in pH. In addition, soil pH measured in water is considered to be the pH closest to the pH of soil solution in the field (Hendershot et al., 1993).

Test Method Deviations

1. There was a deviation related to the reference toxicant test conducted concurrently with this test. At the end of the reference toxicant test, the average nighttime temperature and the maximum nighttime temperature were 21°C and 24°C, respectively which are higher than the maximum nighttime temperature required by the Environment Canada Test Method (EPS 1/RM/45, February 2005, with June 2007 amendments) (18°C). After reviewing the test results, procedures, and conditions, it appears that the data logger used to monitor temperatures was set to record temperatures approximately 15-20 minutes later than usual which captured temperatures at 6:20 am when the lights were on in the growth room, instead of 6:00 am when lights were still off. We concluded that the temperature deviation did not affect the test results. All test validity criteria for emergence and growth were met for Blue Grama Grass. The plants appeared to be healthy and showed no signs of stress. The reference toxicant test results were added to the warning charts and all results fit within the warning limits.

References

Environment Canada (EC). 2005. Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.

Hendershot W.H., H. Lalonde, and M. Duquette. 1993. Soil reaction and exchangeable acidity. P 141-145 in: Soil Sampling and Methods of Analysis, M.R. Carter, ed., Canadian Society of Soil Science, Lewis Publishers, Boca Raton, Florida.

McKeague, J.A. ed. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Ottawa, Ontario.

Microsoft® Office Professional Plus 2010. 2010. Version 14.0.5112.5000 (32-bit). Copyright 2010 Microsoft Corporation.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Soil Analysis Handbook. 1992. Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc., Georgia University Station, Athens, Georgia, 202 p.

Systat Software Inc. (SSI). 2007. SYSTAT© 12 for Windows. Version 12.00.08. Systat Software Inc., Chicago, IL.

Appendix C:

Test Conditions, Experimental Design, Data Summaries, and Results of the Northern Wheatgrass Definitive Plant Test

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Sample Identification

Client:	Johan Skoglund (Canzinco Ltd.)
Sample(s) description:	Field-collected site soils contaminated with PHCs (contaminant of concern - F2) Artificial soil (AS) used as an experimental control.
Sample(s) identification:	See below

Bucket Label	Sample Login ID	Figure and Table ID***
Artificial Soils	AS mixed 2014-07-21-1	AS
14431 1/6	1457_14431_01	A
14431 2/6	1457_14431_02	B
14432 1/4	1458_14432_01	C
14432 2/4	1458_14432_02	D
14433 1/3	1459_14433_01	E
14433 2/3	1459_14433_02	F

***AS is the negative control soil, A and B are reference control soils

Date collected/formulated:	2014-06-30; AS formulated 2014-07-21
Method of soil collection:	Composite
Date sample(s) received:	2014-07-03
Time sample(s) received:	09:30
Temperature on arrival:	25 °C
Soil storage temperature:	21.6 ± 0.4 °C
Date sample(s) tested:	2014-07-31 to 2014-08-21
Technician(s):	Timothy Clemens, Alvin Leung, Kelly Olaveson, Wai Ma, Emma Shrive, and Jessica Sosa-Campos
Analyst(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
QA/QC:	Gladys Stephenson

Test Organism

Test organism:	Northern Wheatgrass (*Elymus lanceolatus*) Common No. 1
Organism source:	Hannas Seeds, Lacombe, Alberta
Stantec seed batch number:	NW_2013

Test Conditions and Procedures

Test type:	Static, definitive
Location of testing:	Test setup and process: Stantec Southgate Laboratory Duration of test: University of Guelph, Growth Room 27A
Test duration:	21 days
Number of treatments:	3 (2 buckets of each soil), plus 1 experimental control (AS)
Temperature:	24.7 ± 0.3 °C (day), 17.6 ± 0.1 °C (night)
Light intensity:	330 ± 29 µmol/(m²•s)
Photoperiod:	16 h light; 8 h dark
Watering regime:	Artificial soil treatment watered with nutrient solution, site soil treatments watered with de-chlorinated municipal tap water, as required
Test unit description:	1-L clear polypropylene container covered with lid (until Day 7 or earlier if plants touched lid)
Soil volume/test unit:	600 g soil wet weight
No. organisms/test unit:	5
No. field samples/treatment:	2
No. replicate test units/treatment:	6 (3 per bucket), 6 replicates for AS
Measured soil chemistry parameters:	Initial soil pH, electrical conductivity, and percent moisture content, final soil pH and electrical conductivity
Measured endpoint(s):	Day 21: Seedling emergence, shoot and root lengths, shoot and root dry masses
Test protocol:	Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.
Statistical analyses:	Mean, SD – Microsoft Excel (2010) ANOVA (Shapiro-Wilk test for normality, and ANOVA for homogeneity) - Emergence - Shoot Dry Mass (Systat Version 12.0, SSI, 2007)

ANOVA (with Fisher's LSD test, Shapiro-Wilk test for normality, and ANOVA for homogeneity)
- Shoot Length
- Root Length
- Root Dry Mass (Data was log transformed for analysis)

(Systat Version 12.0, SSI, 2007)

Test acceptability criteria met? Yes
See Table C.1.

Table C.1. Performance of plants (Northern Wheatgrass) in negative control soil treatment relative to test method validity criteria.

Criterion in Negative Control Soil		Negative Control Soil	Criteria Met?	Positive Control Soil	Solvent Control Soil
Measurement	Criterion				
Mean % survival of emerged seedlings (d 21)	≥ 90%	100%	Yes	NA	NA
Mean % seedlings with phytotoxicity symptoms/developmental anomalies (d 21)	≤ 10%	4%	Yes	NA	NA
Mean % emergence (d 21)	≥ 70%	93%	Yes	NA	NA
Mean shoot length (mm) (d 21)	≥ 100	200 mm	Yes	NA	NA
Mean root length (mm) (d 21)	≥ 110	132 mm	Yes	NA	NA

NA = not applicable

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Boric Acid Reference Toxicant Data for Artificial Soil

Type of test:	Seedling emergence and shoot growth
Test duration:	10 days
Date tested:	2014-08-05 to 2014-08-15
Stantec seed batch number:	NW_1_2014
EC50 (Emergence):	1375.8 mg/kg
95% CL:	1151.4 to 1600.1 mg/kg
IC50 (Shoot length):	778.0 mg/kg
95% CL:	695.0 to 873.0 mg/kg
Statistical analyses:	Emergence – Logit (R, 2013) IC50, 95% CL – Linear and non-linear regression (Logistic), (SSI, 2007)
Historical geomean EC50:	919.7 mg/kg
Warning limits (± 2 SD):	331.2 to 1691.5 mg/kg
Historical geomean IC50:	693.6 mg/kg
Warning limits (± 2 SD):	471.7 to 931.7 mg/kg
Technician(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
Analyst(s):	Timothy Clemens and Emma Shrive

Results

Table C.2. Effects on seedling (Northern Wheatgrass) emergence (Day 21) following exposure to the test soils. Results reported are number of seedlings in each test unit, as observed at the end of the test.

Soil Treatment	Number of Seedlings (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	4	5	5	4	5	5
A	3	4	5	NA	NA	NA
B	4	5	4	NA	NA	NA
C	4	4	5	NA	NA	NA
D	5	5	5	NA	NA	NA
E	5	5	4	NA	NA	NA
F	4	4	5	NA	NA	NA

NA = not applicable

Table C.3. Effects on seedling (Northern Wheatgrass) condition (Day 21) following exposure to the test soils. Results reported are seedling condition in each test unit, as observed at the end of the test.

Soil Treatment	Seedling Condition[1] (Day 21)					
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
Artificial Soil	N	N	N	N	N	N
A	G	Di/Cl	G	NA	NA	NA
B	Di/Cl	Di/Cl	Di	NA	NA	NA
C	G	Di/Cl	G/Cl	NA	NA	NA
D	G/ClT	G/ClT	G/ClT	NA	NA	NA
E	G/ClT	G/ClT	G/ClT	NA	NA	NA
F	G/Cl	G/ClT	G/ClT	NA	NA	NA

[1] Condition of seedlings indicates a visual assessment of seedling health and vigour, relative to those in negative control soil. Normal seedlings are green, robust, and without deformities or discolouration. "Non-normal" seedlings are seedlings that exhibit symptoms of suboptimal health such as chlorosis or necrosis, or those that are wilted, desiccated, discoloured, etc. These signs can result from the phytotoxic effect of the contaminant. Explanations of codes are provided below.

N Normal
Cl Chlorotic
ClT Chlorotic Tips
Di Discoloured
G Green but not healthy
NA = not applicable (e.g., uneven replicate test design).

Stantec

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Table C.4. Effect on seedling (Northern Wheatgrass) emergence and growth (Day 21) following exposure to the test soils. Results are reported as treatment means (n = 3 replicates for site soils, 6 replicates for artificial soil) with one standard deviation of the mean in brackets.

Soil Treatment	Percent Emergence (n = 5 seeds)	Shoot Length (mm)	Root Length (mm)	Individual Shoot Dry Mass (mg)	Individual Root Dry Mass (mg)
Artificial Soil	93 (10)	200 (9)	132 (18)	23.1 (3.2)	4.6 (0.7)
A	80 (20)	85 (16)	49 (10)	4.8 (1.2)	0.8 (0.1)
B	87 (12)	61 (18)	32 (15)	2.6 (1.3)	0.5 (0.2)
C	87 (12)	97 (17)	72 (7)	5.0 (1.3)	2.0 (0.3)
D	100 (0)	94 (5)	72 (11)	4.9 (0.9)	1.6 (0.3)
E	93 (12)	102 (6)	81 (6)	5.9 (1.5)	2.3 (0.5)
F	87 (12)	98 (12)	70 (9)	4.6 (0.7)	2.1 (0.7)

The results reported relate only to the sample(s) tested

Date: October 8, 2014 Approved by: Gladys I. Stephenson
Director of Laboratory Services

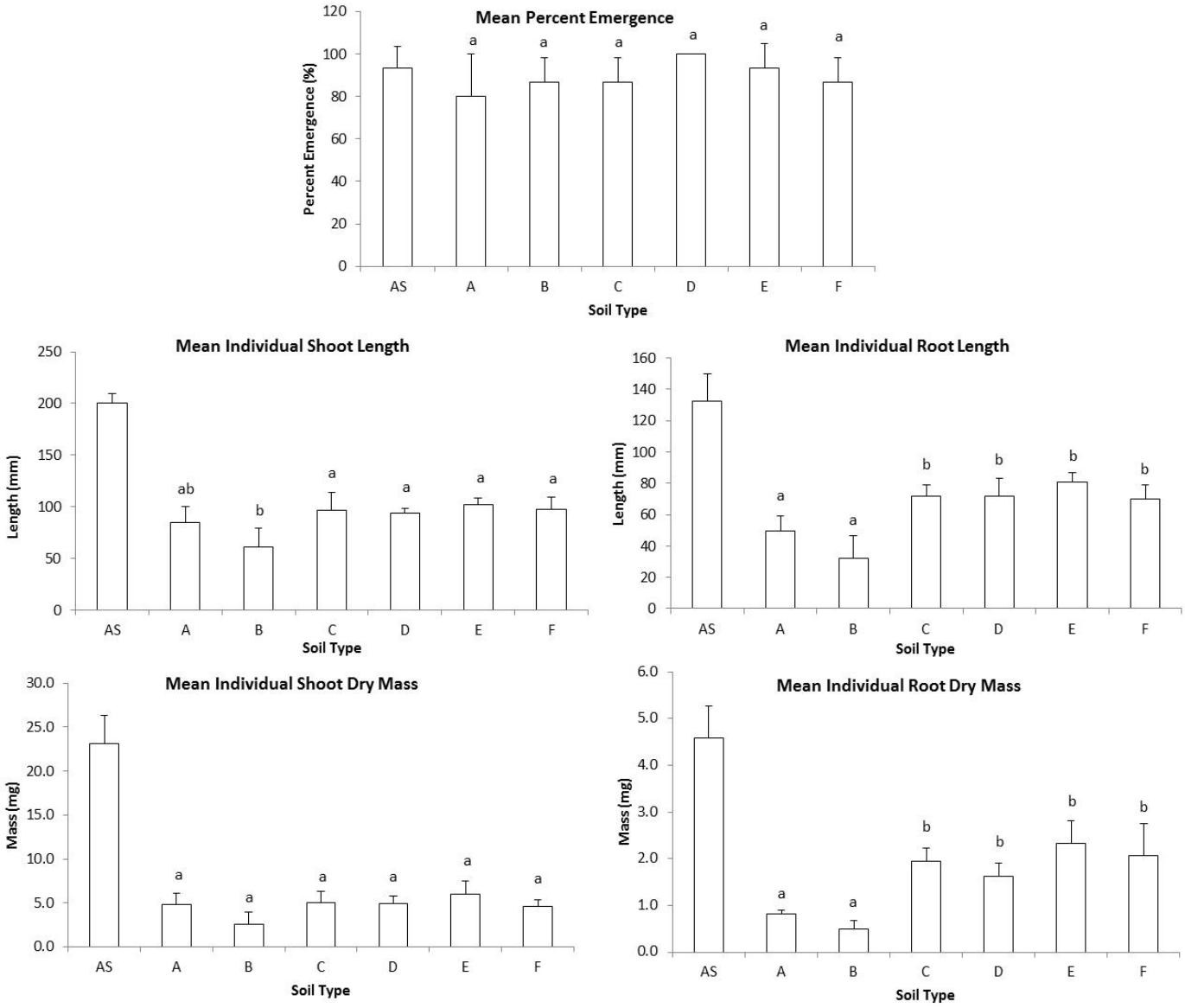

Figure C.1. Seedling (Northern Wheatgrass) emergence and growth (Day 21) following exposure to the test soils. Columns indicate treatment means. Bars above the columns represent one standard deviation of the mean. Letters above the columns that are different indicate a significant difference ($p < 0.05$) among means. Site soils A and B are reference control soils.

Soil Characteristics

Table C.5. pH, conductivity, and moisture content of test soils at the beginning (Day 0) and end (Day 21) of the test.

Soil Treatment	Initial pH[1]	Final pH[1]	Initial Conductivity[1] (µS/cm)	Final Conductivity[1] (µS/cm)	Initial Soil Moisture[2] (% WHC)
Artificial Soil	7.51	7.63	236	286	67
A	8.22	8.22	518	666	33
B	8.26	8.21	541	722	33
C	8.10	8.38	415	398	32
D	8.25	8.33	345	556	37
E	8.08	8.49	392	349	28
F	8.12	8.49	365	360	30

[1] pH and conductivity were measured using a 2:1 water:soil slurry
[2] % WHC - percent of water-holding capacity of the soil
NA = not applicable

Table C.6. Texture, organic matter content, carbon content, fertility, and water-holding capacity of test soils.

Soil	Parameter[1]							
	Sand (%)	Silt (%)	Clay (%)	Organic Matter (% dry)	Organic Carbon (% dry)	Nitrogen (% dry)	Plant Available Phosphorus (mg/kg dry)	Water-holding Capacity (%)
Artificial Soil	78.4	5.8	15.8	6.8	2.81	< 0.05	5.48	80
A	62.6	25.7	11.7	0.6	0.83	<0.05	6.96	27
B	59.4	29.1	11.5	0.8	0.52	<0.05	7.16	27
C	60.2	28.4	11.4	0.8	0.33	<0.05	8.27	27
D	59.4	29.6	11.0	0.7	0.69	<0.05	10.2	27
E	62.6	27.2	10.2	0.9	<0.1	<0.05	3.60	29
F	59.8	27.6	12.6	0.8	0.77	<0.05	5.01	29

[1] Analyses conducted by the University of Guelph, Laboratory Services – Agriculture and Food Laboratory (AS collected: 2014-05-28; report date: 2014-06-10; Site soil collected: 2014-08-26; report date: 2104-09-17, except for water-holding capacity which was determined by the Stantec Southgate Laboratory

Comments

No seeds exhibiting unusual appearance or undergoing unusual treatment were used in this test.

Test Method Modifications

1. Soil pH was measured using a soil-water slurry, which represents our normal practices and is a method modified from the Soil Analysis Handbook (1992), instead of using a $CaCl_2$ slurry, as recommended by the method for pH. This had no impact on the results of the test. The method of using $CaCl_2$ was developed for soil scientists who were comparing the pH of different soils, and wished to minimize the variability of the different pHs (McKeague, 1978). As a result, the $CaCl_2$ method will, by design, minimize the variability of the soil pH among soil samples, and will be less sensitive to differences in pH. In addition, soil pH measured in water is considered to be the pH closest to the pH of soil solution in the field (Hendershot et al., 1993).

Test Method Deviations

1. There was a deviation related to the reference toxicant test conducted concurrently with this test. At the end of the reference toxicant test, the average nighttime temperature and the maximum nighttime temperature were 21°C and 24°C, respectively which are higher than the maximum nighttime temperature required by the Environment Canada Test Method (EPS 1/RM/45, February 2005, with June 2007 amendments) (18°C). After reviewing the test results, procedures, and conditions, it appears that the data logger used to monitor temperatures was set to record temperatures approximately 15-20 minutes later than usual which captured temperatures at 6:20 am when the lights were on in the growth room, instead of 6:00 am when lights were still off. We concluded that the temperature deviation did not affect the test results. All test validity criteria for emergence and growth were met for Northern Wheatgrass. The plants appeared to be healthy and showed no signs of stress. The reference toxicant test results were added to the warning charts and all results fit within the warning limits.

2. There was another deviation related to the reference toxicant test conducted concurrently with this test. Five consecutive EC50 data points have fallen above the historical mean value of the reference toxicant warning chart for emergence. A review of the test system, organisms and technical performance did not reveal any specific problems or anomalies. All validity criteria were met for the test. There were no evident errors in preparation of the stock or test dilutions. Test chemistry such as pH and conductivity are comparable to historical data. The EC50 trends on the warning chart for this species will be monitored. The data point from this reference toxicant test (NW_1_2014) will be included in the control charting and subsequent tests will be monitored for unusual outcomes and/or further trends.

References

Environment Canada (EC). 2005. Biological Test Method: Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Report EPS 1/RM/45, February 2005, with June 2007 amendments. Method Development and Applications Section, Environmental Technology Centre, Environment Canada, Ottawa, Ontario.

Hendershot W.H., H. Lalonde, and M. Duquette. 1993. Soil reaction and exchangeable acidity. P 141-145 in: Soil Sampling and Methods of Analysis, M.R. Carter, ed., Canadian Society of Soil Science, Lewis Publishers, Boca Raton, Florida.

McKeague, J.A. ed. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Ottawa, Ontario.

Microsoft® Office Professional Plus 2010. 2010. Version 14.0.5112.5000 (32-bit). Copyright 2010 Microsoft Corporation.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Soil Analysis Handbook. 1992. Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc., Georgia University Station, Athens, Georgia, 202 p.

Systat Software Inc. (SSI). 2007. SYSTAT© 12 for Windows. Version 12.00.08. Systat Software Inc., Chicago, IL.

Appendix D:

Test Conditions, Experimental Design, Data Summaries, and Results of the Collembola Chronic Test

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Sample Identification

Client:	Johan Skoglund (Canzinco Ltd.)
Sample(s) description:	Field-collected site soils contaminated with PHCs (contaminant of concern - F2) Artificial soil (AS) used as an experimental control.
Sample(s) identification:	See below

Bucket Label	Sample Login ID	Figure and Table ID***
Artificial Soils	AS mixed 2014-07-21-1	AS
14431 1/6	1457_14431_01	A
14431 2/6	1457_14431_02	B
14432 1/4	1458_14432_01	C
14432 2/4	1458_14432_02	D
14433 1/3	1459_14433_01	E
14433 2/3	1459_14433_02	F

***AS is the negative control soil, A and B are reference control soils

Date collected/formulated:	2014-06-30; AS formulated 2014-07-21
Method of soil collection:	Composite
Date sample(s) received:	2014-07-03
Time sample(s) received:	09:30
Temperature on arrival:	25 °C
Soil storage temperature:	221.6 ± 0.4 °C
Date sample(s) tested:	2014-08-01 to 2014-08-29 (soils prepared 2014-07-31)
Technician(s):	Timothy Clemens, Alvin Leung, Kelly Olaveson, Wai Ma, Emma Shrive, and Jessica Sosa-Campos
Analyst(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
QA/QC:	Gladys Stephenson

Test Organism

Test organism:	*Folsomia candida*
Organism source and laboratory code:	In house culture Fc 14-1, 14-2, 14-3, 14-4, 08-9, 11-1, 11-2, 13-1
Age range at start of test:	10-12 days old

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Test Conditions and Procedures

Test type:	Static, chronic
Location of testing:	Stantec Southgate Laboratory
Test duration:	28 days
Number of treatments:	3 (2 buckets of each soil), plus 1 experimental control (AS)
Temperature:	19.7 ± 0.2 °C
Light intensity:	564 ± 76 lux
Photoperiod:	16 h light; 8 h dark
Watering regime:	De-ionized water, misted at test initiation (Day 0) and every 7 days, as required
Feeding regime:	Activated yeast (a pinch equivalent to ~ 25 mg per test unit), fed at test initiation (Day 0) and every 14 days, as required
Test unit description:	125-mL glass wide-mouthed mason jar covered with metal lid and secured with a loosened metal screw ring
Soil volume/test unit:	40 g soil wet weight
No. organisms/test unit:	10
No. field samples/treatment:	2
No. replicate test units/treatment:	6 (3 per bucket), 6 replicates for AS
Measured soil chemistry parameters:	Initial and final soil pH, electrical conductivity, and percent moisture content
Method used for extracting collembola from the soil:	Floatation method
Method used for enumerating collembola at end of test:	Manual method
Measured endpoint(s):	Day 28: Adult survival and number of progeny produced
Test protocol:	Biological Test Method: Test for Measuring Survival and Reproduction of Springtails Exposed to Contaminants in Soil. Report EPS 1/RM/47, September 2007. Method Development and Applications Section, Environmental Science and Technology Centre, Science and Technology Branch, Environment Canada, Ottawa, Ontario.
Statistical analyses:	Mean, SD – Microsoft Excel (2010) ANOVA (without Fisher's LSD test, Shapiro-Wilk test for normality, and ANOVA for homogeneity) - Adult Survival (Systat Version 12.0, SSI, 2007)

ANOVA (with Fisher's LSD test, Shapiro-Wilk test for normality, and ANOVA for homogeneity)
- Progeny Production (Data square root transformed)

(Systat Version 12.0, SSI, 2007)

Test acceptability criteria met? Yes
See Table D.1.

Table D.1. Performance of collembola (*Folsomia candida*) in negative control soil treatment relative to test method validity criteria.

Criterion in Negative Control Soil		Negative Control Soil	Criteria Met?	Positive Control Soil	Solvent Control Soil
Measurement	Criterion				
Mean adult survival rate (d 28)	≥ 80%	95	Yes	NA	NA
Mean reproduction rate (# of live progeny/vessel) (d 28)	≥ 100	1920	Yes	NA	NA

NA = not applicable

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Boric Acid Reference Toxicant Data for Artificial Soil

Type of test:	Acute lethality
Test duration:	14 days
Date tested:	2017-07-30 to 2014-08-13 (soils prepared 2014-07-29)
Organism laboratory code:	Fc 14-1, 14-2, 14-3, 14-4, 08-9, 11-1, 11-2, 13-1
LC50 Survival:	2453.7 mg/kg
95% CL:	2123.9 to 2783.6 mg/kg
Statistical analyses:	Logit (R, 2013)
Historical geomean LC50:	2281.4 mg/kg
Warning limits (± 2 SD):	1464.9 to 3176.4 mg/kg
Technician(s):	Timothy Clemens, Kelly Olaveson, and Emma Shrive
Analyst(s):	Timothy Clemens and Emma Shrive

Stantec Consulting Ltd.
70 Southgate Drive – Suite 1
Guelph, ON N1G 4P5
Tel: (519) 836-6050 Fax: (519) 836-2493
stantec.com

Results

Table D.2. Effect on collembola (*Folsomia candida*) adult survival and reproduction (Day 28) following exposure to the test soils. Results are reported as treatment means (n = 3 replicates for site soils, 6 replicates for artificial soil) with one standard deviation of the mean in brackets.

Soil Treatment	Percent Adult Survival (n = 10 adults)	Number of Progeny
Artificial Soil	95 (8)	1920 (280)
A	87 (12)	81 (115)
B	80 (17)	1 (1)
C	97 (6)	315 (261)
D	97 (6)	1030 (501)
E	90 (10)	578 (103)
F	77 (21)	1294 (254)

The results reported relate only to the sample(s) tested

Date: October 8, 2014 Approved by: Gladys I Stephenson
Director of Laboratory Services

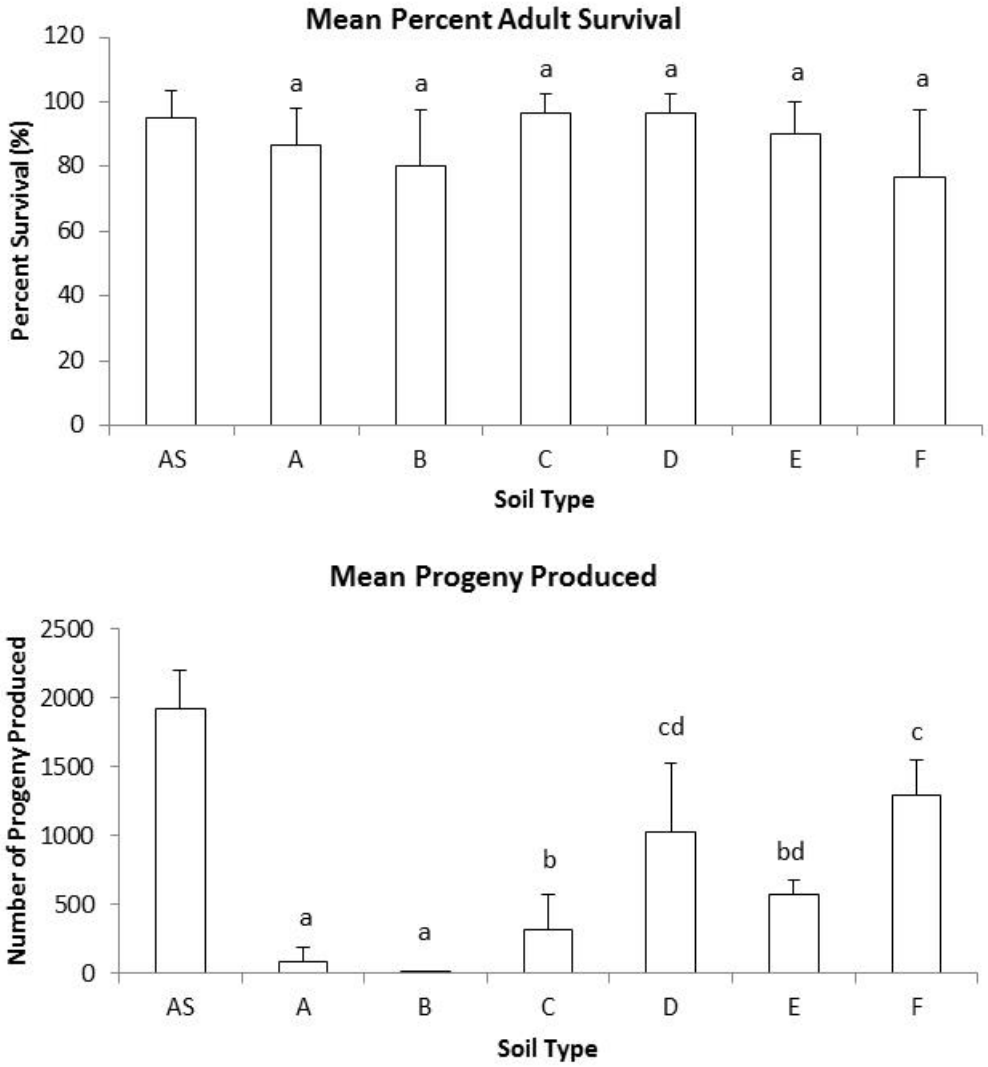

Figure D.1. Collembola (*Folsomia candida*) adult survival and progeny production (Day 28) following exposure to the test soils. Columns indicate treatment means. Bars above the columns represent one standard deviation of the mean. Letters above the columns that are different indicate a significant difference ($p < 0.05$) among means. Site soils A and B are reference control soils.

Soil Characteristics

Table D.3. pH, conductivity, and moisture content of test soils at the beginning (Day 0) and end (Day 28) of the test.

Soil Treatment	Initial pH[1]	Final pH[1]	Initial Conductivity[1] (µS/cm)	Final Conductivity[1] (µS/cm)	Initial Soil Moisture[2] (% WHC)	Final Soil Moisture[2] (% WHC)
Artificial Soil	7.69	7.60	203	164	66	99
A	8.40	8.11	464	926	31	61
B	8.42	8.08	521	904	33	81
C	8.34	8.22	394	618	36	74
D	8.43	8.27	351	562	36	63
E	8.33	8.36	378	456	30	38
F	8.30	8.33	371	448	29	68

[1] pH and conductivity were measured using a 2:1 water:soil slurry
[2] % WHC - percent of water-holding capacity of the soil
NA = not applicable

Table D.4. Texture, organic matter content, carbon content, fertility, and water-holding capacity of test soils.

Soil	Parameter[1]							
	Sand (%)	Silt (%)	Clay (%)	Organic Matter (% dry)	Organic Carbon (% dry)	Nitrogen (% dry)	Plant Available Phosphorus (mg/kg dry)	Water-holding Capacity (%)
Artificial Soil	78.4	5.8	15.8	6.8	2.81	< 0.05	5.48	80
A	62.6	25.7	11.7	0.6	0.83	<0.05	6.96	27
B	59.4	29.1	11.5	0.8	0.52	<0.05	7.16	27
C	60.2	28.4	11.4	0.8	0.33	<0.05	8.27	27
D	59.4	29.6	11.0	0.7	0.69	<0.05	10.2	27
E	62.6	27.2	10.2	0.9	<0.1	<0.05	3.60	29
F	59.8	27.6	12.6	0.8	0.77	<0.05	5.01	29

[1] Analyses conducted by the University of Guelph, Laboratory Services – Agriculture and Food Laboratory (AS collected: 2014-05-28; report date: 2014-06-10; Site soil collected: 2014-08-26; report date: 2104-09-17, except for water-holding capacity which was determined by the Stantec Southgate Laboratory.

Comments

No organisms exhibiting unusual appearance, behaviour or undergoing unusual treatment were used in this test.

Test Method Modifications

1. Soil pH was measured using a soil-water slurry, which represents our normal practices and is a method modified from the Soil Analysis Handbook (1992), instead of using a $CaCl_2$ slurry, as recommended by the method for pH. This had no impact on the results of the test. The method of using $CaCl_2$ was developed for soil scientists who were comparing the pH of different soils, and wished to minimize the variability of the different pHs (McKeague, 1978). As a result, the $CaCl_2$ method will, by design, minimize the variability of the soil pH among soil samples, and will be less sensitive to differences in pH. In addition, soil pH measured in water is considered to be the pH closest to the pH of soil solution in the field (Hendershot et al., 1993).

Test Method Deviations

1. According to the Environment Canada test method for conducting collembola survival and reproduction tests (EPS 1/RM/47), test units must be set up by adding 30 g wet weight soil to each test unit. For this test, 30 g of soil was added to the Artificial Soil (AS) treatment test units, but 40 g of soil was added to the test units for the site soil treatments. Since the site soils being tested had a different texture than the AS, more site soil was required in each test unit to match the volume of soil in the AS treatment test units. This deviation did not affect the test in any way.

References

Environment Canada (EC). 2007. Biological Test Method: Test for Measuring Survival and Reproduction of Springtails Exposed to Contaminants in Soil. Report EPS 1/RM/47, September 2007. Method Development and Applications Section, Environmental Science and Technology Centre, Science and Technology Branch, Environment Canada, Ottawa, Ontario.

Hendershot, W.H., H. Lalonde, and M. Duquette. 1993. Soil reaction and exchangeable acidity. P 141-145 in: Soil Sampling and Methods of Analysis, M.R. Carter, ed., Canadian Society of Soil Science, Lewis Publishers, Boca Raton, Florida.

McKeague, J.A. ed. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Ottawa, Ontario.

Microsoft® Office Professional Plus 2010. 2010. Version 14.0.5112.5000 (32-bit). Copyright 2010 Microsoft Corporation.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Soil Analysis Handbook. 1992. Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc., Georgia University Station, Athens, Georgia, 202 p.

Systat Software Inc. (SSI). 2007. SYSTAT© 12 for Windows. Version 12.00.08. Systat Software Inc., Chicago, IL.

Appendix E:

Packing Slips

PACKING SLIP

Date: June 30, 2014

Ship To
Gladys Stephenson
Stantec
70 Southgate Drive, Suite 1
Guelph ON, N1G 4P5
(519) 836-6966 ext 219

Shipped From
Arlene Laudrum
Nanisivik Mine
Nunavut

General Description

7 buckets of sand and gravel, screened through a 1 inch chicken wire mesh. Each sample was blended in the field. ½ of sample collected is shipped. Remaining sample is stored in buckets in a cool location.

Sample #	Sample Location	Date Collected	Quantity
14431	UTA-10-2	June 30, 2014	3 buckets
14432	LTA-1-2	June 30, 2014	2 buckets
14433	UTA-3-2	June 30, 2014	2 buckets

PACKING SLIP

Date: July 3, 2014

Ship To	Gladys Stephenson Stantec 70 Southgate Drive, Suite 1 Guelph ON, N1G 4P5 (519) 836-6966 ext 219	Shipped From	Arlene Laudrum Nanisivik Mine Nunavut

General Description

2 buckets of sand and gravel, screened through a 1 inch chicken wire mesh. Each sample was blended in the field. ½ of sample collected is shipped. Remaining sample is stored in buckets in a cool location.

Sample #	Sample Location	Date Collected	Quantity
14434	Untreated soil from excavation. Highest accessible concentration of PHC. F1 and possible PAH and F3 contamination in addition to residual F2 contamination.	July 2, 2014	2 buckets

PACKING SLIP

Date: July 22, 2014

Ship To	Gladys Stephenson Stantec 70 Southgate Drive, Suite 1 Guelph ON, N1G 4P5 (519) 836-6966 ext 219	Shipped From	Stuart McPhee Nanisivik Mine Nunavut

General Description

2 buckets of sand and gravel, screened through a 1 inch chicken wire mesh. Each sample was blended in the field. ½ of sample collected is shipped. Remaining sample is stored in buckets in a cool location.

Sample #	Sample Location	Date Collected	Quantity
14947, 14948	Soil from the fine stockpile (FSP) on Area 2 known to have F2 contamination. Soil was treated with a small dose of DAP and Urea in 2013 after it was screened through a 4 inch vibrating screener to remove rocks.	July 22, 2014	2 buckets

Appendix F:

Analytical Results from Exova

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Dear Johan Skoglund:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____

Justin Deagle
Acting Team Leader, Organics

Certificate of Analysis

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118897 Soil 2014-06-30 14431	1118898 Soil 2014-06-30 14432	1118899 Soil 2014-06-30 14433	1118900 Soil 2014-07-02 14434
Agri. - Soil	pH	2.0			8.2	8.1	8.0	8.3
General Chemistry	Moisture	0.1	%		5.1	5.6	6.6	6.2
Hydrocarbons	F1 (C6-C10)	10	ug/g		10	10	20	80
	F1-BTEX (C6-C10)	10	ug/g		<10	<10	20	70
	F2 (C10-C16)	10	ug/g		100	360	610	140
	F3 (C16-C34)	20	ug/g		30	20	40	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20
Mercury	Hg	0.1	ug/g		<0.1	<0.1	<0.1	<0.1
Metals	Ag	0.2	ug/g		0.2	0.4	0.4	0.3
	Al	5	ug/g		14500	14700	15000	13700
	As	1	ug/g		6	6	6	9
	Ba	1	ug/g		82	95	80	85
	Be	1	ug/g		<1	<1	<1	<1
	Ca	100	ug/g		134000	129000	132000	125000
	Cd	0.5	ug/g		0.9	2.1	1.9	1.0
	Co	1	ug/g		8	9	8	9
	Cr	1	ug/g		28	28	35	38
	Cu	1	ug/g		22	26	24	24
	Fe	5	ug/g		25400	28200	28000	26900
	K	100	ug/g		4100	3800	3800	3600
	Mg	100	ug/g		155000	145000	148000	144000
	Mn	1	ug/g		333	362	334	373
	Mo	1	ug/g		1	2	2	2
	Na	100	ug/g		600	600	600	600
	Ni	1	ug/g		24	26	28	32
	Pb	1	ug/g		33	62	71	29

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1118897 Soil 2014-06-30 14431	1118898 Soil 2014-06-30 14432	1118899 Soil 2014-06-30 14433	1118900 Soil 2014-07-02 14434
Metals	Sb	1	ug/g			<1	<1	<1	<1
	Se	1	ug/g			<1	<1	<1	<1
	Sr	1	ug/g			66	61	59	62
	Tl	1	ug/g			<1	<1	<1	<1
	V	2	ug/g			42	47	46	48
	Zn	2	ug/g			336	718	670	306
Nutrients	Total Kjeldahl Nitrogen	0.01	%			0.04	0.03	0.02	0.01
Others	Total P	0.01	%			0.03	0.05	0.04	0.04
VOCs	Benzene	0.02	ug/g			<0.02	<0.02	<0.02	0.13
	Ethylbenzene	0.05	ug/g			<0.05	<0.05	<0.05	0.48
	m/p-xylene	0.05	ug/g			0.22	0.21	0.21	3.40
	o-xylene	0.05	ug/g			0.09	0.12	0.11	1.58
	Toluene	0.20	ug/g			<0.20	<0.20	<0.20	1.57
VOCs Surrogates (%	Toluene-d8	0	%			99	99	94	96

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118901 Soil 2014-07-02 14435	1118902 Soil 2014-07-02 14436	1118903 Soil 2014-07-02 14437	1118904 Soil 2014-06-30 14438
General Chemistry	Moisture	0.1	%		5.4	6.3	2.9	1.8
Hydrocarbons	F2 (C10-C16)	10	ug/g		2140	360	<10	<10
	F3 (C16-C34)	20	ug/g		310	30	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20
Mercury	Hg	0.1	ug/g					<0.1
Metals	Ag	0.2	ug/g					1.3
	Al	5	ug/g					16400
	As	1	ug/g					5
	Ba	1	ug/g					40
	Be	1	ug/g					<1
	Ca	100	ug/g					122000
	Cd	0.5	ug/g					9.1
	Co	1	ug/g					8
	Cr	1	ug/g					30
	Cu	1	ug/g					29
	Fe	5	ug/g					24700
	K	100	ug/g					4700
	Mg	100	ug/g					150000
	Mn	1	ug/g					325
	Mo	1	ug/g					2
	Na	100	ug/g					800
	Ni	1	ug/g					25
	Pb	1	ug/g					251
	Sb	1	ug/g					<1
	Se	1	ug/g					<1
	Sr	1	ug/g					65

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118901 Soil 2014-07-02 14435	1118902 Soil 2014-07-02 14436	1118903 Soil 2014-07-02 14437	1118904 Soil 2014-06-30 14438
Metals	Tl	1	ug/g					<1
	V	2	ug/g					42
	Zn	2	ug/g					4060

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118905 Soil 2014-06-30 14439	1118906 Soil 2014-07-07 14622	1118907 Soil 2014-07-07 14636	1118908 Soil 2014-07-07 14637
General Chemistry	Moisture	0.1	%		1.1	6.0	5.4	6.9
Hydrocarbons	F1 (C6-C10)	10	ug/g				30	30
	F1-BTEX (C6-C10)	10	ug/g				30	30
	F2 (C10-C16)	10	ug/g		70	510	450	650
	F3 (C16-C34)	20	ug/g		780	50	40	<20
	F4 (C34-C50)	20	ug/g		70	<20	<20	<20
VOCs	Benzene	0.02	ug/g				<0.02	<0.02
	Ethylbenzene	0.05	ug/g				0.17	0.05
	m/p-xylene	0.05	ug/g				0.93	0.24
	o-xylene	0.05	ug/g				0.51	0.14
	Toluene	0.20	ug/g				0.28	<0.20
VOCs Surrogates (%	Toluene-d8	0	%				98	93

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118909 Soil 2014-07-07 14638	1118910 Soil 2014-07-07 14662	1118911 Soil 2014-07-07 14680	1118912 Soil 2014-07-07 14682
General Chemistry	Moisture	0.1	%		6.8	7.7	5.7	5.0
Hydrocarbons	F1 (C6-C10)	10	ug/g		30		170	100
	F1-BTEX (C6-C10)	10	ug/g		30		160	100
	F2 (C10-C16)	10	ug/g		570	440	70	220
	F3 (C16-C34)	20	ug/g		<20	<20	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20
VOCs	Benzene	0.02	ug/g		<0.02		0.05	0.03
	Ethylbenzene	0.05	ug/g		<0.05		0.18	0.08
	m/p-xylene	0.05	ug/g		0.21		3.10	0.75
	o-xylene	0.05	ug/g		0.10		1.87	0.51
	Toluene	0.20	ug/g		<0.20		0.37	0.22
VOCs Surrogates (%	Toluene-d8	0	%		96		103	102

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118913 Soil 2014-07-07 14683	1118914 Soil 2014-07-07 14684	1118915 Soil 2014-07-08 14688	1118916 Soil 2014-07-08 14689
Agri. - Soil	pH	2.0					8.1	
General Chemistry	Moisture	0.1	%		6.3	5.9	7.7	6.9
Hydrocarbons	F1 (C6-C10)	10	ug/g		110	100	30	
	F1-BTEX (C6-C10)	10	ug/g		110	100	30	
	F2 (C10-C16)	10	ug/g		<10	40	560	400
	F3 (C16-C34)	20	ug/g		<20	<20	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118913 Soil 2014-07-07 14683	1118914 Soil 2014-07-07 14684	1118915 Soil 2014-07-08 14688	1118916 Soil 2014-07-08 14689
Nutrients	Total Kjeldahl Nitrogen	0.01	%				0.03	
Others	Total P	0.01	%				0.05	
VOCs	Benzene	0.02	ug/g		0.05	0.04	<0.02	
	Ethylbenzene	0.05	ug/g		0.12	0.10	<0.05	
	m/p-xylene	0.05	ug/g		1.03	0.97	0.19	
	o-xylene	0.05	ug/g		0.66	0.68	0.10	
	Toluene	0.20	ug/g		0.27	0.24	<0.20	
VOCs Surrogates (%	Toluene-d8	0	%		103	98	94	

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118917 Soil 2014-07-08 14690	1118918 Soil 2014-07-07 14693	1118919 Soil 2014-07-08 14694	1118920 Soil 2014-07-09 14718
General Chemistry	Moisture	0.1	%		5.8	5.8	6.5	4.8
Hydrocarbons	F1 (C6-C10)	10	ug/g			90		
	F1-BTEX (C6-C10)	10	ug/g			90		
	F2 (C10-C16)	10	ug/g		1250	<10	660	310
	F3 (C16-C34)	20	ug/g		<20	<20	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20
VOCs	Benzene	0.02	ug/g			0.04		
	Ethylbenzene	0.05	ug/g			0.13		
	m/p-xylene	0.05	ug/g			1.39		
	o-xylene	0.05	ug/g			0.95		
	Toluene	0.20	ug/g			0.32		

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1118917 Soil 2014-07-08 14690	1118918 Soil 2014-07-07 14693	1118919 Soil 2014-07-08 14694	1118920 Soil 2014-07-09 14718
VOCs Surrogates (%	Toluene-d8	0	%			107		

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.		
					1118921 Soil 2014-07-09 14719	1118922 Soil 2014-07-09 14722	1118923 Soil 2014-07-09 14747
General Chemistry	Moisture	0.1	%		5.4	4.7	4.9
Hydrocarbons	F2 (C10-C16)	10	ug/g		320	340	310
	F3 (C16-C34)	20	ug/g		<20	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 0 **Analysis Date** 2014-07-18 **Method** CCME			
F1-BTEX (C6-C10)			
Run No 272707 **Analysis Date** 2014-07-16 **Method** C NONE			
Total P	<0.01 %	103	
Run No 272800 **Analysis Date** 2014-07-16 **Method** EPA 200.8			
Ag	<0.2 ug/g	94	70-130
Al	<5 ug/g	96	70-130
As	<1 ug/g	97	70-130
Ba	<1 ug/g	94	70-130
Be	<1 ug/g	96	70-130
Cd	<0.5 ug/g	94	70-130
Co	<1 ug/g	94	70-130
Cr	<1 ug/g	89	70-130
Cu	<1 ug/g	97	70-130
Fe	<5 ug/g	83	70-130

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Mn	<1 ug/g	94	70-130
Mo	<1 ug/g	99	70-130
Ni	<1 ug/g	95	70-130
Pb	<1 ug/g	95	70-130
Sb	<1 ug/g	91	70-130
Se	<1 ug/g	97	70-130
Sr	<1 ug/g	100	70-130
Tl	<1 ug/g	91	70-130
V	<2 ug/g	97	70-130
Zn	<2 ug/g	92	70-130
Run No 272855 **Analysis Date** 2014-07-17 **Method** EPA 200.8			
Ag	<0.2 ug/g	92	70-130
As	<1 ug/g	100	70-130
Ba	<1 ug/g	95	70-130
Be	<1 ug/g	94	70-130
Cd	<0.5 ug/g	96	70-130
Co	<1 ug/g	100	70-130

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Cr	<1 ug/g	96	70-130
Cu	<1 ug/g	99	70-130
Mn	<1 ug/g	98	70-130
Mo	<1 ug/g	102	70-130
Ni	<1 ug/g	102	70-130
Pb	<1 ug/g	97	70-130
Sb	<1 ug/g	91	70-130
Se	<1 ug/g	99	70-130
Sr	<1 ug/g	102	70-130
Tl	<1 ug/g	94	70-130
V	<2 ug/g	103	70-130
Run No 272891 **Analysis Date** 2014-07-17 **Method** M SM3112B-3500B			
Hg	<0.1 ug/g	99	70-130
Run No 272913 **Analysis Date** 2014-07-16 **Method** V 8260B			
Benzene	<0.02 ug/g	85	80-120
Ethylbenzene	<0.05 ug/g	110	80-120
m/p-xylene	<0.05 ug/g	106	80-120

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
o-xylene	<0.05 ug/g	106	80-120
Toluene	<0.20 ug/g	119	80-120
Toluene-d8	100 %	111	
Run No 272916 **Analysis Date** 2014-07-18 **Method** CCME			
F1 (C6-C10)	<10 ug/g	95	80-120
Run No 272986 **Analysis Date** 2014-07-18 **Method** CCME			
F2 (C10-C16)	<10 ug/g	94	50-120
F3 (C16-C34)	<20 ug/g	94	50-120
F4 (C34-C50)	<20 ug/g	94	50-120
Moisture	<0.1 %	100	80-120
Run No 273024 **Analysis Date** 2014-07-21 **Method** Ag Soil			
pH			90-110
Run No 273026 **Analysis Date** 2014-07-21 **Method** Ag Soil			
pH			90-110
Run No 273027 **Analysis Date** 2014-07-21 **Method** C SM4500-Norg-B			
Total Kjeldahl Nitrogen	<0.01 %	100	90-110
Run No 273029 **Analysis Date** 2014-07-21 **Method** M SM3111B-3050B			

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Ca	<100 ug/g	88	90-100
K	<100 ug/g	111	80-120
Mg	<100 ug/g	96	89-111
Na	<100 ug/g	106	60-140
Run No 273038 **Analysis Date** 2014-07-18 **Method** CCME			
F2 (C10-C16)	<10 ug/g	84	50-120
F3 (C16-C34)	<20 ug/g	84	50-120
F4 (C34-C50)	<20 ug/g	84	50-120
Moisture	<0.1 %	100	80-120

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1414350
Date Submitted: 2014-07-14
Date Reported: 2014-07-21
Project:
COC #: 787480

Sample Comment Summary

Sample ID: 1118897	14431	TP was analysed and reported on dried sample basis. TKN was analysed as received and reported on dried sample basis, for entire report.
Sample ID: 1118898	14432	TP was analysed and reported on dried sample basis.
Sample ID: 1118899	14433	TP was analysed and reported on dried sample basis.
Sample ID: 1118900	14434	TP was analysed and reported on dried sample basis.
Sample ID: 1118915	14688	TP was analysed and reported on dried sample basis.

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1416447
Date Submitted: 2014-08-06
Date Reported: 2014-08-13
Project:
COC #: 788233

Dear Johan Skoglund:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____

Tanya Baillargeon
Team Lead, Organics

Exova (Ottawa) is certified and accredited for specific parameters by:
CALA, Canadian Association for Laboratory Accreditation (to ISO 17025), OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils), Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by:
SCC, Standards Council of Canada (to ISO 17025)

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only.

Guideline values listed on this report are provided for ease of use (informational purposes) only. Exova recommends consulting the official provincial or federal guideline as required.

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1416447
Date Submitted: 2014-08-06
Date Reported: 2014-08-13
Project:
COC #: 788233

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1124324 Soil 2014-07-31 14431-01-1	1124325 Soil 2014-07-31 14431-01-2	1124326 Soil 2014-07-31 14431-01-3	1124327 Soil 2014-07-31 14431-02-1
General Chemistry	Moisture	0.1	%		8.7	7.5	6.8	8.3
Hydrocarbons	F2 (C10-C16)	10	ug/g		60	40	90	60
	F3 (C16-C34)	20	ug/g		<20	<20	<20	<20
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1124328 Soil 2014-07-31 14431-02-2	1124329 Soil 2014-07-31 14431-02-3	1124330 Soil 2014-07-31 14432-01-1	1124331 Soil 2014-07-31 14432-01-2
General Chemistry	Moisture	0.1	%		9.2	7.8	9.1	8.7
Hydrocarbons	F2 (C10-C16)	10	ug/g		70	60	220	260
	F3 (C16-C34)	20	ug/g		<20	<20	<20	30
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1416447
Date Submitted: 2014-08-06
Date Reported: 2014-08-13
Project:
COC #: 788233

				Lab I.D.	1124332	1124333	1124334	1124335
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2014-07-31	2014-07-31	2014-07-31	2014-07-31
				Sample I.D.	14432-01-3	14432-02-1	14432-02-2	14432-02-3
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
General Chemistry	Moisture	0.1	%		8.8	26.0	9.1	7.2
Hydrocarbons	F2 (C10-C16)	10	ug/g		240	230	180	210
	F3 (C16-C34)	20	ug/g		50	<20	40	40
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20

				Lab I.D.	1124336	1124337	1124338	1124339
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2014-07-31	2014-07-31	2014-07-31	2014-07-31
				Sample I.D.	14433-01-1	14433-01-2	14433-01-3	14433-02-1
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
General Chemistry	Moisture	0.1	%		8.7	8.0	6.7	9.2
Hydrocarbons	F2 (C10-C16)	10	ug/g		340	40	290	400
	F3 (C16-C34)	20	ug/g		60	70	60	70
	F4 (C34-C50)	20	ug/g		<20	<20	<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1416447
Date Submitted: 2014-08-06
Date Reported: 2014-08-13
Project:
COC #: 788233

				Lab I.D.	1124340	1124341
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2014-07-31	2014-07-31
				Sample I.D.	14433-02-2	14433-02-3
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
General Chemistry	Moisture	0.1	%		8.6	7.6
Hydrocarbons	F2 (C10-C16)	10	ug/g		440	380
	F3 (C16-C34)	20	ug/g		60	60
	F4 (C34-C50)	20	ug/g		<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o SRK)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1416447
Date Submitted: 2014-08-06
Date Reported: 2014-08-13
Project:
COC #: 788233

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 274366 **Analysis Date** 2014-08-08 **Method** CCME			
F2 (C10-C16)	<10 ug/g	86	50-120
F3 (C16-C34)	<20 ug/g	86	50-120
F4 (C34-C50)	<20 ug/g	86	50-120
Moisture	<0.1 %	100	80-120
Run No 274430 **Analysis Date** 2014-08-08 **Method** CCME			
F2 (C10-C16)	<10 ug/g	85	50-120
F3 (C16-C34)	<20 ug/g	85	50-120
F4 (C34-C50)	<20 ug/g	85	50-120
Moisture	<0.1 %	100	80-120

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Nyrstar (c/o Stantec)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1418159
Date Submitted: 2014-08-27
Date Reported: 2014-09-02
Project:
COC #: 789091

Dear Johan Skoglund:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____

Charlie (Long) Qu
Laboratory Supervisor, Organics

Client: Nyrstar (c/o Stantec)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1418159
Date Submitted: 2014-08-27
Date Reported: 2014-09-02
Project:
COC #: 789091

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1128931 Soil - 2014-08-21 14431 - 01	1128932 Soil - 2014-08-21 14431 - 02	1128933 Soil - 2014-08-21 14432 - 01	1128934 Soil - 2014-08-21 14432 - 02
General Chemistry	Moisture	0.1	%			13.0	14.4	15.0	14.2
Hydrocarbons	F2 (C10-C16)	10	ug/g			70	50	180	180
	F3 (C16-C34)	20	ug/g			20	<20	30	30
	F4 (C34-C50)	20	ug/g			<20	<20	<20	<20

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1128935 Soil - 2014-08-21 14433 - 01	1128936 Soil - 2014-08-21 14433 - 02
General Chemistry	Moisture	0.1	%			13.3	15.6
Hydrocarbons	F2 (C10-C16)	10	ug/g			290	280
	F3 (C16-C34)	20	ug/g			60	40
	F4 (C34-C50)	20	ug/g			<20	<20

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Nyrstar (c/o Stantec)
2840-650 West Georgia St.
Vancouver, BC
V6B 4N8
Attention: Mr. Johan Skoglund
PO#: ENV/2012/0
Invoice to: Canzinco Ltd.

Report Number: 1418159
Date Submitted: 2014-08-27
Date Reported: 2014-09-02
Project:
COC #: 789091

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 275417 **Analysis Date** 2014-09-02 **Method** CCME			
F2 (C10-C16)	<10 ug/g	105	50-120
F3 (C16-C34)	<20 ug/g	105	50-120
F4 (C34-C50)	<20 ug/g	105	50-120
Run No 275418 **Analysis Date** 2014-09-02 **Method** C SM2540B			
Moisture	<0.1 %	100	80-120

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Appendix G:

Physico-chemical Characterization from Laboratory Services, University of Guelph

UNIVERSITY of GUELPH
LABORATORY SERVICES
Agriculture and Food Laboratory

FINAL Report
Submission# **14-064035**
Reported: 2014-Sep-17

Submitted By:

STANTEC CONSULTING LTD
STANTEC CONSULTING LTD
EMMA SHRIVE
70 SOUTHGATE DR
SUITE 1
GUELPH, ON N1G 4P5

Phone: 519 836-6050
Fax: 519 836-2493
Sampling Date: 2014-Aug-26
Received Date: 2014-Aug-26
PO#: 2430

Owner:
EMMA SHRIVE

Carbon Package

Date Authorized: 2014-Sep-17 11:26

Sample ID	Client Sample ID	Specimen type	Sampling date / time	Test	Result		Note
0001	14431-01	Soil	14-Aug-26 09:35	Total Carbon	5.33	% dry	
0001	14431-01	Soil	14-Aug-26 09:35	Inorganic Carbon	4.50	% dry	
0001	14431-01	Soil	14-Aug-26 09:35	Organic Carbon	0.830	% dry	
0002	14431-02	Soil	14-Aug-26 09:37	Total Carbon	4.91	% dry	
0002	14431-02	Soil	14-Aug-26 09:37	Inorganic Carbon	4.39	% dry	
0002	14431-02	Soil	14-Aug-26 09:37	Organic Carbon	0.520	% dry	
0003	14432-01	Soil	14-Aug-26 09:40	Total Carbon	4.82	% dry	
0003	14432-01	Soil	14-Aug-26 09:40	Inorganic Carbon	4.49	% dry	
0003	14432-01	Soil	14-Aug-26 09:40	Organic Carbon	0.330	% dry	
0004	14432-02	Soil	14-Aug-26 09:43	Total Carbon	4.80	% dry	
0004	14432-02	Soil	14-Aug-26 09:43	Inorganic Carbon	4.11	% dry	
0004	14432-02	Soil	14-Aug-26 09:43	Organic Carbon	0.690	% dry	
0005	14433-01	Soil	14-Aug-26 09:46	Total Carbon	4.79	% dry	
0005	14433-01	Soil	14-Aug-26 09:46	Inorganic Carbon	5.08	% dry	
0005	14433-01	Soil	14-Aug-26 09:46	Organic Carbon	<0.1	% dry	
0006	14433-02	Soil	14-Aug-26 09:48	Total Carbon	5.23	% dry	

Carbon Package ....Continued

Date Authorized: 2014-Sep-17 11:26

0006	14433-02	Soil	14-Aug-26 09:48	Inorganic Carbon	4.46	% dry
0006	14433-02	Soil	14-Aug-26 09:48	Organic Carbon	0.770	% dry

Organic Matter

Date Authorized: 2014-Sep-17 11:26

Sample ID	Client Sample ID	Specimen type	Sampling date / time	Test	Result		Note
0001	14431-01	Soil	14-Aug-26 09:35	Organic matter, walkley-black	0.6	% dry	
0002	14431-02	Soil	14-Aug-26 09:37	Organic matter, walkley-black	0.8	% dry	
0003	14432-01	Soil	14-Aug-26 09:40	Organic matter, walkley-black	0.8	% dry	
0004	14432-02	Soil	14-Aug-26 09:43	Organic matter, walkley-black	0.7	% dry	
0005	14433-01	Soil	14-Aug-26 09:46	Organic matter, walkley-black	0.9	% dry	
0006	14433-02	Soil	14-Aug-26 09:48	Organic matter, walkley-black	0.8	% dry	

Particle Size

Date Authorized: 2014-Sep-17 11:26

Sample ID	Client Sample ID	Specimen type	Sampling date / time	Test	Result		Note
0001	14431-01	Soil	14-Aug-26 09:35	Gravel	45.5	%	
0001	14431-01	Soil	14-Aug-26 09:35	Sand	62.6	%	
0001	14431-01	Soil	14-Aug-26 09:35	Very Fine Sand	6.0	%	
0001	14431-01	Soil	14-Aug-26 09:35	Fine Sand	10.2	%	
0001	14431-01	Soil	14-Aug-26 09:35	Medium Sand	11.6	%	
0001	14431-01	Soil	14-Aug-26 09:35	Coarse Sand	16.3	%	
0001	14431-01	Soil	14-Aug-26 09:35	Very Coarse Sand	18.5	%	
0001	14431-01	Soil	14-Aug-26 09:35	Silt	25.7	%	
0001	14431-01	Soil	14-Aug-26 09:35	Clay	11.7	%	

Particle Size ....Continued

Date Authorized: 2014-Sep-17 11:26

0001	14431-01	Soil	14-Aug-26	09:35	Texture	Gravelly coarse sandy loam	
0002	14431-02	Soil	14-Aug-26	09:37	Gravel	46.5	%
0002	14431-02	Soil	14-Aug-26	09:37	Sand	59.4	%
0002	14431-02	Soil	14-Aug-26	09:37	Very Fine Sand	6.9	%
0002	14431-02	Soil	14-Aug-26	09:37	Fine Sand	12.2	%
0002	14431-02	Soil	14-Aug-26	09:37	Medium Sand	12.4	%
0002	14431-02	Soil	14-Aug-26	09:37	Coarse Sand	14.1	%
0002	14431-02	Soil	14-Aug-26	09:37	Very Coarse Sand	13.8	%
0002	14431-02	Soil	14-Aug-26	09:37	Silt	29.1	%
0002	14431-02	Soil	14-Aug-26	09:37	Clay	11.5	%
0002	14431-02	Soil	14-Aug-26	09:37	Texture	Gravelly coarse sandy loam	
0003	14432-01	Soil	14-Aug-26	09:40	Gravel	46.1	%
0003	14432-01	Soil	14-Aug-26	09:40	Sand	60.2	%
0003	14432-01	Soil	14-Aug-26	09:40	Very Fine Sand	6.5	%
0003	14432-01	Soil	14-Aug-26	09:40	Fine Sand	11.2	%
0003	14432-01	Soil	14-Aug-26	09:40	Medium Sand	11.8	%
0003	14432-01	Soil	14-Aug-26	09:40	Coarse Sand	14.3	%
0003	14432-01	Soil	14-Aug-26	09:40	Very Coarse Sand	16.4	%
0003	14432-01	Soil	14-Aug-26	09:40	Silt	28.4	%
0003	14432-01	Soil	14-Aug-26	09:40	Clay	11.4	%
0003	14432-01	Soil	14-Aug-26	09:40	Texture	Gravelly coarse sandy loam	
0004	14432-02	Soil	14-Aug-26	09:43	Gravel	43.9	%
0004	14432-02	Soil	14-Aug-26	09:43	Sand	59.4	%

Particle Size ....Continued

Date Authorized: 2014-Sep-17 11:26

0004	14432-02	Soil	14-Aug-26 09:43	Very Fine Sand	6.2	%
0004	14432-02	Soil	14-Aug-26 09:43	Fine Sand	10.8	%
0004	14432-02	Soil	14-Aug-26 09:43	Medium Sand	11.1	%
0004	14432-02	Soil	14-Aug-26 09:43	Coarse Sand	15.1	%
0004	14432-02	Soil	14-Aug-26 09:43	Very Coarse Sand	16.1	%
0004	14432-02	Soil	14-Aug-26 09:43	Silt	29.6	%
0004	14432-02	Soil	14-Aug-26 09:43	Clay	11.0	%
0004	14432-02	Soil	14-Aug-26 09:43	Texture	Gravelly coarse sandy loam	
0005	14433-01	Soil	14-Aug-26 09:46	Gravel	50.4	%
0005	14433-01	Soil	14-Aug-26 09:46	Sand	62.6	%
0005	14433-01	Soil	14-Aug-26 09:46	Very Fine Sand	6.4	%
0005	14433-01	Soil	14-Aug-26 09:46	Fine Sand	11.0	%
0005	14433-01	Soil	14-Aug-26 09:46	Medium Sand	11.1	%
0005	14433-01	Soil	14-Aug-26 09:46	Coarse Sand	13.7	%
0005	14433-01	Soil	14-Aug-26 09:46	Very Coarse Sand	20.4	%
0005	14433-01	Soil	14-Aug-26 09:46	Silt	27.2	%
0005	14433-01	Soil	14-Aug-26 09:46	Clay	10.2	%
0005	14433-01	Soil	14-Aug-26 09:46	Texture	Very gravelly coarse sandy loam	
0006	14433-02	Soil	14-Aug-26 09:48	Gravel	55.4	%
0006	14433-02	Soil	14-Aug-26 09:48	Sand	59.8	%
0006	14433-02	Soil	14-Aug-26 09:48	Very Fine Sand	6.2	%
0006	14433-02	Soil	14-Aug-26 09:48	Fine Sand	10.8	%
0006	14433-02	Soil	14-Aug-26 09:48	Medium Sand	10.4	%

Particle Size ....Continued

Date Authorized: 2014-Sep-17 11:26

0006	14433-02	Soil	14-Aug-26 09:48	Coarse Sand	14.8	%
0006	14433-02	Soil	14-Aug-26 09:48	Very Coarse Sand	17.7	%
0006	14433-02	Soil	14-Aug-26 09:48	Silt	27.6	%
0006	14433-02	Soil	14-Aug-26 09:48	Clay	12.6	%
0006	14433-02	Soil	14-Aug-26 09:48	Texture	Very gravelly coarse sandy loam	

Phosphorus, Soil (mass)

Date Authorized: 2014-Sep-17 11:26

Sample ID	Client Sample ID	Specimen type	Sampling date / time	Test	Result		Note
0001	14431-01	Soil	14-Aug-26 09:35	Phosphorus (Extractable)	6.96	mg/kg dry	
0002	14431-02	Soil	14-Aug-26 09:37	Phosphorus (Extractable)	7.16	mg/kg dry	
0003	14432-01	Soil	14-Aug-26 09:40	Phosphorus (Extractable)	8.27	mg/kg dry	
0004	14432-02	Soil	14-Aug-26 09:43	Phosphorus (Extractable)	10.2	mg/kg dry	
0005	14433-01	Soil	14-Aug-26 09:46	Phosphorus (Extractable)	3.60	mg/kg dry	
0006	14433-02	Soil	14-Aug-26 09:48	Phosphorus (Extractable)	5.01	mg/kg dry	

Total Nitrogen

Date Authorized: 2014-Sep-17 11:27

Sample ID	Client Sample ID	Specimen type	Sampling date / time	Test	Result		Note
0001	14431-01	Soil	14-Aug-26 09:35	Nitrogen	<0.05	% dry	
0002	14431-02	Soil	14-Aug-26 09:37	Nitrogen	<0.05	% dry	
0003	14432-01	Soil	14-Aug-26 09:40	Nitrogen	<0.05	% dry	
0004	14432-02	Soil	14-Aug-26 09:43	Nitrogen	<0.05	% dry	
0005	14433-01	Soil	14-Aug-26 09:46	Nitrogen	<0.05	% dry	
0006	14433-02	Soil	14-Aug-26 09:48	Nitrogen	<0.05	% dry	

Test method(s): SNL-006 SNL-026 SNL-022 SNL-027 CHEM-046

Supervisor: Nicolaas Schrier MSc 519 823 1268 ext. 57215 nschrier@uoguelph.ca

Appendix H:

Photographic Record

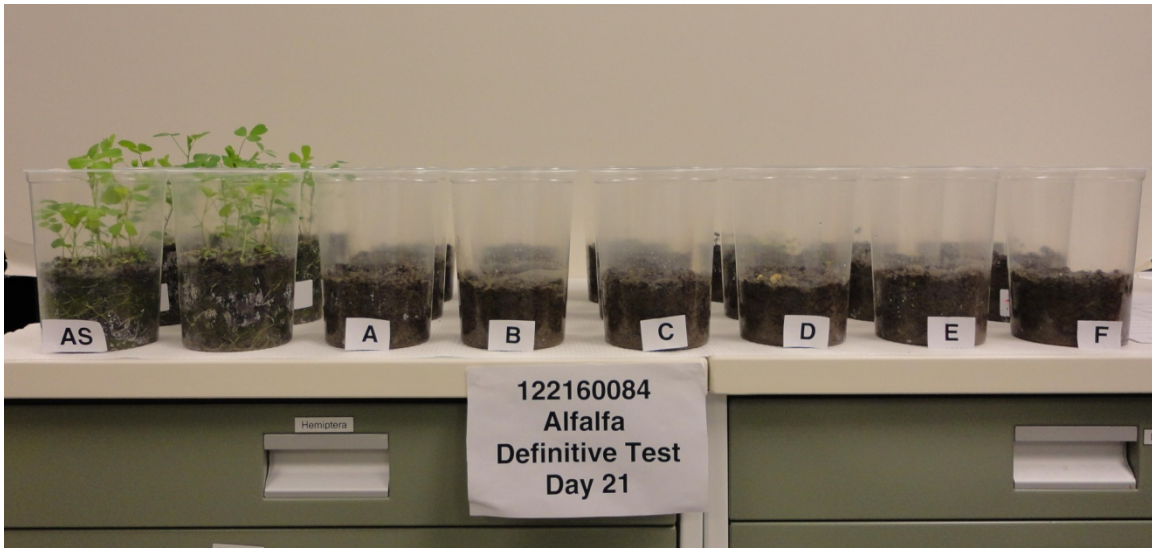

Photo 1: Test units of alfalfa prior to processing the test. Test units are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

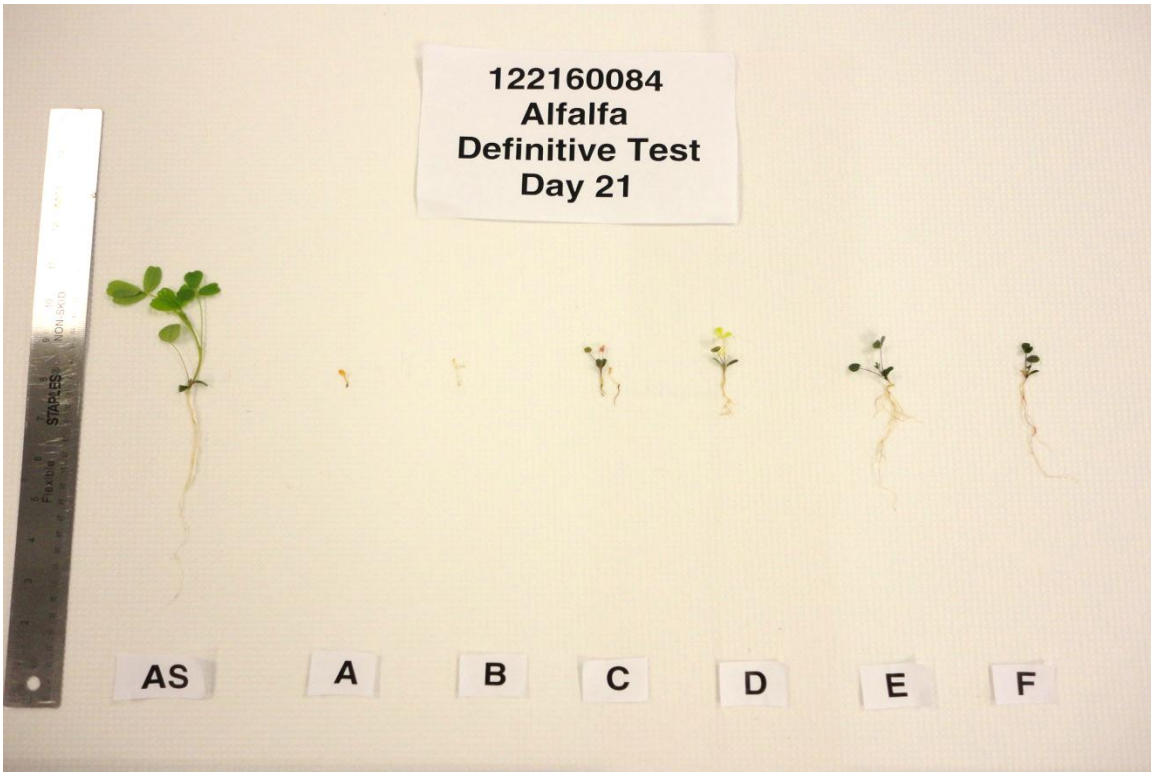

Photo 2: Selected representative alfalfa plants from each treatment after being removed from the soil and washed. Plants are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

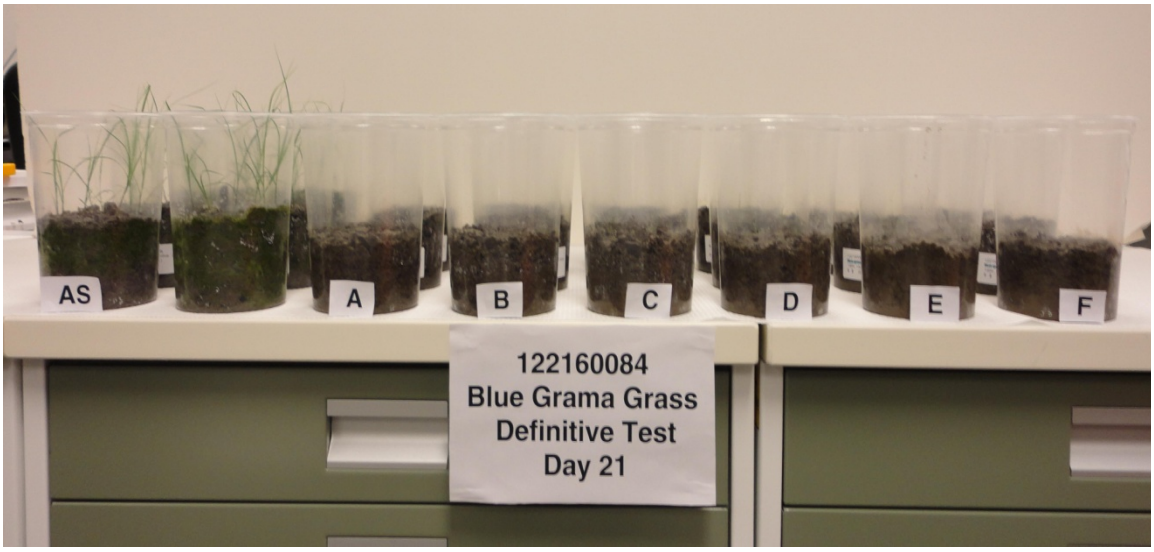

Photo 3: Test units of blue grama grass prior to processing the test. Test units are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

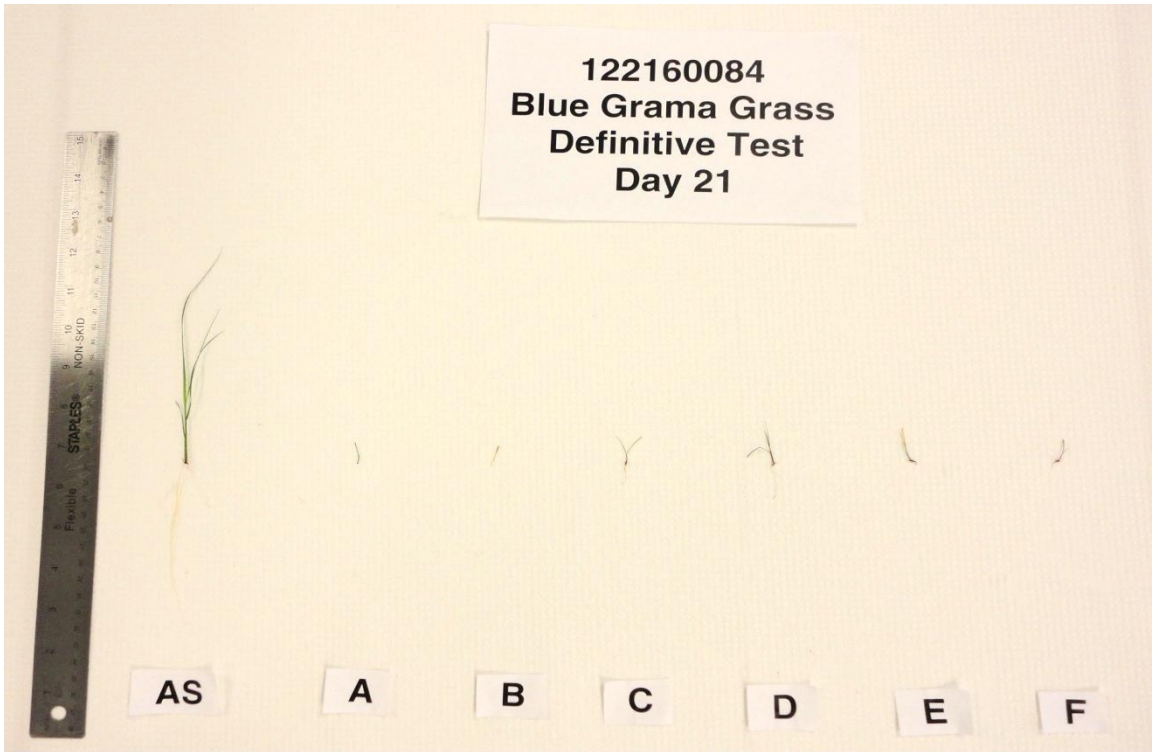

Photo 4: Selected representative blue grama grass plants from each treatment after being removed from the soil and washed. Plants are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

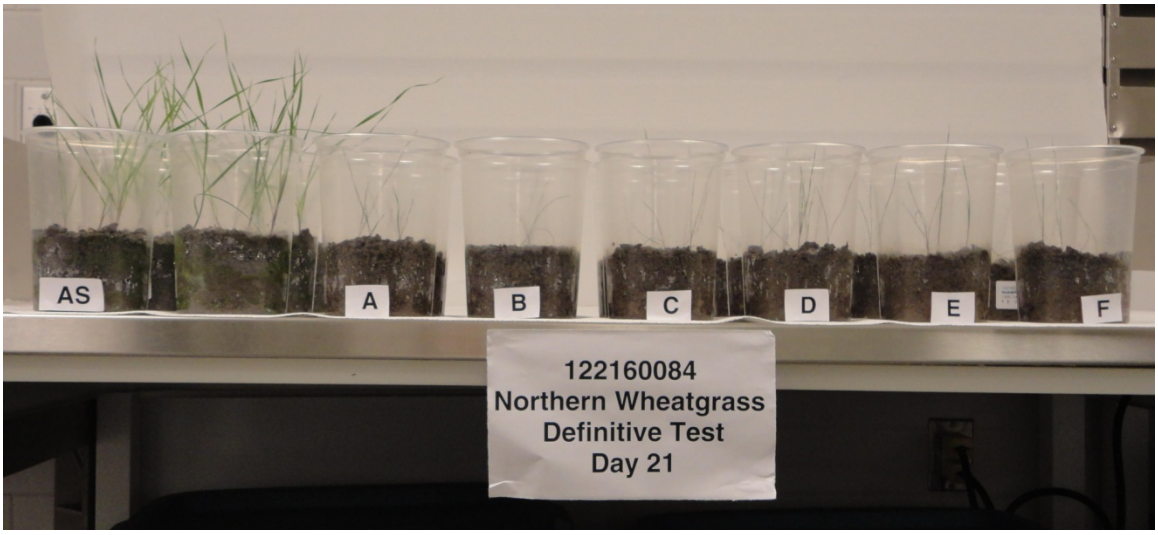

Photo 5: Test units of northern wheatgrass prior to processing the test. Test units are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

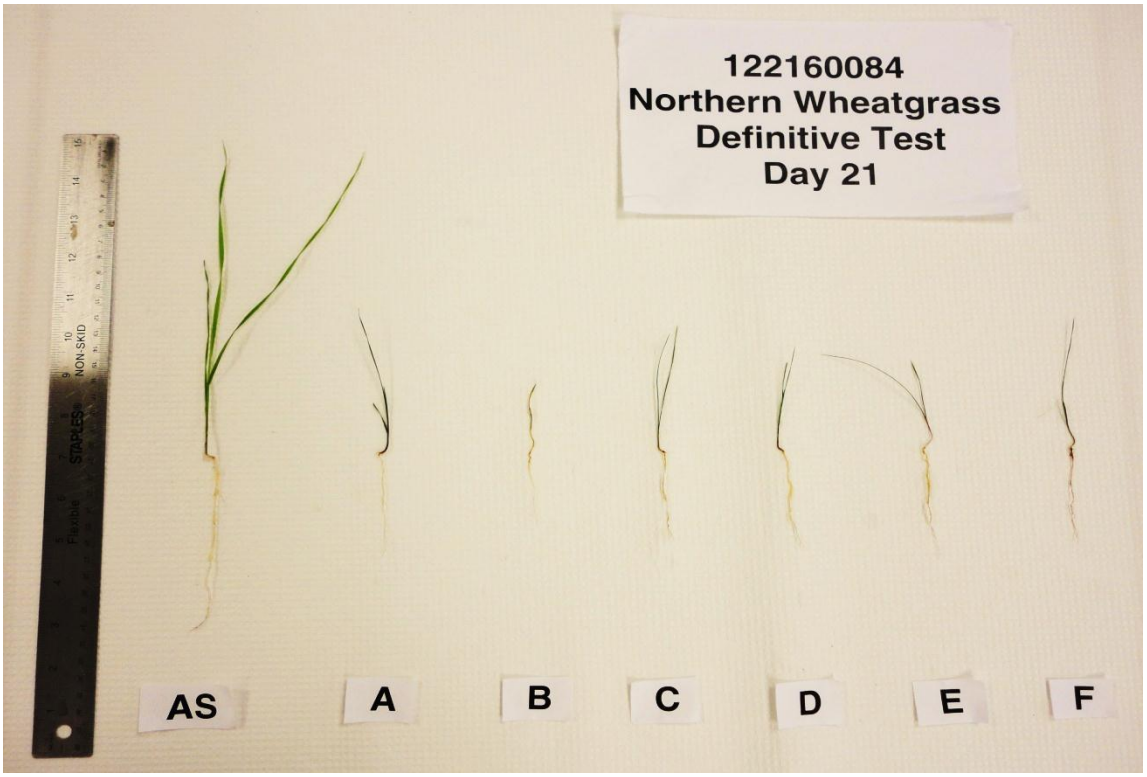

Photo 6: Selected representative northern wheatgrass plants from each treatment after being removed from the soil and washed. Plants are organized in the following order: Artificial soil (AS), 14431-01 (A), 14431-02 (B), 14432-01 (C), 14432-02 (D), 14433-01 (E), and 14433-02 (F).

Photo 7: Example of grasses in glacial till from Nanisivik.

Photo 8: Example of vegetation associated with riparian zones of glacial seeps or meltwaters.

Photograph 8: View of the vegetative barrenness associated with a polar desert environment.