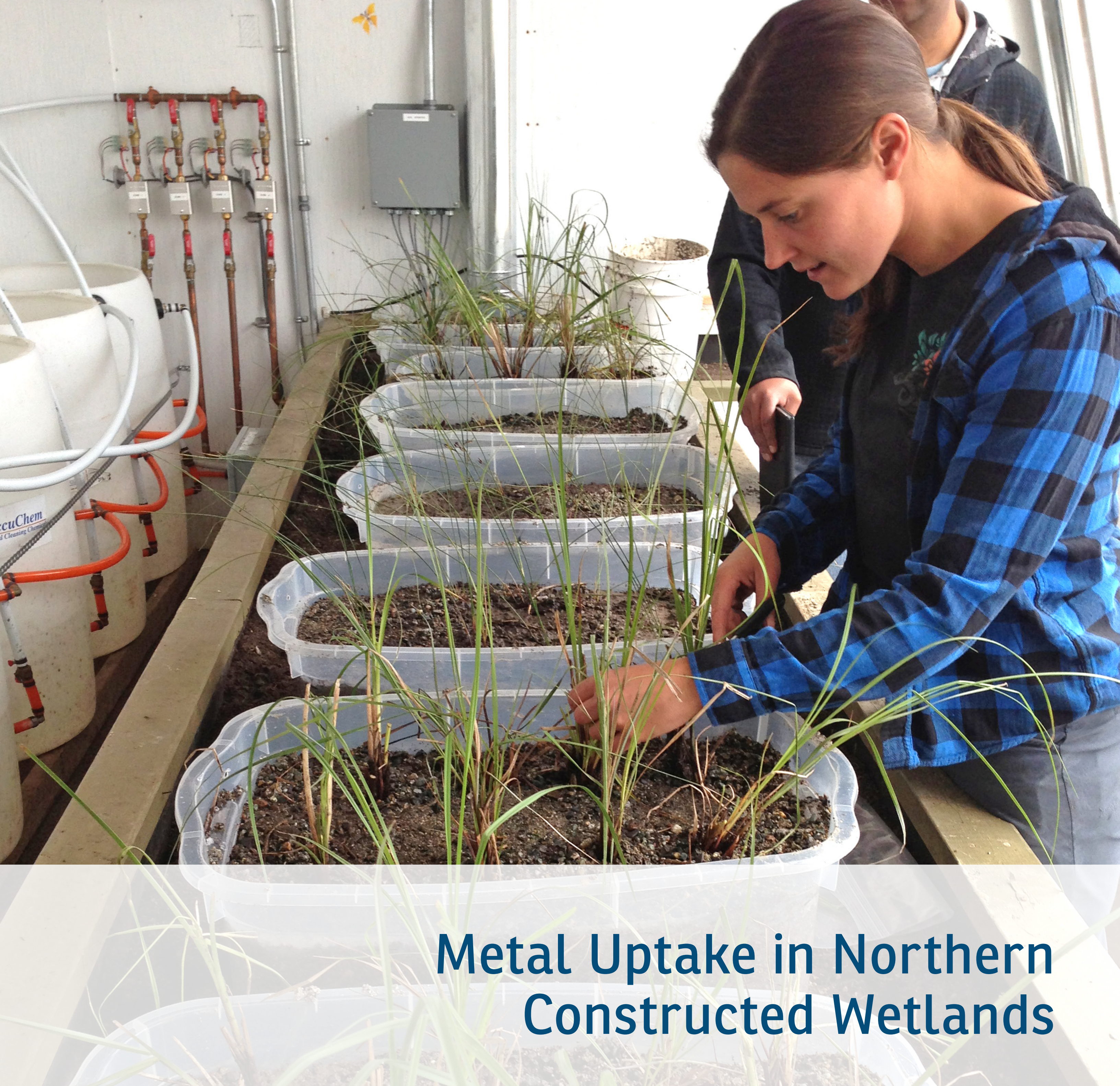

Metal Uptake in Northern Constructed Wetlands

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EXECUTIVE SUMMARY

Constructed wetlands (CWs) have been employed as passive treatment systems for metal contaminated mine drainage in Canada. However, relatively few CWs have been documented in northern environments and further studies are needed to understand the metal removal mechanisms in wetlands operating under cold climates, with short growing seasons. The goal of this study was to evaluate the performance of laboratory-scale CWs for the removal of Cd, Cu, Se and Zn, as well as, to evaluate Cu and Se uptake in two northern plant species (*Carex aquatilis* and *Juncus balticus*). Eight laboratory-scale wetlands were constructed using local materials, including locally harvested plant species and microorganisms and operated under northern summer conditions for 10 weeks. The CWs were fed continuously with synthetic influent containing Cd, Cu, Fe, Se and Zn at concentrations predicted at mine closure. Average removal efficiencies of 96%, 99%, 79% and 97% were observed for Cd, Cu, Se and Zn respectively. There were no significant differences in plant establishment or growth between our CW treatments, or any evidence of increasing Cu uptake with increasing contaminant availability in either northern plant species. Increased belowground uptake of Se was observed at the higher influent concentration in the Pit treatment. However, overall our study suggests that uptake of contaminants by these two northern species is very minor (<0.06% Cu and <0.11% Se, except for *C. aquatilis* in one treatment <0.2% Cu and <0.4 % Se) and likely does not pose a risk to the surrounding environment. We conclude that CWs could operate as successful passive treatment solutions in a northern environment, at least during the summer months, pending further studies on winter treatment. Further studies are required to examine seasonal metal removal rates in relation to rates of sulfate reduction, carbon consumption, metal precipitation and sorption. In addition, potential contaminant uptake and the influence of functional plant characteristics on metal removal in a suite of northern plant species would further assist in the development of large-scale long-term northern CWs.

ACKNOWLEDGEMENTS

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1. BACKGROUND

Constructed wetlands (CWs) are biogeochemical systems where an effluent flows through a plant-soil matrix and natural processes reduce pollutant levels to a given discharge limit (Bathia and Goyal 2014). CWs have been applied for treatment of municipal, agricultural and industrial effluents with complex physical, chemical and/or biological mechanisms (Kaldec and Knight 1996, Kaldec and Wallace 2008). Once established, CWs can become self-sustaining ecosystems with the plants providing yearly renewal of carbon to fuel microbial activity (Contango Strategies 2014). CWs have been proposed as a sustainable and long-term solution for water treatment at mine closure in Canada due to their low maintenance and operational cost requirements and high removal capacity (Eger and Kairies Beatty 2013; Sheoran and Sheoran 2006). However, relatively few wetlands have been used in northern environments and further studies are needed to design systems that will best fit the remediation objectives and environmental constraints (Kaldec and Reddy 2001).

The processes involved in metals removal from mine-impacted water include, but are not limited to, reduction/oxidation, precipitation, bio-sorption, bioaccumulation and volatilization (Sobolewski 1999, Guittonny-Philippe et al 2014). Microbial sulfate reduction processes and metal precipitation as sulfide salts in the anaerobic zone of the substrate is considered a major mechanism for metal sequestration in CWs (Arroyo et al 2013). While wetland sediments are known to act as a sink for heavy metals (Sheoran and Sheoran 2006, Baldwin and Hodaly 2003, August et al 2002), bioaccumulation in plants is also considered to some extent a metal removal pathway. Metal uptake by plants growing in wetlands treating mine-impacted waters has been sparsely studied with records of metal uptake by *Carex aquatilis* and *C. rostrata* (August et al 2002, Stoltz and Greger 2002, Nyquist and Greger 2009), *Juncus maritimus* and *J. effuses* (Conesa et al 2011, Rahman et al 2011), *Typha latifolia* and *T. domingensis* (Mitsh and Wise 1998, Taylor and Crowder 1983, Maine et al 2006), *Phragmites australis* (Batty and Younger 2004, Stoltz and Greger 2002, Nyquist and Greger 2009) *Eichhornia crassipes* (Maine et al 2006) and *Salix Sp*. (Stoltz and Greger 2002). In most of these cases heavy metals were reported to be largely found in plant roots with minimal or no uptake into shoots. Metal uptake potential in aboveground shoots should be well characterized in CWs that are used for mine closure, as it could pose a risk by exposing foraging wildlife to contaminants. Uptake by wetlands plants can be strongly affected by the water chemistry, the plant species (Deng et al 2004, Sheoran 2006), as well as, the redox conditions and geochemistry in the wetland substrate (Sobolewski 2010).

Implementation of two large CWs has been proposed as part of the billion-ton Copper-Gold Casino deposit project, located in the Yukon, 300 km northwest of Whitehorse. CWs have been proposed as a passive option for remediation to mitigate the risk of metals discharge into the downstream environment. One 10 ha CW has been proposed to treat discharge from the 3.14 km^2 open pit, which then flows into the proposed 1,120 ha Tailings Management Facilities (TMF). A second 6 ha CW has been proposed down-gradient of the TMF for final water treatment before release into the Casino Creek watershed (Casino Mining Corp 2014). This plan was submitted earlier this year for revision under the Yukon

Socio-Economic and Environmental Assessment Act, one of the regulations framing environmental permitting in Yukon Territory. However, very few data on northern wetlands with northern plants are available in the literature and a deeper understanding of northern wetland systems and plant uptake capacity is required for assessment and development of passive water treatment in the North.

The three objectives of this study were to: 1) Assess the short term efficiency of laboratory-scale CWs for mine effluents containing Cd, Cu, Fe, Se and Zn, 2) assess the potential uptake of Cu and Se by two northern wetlands plants, and 3) examine the influence of a methanol-amendment on metals removal by the laboratory-scale CWs.

2. MATERIAL AND METHODS

2.1. Laboratory-scale wetland setup

Eight laboratory-scale CWs were established in late June 2014 in the Yukon Research Centre greenhouse (Fig. 1). Each wetland consisted of a 47 L tote filled with 35 L soil substrate (13 cm height) made up of a homogeneous mixture of 5% (v/v) peat (Premier®, PremierTech Horticulture, Rivière-du-Loup, Quebec), 55% (v/v) washed sand (GE Cement plant, Whitehorse) and 40% (v/v) washed pea gravel (GE Cement plant, Whitehorse) (Fig. 2). Hydraulic conductivity tests were conducted to achieve the appropriate ratio of peat, sand and pea gravel to allow for a 5 ml/min flow rate with a hydraulic residence time of approximately 5 days (Fig. 3). *Carex aquatilis* and *Juncus balticus*, two plant species common in northern natural wetlands with different root oxygen exchange rates, were collected from a natural wetland located on McIntyre Creek in Whitehorse, YT (60°44'48.6"N 135°06'17.5"W) (Fig. 4). Eight plugs of either species containing rhizomes, roots and approximately 250 ml of natural wetland substrate were transplanted from the natural wetland into each laboratory-scale CW. Each wetland contained only one species; therefore, 4 wetlands contained *C. aquatilis* and 4 contained *J. balticus*. Two days after transplant, fertilizer was added (Alaska® Fish Fertilizer 5-1-1, Lilly Miller, dosage of 20 ml/m^2). The CWs were then saturated with tap water up to the level of the substrate surface and left undisturbed (no flow) for 2 weeks to allow the rhizomes to establish and the microorganisms within the transplanted substrate to incubate. Tap water was then circulated for another 2 weeks through the CWs. After 4 weeks of incubation with tap water, the aboveground biomass was removed at a height of 2 cm, leaving no shoots. Synthetic influents containing metals were then circulated through the CWs for 10 weeks and new shoot growth was monitored.

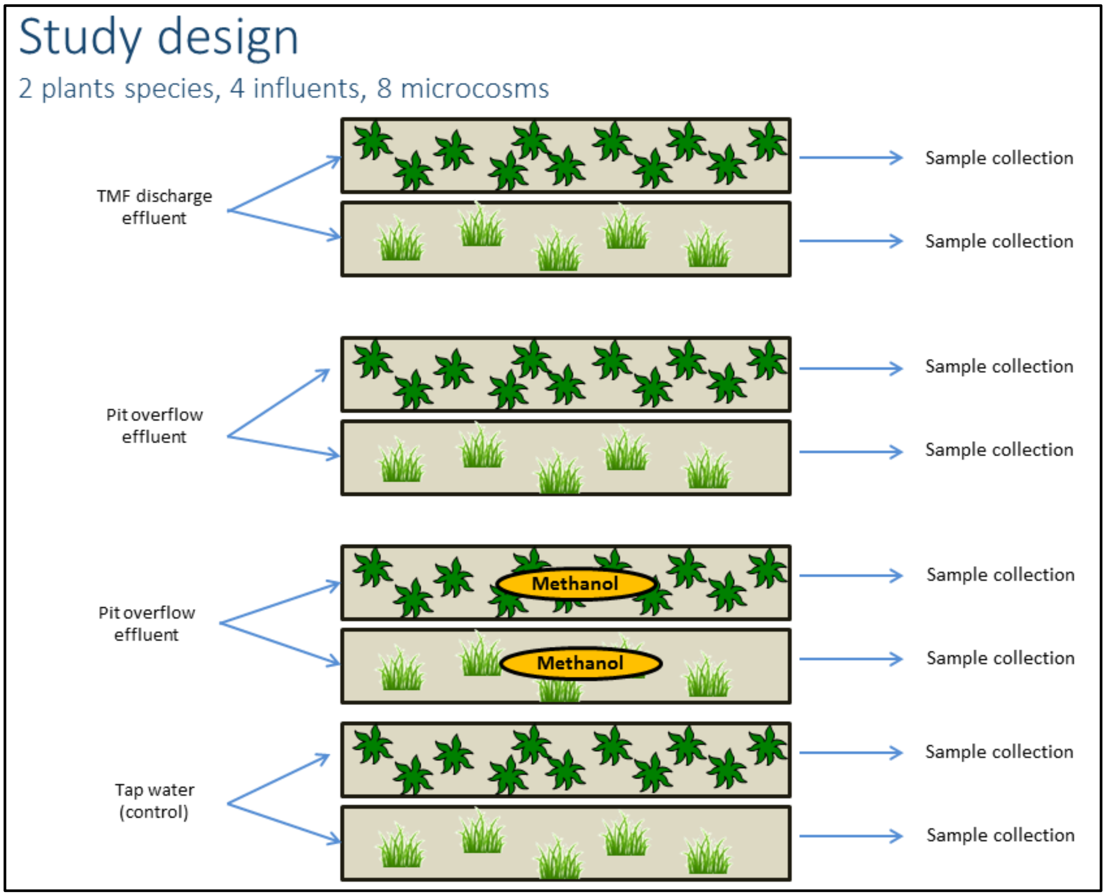

Figure 1 Constructed Wetland (CW) study design using two plant species (***Carex aquatailis*** and ***Juncus balticus***) and 4 different synthetic influents (TMF, Pit, Pit(MeOH) and Control) for a total of 8 laboratory-scale CWs.

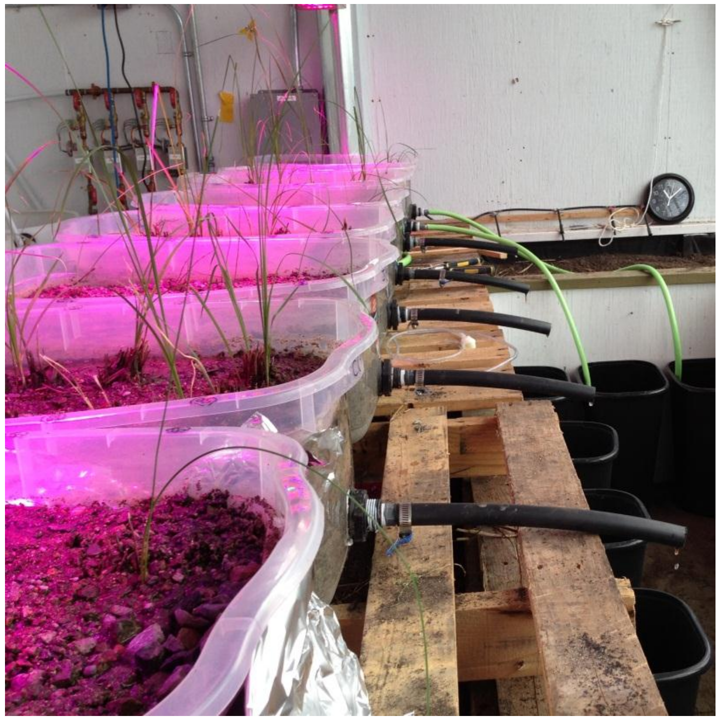

Figure 2 **Laboratory-scale constructed wetlands with northern plant species, *Carex aquatailis* and *Juncus balticus*.**

Figure 3 **Sampling *Carex aquatailis* and *Juncus balticus* for the constructed wetlands from a natural wetland located on McIntyre Creek in Whitehorse, YT.**

Figure 4 **Hydraulic conductivity testing to determine the appropriate ratio of peat, sand and pea gravel to achieve a 5 ml/min flow rate with a hydraulic residence time of approximately 5 days.**

2.2. Synthetic influent preparation

Synthetic influents were prepared weekly by dissolving $CdSO_4*8/3H_2O$ (Acros Organics, ACS Reagent), $CuSO_4*5H_2O$ (Fisher Scientific, Fisher Bioreagents), $FeSO_4*7H_2O$ (Fisher Scientific, Reagent Grade), SeO_2 (anhydrous; Acros Organics, 99.8%) $ZnSO_4*7H_2O$ (Acros Organics, ACS Reagent) and Na_2SO_4 (anhydrous; Fisher scientific; Lab Grade) in DI water. Four CWs each had different water treatments (4 water treatments x 2 species for a total of 8 CWs):

i) TMF with metal concentrations that reflected the concentrations predicted at closure in the Tailings Management Facility,

ii) Pit with metal concentrations predicted at closure in the open pit,

iii) Pit(MeOH) with Pit metal concentrations and the addition of 1% MeOH (Fisher Scientific) added weekly and

iv) City of Whitehorse tap water that was considered a Control treatment (Fig. 1).

pH was similar in all influents while Cd, Cu and Se concentrations were about twice in the Pit treatment as in the TMF treatment (Table 1). Cadmium, Se and Zn concentrations in the tap water Control were below quantification limits or quantified under 5% of the measured concentrations in TMF, Pit and Pit(MeOH) (Table 1). Cu concentrations were detected in tap water (35.3 ± 14.4 ug/L) that were approximately 30% of the concentrations found in the TMF influent.

Table 1 Average and standard deviation for pH, SO_4, Cd, Cu, Se and Zn concentrations in the influents between Week 2 and 10 for each of the CW treatments. Values below quantification limit are assumed to be equal to the quantification limit of 0.05 ug Cd/L, 0.6 ug Cu/L, 0.7 ug Se/L and 0.4 ug Zn/L.

	Control	TMF	Pit	Pit(MeOH)
pH	7.9 ± 0.3	7.8 ± 0.1	7.9 ± 0.1	7.7 ± 0.1
Cd (ug/L)	0.07 ± 0.05	1.6 ± 0.9	6.1 ± 0.44	5.5 ± 0.74
Cu (ug/L)	35 ± 14	121 ± 33	644 ± 181	607 ± 192
Se (ug/L)	0.7 ± 0.0	2.8 ± 1.2	4.4 ± 1.7	4.5 ± 2.3
Zn (ug/L)	24 ± 3.7	525 ± 63	576 ± 53	540 ± 84
SO_4 (mg/L)	37 ± 3.3	600 ± 243	610 ± 237	496 ± 215

2.3. Laboratory-scale constructed wetlands operation and monitoring

The 8 CWs were operated and monitored over 10 weeks following 4 weeks of incubation in a greenhouse under northern summer conditions. Temperature was 11^{o}C with no light from 23:00-5:00 and 16^{o}C with 175 µmol/m^{2}/s of light from 5:00-23:00. Synthetic influents or tap water were pumped at the bottom of the substrate using a multi-channel peristaltic pump (Masterflex pump, head and C-flex tubing) at 5 ml/min with sub-surface vertical flow (Fig. 5). The hydraulic residence time was approximately 5 days. Effluents from the CWs were discharged into outlet collection containers. The volume of the effluent accumulated in the collection containers over a week were recorded while pH measurements and samples were collected weekly. Samples for total metal analysis were preserved with 5% HNO_3 (trace metal grade) and stored at 4°C and samples for sulfate analysis were stored frozen.

Figure 5 Synthetic influents or tap water being pumped at the bottom of the substrate using a multi-channel peristaltic pump (Masterflex pump, head and C-flex tubing) at 5 ml/min with sub-surface vertical flow.

At the end of the experiment period, Oxygen Reduction Potential (ORP) and pH were measured in the center of each CW at a depth of 5 cm and 10 cm from the outlet. CWs were drained and interstitial water that remained within the substrate was sampled and preserved with 5% HNO3 (trace metal grade) for total Cu and Se analysis. All plant materials were extracted from the wetland and above- and belowground biomass were carefully washed with DI water, brushing the materials to remove any remaining soil particles. Root and shoot length were recorded and dry biomass was determined following drying at 105°C for 72 hrs. Three replicates of live shoots and roots were further analyzed for metal content. Wetland substrates from each CW were thoroughly mixed, sampled and also analyzed for metal contents.

2.4. Contaminants Analysis

Total Cd, Cu, Se and Zn metal concentrations in effluents were measured using Perkin Elmer PinAAcle Atomic Absorption (AA) analyzer (Perkin Elmer, Waltham, MA). Cadmium, Cu and Se were analyzed by Graphite Furnace (GFAA) and Zn by Flame (FAA). The Quantification Limits (QL) used in this work have been defined for each element as 10-σ and are 0.05 ug Cd/L, 0.6 ug Cu/L, 0.7 ug Se/L and 0.4 ug Zn/L. Calibrations were completed on a daily basis using single element standards (SCP Science, Baie D'Urfé, QC), and blanks and mixed verification standards (Perkin Elmer, Waltham, MA) were analyzed every 15 samples. Up to ±20% deviation was tolerated for the verification standards at the low end of the calibration curve and up to ±10% on the high end of the calibration curve. Quality control reports and analysis details are reported in Appendix A. pH was measured using Oakton PCD650 meter (Vernon Hills, IL) with a double junction pH electrode. Sulfate was analyzed by spectrophotometry using a SmartChem 170® Automated Discrete Analyzer (Westco, Guelph, ON) according to the STM Method D516-90, 02. Biomass samples were digested with nitric acid (trace metal grade) according to the method described by Zarcinas et al (1987) while substrate samples were digested with aqua regia according to USEPA reference method 3050B.

2.5. Statistical analyses

All data were tested to meet the assumptions of ANOVA and log transformation and boxcox transformations were performed. Differences in contaminant outlet concentrations, pH and SO_4 consumption between CW treatments were examined using repeated measures ANOVA with TukeyHSD posthoc comparisons (significant differences indicated by $p<0.05$ for all comparisons). Due to independent replication for CW vegetation (i.e. *Carex aquatailis* and *Juncus balticus*) ANOVA was TukeyHSD posthoc comparisons ($p<0.05$) was used. All analyses were conducted in R (R package version 2.1.50). Mass balance calculations and partitioning of Cu and Se into CW elements (i.e. water, substrate and plants) was conducted by summing total Cu and Se contained in the plant (metal content in above and belowground biomass x biomass weight before and after the experiment), in the soil (metal content in the soil x dry weight of soil contained in each CW before and after the experiment including initial peat, natural substrate and fish fertilizer), the water flowing in and out of the wetlands (weekly measurements of metal concentrations and volumes) and the interstitial water contained within the CWs at the end of the experiment.

3. RESULTS

3.1. Heavy metal removal from contaminated waters

The laboratory-scale constructed wetlands demonstrated a strong ability to remove heavy metals from contaminated water. Total removal efficiencies above or equal to 96%, 99%, 79% and 97% were observed for Cd, Cu, Se and Zn respectively, across the four CWs treating Pit and TMF synthetic influents (Fig. 6). Although the Pit treatment had higher metal concentrations in the influent (Table 1), there were no significant differences in the outlet contaminant concentrations between the different CWs treatments (repeated measures ANOVA with Tukey posthoc, $p>0.05$ for all comparisons). These consistently high metal removal efficiencies across CW treatments, regardless of synthetic influent concentrations, suggest that the short-term metal removal capacity of these laboratory-scale CWs were not reached. Further studies that include higher concentrations of contaminant inputs, larger-scale wetlands and a greater duration of treatment would be highly useful in determining the long-term metal sequestration capacity.

Although the CWs were only at a small laboratory-scale, the Cd, Cu and Zn removal efficiencies observed were similar to the efficiencies observed in other pilot or full-scale wetlands. Removal efficiencies of 94-99% for Cd (Gammons et al 2000, Yang et al 2006), 89-97% for Cu (Banks et al 1997, Gammons et al 2000, Lesage et al 2007, Contango Strategies 2014) and 87-98% for Zn (Sobolewski 1996, Banks et al 1997, Yang et al 2006, Lesage et al 2007) have been reported. Selenium treatment of mine-impacted water by CWs seems less common than transition metals treatment and Se had the lowest average removal compared with the other contaminants. However, removal efficiencies above 83 % were observed in this study. In another study examining a northern wetland planted with the same *Carex* species, an efficiency of 26% was reported for Se removal (Contango Strategies

2014). This low efficiency was attributed to the elevated concentrations of nitrate, which competes over Se as an electron-acceptor.

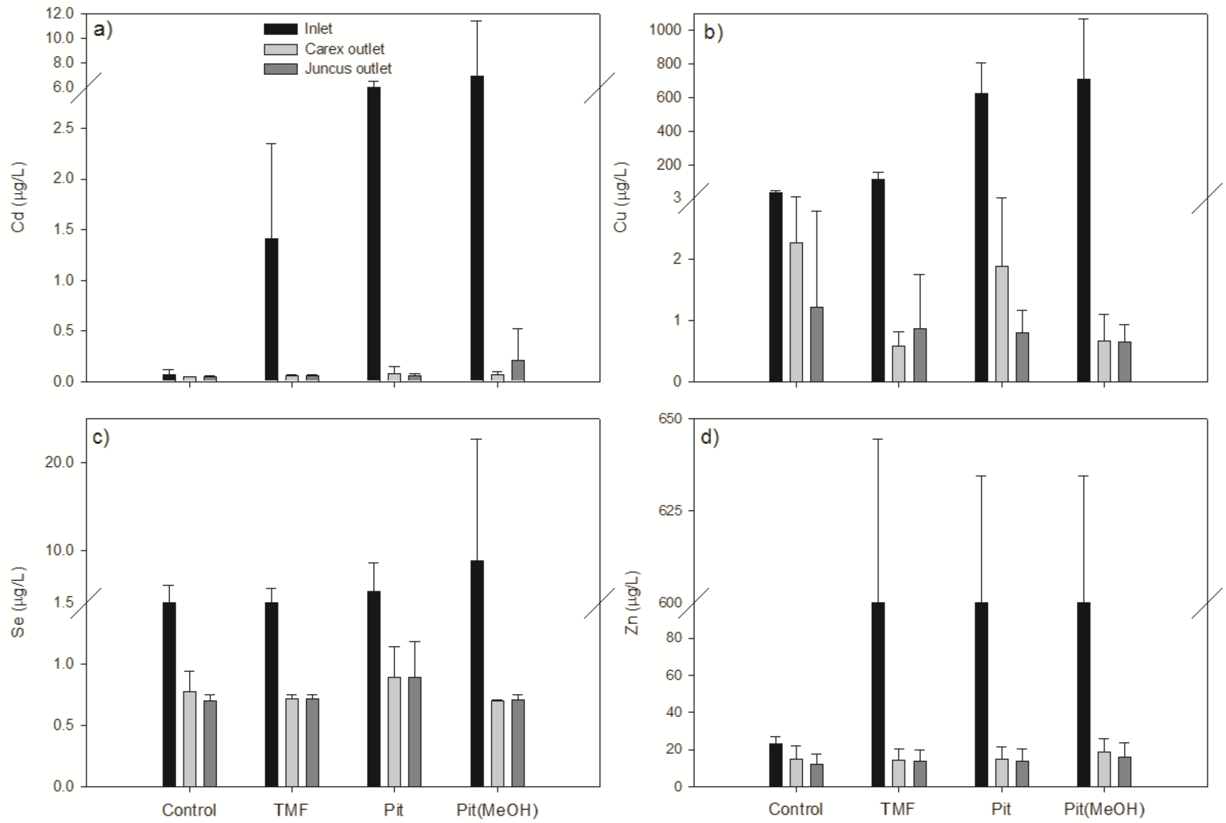

Figure 6 Cd (a), Cu (b), Se (c) and Zn (d) concentrations in CWs with C. aquatilis (Carex) and *J. balticus* (Juncus) fed with Control, TMF, Pit or Pit(MeOH) waters. Bars represent means with standard error. There were no significant differences in the outlet concentrations for any of the contaminants between the wetland treatments (repeated measures ANOVA with Tukey posthoc ($p>0.05$ for all comparisons). Note the broken Y-axis.

Over the trial a significant increase in pH in the TMF, Pit and Pit(MeOH) treatments was detected compared to the Control treatment (ANOVA with Tukey posthoc, $p<0.05$ for all comparisons) (Fig. 7). Starting at week 7 significant increases in pH were observed for the Pit(MeOH) treatment compared to all other treatments. In addition, higher consumption of SO_4 was observed for the Pit(MeOH) treatment where a carbon source (i.e.1% MeOH) was being added to the CWs. Both CWs with a Pit(MeOH) treatment had higher consumption of SO_4 compared with the Pit treatments starting at week 6 (Fig. 8). Although, the Pit(MeOH) with *J. balticus* was not significantly higher than the Pit treatment with *J. balticus*, both the Pit(MeOH) treatments were significantly higher than the Pit treatment with *C. aquatilis* (ANOVA with Tukey posthoc, $p=0.05$ for Carex and $p=0.02$ for Juncus). An increase in reducing conditions in the CW substrate of the Pit(MeOH) treatment was observed, with an average Oxygen Reducing Potential (ORP) of -341.9 mV, compared to an average of -109.4 mV when no MeOH was added (i.e. Pit). Black deposits on the wetland surface, characteristic of sulfide precipitates, and odiferous evidence of H_2S from the Pit(MeOH) CWs indicated a strong reducing environment (Fig. 9). Low ORP, increased SO_4 consumption and black deposits on the wetland surface for the Pit(MeOH) treatment likely indicate that methanol addition to the CWs was stimulating microbial-induced sulfate reduction (Eq. 1) and subsequent metal sulfide salts precipitation (Eq. 2). Reduction of one mol of sulfate leads to the production of 3 moles of bicarbonate (HCO_3^-), which likely explains the increase in pH observed in Fig. 7 as bicarbonate consumes hydrogen ions (Eq. 3).

(Eq. 1) $$4\,CH_3OH + 3\,SO_4^{2-} \xrightarrow{microbial} 3\,HCO_3^- + 3HS^- + 5\,H_2O + CO_2$$

(Eq. 2) $$HS^- + M^{2+} \leftrightarrow MS(s) + H^+$$

(Eq. 3) $$HCO_3^- + H^+ \leftrightarrow H_2O + CO_2$$

In natural wetlands organic matter decomposition typically decreases the ambient redox potential. Organic carbon acts as an electron donor to microorganisms, such as sulfate-reducing bacteria, which reduce sulfate (SO_4) releasing sulfide (S^2) (Sobolewski 2010). Sulfide is highly reactive and forms insoluble metal salts, such as CdS, CuS and ZnS. To offset the reduction in organic matter decomposition often encountered in northern wetlands and bioreactors, addition of liquid carbon may be advantageous (Tsukamoto et al 2004, Sobolewski 2010, Alexco 2012, Gould et al 2012). The addition of liquid methanol at 1% (v/v) in the Pit(MeOH) treatment was intended to assess the impact of additional carbon sources on the substrate conditions and subsequently on the metal uptake by northern wetland plant species. It appears that the addition of liquid methanol did impact the substrate conditions and led to greater reducing conditions, although significantly higher heavy metal removal efficiency was not observed (Fig. 6). Therefore, the presence of electron donors in the substrate was likely not a limiting factor in the Pit CWs that were not fed with methanol. In addition, the Pit(MeOH) CWs may have produced HS^- in excess accounting for the odor associated with this treatment.

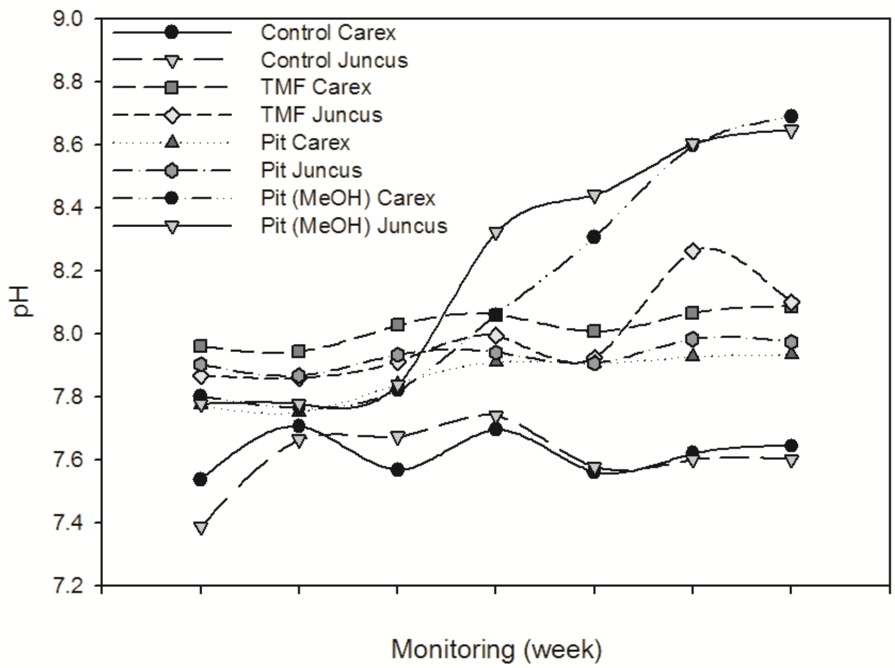

Figure 7 pH of outlet waters for each CW treatment monitored from week 4 to week 10 of the laboratory-scale trial. At week 7 significant increases in pH were observed for the Pit(MeOH) treatment compared to all other treatments. Similarly, both the TMF and Pit treatment had significant increases in pH compared to the control (ANOVA with TukeyHSD, $p<0.05$ for all comparisons).

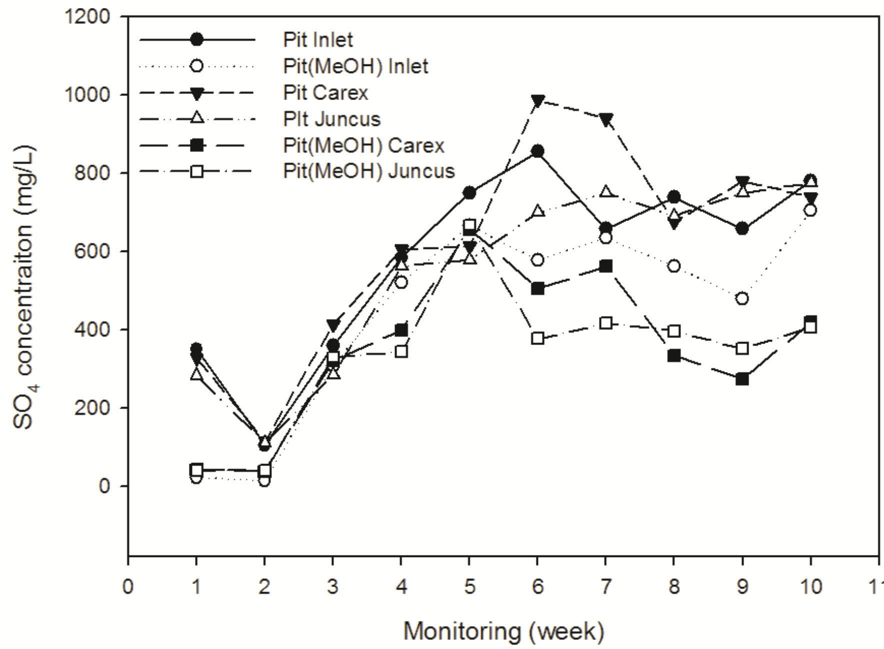

Figure 8 Sulfate concentration in the inlet and outlet waters of the Pit and Pit(MeOH) CWs with ***C. aquatilis*** (Carex) and ***J. Balticus*** (Juncus) monitored over the 10 week trial. Significantly higher sulfate consumption (i.e. Inlet-Outlet for each CW) for both Pit(MeOH) CWs compared with the Carex Pit treatment were detected (ANOVA with Tukey posthoc, $p=0.05$ for Carex and $p=0.02$ for Juncus).

Figure 9 Black deposits on the wetland surface, characteristic of sulfide precipitates found only in the Pit(MeOH) CW treatment. In addition, an odiferous evidence of H_2S from the Pit(MeOH) was present.

To better understand the mechanisms by which metal sequestration occurs in northern CWs further studies are required. In particular, characterization of metal endpoints, examination of the relative importance of sorption versus metal precipitation and characterization of the microbial community and its' activity are needed. Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in wetlands at permanently low temperatures is crucial (Robador et al 2009). More importantly, studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption (Gammons et. al. 2000). Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for northern CWs that function year-round.

Metal uptake by plants is thought to depend on the geochemistry in the substrate and is affected by the speciation and availability of the metals. At the end of 10 weeks of treatment in our laboratory-scale study shoots of both *C. aquatilis* and *J. balticus* were yellowed and dead in the Pit(MeOH) treatment. Sulfide is known as a strong phytotoxcin to plants by causing basic disturbance to cell metabolism and energy transfer, which can hamper plant nutrient uptake (Lamers et al 2013). Death of plants within the Pit(MeOH) treatment and the strong H_2S odour may indicate that the concentration of organic carbon used was too high. In addition, other sources of carbon may be more appropriate for use in northern CWs with northern plant species. Glucose, lactate/acetate, ethanol, methanol, ethylene glycol are all carbon sources that have been used to supplement northern bioreactors or CWs (Ness et al. 2014). Further studies are needed to examine the influence of sources and concentrations of carbon in northern CWs and how these may influence metal sequestration in both wetland substrates and plants.

3.2. Establishment, growth and metal uptake of northern wetland plants

There were no significant differences in metal removal efficiency or pH between CW treatments containing either *C. aquatalis* or *J. balticus*. Nor were there significant differences in the shoot and root length or in the above and belowground biomass across our different CW treatments for either of the northern plant species (Table 2; ANOVA with TukeyHSD posthoc, $p>0.05$ for all comparisons). While growth of belowground biomass was more difficult to quantify for the transplants, aboveground biomass was removed for both species prior to initiating treatment with contaminated synthetic influent; therefore, strong growth within 10 weeks with stems as long as 74 cm and 50 cm for *C. aquatalis* and *J. balticus*, respectively, was observed. With the exception of mortality of both species in the Pit(MeOH) treatment, discussed above, the establishment and growth of both plant species did not appear to be negatively impacted by the addition of contaminants into the CWs. Our study suggests that both of these species may be good candidates for northern CWs due to their vigorous growth, high tolerance to contaminants and limited uptake of Cu and Se.

Although no treatment effects on establishment were observed, *C. aquatalis* had a 53% survival rate and *J. balticus* had only a 38% survival rate following transplanting. The results suggest that if using locally transplanted materials high numbers of replicate plants may be needed to account for transplant related mortality. Although transplantation of plant materials is advantageous since plants are adapted to the local conditions (Galbrand et al. 2008), much higher rates of plant propagation success can be achieved by purchasing plugs from commercial native plant nurseries. However, plant materials for growing plugs should ultimately be sourced from as close as possible to the site of the CW. Further determination of species for northern CWs requires an evaluation of a much larger suite of locally available plants. To ensure effective naturalization of the vegetation community to be established in a CW, community modeling based on surveying of plant communities inhabiting similar local natural wetlands, including vegetation composition, structure and abundance should be conducted (Daigle and Havinga 1996, Hoag 2003). Based on the following criteria, species can be further screened for suitability in CWs: (a) phytoremediation potential (especially metal uptake), (b) sedimentation and erosion control, (c) habitat function, (d) public deterrent potential and (e) rate of plant establishment, tolerances and maintenance requirements (Galbrand et al. 2008).

Table 2 **Average and standard deviation of root and shoot length and biomass (dry weight)** ***of Carex aquatilis*** **(Carex) and** ***Juncus balticus*** **(Juncus) after 10 weeks of growth in constructed wetlands (CWs) treated with either Control, Pit, TMF and Pit(MeOH) waters. There were no significant differences in root and shoot length or biomass between the CW treatments for either species (ANOVA, p>0.05 for all comparisons).**

Plant species	CW Treatment	Root length (cm)	Shoot length (cm)	Root biomass (g)	Shoot biomass (g)
Carex	Control	20 ± 8.9	35 ± 21	0.38 ± 0.23	0.76 ± 0.47
	TMF	24 ± 21	35 ± 22	0.50 ± 0.23	9.2 ± 23
	Pit	25 ± 20	24 ± 23	0.42 ± 0.27	1.4 ± 1.2
	Pit(MeOH)	21 ± 9.1	28 ± 18	0.49 ± 0.23	0.91 ± 0.31
Juncus	Control	11± 10	25 ± 24	0.29 ± 0.31	0.30 ± 0.19
	TMF	11 ± 7.1	15 ± 12	0.27 ± 0.21	0.20 ± 0.14
	Pit	10 ± 6.1	21± 15	0.25 ± 0.15	0.21± 0.07
	Pit(MeOH)	7.2 ± 2.8	16 ± 8.8	0.30 ± 0.21	0.23 ± 0.09

No significant uptake of Cu or Se into the aboveground biomass by *C. aquatilis* or *J. balticus* was observed in this study. Furthermore, there was no significant difference in above or belowground Cu content in either plant species across the different CWs treatments (Fig. 10; ANOVA, p=0.51). Although in most treatments Cu content was observed to be slightly higher in the belowground biomass compared to the aboveground biomass this was not significant, suggesting an almost equal distribution of Cu throughout the biomass of *C. aquatilis* and *J. balticus*. Analysis of Cu content in *C. aquatilis* and *J. balticus* shoots taken directly from the natural wetland collection site found concentrations of 7.07 ± 2.79 and 7.14 ± 2.71 mg/kg respectively. Despite the differences in the root oxygen exchange between these two species (*C. aquatilis* 6.7 µmol O_2 loss/g dry root/day vs *J. balticus* 9.9 µmol O_2 loss/g dry root/day (Taylor 2009)) there were no differences in their uptake of Cu within the CWs. Contango Strategies (2014) reported similar Cu contents (4 to 20 mg Cu/kg) in *C. aquatilis* growing in a natural wetland area where Cu-loaded seepages are known to occur within the Minto Cu-Au mine area in the Yukon Territory. Even though small-scale experiments have been shown to overestimate metal plant uptake capability (Conesa et al 2007), both the results from this study and those observed from the natural wetland located at Minto mine (Contango Strategies 2014) suggest a low tendency for Cu uptake in these wetland plants. Other studies have found Cu uptake in *Carex* spp. For example in a CW treating acid mine drainage in Sweden, *Carex rostrata* had Cu concentrations of 84 ± 9 mg/kg in belowground biomass and 12 ± 1.0 mg/kg in aboveground biomass, which exceeds the 3 ±1 mg/kg and 1.3 ±0.3 mg/kg found in the control plants respectively (Nyquist and Greger 2009). Similarly elevated levels of Cu were found in the biomass of *C. rostrata* grown on submerged tailings in northern Sweden (22.6 mg/kg) compared to untreated plants (4-15 mg/kg), but in both cases the aboveground biomass was well below levels that were deemed tolerable for animals (25-800 mg/kg in air dried forage) (Stoltz and Greger 2002).

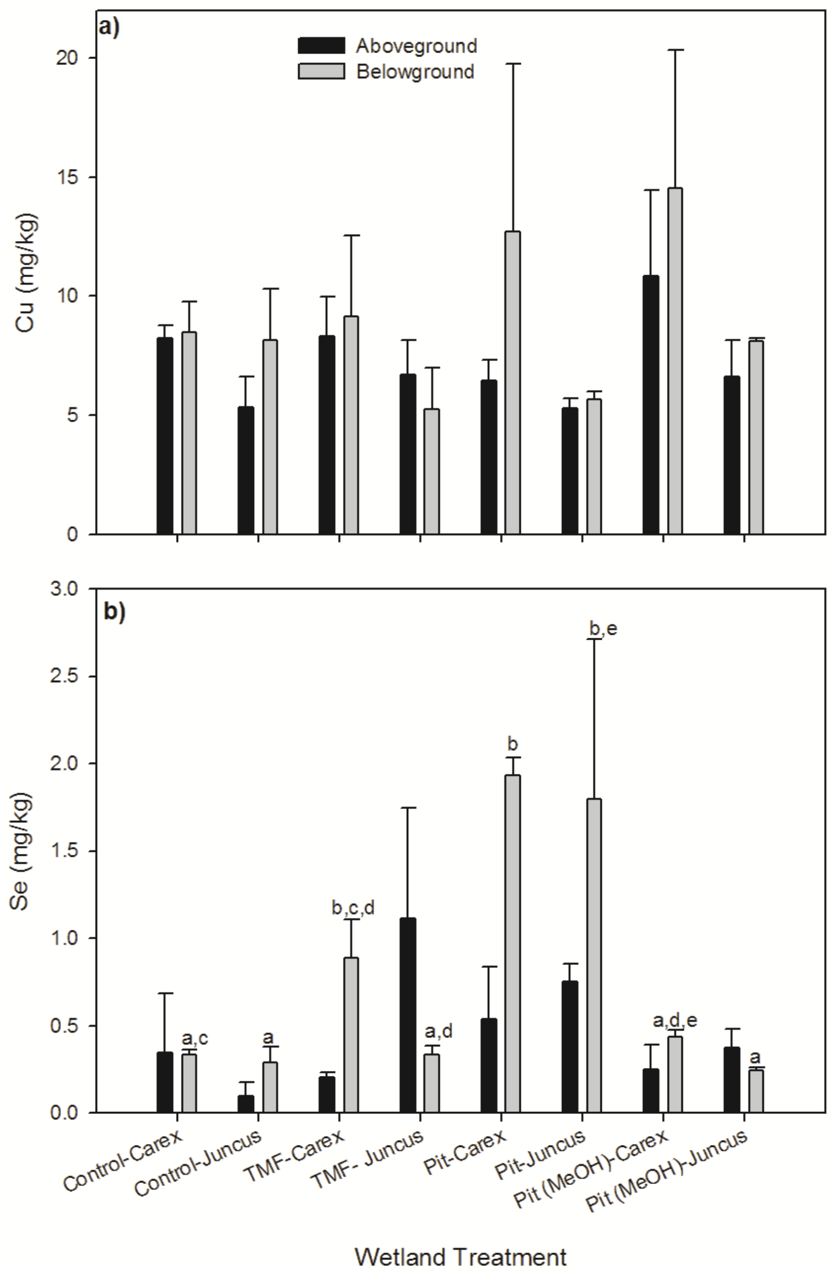

Figure 10 Copper and Selenium content in *C. aquatilis* (Carex) and *J. balticus* (Juncus) in constructed laboratory-scale wetlands after 10 weeks of operation with tap water (Control), TMF, Pit or Pit (MeOH) synthetic waters. There was no significant difference in Cu content of above or belowground biomass across the treatments for either northern plant species (ANOVA, $p=0.51$). We detected significantly higher Se in belowground biomass in the Pit treatment compared with the control and pit (MeOH) treatments for both Carex and Juncus (ANOVA, $p<0.05$ for all comparisons). Bar

represent means with standard error. Different letters indicate significantly different means.

Se uptake into the aboveground biomass had a similar trend as Cu with no significant differences across the CWs treatments for either species (ANOVA, p=0.12). Analysis of Se content in *C. aquatilis* and *J. balticus* shoots taken directly from the natural wetland collection site had concentrations of 0.25 ± 0.01 and 0.29 ± 0.14 mg/kg respectively. Very few studies have examined Se uptake in CWs, however, the belowground systems of *Schoenoplectus californicus* and *Typha angustifolia* were observed to sorb and bioconcentrate Se in a pilot constructed wetland for flue gas desulfurization wastewater treatment (Sundberg-Jones and Hassan 2007). Sorption on roots accounted for 4.4 +2.7 mg/kg for *S. californicus* and 0.5 +0.4 mg/kg for *T. angustifolia*, however when both adsorption and plant tissue were considered Se concentrations were as high as 4224 +2843 mg/kg for *S. californicus* and 170 +109 mg/kg for *T. angustifolia*. In a CW vegetated mainly with *Scirpus robustus*, *Polypogon monspeliensis* and *Typha latifolia* treating oil-refinery effluent approximately 90% of the Se entering the CW was removed (Hansen et al 1998, de Sousa et al 1999), however these wetland plants accumulated Se in their tissues at concentrations that were at least 3 orders of magnitude above those in the effluent (deSousa et al 1999). It should be noted that the concentration of Se in both of these systems far exceeded the highest Se concentration the laboratory-scale CWs (4.5 µg/L) with concentrations of 8.5 mg/L and 1.6 mg/L respectively.

Water-saturated soil conditions and the resulting low ORP appear to limit the Se concentration in *Carex* spp., for example under saturated soil conditions the average Se concentration in *Carex* spp. was found to be 17.7 µg/L ±11.0 versus 43.4 µg/L ± 15.9 in normal alpine soils (Michner et al 2007). The most highly oxidized species of Se is selenate ($SeO4^{-}$), which is water-soluble and readily assimilated by plants, and is the form commonly found in alkaline soil where cases of Se toxicity occur (Lakin 1972, van Dorst and Peterson 1984, Michner et al 2007). Since reduced forms of Se are less available it is the abundance of the various species of Se, rather than total concentration that governs availability. The overall low levels of Se uptake observed in both *C. aquatilis* and *J. balticus* therefore, may in part be related to the water-saturated and low ORP conditions typical of wetlands.

Both northern plant species had higher Se content in the Pit treatment compared with both of their respective Control and Pit(MeOH) treatments (ANOVA with TukeyHSD posthoc, *C. aquatilis*, p <0.01 and 0.03; *J. balticus*, p<0.01 for both comparisons; Fig 10). It is not surprising that the only uptake observed in this study occurred in the belowground biomass. Many other studies have observed that the concentrations of heavy metals in various parts of macrophytes growing in CWs and natural wetlands, generally decrease in the order of roots >rhizomes > leaves > stems (Vymazal and Březinová 2015). Higher belowground Se in the Pit treatment corresponds with the higher level of contaminants in the synthetic influent (Table 1). However, in the Pit(MeOH) treatment we did not see a similar increase in uptake of Se into the belowground biomass despite the same levels of Se being introduced to the system. In the Pit(MeOH) treatment we observed a 100% mortality rate of both species by week 10, which, as discussed above, is likely due to the phytotoxicity of sulphide. Progressive death of the belowground system would reduce Se uptake. Alternatively metal precipitation associated with increased SRB activity in the Pit(MeOH) CWs may have reduced the bioavailability of Se to *C. aquatilis* and *J. balticus.*

Hyperaccumulators are defined as plants that complete their life cycle with foliar metal concentrations exceeding (mg/kg dry weight, DW) Cd > 100, Ni and Cu > 1000, and Zn and Mn > 10,000 (Zavoda et al 2001, Marchand et al 2010). However, to date, no emergent wetland plants have been identified as hyperaccumulators. As our results confirm, metal removal through uptake by macrophytes in wetlands is relatively minor compared to other processes. Although the concentrations of heavy metals in plants growing in CWs vary considerably between species and systems, the concentrations are generally within the range commonly found in natural stands (Vymazal and Březinová 2015). The importance of macrophytes in these systems is to provide organic matter needed to perpetuate the biogeochemical processes in the substrate through die-back, and organic compounds via exudation from the roots (Jenssen et al 1993, Marchand et al 2010). Although investigating potential uptake of contaminants in a greater number of northern plant species, both at higher influent concentrations and over longer time periods is advisable, examination of other functions that wetland plants provide may be more informative for northern CW design. For example, higher removal efficiency has been observed for Zn and Cu when monocots rather than dicots are used. Since uptake in plants is not an important factor in metal removal in wetlands, differences between monocots and dicots with respect to metal acquisition cannot account for the differences in removal (Marchand et al 2010). Differences in rooting morphology and exudation of organic compounds may be the cause of this variation. Monocots have adventitious rooting systems with a greater surface area and produce phytosiderophores that chelate metals such as ferric iron due to their amine and carboxyl groups (Kidd et al 2009), whereas dicots have vertical tap roots and no phytosiderophore production (Marchand et al 2010). Further examination of the functional characteristics of northern wetland plant species in relation to long-term metal sequestration would be highly valuable. In addition, heavy metal concentrations in wetland plant biomass vary considerably during the season, but do not follow the well-known pattern for nutrients (Vymazal and Březinová 2015). In cold climates maximum concentrations of nutrients, such as nitrogen and phosphorus, tend to occur early in the growing season, while the maximum standing stock for nutrients (i.e. nutrient concentrations within plants), tends to occur later in the season at the time of maximum biomass (Vymazal and Březinová 2015). However, the standing stock for heavy metals has no consistent temporal pattern and varies both between metals and between plant species (Vymazal and Kröpfelová 2008, Vymazal and Březinová 2015). Further studies examining the seasonal patterns of heavy metal concentrations in wetland plant biomass are needed to assist in predicting any potential contaminant availability to the surrounding environment.

3.3. Cu and Se distribution within the CWs

As discussed previously, high efficiencies were observed for removal of Cu (>99%) and Se (>79%) from influent waters by the wetlands (Fig. 6). Analysis of the distribution of both contaminants in the water, plants and substrate systems suggests that both Cu and Se were primarily contained within the substrate in all the CWs as indicated by high percentile amounts (Table 3). More than 99.8% of the total load of Cu and >90.2% of the total load of Se were measured in the substrate at the end of the experiment.

Conversely, in all of the CW treatments for both Cu and Se, <0.06% of Cu and <0.11% of Se was found in plant biomass, with the exception of the TMF treatment with *C. aquatilis* (i.e. <0.2% Cu and <0.4 % Se) (Table 3). The loads in mg of metal in biomass are calculated as the metal contents (in mg/kg) times the weight of biomass (in kg). Noteworthy, although metal concentrations are generally smaller in the shoots than in the roots, the loads measured in the shoots are higher as it reflects the larger biomass produced aboveground. Nonetheless, metal uptake by *C. aquatilis* or by *J. balticus* is clearly not a major Cu or Se removal mechanism in the CWs studied. Similar observations were made for Fe uptake by Mitsh and Wise (1998) who observed <0.07 % uptake in a constructed wetland in Ohio and by August et al (2002) who measured <0.5 % uptake in a natural wetland in Colorado. In northern Sweden *Carex rostrata*, *Eriophorum angustifolium* and *Phragmites australis* were observed to uptake of Zn, Cu and Cd at <0.4%, 0.3% and 2.9% respectively (Nyquist and Greger 2009). In smaller-scale experiments in greenhouses, Allende et al. (2014) and Rahman et al (2011) reported that <0.11% and 1% of the total mass of As load in the wetlands was uptaken by *P. autralis* and *J. effuses* shoots respectively.

Overall, our study supports the findings of others that suggest metal removal mechanisms are most likely driven by chemical and microbial reactions occurring within the substrates (Sobolewski 1999, Sheoran and Sheoran 2006, Vymazal and Březinová 2015). In addition, we found a higher average removal efficiency for Cu (99%) than for Se (79%) and we also found a larger distribution of Cu in the substrate (>99.8%) compared with Se (90.2-98.0%). This higher removal efficiency of Cu appears to be primarily the result of metal sequestration within the wetlands substrate. With the exception of the TMF CW treatment with *C. aquatilis*, the percentage of total Se in plants was higher than for Cu in all of CW treatments. Although the percentages for both contaminants in plant biomass were still very low, the partitioning of Se into plants may be more of a concern than the partitioning of Cu into plants. Due to the lack of information on Se uptake into wetland plants and the observed trend in this study, further examination of Se uptake in plants is recommended.

Table 3 **Distribution of total Copper and Selenium partitioned by water, plants and substrate for each constructed wetland (CW) treatment and plant species (*Carex aquatilis* (Carex) and *Juncus balticus* (Juncus)) after 10 weeks of treatment with synthetic contaminated waters. Values are given in mg Cu or Se and values in parentheses are percentile amounts of total mass of Cu or Se in the CWs.**

Copper						
CW Treatment	TMF	Pit	Pit(MeOH)	TMF	Pit	Pit(MeOH)
	Carex	Carex	Carex	Juncus	Juncus	Juncus
Total load (mg)	318.6	306.4	604.3	257.2	503.0	604.3
Distribution						
Water	0.41 (0.13)	0.97 (0.32)	0.50 (0.08)	0.57 (0.22)	0.44 (0.09)	0.37 (0.06)
effluent	0.31 (0.10)	0.95 (0.31)	0.46 (0.08)	0.45 (0.18)	0.43 (0.08)	0.35 (0.06)
Interstitial	0.10 (0.03)	0.02 (0.01)	0.04 (0.01)	0.12 (0.05)	0.02 (0.004)	0.02 (0.003)
Plants	0.74 (0.23)	0.19 (0.06)	0.14 (0.02)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)
Shoots	0.70 (0.22)	0.14 (0.05)	0.07 (0.01)	0.01 (0.01)	0.01 (0.003)	0.01 (0.002)
Roots	0.04 (0.01)	0.04 (0.01)	0.07 (0.01)	0.02 (0.01)	0.02 (0.004)	0.02 (0.003)
Substrate	317 (99.6)	305 (99.6)	604 (99.9)	257 (99.8)	503 (99.9)	604 (99.9)

Selenium						
CW Treatment	TMF	Pit	Pit(MeOH)	TMF	Pit	Pit(MeOH)
Plant Species	Carex	Carex	Carex	Juncus	Juncus	Juncus
Total load (mg)	8.20	10.89	19.07	3.96	5.69	9.14
Distribution						
Water	0.38 (4.69)	0.47 (4.35)	0.38 (1.99)	0.38 (9.72)	0.48 (8.50)	0.38 (4.23)
effluent	0.38 (4.67)	0.47 (4.32)	0.38 (1.98)	0.38 (9.66)	0.48 (8.42)	0.38 (4.20)
Interstitial	0.002 (0.03)	0.002 (0.02)	0.003 (0.02)	0.002 (0.06)	0.004 (0.08)	0.003 (0.03)
Plants	0.03 (0.39)	0.01 (0.11)	0.005 (0.03)	0.002 (0.06)	0.004 (0.08)	0.001 (0.01)
Shoots	0.03 (0.34)	0.005 (0.05)	0.003 (0.02)	0.001 (0.03)	0.001 (0.03)	0.0004 (0.01)
Roots	0.004 (0.05)	0.006 (0.06)	0.001 (0.01)	0.001 (0.03)	0.002 (0.05)	0.0005 (0.01)
Substrate	7.78 (94.9)	10.4 (95.5)	18.7 (98.0)	3.58 (90.2)	5.20 (91.4)	8.75 (95.8)

4. SUMMARY OF KEY FINDINGS

The laboratory-scale CWs evaluated herein demonstrated a strong ability to remove contaminants from synthetically contaminated waters with average removal efficiencies above or equal to 96%, 99%, 79% and 97% for Cd, Cu, Se and Zn respectively. Even with increased contaminant concentrations in the influent waters (i.e. Pit treatment compared to TMF treatment) there was no decline in removal efficiencies suggesting that the short-term metal removal capacity of these laboratory-scale CWs was not reached. While transplant related mortality did reduce the overall biomass accumulation in our CWs, no treatment effects on the establishment and growth of the two northern plant species *C. aquatilis* and *J. balticus* were observed. Furthermore, there was no evidence of Cu or Se uptake into the aboveground biomass of either species with increasing contaminant availability. Increased belowground uptake of Se was observed at the higher influent concentration in the Pit treatment. Overall, this study suggests that uptake of contaminants by these two northern species is very minor (i.e. <0.06% Cu and <0.11% Se, except for *C. aquatilis* in the TMF CW <0.2% Cu and <0.4 % Se) and likely does not pose a risk to the surrounding environment. This study concludes that CWs could operate as successful passive treatment solutions in a northern environment, at least during the summer months. Further studies are required to examine seasonal metal removal rates in relation to rates of sulfate reduction, carbon consumption, metal precipitation and sorption. In addition, potential contaminant uptake and the influence of functional plant characteristics on metal removal in a suite of northern plant species would further assist in the development of large-scale long-term northern CWs.

5. RECOMMENDATIONS FOR FUTURE WORK

- Further studies that include higher concentrations of contaminant inputs, larger-scale wetlands and a greater duration of treatment would be highly useful in determining the long-term metal sequestration capacity.

- To better understand the mechanisms by which metal sequestration occurs in northern CWs further studies are required. In particular, characterization of metal endpoints, speciation of the sequestered metals and characterization of the microbial community and its' activity are needed.

- Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in wetlands at permanently low temperatures is crucial. Examination of the microbial community in natural wetlands, particularly those receiving contaminants would be highly informative.

- Studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption. Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for northern CWs that function year-round.

- Further studies are needed to examine the influence of sources and concentrations of carbon in northern CWs and how these may influence metal sequestration in both wetland substrates and plants.

- Determination of species for northern CWs requires an evaluation of a much larger suite of locally available plants. To ensure effective naturalization of the vegetation community to be established in a CW, community modeling based on surveying of plant communities inhabiting similar local natural wetlands is needed.

- Local naturally occurring wetland species should also be screened for their suitability for inclusion in CWs based upon, phytoremediation potential, sedimentation and erosion control, habitat function and rate of plant establishment, tolerance and maintenance requirements.

- Due to the lack of information on Se sequestration in CWs and Se uptake in plants, as well as, the observed uptake in the belowground systems of *Carex aquatilis* and *Juncus balticus*, special attention should be given to future studies focusing on Se.

- In addition to investigating potential uptake of contaminants in a greater number of northern plant species, both at higher influent concentrations and over longer time periods, examination of other functions that wetland plants provide may be more informative for northern CW design.

- Since contaminant concentrations within the biomass of wetland plants are known to be inconsistent both between metals and between species, further studies examining the seasonal patterns of heavy metal concentrations in wetland plant biomass are needed to assist in predicting any potential contaminant availability to the surrounding environment.

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APPENDIX 1 – IN-HOUSE METAL ANALYSIS QC REPORT

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	08/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	nonlinear through zero	**Correlation coefficient**	0.9998
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.001524084		
1 ppb	0.001851502		
2 ppb	0.003652053		
5 ppb	0.009825244		
10 ppb	0.019049594		
25 ppb	0.043194113		
50 ppb	0.0793924		
Blank	0.000904054	0.4726	
low level	0.00219665	1.1513	115.13
high level	0.081705997	51.3574	102.71
WL1 Jul 8	0.021114221	11.5221	
WL2 Jul 8	0.034464359	19.3699	
WL3 Jul 8	0.097203726	63.5675	
WL3 Jul 8	0.047490741	27.4935	
WL4 Jul 8	0.004434268	2.3351	
WL5 Jul 8	0.002755716	1.4460	
WL6 Jul 8	0.017093365	9.2470	
Blank	0.00033602	0.1754	
low level	0.002305341	1.2086	120.86
high level	0.083042277	52.3727	104.75

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	14/8/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000303142		
10 ppb	0.006022659		
300 ppb	0.176270286		
1000 ppb	0.51803534		
2000 ppb	0.869532822		
blank	-0.00056963		
low level	0.006047574	9.9913	99.91
high level	0.86735619	1998.9544	99.95
mid level	0.528209761	1015.7440	101.57
Jul 28 WL11	0.002382633	≤5.40	
Jul 28 WL12	0.002510663	≤5.40	
Aug 4 WL1	0.231781411	404.2098	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	14/8/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 4 WL2	0.003522687	5.8167	
Aug 4 WL3	0.003371875	5.5675	
blank	0.000905874	1.4950	
low level	0.007121771	11.7687	117.69
high level	0.879597615	2044.6623	102.23
mid level	0.534811921	1031.1847	103.12
Aug 4 WL4	0.284752591	504.0325	
Aug 4 WL5	0.004906346	8.1040	
Aug 4 WL6	0.002582176	≤5.40	
Aug 4 WL7	0.347224255	626.2643	
Aug 4 WL8	0.003907462	6.4526	
Aug 4 WL9	0.003652403	6.0311	
Aug 4 WL10	0.012273354	20.3037	
Aug 4 WL11	0.001474971	≤5.40	
Aug 4 WL12	0.002237319	≤5.40	
blank	-0.000899909	-1.4846	
low level	0.005534711	9.1429	91.43
high level	0.898394559	2117.4138	105.87
mid level	0.5375641	1037.7343	103.77
Aug 11 WL1	0.253697425	445.1050	
Aug 11 WL2	0.003760389	6.2096	
Aug 11 WL3	0.00519786	8.5859	
Aug 11 WL4	0.285375123	505.2129	
Aug 11 WL5	0.005849777	9.6641	
Aug 11 WL6	0.004665631	7.7059	
Aug 11 WL7	0.201471013	348.5222	
Aug 11 WL8	0.006467837	10.6865	
Aug 11 WL9	0.005945815	9.8229	
Aug 11 WL10	0.015883962	26.2970	
Aug 11 WL11	0.004762752	7.8664	
Aug 11 WL12	0.004112321	6.7912	
blank	-0.000143279	-0.2364	
low level	0.006247081	10.3213	103.21
high level	0.902166953	2132.3851	106.62
mid level	0.538387825	1039.5920	103.96

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Analyte	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9962
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.001879649		
1 ppb	0.002548482		
2 ppb	0.005625086		
5 ppb	0.013254335		
10 ppb	0.027608774		
25 ppb	0.07572147		
50 ppb	0.131108067		
Blank	0.000105518	0.0386	
low level	0.003141609	1.1493	114.93
high level	0.132579196	47.7766	95.55
Jul 28 WL1	0.024583933	8.9710	
Jul 28 WL1	0.042621681	15.5205	
Jul 28 WL2	0.001888707	0.6910	
Jul 28 WL3	0.001772567	≤0.68	
Jul 28 WL4	0.037318965	13.5980	
Jul 28 WL5	0.003071641	1.1237	
Jul 28 WL6	0.004290238	1.5693	
Jul 28 WL7	0.132625429	47.7930	
Jul 28 WL8	0.001228877	≤0.68	
Jul 28 WL9	0.001787561	≤0.68	
Jul 28 WL10	0.037161375	13.5408	
Blank	0.000590224	0.2160	
low level	0.002801649	1.0250	102.50
high level	0.132102696	47.6075	95.22
Jul 28 WL11	0.002795962	1.0229	
Jul 28 WL11	0.024692547	9.0105	
Jul 28 WL12	0.002202501	0.8058	
Aug 4 WL1	0.010234333	3.7409	
Aug 4 WL2	0.001857484	≤0.68	
Aug 4 WL3	0.002246496	0.8219	
Aug 4 WL4	0.015758616	5.7565	
Aug 4 WL5	0.002423472	0.8867	
Aug 4 WL6	0.002577976	0.9432	
Aug 4 WL7	0.021894301	7.9920	
Aug 4 WL8	0.001954852	0.7152	
Blank	-0.000329388	-0.1205	
low level	0.002586221	0.9462	94.62
high level	0.148552387	53.4342	106.87
Aug 4 WL9	0.001178027	≤0.68	
Aug 4 WL9	0.022324406	8.1486	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Analyte	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/08/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9962
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
Aug 4 WL10	0.001698192	0.6214	
Aug 4 WL11	0.001390676	≤0.68	
Aug 4 WL12	0.001263633	≤0.68	
Aug 11 WL1	0.006677422	2.4418	
Aug 11 WL2	0.002159801	0.7902	
Aug 11 WL3	0.00200744	0.7345	
Aug 11 WL4	0.009793499	3.5800	
Aug 11 WL5	0.002964604	1.0846	
Aug 11 WL6	0.002785984	1.0192	
Blank	-0.000212777	-0.0779	
low level	0.002885126	1.0555	105.55
high level	0.135228944	48.7166	97.43
Aug 11 WL7	0.008058052	2.9462	
Aug 11 WL7	0.021569587	7.8738	
Aug 11 WL8	0.001082891	≤0.68	
Aug 11 WL9	0.0022478	0.8224	
Aug 11 WL10	0.001296226	≤0.68	
Aug 11 WL11	0.001736488	≤0.68	
Aug 11 WL12	0.001058766	≤0.68	
Aug 14 WL1	0.012261924	4.4810	
Aug 14 WL4	0.015243826	5.5688	
Aug 14 WL7	0.02128361	7.7697	
Aug 14 WL10	0.001653774	≤0.68	
Blank	-8.72E-05	-0.0319	
low level	0.002409657	0.8816	88.16
high level	0.135619348	48.8550	97.71

Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	-0.003331556		
0.1 ppb	0.008115575		
0.2 ppb	0.015560695		
0.5 ppb	0.043761667		
1 ppb	0.086968326		
2 ppb	0.17535536		

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
5 ppb	0.423729351		
blank	-5.93E-06	-0.0001	
low level	0.007931778	0.0949	94.87
high level	0.4341052	5.0074	100.15
Aug 4 WL1	0.100526814	1.1928	
blank	0.000557584	0.0067	
low level	0.008340819	0.0998	99.76
high level	0.45475571	5.2366	104.73
Aug 4 WL2	0.000846988	≤0.05	
Aug 4 WL3	0.000816887	≤0.05	
Aug 4 WL3	0.094463713	1.1215	
Aug 4 WL4	0.478070996	5.4944	
Aug 4 WL4	0.242172088	2.8390	
Aug 4 WL5	0.00266314	≤0.05	
Aug 4 WL6	0.001746556	≤0.05	
Aug 4 WL7	0.556964874	6.3594	
Aug 4 WL7	0.445227303	5.1310	
Aug 4 WL7	0.130533011	1.5449	
Aug 4 WL8	0.000771359	≤0.05	
blank	0.001870404	0.0224	
low level	0.009936529	0.1188	118.83
high level	0.455448797	5.2443	104.89
Aug 4 WL9	0.002286002	≤0.05	
Aug 4 WL10	-0.000261605	≤0.05	
Aug 4 WL11	0.000592602	≤0.05	
Aug 4 WL12	-2.85E-05	≤0.05	
Aug 11 WL1	0.128411823	1.5200	
Aug 11 WL1	0.201327626	2.3684	
Aug 11 WL2	0.002159314	≤0.05	
Aug 11 WL3	0.00365273	≤0.05	
Aug 11 WL4	0.466416337	5.3657	
Aug 11 WL4	0.264933057	3.0998	
Aug 11 WL5	0.0040489	≤0.05	
blank	-0.000703975	-0.0084	
low level	0.009319608	0.1115	111.46
high level	0.45086362	5.1935	103.87
Aug 11 WL6	0.001991877	≤0.05	
Aug 11 WL7	0.369772176	4.2884	
Aug 11 WL8	0.003386749	≤0.05	
Aug 11 WL9	0.004944395	0.0592	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Analyte	Cd 228.80	**QC Source**	Perkin Elmer Mixed Std
Date	09/02/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9995
Detection Limit	0.05		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 11 WL10	0.000175505	≤0.05	
Aug 11 WL11	0.001644273	≤0.05	
Aug 11 WL11	0.09781941	1.1610	
Aug 11 WL12	0.00070503	≤0.05	
Aug 14 WL1	0.148505422	1.7549	
Aug 14 WL4	0.504965968	5.7905	
Aug 14 WL4	0.272503422	3.1863	
blank	-0.000606952	-0.0073	
low level	0.009007601	0.1077	107.73
high level	0.467973912	5.3829	107.66
Aug 14 WL7	0.526362571	6.0252	
Aug 14 WL7	0.28186189	3.2932	
Aug 14 WL10	0.017070479	0.2040	
Aug 18 WL2	0.00429138	0.0513	
Aug 18 WL3	0.005397818	0.0646	
Aug 18 WL5	0.007108622	0.0850	
Aug 18 WL6	0.008084996	0.0967	
Aug 18 WL8	0.00798436	0.0955	
Aug 18 WL8	0.088932148	1.0563	
Aug 18 WL9	0.045987351	0.5482	
Aug 18 WL11	-0.000498076	≤0.05	
blank	6.05E-05	0.0007	
low level	0.008992254	0.1075	107.54
high level	0.474209326	5.4518	109.04
Aug 18 WL12	0.001384125	≤0.05	
blank	0.000138315	0.0017	
low level	0.008988161	0.1075	107.50
high level	0.452607598	5.2128	104.26

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	09/04/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9989
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.000924804		
1 ppb	0.002179419		
2 ppb	0.00394895		
5 ppb	0.01160137		
10 ppb	0.024136548		
25 ppb	0.061092115		
50 ppb	0.120173986		
Blank	0.000523937	0.2364	
low level	0.002045318	0.9213	92.13
high level	0.128374185	51.4079	102.82
Aug 4 WL1	0.010206643	4.5607	
Aug 4 WL2	0.002074029	0.9342	
Aug 4 WL3	0.002297185	1.0345	
Aug 4 WL3	0.025183107	11.0900	
Aug 4 WL4	0.015273901	6.7912	
Aug 4 WL5	0.002160848	0.9732	
Aug 4 WL6	0.002484341	1.1186	
Aug 4 WL7	0.021431334	9.4721	
Aug 4 WL8	0.001046304	≤0.68	
Aug 4 WL9	0.001355678	≤0.68	
Aug 4 WL10	0.001704024	0.7678	
Blank	-5.43E-05	-0.0245	
low level	0.002344869	1.0559	105.59
high level	0.129725445	51.8875	103.77
Aug 4 WL11	0.00153172	0.6903	
Aug 4 WL12	0.0011148	≤0.68	
Aug 11 WL1	0.005989162	2.6873	
Aug 11 WL1	0.018588816	8.2385	
Aug 11 WL2	0.001690287	0.7616	
Aug 11 WL3	0.001424201	≤0.68	
Aug 11 WL4	0.010297334	4.6008	
Aug 11 WL5	0.002933624	1.3203	
Aug 11 WL6	0.001416259	≤0.68	
Aug 11 WL7	0.008869006	3.9682	
Aug 11 WL8	0.001199705	≤0.68	
Blank	-9.18E-05	-0.0415	
low level	0.002641518	1.1891	118.91
high level	0.131847244	52.6381	105.28
Aug 11 WL9	0.001410542	≤0.68	
Aug 11 WL10	0.001213391	≤0.68	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	Standards source	SCP
Element/Wavelength	Se 196.03	QC Source	Perkin Elmer Mixed Std
Date	09/04/2014	QC Frequency	every 10 samples
Operator	HM	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	Correlation coefficient	0.9989
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 11 WL11	0.001148154	≤0.68	
Aug 11 WL11	0.022544018	9.9532	
Aug 11 WL12	0.001106	≤0.68	
Aug 14 WL1	0.011097428	4.9544	
Aug 14 WL4	0.016904722	7.5044	
Aug 14 WL7	0.020614976	9.1185	
Aug 14 WL10	0.001460851	≤0.68	
Aug 18 WL2	0.00175023	0.7886	
Aug 18 WL3	0.001007379	≤0.68	
Blank	-0.000382122	-0.1725	
low level	0.002616343	1.1778	117.78
high level	0.132284115	52.7923	105.58
Aug 18 WL5	0.001947331	0.8772	
Aug 18 WL6	0.002648805	1.1924	
Aug 18 WL8	0.000995318	≤0.68	
Aug 18 WL8	0.015114963	6.7216	
Aug 18 WL9	0.00116432	≤0.68	
Aug 18 WL11	0.001109198	≤0.68	
Aug 18 WL12	0.001164352	≤0.68	
Blank	-0.000379849	-0.1715	
low level	0.002527278	1.1378	113.78
high level	0.131890087	52.6533	105.31

Conditions	Flame AAS	Standards source	SCP
Element/Wavelength	Zn 213.86	QC Source	Perkin Elmer Mixed Std
Date	09/09/2014	QC Frequency	every 10 samples
Operator	HM	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	Correlation coefficient	0.9949

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.001720502		
10 ppb	0.004214334		
300 ppb	0.168835188		
1000 ppb	0.516298064		
2000 ppb	0.866859074		
blank	-0.00166597	-3.2584	
low level	0.004391502	8.5947	85.95
high level	0.850163415	1827.0318	91.35
mid level	0.511293875	1057.2792	105.73
Aug 14 WL1	0.266204164	535.8041	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	09/09/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9949

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 14 WL4	0.281848194	568.2576	
Aug 14 WL7	0.298955972	603.8745	
Aug 14 WL10	0.011106746	21.7527	
blank	-0.001833912	-3.5868	
low level	0.004987383	9.7615	97.62
high level	0.854423026	1837.0720	91.85
mid level	0.504719251	1042.8745	104.29
Aug 18 WL2	0.011709385	22.9362	
Aug 18 WL2	0.008678152	16.9919	
Aug 18 WL3	0.007118474	13.9357	
Aug 18 WL5	0.008313125	16.2766	
Aug 18 WL6	0.006633667	12.9860	
Aug 18 WL8	0.008368634	16.3853	
Aug 18 WL9	0.008282143	16.2159	
Aug 18 WL11	0.013097502	25.6570	
Aug 18 WL12	0.007449708	14.5848	
Aug 18 WL12	0.007689014	15.0536	
blank	-0.000866621	-1.6951	
low level	0.005754929	11.2647	112.65
high level	0.845057784	1814.9443	90.75
mid level	0.512236157	1059.3030	105.93
Aug 21 WL2	0.006700812	13.1176	
Aug 21 WL2	0.007552138	14.7854	
Aug 21 WL3	0.006661507	13.0405	
Aug 21 WL5	0.006600151	12.9203	
Aug 21 WL6	0.004914165	9.6182	
Aug 21 WL8	0.007298528	14.2885	
Aug 21 WL9	0.005816139	11.3846	
Aug 21 WL11	0.004309029	8.4332	
Aug 21 WL12	0.005664984	11.0886	
Aug 21 WL12	0.00593474	11.6169	
blank	-0.00235655	-4.6088	
low level	0.004453023	8.7152	87.15
high level	0.849797607	1826.1514	91.31
mid level	0.509979993	1054.3598	105.44
Aug 21 WL1	0.277257095	558.7176	
Aug 21 WL4	0.277059868	558.3181	
Aug 21 WL7	0.00887566	17.3790	
Aug 21 WL10	0.008970489	17.5648	
Aug 21 WL7	0.288240621	581.5519	

YRC AA QC Report

Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	09/09/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9949
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
Aug 22 WL2	0.0076565	14.9899	
Aug 22 WL3	0.005812442	11.3774	
Aug 22 WL3	0.006441952	12.6104	
Aug 22 WL5	0.006554127	12.8302	
Aug 22 WL6	0.007323358	14.3372	
Aug 22 WL8	0.006672226	13.0615	
Aug 22 WL9	0.008364496	16.3773	
Aug 22 WL9	0.008827707	17.2850	
Aug 22 WL11	0.004772811	9.3414	
Aug 22 WL12	0.005598708	10.9588	
blank	-0.001840914	-3.6005	
low level	0.005093732	9.9698	99.70
high level	0.842711308	1809.5170	90.48
mid level	0.515087913	1065.5478	106.55
Aug 25 WL2	0.006577767	12.8765	
Aug 25 WL2	0.006211399	12.1588	
Aug 25 WL2	0.005479728	10.7257	
Aug 25 WL3	0.005279522	10.3337	
Aug 25 WL3	0.00606176	11.8657	
Aug 25 WL3	0.006033953	11.8113	
Aug 25 WL5	0.006470919	12.6672	
Aug 25 WL6	0.005656724	11.0724	
Aug 25 WL8	0.007305649	14.3025	
Aug 25 WL8	0.008143671	15.9445	
Aug 25 WL9	0.007112422	13.9239	
Aug 25 WL11	0.010909316	21.3656	
Aug 25 WL12	0.003462103	6.7751	
blank	-0.00338644	-6.6222	
low level	0.00390577	7.6437	76.44

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	23/9/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991/0.9933
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.002021639		
0.5 ppb	0.002556265		
1 ppb	0.004112648		

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	23/9/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991/0.9933
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
2 ppb	0.007880763		
5 ppb	0.020396179		
10 ppb	0.04147264		
25 ppb	0.105115715		
blank	-8.94E-05	-0.0204	
low level	0.001886435	0.4306	86.13
high level	0.104755312	25.6377	102.55
Aug 4 WL1	0.002171989	49.5903	
Aug 4 WL1	0.009257615	212.3515	
Aug 4 WL2	0.005566461	1.2737	
Aug 4 WL3	0.004399891	1.0060	
Aug 4 WL4	0.018329237	422.9581	
Aug 4 WL5	0.00415604	0.9501	
Aug 4 WL6	0.004104299	0.9383	
Aug 4 WL7	0.021546267	498.2526	
blank	-0.000133889	-0.0305	
low level	0.002033564	0.4643	92.85
high level	0.107151706	26.2683	105.07
blank	0.00115203		
0.5 ppb	0.003008864		
1 ppb	0.004143695		
2 ppb	0.007814518		
5 ppb	0.019864043		
10 ppb	0.039258411		
25 ppb	0.098492606		
Aug 4 WL8	0.008646259	1.8565	
Aug 4 WL9	0.006236636	1.3313	
Aug 4 WL10	0.079096419	20.5312	
Aug 4 WL11	0.005206185	1.1085	
Aug 4 WL11	0.012293497	2.6635	
Aug 4 WL12	0.005369748	1.1438	
Aug 11 WL1	0.004017371	85.2937	
Aug 11 WL2	0.001694562	≤0.57	
Aug 11 WL3	0.001232136	≤0.57	
Aug 11 WL4	0.020746434	459.0967	
Aug 11 WL5	0.003282011	0.6956	
blank	-0.000294205	-0.0618	
low level	0.002455856	0.5194	103.89
high level	0.104746744	29.4271	117.71

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	-0.002242679		
1 ppb	0.002906817		
2 ppb	0.005975021		
5 ppb	0.013905937		
10 ppb	0.027073951		
25 ppb	0.066081708		
50 ppb	0.12768428		
Blank	0.000784481	0.2657	
low level	0.003404753	1.1656	116.56
high level	0.127976085	50.1077	100.22
Aug 21 WL1	0.005070508	1.7467	
Aug 21 WL1	0.01126537	3.9582	
Aug 25 WL2	0.00084686	≤0.68	
Aug 25 WL3	0.001112898	≤0.68	
Aug 21 WL4	0.00523533	1.8045	
Aug 25 WL5	0.00105555	≤0.68	
Aug 25 WL6	0.000751423	≤0.68	
Aug 21 WL7	0.005685648	1.9628	
Aug 25 WL8	0.000376847	≤0.68	
Aug 25 WL9	0.000838325	≤0.68	
Aug 21 WL10	0.000945175	≤0.68	
Blank	0.000837897	0.2839	
low level	0.003041743	1.0399	103.99
high level	0.127514001	49.9198	99.84
Aug 25 WL11	0.000445558	≤0.68	
Aug 25 WL11	0.015604325	5.5459	
Aug 25 WL12	0.000398654	≤0.68	
Aug 28 WL1	0.00577754	1.9952	
Sep 1 WL2	0.001208936	≤0.68	
Sep 1 WL3	0.000425236	≤0.68	
Aug 28 WL4	0.010520164	3.6884	
Sep 1 WL5	0.001033825	≤0.68	
Sep 1 WL6	0.000182214	≤0.68	
Aug 28 WL7	0.008052689	2.8021	
Sep 1 WL8	0.000380202	≤0.68	
Blank	0.001455855	0.4945	
low level	0.002371739	0.8087	80.87
high level	0.129257385	50.6289	101.26
Sep 1 WL9	0.000214605	≤0.68	
Sep 1 WL9	0.007472072	2.5952	

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Aug 28 WL10	0.000738918	≤0.68	
Sep 1 WL11	0.000182051	≤0.68	
Sep 1 WL12	0.000434983	≤0.68	
Sep 4 WL1	-5.13E-05	≤0.68	
Sep 8 WL2	0.0008358	≤0.68	
Sep 8 WL3	0.000640263	≤0.68	
Sep 4 WL4	0.005663419	1.9550	
Sep 8 WL5	0.000547937	≤0.68	
Sep 8 WL6	0.000737062	≤0.68	
Blank	0.001057757	0.3587	
low level	0.002693087	0.9194	91.94
high level	0.12902248	50.5333	101.07
Sep 4 WL7	0.006073605	2.0996	
Sep 4 WL7	0.011162352	3.9208	
Sep 8 WL8	0.000651822	≤0.68	
Sep 8 WL9	-0.000284445	≤0.68	
Sep 4 WL10	0.000473433	≤0.68	
Sep 8 WL11	0.000769834	≤0.68	
Sep 8 WL12	0.000456853	≤0.68	
Sep 11 WL1	0.007582452	2.6345	
Sep 15 WL2	0.001188998	≤0.68	
Sep 15 WL3	0.000270971	≤0.68	
Sep 11 WL4	0.014071446	4.9819	
Blank	-0.000272831	-0.0920	
low level	0.002395199	0.8168	81.68
high level	0.129990646	50.9272	101.85
Sep 15 WL5	0.004180689	1.4355	
Sep 15 WL5	0.01137816	3.9991	
Sep 15 WL6	0.000350961	≤0.68	
Sep 11 WL7	0.014340692	5.0807	
Sep 15 WL8	0.000233479	≤0.68	
Sep 15 WL9	0.000714803	≤0.68	
Sep 11 WL10	0.000744549	≤0.68	
Sep 15 WL11	0.000386659	≤0.68	
Sep 15 WL12	0.000726097	≤0.68	
Sep 18 WL1	0.009673825	3.3832	
Sep 22 WL2	0.000685108	≤0.68	
Blank	0.000371134	0.1255	
low level	0.002793687	0.9541	95.41
high level	0.129941362	50.9071	101.81

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	10/03/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9999
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 22 WL3	0.00089484	≤0.68	
Sep 22 WL3	0.007680107	2.6693	
Sep 18 WL4	0.014451862	5.1216	
Sep 22 WL5	0.00063528	≤0.68	
Sep 22 WL6	0.000871539	≤0.68	
Sep 18 WL7	0.014237663	5.0429	
Sep 22 WL8	0.000214632	≤0.68	
Sep 22 WL9	0.000556132	≤0.68	
Sep 18 WL10	0.001178629	≤0.68	
Sep 22 WL11	0.000233898	≤0.68	
Sep 22 WL12	0.000945904	≤0.68	
Blank	0.001017828	0.3451	
low level	0.002396637	0.8172	81.72
high level	0.126317834	49.4334	98.87
blank	-0.002306704		
1 ppb	0.002210213		
2 ppb	0.004418832		
5 ppb	0.011242485		
10 ppb	0.023637822		
25 ppb	0.060400348		
50 ppb	0.123888266		
Blank	0.000984829	0.4491	
low level	0.002497452	1.1315	113.15
high level	0.118855434	48.0203	96.04
Sep 25 WL1	0.008841176	3.9176	
Sep 25 WL1	0.016426842	7.1399	
Sep 29 WL2	0.001138537	≤0.68	
Sep 29 WL3	0.001082364	≤0.68	
Sep 25 WL4	0.015460042	6.7340	
Sep 29 WL5	0.000966319	≤0.68	
Sep 29 WL6	0.000926813	≤0.68	
Sep 25 WL7	0.011531595	5.0712	
Sep 29 WL8	0.000699483	≤0.68	
Sep 29 WL9	0.000796952	≤0.68	
Sep 25 WL10	0.000821831	≤0.68	
Blank	0.000669421	0.3057	
low level	0.002028892	0.9211	92.11
high level	0.126310417	50.9468	101.89
Sep 29 WL11	0.00253344	1.1477	
Sep 29 WL11	0.024791081	10.6098	

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Conditions	GF AAS	Standards source	SCP
Element/Wavelength	Se 196.03	QC Source	Perkin Elmer Mixed Std
Date	10/03/2014	QC Frequency	every 10 samples
Operator	HM	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	Correlation coefficient	0.9999/0.9999
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
Sep 29 WL12	0.001254789	≤0.68	
Oct1 WL1	0.007020291	3.1285	
Oct1 WL4	0.008402776	3.7283	
Oct1 WL7	0.010587002	4.6677	
Oct1 WL10	0.000843314	≤0.68	
Jul 28 WL10	0.019868712	8.5761	
Blank	0.000146174	0.0669	
low level	0.002256379	1.0233	102.33
high level	0.124294107	50.1555	100.31

Conditions	Flame AAS	Standards source	SCP
Element/Wavelength	Zn 213.86	QC Source	Perkin Elmer Mixed Std
Date	20/10/2014	QC Frequency	every 10 samples
Operator	HM	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	Correlation coefficient	0.9998/0.9999
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.420360173		
10 ppb	0.005966746		
300 ppb	0.1789273		
1000 ppb	0.528848007		
2000 ppb	0.903043039		
blank	-0.001515436	-2.5126	
low level	0.006339549	10.5236	105.24
high level	0.906217808	2026.5109	101.33
mid level	0.531644518	990.0639	99.01
Aug 28 WL1	0.328393087	578.6193	
Sep1 WL2	0.012714532	21.1258	
Sep1 WL3	0.010694989	17.7649	
Aug 28 WL4	0.361235833	641.4593	
Sep1 WL5	0.011652229	19.3577	
Sep1 WL6	0.011591494	19.2566	
Aug 28 WL7	0.284075498	495.5948	
Sep1 WL8	0.012450578	20.6865	
Sep1 WL9	0.011973891	19.8930	
Aug 28 WL10	0.018984512	31.5746	
Aug 28 WL10	0.016169278	26.8800	
blank	-0.001071608	-1.7768	
low level	0.005099276	8.4631	84.63
high level	0.900125916	2004.3207	100.22

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Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
mid level	0.529838529	986.2038	98.62
Sep1 WL11	0.009895092	16.4344	
Sep1 WL11	0.00834672	13.8595	
Sep1 WL12	0.007399771	12.2854	
Sep 4 WL1	0.320582801	563.8838	
Sep 8 WL2	0.009164648	15.2195	
Sep 8 WL2	0.009302224	15.4483	
Sep 8 WL2	0.009991965	16.5955	
Sep 8 WL3	0.00786674	13.0615	
Sep 4 WL4	0.335455119	592.0138	
Sep 8 WL5	0.009405436	15.6199	
Sep 8 WL6	0.008295518	13.7743	
Sep 4 WL7	0.293133727	512.4083	
Sep 8 WL8	0.011429451	18.9870	
blank	-0.000889507	-1.4750	
low level	0.005577574	9.2576	92.58
high level	0.891481966	1973.1457	98.66
mid level	0.542922104	1014.7879	101.48
Sep 8 WL9	0.012680452	21.0693	
Sep 8 WL9	0.011218303	18.6357	
Sep 4 WL10	0.014918947	24.7968	
Sep 8 WL11	0.009308917	15.4594	
Sep 8 WL12	0.007542543	12.5226	
Sep 11 WL1	0.338269899	597.3698	
Sep 15 WL2	0.01355407	22.5236	
blank	-0.001054448	-1.7484	
low level	0.005654432	9.3852	93.85
high level	0.871800262	1902.9510	95.15
mid level	0.532543902	992.1868	99.22
blank	-0.002160573		
10 ppb	0.005701579		
300 ppb	0.156842622		
1000 ppb	0.486758137		
2000 ppb	0.82515406		
blank	0.001055874	1.8768	
low level	0.005873037	10.4532	104.53
high level	0.821551192	1980.9958	99.05
mid level	0.482366448	1003.9894	100.40
Sep 15 WL3	0.011089602	19.7671	
Sep 11 WL4	0.325598192	640.2363	

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Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 15 WL5	0.014367731	25.6342	
Sep 15 WL6	0.013729625	24.4913	
Sep 11 WL7	0.280834386	543.9034	
Sep 15 WL8	0.014923794	26.6306	
Sep 15 WL9	0.013572007	24.2090	
Sep 11 WL10	0.015996852	28.5540	
Sep 15 WL11	0.010462949	18.6468	
Sep 15 WL12	0.011146085	19.8682	
blank	0.000525414	0.9338	
low level	0.006208232	11.0509	110.51
high level	0.848258291	2072.9494	103.65
mid level	0.493882267	1032.4675	103.25
Sep 18 WL1	0.265214306	510.9919	
Sep 22 WL2	0.010108991	18.0142	
Sep 22 WL3	0.011558928	20.6064	
Sep 18 WL4	0.284493218	551.6652	
Sep 22 WL5	0.00820523	14.6138	
Sep 22 WL6	0.009296288	16.5623	
Sep 22 WL6	0.008642791	15.3950	
Sep 18 WL7	0.285457341	553.7146	
Sep 22 WL8	0.012810645	22.8460	
Sep 22 WL9	0.013977812	24.9358	
Sep 18 WL10	0.014930596	26.6427	
Sep 22 WL11	0.009584577	17.0771	
Sep 22 WL12	0.009119938	16.2472	
blank	-0.000666624	-1.1843	
low level	0.00491572	8.7470	87.47
high level	0.847111227	2068.9553	103.45
mid level	0.493615578	1031.9337	103.19
Sep 25 WL1	0.273675506	528.7758	
Sep 29 WL2	0.009994445	17.8095	
Sep 29 WL3	0.011831648	21.0942	
Sep 25 WL4	0.319073339	626.0077	
Sep 29 WL5	0.012524489	22.3339	
Sep 29 WL6	0.012620316	22.5054	
Sep 25 WL7	0.304686756	594.8568	
Sep 29 WL8	0.015896201	28.3735	
Sep 29 WL9	0.013222954	23.5841	
Sep 25 WL10	0.011789986	21.0197	
Sep 29 WL11	0.011487331	20.4784	

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Conditions	Flame AAS	**Standards source**	SCP
Element/Wavelength	Zn 213.86	**QC Source**	Perkin Elmer Mixed Std
Date	20/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero		Mid level: ±10%
Detection Limit	5.40	**Correlation coefficient**	0.9998/0.9999

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sep 29 WL12	0.010703869	19.0774	
blank	0.000544883	0.9684	
low level	0.00607136	10.8068	108.07
high level	0.844765802	2061.3352	103.07
blank	-0.004187681		
10 ppb	0.007499846		
300 ppb	0.172956124		
1000 ppb	0.501478551		
2000 ppb	0.855038044		
blank	0.004600027	6.2642	
low level	0.008542029	11.6807	116.81
high level	0.855454992	1989.0195	99.45
mid level	0.504115793	1032.4798	103.25
Oct1 WL1	0.249006146	437.9382	
Oct1 WL4	0.298150762	543.5597	
Oct1 WL4	0.309601464	568.6435	
Oct1 WL7	0.305417049	559.3826	
Oct1 WL10	0.007116039	9.7108	
Oct2 WL2	0.060719371	89.0190	
blank	-0.000304524	-0.4108	
low level	0.006046573	8.2385	82.39
high level	0.865180926	2017.2012	100.86
mid level	0.506430055	1038.4319	103.84
Oct2 WL3	0.04570743	65.7522	
Oct2 WL3	0.039369475	56.1633	
Oct2 WL5	0.048083337	69.3705	
Oct2 WL6	0.03063359	43.2108	
Oct2 WL6	0.029321744	41.2740	
Oct2 WL8	0.101845187	156.5709	
Oct2 WL9	0.070085168	103.9868	
Oct2 WL9	0.064832934	95.5056	
Oct2 WL11	0.016377309	22.6458	
Oct2 WL12	0.014068009	19.3906	
Oct2 WL12	0.013289913	18.2967	
blank	-0.000308608	-0.4163	
low level	0.007063092	9.6377	96.38
high level	0.838952864	1941.5494	97.08
mid level	0.510868935	1049.6322	104.96

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	24/10/2014	**QC Frequency**	every 10 samples
Operator	HM	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000487194		
1 ppb	0.001961169		
2 ppb	0.004667266		
5 ppb	0.012688935		
10 ppb	0.025438482		
25 ppb	0.062104194		
50 ppb	0.122908614		
Blank	-0.000453045	-0.1932	
low level	0.002183181	0.9297	92.97
high level	0.135461216	53.2238	106.45
Oct 2 WL2	0.00136311	≤0.68	
Oct 2 WL2	0.006912836	2.9351	
Oct 2 WL3	0.001318478	≤0.68	
Oct 2 WL5	-0.000331929	≤0.68	
Blank	-0.000262655	-0.1120	
low level	0.00258288	1.0996	109.96
high level	0.126856609	50.0931	100.19
Oct 2 WL6	0.00304865	1.2975	
Oct 2 WL8	0.002432184	1.0356	
Oct 2 WL9	0.002258739	0.9618	
Oct 2 WL11	0.000194264	≤0.68	
Oct 2 WL12	0.00085298	≤0.68	
Blank	-0.000364903	-0.1556	
low level	0.002145221	0.9136	91.36
high level	0.128834595	50.8156	1.00

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.002084538		
0.5 ppb	0.001725028		
1 ppb	0.003593875		
2 ppb	0.007163194		
5 ppb	0.018541995		
10 ppb	0.038956882		
25 ppb	0.094758603		

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.00092491	0.2574	
low level	0.00191356	0.5320	106.40
high level	0.105185181	26.9313	107.73
2R	0.015177904	41.7382	
2R	0.022636752	61.8700	
2S	0.03027003	82.2199	
5R	0.016699025	45.8638	
5S	0.024164941	65.9643	
8R	0.050224222	134.2433	
8S	0.022571161	61.6940	
11R	0.028621995	77.8477	
11R	0.002230765	6.2005	
11S	0.01577296	43.3534	
12R	0.010733847	29.6257	
blank	-0.000315004	-0.0877	
low level	0.001856548	0.5162	103.24
high level	0.106036971	27.1317	108.53
blank	0.003068128		
0.5 ppb	0.000876996		
1 ppb	0.002850681		
2 ppb	0.006750018		
5 ppb	0.018063193		
10 ppb	0.037843036		
25 ppb	0.096132177		
12S	0.019568825	54.0344	
12S	0.026462665	71.7271	
14R	0.020897122	57.4488	
blank	-0.001784071	-1.9987	
low level	0.001514088	0.5691	113.83
high level	0.10756439	27.8761	111.50
14S	0.015772361	44.2526	
18R	0.017219664	47.9864	
18S	0.020258913	55.8087	
20R	0.013427214	38.1854	
20S	0.022320825	61.1051	
21R	0.028090394	75.8968	
21S	0.021479354	58.9445	
25R	0.02249885	61.5621	
blank	-0.001561816	-1.3535	
low level	0.001145679	0.4454	89.08

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/07/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993/0.9999/0.9955
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.097862387	25.4018	101.61
25S	0.013482071	38.3276	
25S	0.020953443	57.5935	
26R	0.022963856	6.2756	
26S	0.016790637	4.6880	
32R	0.012089984	3.4713	
32S	0.012077779	3.4681	
S1	0.052526041	13.8350	
S2	0.029578901	7.9708	
S3	0.027431697	7.4210	
B1	0.072017559	18.8092	
B2	0.216143871	55.5619	
B2	0.116198833	60.1562	
B2	0.116198833	60.1562	
blank	-0.000149757	-0.0702	
low level	0.001336869	0.5104	102.07
high level	0.097461777	25.2996	101.20
B3	0.075975091	19.8189	
B3	0.083663169	21.7801	
B2	0.006404558	19.7321	
P2R	0.448884188	114.8986	
P2R	0.235414511	120.9503	
P2R	0.011166671	12.9232	
P2S	0.020145441	5.5517	
P11R	0.010897535	3.1606	
P11S	0.014108302	3.9950	
P26R	0.02356283	6.4292	
P26S	0.019261555	5.3244	
blank	-0.001678355	-1.6410	
low level	0.001462204	0.5521	110.41
high level	0.098062842	25.4529	101.81
0.5 ppb	0.001791648		
1 ppb	0.004514763		
2 ppb	0.012082321		
5 ppb	0.019226983		
10 ppb	0.038921798		
25 ppb	0.104004945		
blank	-2.25E-05	-0.0048	
low level	0.002384256	0.5096	101.92
high level	0.0979602	24.4174	97.67

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	Standards source	SCP
Element/Wavelength	Cu 324.75	QC Source	Perkin Elmer Mixed Std
Date	11/07/2014	QC Frequency	every 10 samples
Operator	IN	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	Correlation coefficient	0.9993/0.9999/0.9955
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
P42R	0.017739006	3.8804	
P42S	0.014899893	3.2453	
P50R	0.017997169	3.9384	
P50S	0.00969844	2.0958	
P36R	0.017798024	3.8936	
P36R	0.013618135	2.9603	
P36S	0.018504839	4.0526	
blank	0.000142295	0.0303	
low level	0.002588355	0.5534	110.68
high level	0.100722546	25.2271	100.91

Conditions	GF AAS	Standards source	SCP
Element/Wavelength	Cu 324.75	QC Source	Perkin Elmer Mixed Std
Date	11/12/2014	QC Frequency	every 10 samples
Operator	IN	QC Limits	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	Correlation coefficient	0.9999/0.9998
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.00239559		
0.5 ppb	0.001097302		
1 ppb	0.002559348		
2 ppb	0.005894417		
5 ppb	0.016282656		
10 ppb	0.033441745		
25 ppb	0.08878132		
blank	0.000100366	0.0433	
low level	0.001420153	0.5719	114.38
high level	0.093096118	26.1850	104.74
36R	0.016621973	52.1900	
36R	0.02223021	67.9186	
36S	0.01039415	34.3243	
38R	0.009052253	30.3710	
38S	0.014277105	45.5321	
40R	0.039159023	114.6508	
40S	0.040504892	118.3428	
42R	0.013231625	42.5408	
42S	0.011066815	36.2876	
43R	0.014596527	46.4430	
43S	0.014830786	47.1101	
blank	7.04E-05	0.0305	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/12/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9998
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
low level	0.001241068	0.5039	100.78
high level	0.097127928	27.2824	109.13
blank	0.002192108		
0.5 ppb	0.001844367		
1 ppb	0.003524253		
2 ppb	0.006557337		
5 ppb	0.016921205		
10 ppb	0.03611567		
25 ppb	0.09805002		
blank	0.000785158	0.2271	
low level	0.001542654	0.4458	89.17
high level	0.095427231	24.6116	98.45
47R	0.007003199	20.0992	
47R	0.013189139	37.5565	
47S	0.006480025	18.6101	
49R	0.020220383	57.0704	
49S	0.015978824	45.3402	
50R	0.018613442	52.6410	
50S	0.016589285	47.0361	
56R	0.009744753	27.8700	
56S	0.014479034	41.1623	
57R	0.000890611	2.5761	
57S	0.000543778	1.5736	
blank	-3.37E-05	-0.0098	
low level	0.001655702	0.4785	95.69
high level	0.096222314	24.7941	99.18
60R	0.018899864	53.4318	
60R	0.003398137	9.7977	
60S	0.001209984	3.4985	
62R	0.00693535	19.9062	
62S	0.000919556	2.6598	
S1	0.000194329	≤0.57	
S2	0.001063065	3.0743	
S3	-0.000354423	≤0.57	
B1	0.001332616	3.8525	
B2	0.000993766	2.8741	
B3	0.000573069	1.6583	
blank	-0.000197967	-0.0573	
low level	0.001589567	0.4594	91.88
high level	0.09821582	25.2501	101.00

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	11/12/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9999/0.9998
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
S1	0.000651924	1.8863	
S1	0.003128018	9.0220	
57R	-0.000449681	≤0.57	
57S	0.012964081	36.9262	
62S	0.006378906	18.3221	
S1	0.019584919	55.3209	
S2	0.020781999	58.6142	
S3	0.019615613	55.4055	
57R	-0.00058176	≤0.57	
blank	0.000586839	0.1698	
low level	0.002010394	0.5807	116.14
high level	0.098079503	25.2190	100.88
57R	0.000346623	1.0033	
Oct2-Cont-Car	0.0046792	13.4692	
Oct2-Cont-Jun	0.005940063	17.0711	
Oct2-PitC-Car	0.003772748	108.7260	
Oct2-PitC-Jun	0.0008224	23.7905	
Oct2-TMF-Car	0.01160311	33.1067	
blank	0.000216849	0.0628	
low level	0.001413557	0.4086	81.72
high level	0.103192236	26.3795	105.52
Oct2-TMF-Jun	0.011849071	33.7979	
Oct2-Pit-Car	-0.00055869	≤0.57	
Oct2-Pit-Jun	-0.000767135	≤0.57	
blank	0.00041745	0.1208	
low level	0.001817681	0.5251	105.03
high level	0.104756743	26.7319	106.93
Oct2-Pit-Jun	-0.000188959	≤0.57	
Oct2-Pit-Car	-0.000520331	≤0.57	
57R	0.018950981	53.5729	
blank	0.000298669	0.0865	
low level	0.001675301	0.4841	96.82
high level	0.106841387	27.1996	108.80

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Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	13/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9997
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.002698205		
0.5 ppb	0.002096831		
1 ppb	0.00268443		
2 ppb	0.006416297		
5 ppb	0.016885123		
10 ppb	0.035039951		
25 ppb	0.090619001		
blank	5.22E-05	0.0151	
low level	0.001909017	0.5521	110.43
high level	0.094536353	26.3529	105.41
Oct2-TMF-Car	0.018338068	5.2687	
Oct2-Pit-Car	0.02229913	6.3965	
Oct2-Pit-Jun	0.02136957	6.1322	
blank	0.000800192	0.2315	
low level	0.001738996	0.5030	100.60
high level	0.092664172	25.8499	103.40

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	-0.00020016		
1 ppb	0.002202941		
2 ppb	0.005342407		
5 ppb	0.012240822		
10 ppb	0.026372351		
25 ppb	0.062275826		
50 ppb	0.115137247		
Blank	-0.000263706	-0.1046	
low level	0.002540199	1.0094	100.94
high level	0.107689826	45.3700	90.74
B1	0.00363194	1.4441	
B2	0.002182959	0.8673	
B3	0.003111839	1.2370	
S1	0.006581208	2.6210	
Blank	0.000153587	0.0610	
low level	0.002701332	1.0736	107.36

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.118990096	50.4572	100.91
S2	0.006154059	2.4503	
S3	0.005412402	2.1542	
P2R	0.008157373	3.2515	
P2S	0.005014653	1.9954	
P11R	0.006330826	2.5209	
P11S	0.005926202	2.3593	
P26R	0.005713715	2.2744	
P26S	0.004913956	1.9552	
2R	0.012396381	4.9525	
2S	0.009741985	3.8864	
Blank	0.001254775	0.4983	
low level	0.002653361	1.0545	105.45
high level	0.117767398	49.9036	99.81
5R	0.02252169	9.0474	
5S	0.003454532	1.3735	
8R	0.045761731	18.6196	
8S	0.010393169	4.1477	
11R	0.019477787	7.8116	
11S	0.009136588	3.6437	
12R	0.019682828	7.8948	
12S	0.014816684	5.9272	
14R	0.017890041	7.1687	
14S	0.016351154	6.5465	
Blank	-0.000558103	-0.2214	
low level	0.002784676	1.1067	110.67
high level	0.123513826	52.5123	105.02
18R	0.018013391	7.2186	
18S	0.005918615	2.3563	
20R	0.009058676	3.6125	
20S	0.006308185	2.5119	
21R	0.016957061	6.7914	
21S	0.005644038	2.2466	
25R	0.004879355	1.9414	
25S	0.005720097	2.2770	
26R	0.007815612	3.1147	
26S	0.012934033	5.1688	
Blank	0.000159446	0.0633	
low level	0.002462278	0.9784	97.84
high level	0.122751804	52.1654	104.33

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AA-MS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	14/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9993
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
32R	0.007268585	2.8958	
32S	0.012415528	4.9602	
Blank	-7.37E-05	-0.0292	
low level	0.002896816	1.1514	115.14
high level	0.124635842	53.0237	106.05

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.000654297		
1 ppb	0.002381765		
2 ppb	0.004384457		
5 ppb	0.010194361		
10 ppb	0.022043857		
25 ppb	0.056310803		
50 ppb	0.110146362		
Blank	-5.40E-05	-0.0243	
low level	0.001968726	0.8862	88.62
high level	0.113881563	51.6465	103.29
B1	-0.000368901	≤0.68	
B1	0.025803528	11.6341	
B2	-0.000117625	≤0.68	
B3	-7.52E-05	≤0.68	
S1	0.002382341	1.0725	
S2	0.001816988	0.8179	
S3	0.001131602	≤0.68	
36R	0.003968414	1.7867	
36S	0.00249049	1.1212	
38R	0.004272275	1.9235	
38S	0.001478981	≤0.68	
Blank	-0.000706464	-0.3180	
low level	0.001996756	0.8989	89.89
high level	0.120465209	54.6561	109.31
40R	0.005088691	2.2912	
40R	0.02926857	13.1994	
40S	0.007241999	3.2612	

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
42R	0.002509036	1.1295	
42S	0.003054619	1.3752	
43R	0.003411661	1.5359	
43S	0.006572578	2.9596	
47R	0.002770528	1.2473	
47S	0.003988505	1.7957	
49R	0.004683099	2.1085	
49S	0.000797869	≤0.68	
Blank	-4.97E-05	-0.0224	
low level	0.001946065	0.8760	87.60
high level	0.120814524	54.8159	109.63
blank	0.000379221		
1 ppb	0.001939501		
2 ppb	0.004479326		
5 ppb	0.011917518		
10 ppb	0.025793855		
25 ppb	0.060880264		
50 ppb	0.134687601		
Blank	-0.000959307	-0.4229	
low level	0.002547866	1.1193	111.93
high level	0.120561097	47.2749	94.55
50R	0.004856353	2.1284	
50R	0.029955186	12.8018	
50S	0.000403869	≤0.68	
56R	0.003633222	1.5943	
56S	0.012709533	5.5261	
57R	0.002594036	1.1395	
57S	0.001458485	≤0.68	
60R	0.005677392	2.4862	
60S	0.00330461	1.4506	
62R	0.003092133	1.3576	
62S	-0.000188699	≤0.68	
high level	0.128700238	50.0954	100.19
Blank	-0.00088139	-0.3886	
low level	0.00250946	1.1025	110.25
P36R	0.006895944	3.0161	
P36R	0.03398552	14.4663	
P36S	0.002156889	0.9479	
P42R	0.006967483	3.0471	
P42S	0.001854583	0.8153	

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	21/1/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9998/0.9992
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
P50R	0.006433997	2.8153	
P50S	0.002478843	1.0890	
B1	0.029188528	12.4836	
B2	0.005825097	2.5505	
B3	0.005116343	2.2418	
S1	0.050722266	2123.9369	
Blank	0.000362586	0.1596	
low level	0.002383811	1.0474	104.74
high level	0.114828173	45.2631	90.53
S2	0.07577841	3097.7038	
S2	0.092068998	3706.3545	
S3	0.062205417	2576.0329	
Blank	0.000459274	0.2022	
low level	0.002713453	1.1918	119.18
high level	0.115634496	45.5473	91.09

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.001191273		
0.5 ppb	0.003484426		
1 ppb	0.003840771		
2 ppb	0.008125533		
5 ppb	0.021762119		
10 ppb	0.046049765		
25 ppb	0.117747726		
0.5 ppb	0.002752097		
1 ppb	0.004428422		
blank	-0.000358457	-0.0767	
low level	0.002124163	0.4546	90.92
high level	0.111021956	24.0886	96.35
blank	3.11E-05	0.0067	
60S	0.184379167	40.3804	
60S	0.091883052	39.7755	
blank	-0.000320434	-6.8558	
low level	0.002223097	47.5788	95.16

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
high level	0.110857891	240.5248	96.21
PCC1	0.053121876	11.4420	
PCC2	0.044884359	9.6577	
PCC3	0.048596695	10.4613	
PCJ1	0.047110031	10.1394	
PCJ2	0.033809339	7.2646	
PCJ3	0.069497229	15.0000	
PC1	0.043652316	9.3911	
PC2	0.041805239	8.9917	
PC3	0.038790883	8.3402	
PJ1	0.076679274	16.5651	
blank	0.000767867	16.4309	
low level	0.00230115	49.2498	98.50
high level	0.106512755	230.9701	92.39
PJ2	0.044726791	9.6236	
PJ3	0.032088306	6.8933	
TJ1	0.017245604	3.6979	
TJ2	0.031294714	6.7221	
TJ3	0.036325926	7.8078	
TC1	0.016730862	3.5873	
TC2	0.023094817	4.9557	
TC3	0.0272307	5.8462	
S1	0.678328741	158.5782	
S1	0.476221754	216.6808	
S1	0.272867797	241.7767	
S1	0.272867797	241.7767	
blank	0.001017221	21.7673	
low level	0.002606895	55.7956	111.59
high level	0.108826741	236.0571	94.42
Sp1	0.141343407	30.7858	
Sp1	0.070767537	30.5532	
Sp2	0.143978066	31.3701	
Sp2	0.072326005	31.2322	
Sp3	0.135147768	29.4131	
Sp3	0.067268036	29.0295	
CC1	0.036050732	7.7484	
CC2	0.028468853	6.1130	
CC3	0.029409602	6.3157	
CJ1	0.014640894	3.1383	
blank	0.00020317	4.3472	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	24/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9994
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
low level	0.002076432	44.4391	88.88
high level	0.110064756	238.7799	95.51
PreMin1	0.282778612	62.7200	
PreMin1	0.282778612	62.7200	
CJ2	0.03151509	6.7697	
CJ3	0.022825	4.8976	
B1	0.006628798	14.1948	
B2	0.006492568	1.3903	
B3	0.006450583	1.3813	
PreMud1	0.047272626	10.1746	
PreMud2	0.042616333	9.1671	
PreMud3	0.02123167	4.5548	
preMin1	0.016885969	3.6206	
blank	0.000251616	5.3838	
low level	0.00220291	47.1467	94.29
high level	0.112983028	245.2017	98.08
preMin2	0.020774893	4.4566	
PreMin3	0.022397624	4.8057	
blank	0.000458628	0.0981	
low level	0.00243592	0.5214	104.27
high level	0.118450715	25.7246	102.90
S3	0.113240776	24.5769	
S2	0.125168061	27.2066	
S2	0.063631361	27.4475	
S1	0.125014194	27.1727	
S1	0.06255466	26.9794	
blank	0.001107517	0.2370	
low level	0.002554003	0.5466	109.33
high level	0.12176247	26.4550	105.82

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	25/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9987
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.000798239		
1 ppb	0.002353703		
2 ppb	0.004167162		
5 ppb	0.009993193		
10 ppb	0.021883981		
25 ppb	0.055150505		
50 ppb	0.096837007		
Blank	0.000810504	0.3682	
low level	0.001837857	0.8357	83.57
high level	0.09566737	47.9226	95.85
PCC1	0.002716392	123.6212	
PCC2	-0.000161921	≤0.68	
PCC3	0.002107249	95.8420	
PCC2	0.00711462	3.2519	
PCJ1	0.006618074	302.3455	
PCJ2	0.007679514	351.2055	
PCJ3	0.005870373	267.9888	
PC1	0.005069665	231.2528	
PC2	0.003638604	165.7409	
PC2	0.030776693	1440.4157	
PC3	0.004364084	198.9292	
Blank	-0.000786377	-0.3566	
low level	0.001815786	0.8256	82.56
high level	0.090900599	45.3008	90.60
S1	0.108711627	55.2376	
S1	0.040054384	37.8481	
PJ1	0.005337319	243.5262	
PJ2	0.00501984	228.9688	
PJ3	0.004709709	214.7572	
TJ1	0.003399502	154.8132	
TJ2	0.004152577	189.2486	
TJ3	0.003134844	142.7235	
TC1	0.005153422	235.0928	
TC2	0.004781828	218.0612	
Blank	0.000517368	0.2349	
low level	0.002152857	0.9792	97.92
high level	0.092745246	46.3122	92.62
TC3	0.018120387	837.3443	
Sp1	0.067307052	3271.0892	
Sp2	0.064667841	3134.1292	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	25/11/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9987
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
Sp3	0.055989574	2689.0718	
CC1	0.004496873	205.0090	
CC2	0.003215413	146.4032	
CC3	0.003043217	138.5393	
CJ1	0.002879023	131.0434	
CJ2	0.002809783	127.8831	
CJ3	0.002758704	125.5520	
Blank	0.000390451	0.1773	
low level	0.002133496	0.9704	97.04
high level	0.099198713	49.8825	99.76
B1	0.075878726	3721.2003	
B2	0.012430788	571.1791	
B3	0.008493731	388.7551	
PreMud1	0.006981649	319.0700	
PreMud2	0.00520693	237.5463	
PreMud3	0.006384028	291.5857	
preMin1	0.00203522	92.5595	
preMin2	0.001837177	83.5364	
PreMin3	0.00193968	88.2061	
S3	0.074993951	3674.3610	
Blank	1.23E-05	0.0056	
low level	0.002145089	0.9757	97.57
high level	0.0927814	46.3321	92.66
S2	0.088716556	4410.8556	
S1	0.084485686	4181.4766	
Blank	-0.000173284	-0.0786	
low level	0.00185101	0.8417	84.17
high level	0.091274177	45.5053	91.01

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	12/03/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991
Detection Limit	0.57		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
blank	0.001587511		
0.5 ppb	0.002121027		
1 ppb	0.004637727		
2 ppb	0.008500616		
5 ppb	0.017990999		
10 ppb	0.045343474		
25 ppb	0.118435827		
blank	0.001206153	0.2847	
low level	0.002509736	0.5917	118.35
high level	0.104958433	22.6176	90.47
2R	0.009258871	21.6958	
2S	0.007445809	17.4763	
5R	0.015358993	35.7905	
5S	0.016503203	38.4169	
B1	0.00184378	4.3499	
Std1	0.203354842	404.7635	
Std1	0.099226104	429.7162	
B2	0.003780381	8.9029	
B3	0.002222143	5.2407	
Std2	0.194827879	3903.7339	
Std2	0.101006217	4367.6914	
blank	0.00114433	0.2701	
low level	0.002130544	0.5025	100.50
high level	0.105393143	22.7030	90.81
Std2	0.018925585	439.5924	
Std3	0.018336559	426.1381	
CRM1	0.020309818	47.1154	
CRM2	0.017540006	40.7921	
CRM3	0.020177073	46.8131	
8R	0.076677605	169.2537	
8S	0.020418698	47.3633	
11R	0.016721475	38.9173	
11S	0.01418389	33.0875	
12R	0.014709317	34.2968	
blank	-0.000170869	-0.0404	
low level	0.001942261	0.4582	91.64
high level	0.10742539	23.1014	92.41
Spike1	0.101789231	219.9324	
12S	0.011967715	27.9741	
14R	0.01648041	38.3647	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Cu 324.75	**QC Source**	Perkin Elmer Mixed Std
Date	12/03/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9991
Detection Limit	0.57		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
14S	0.014197708	33.1194	
18R	0.013006057	30.3725	
18S	0.028187534	64.9280	
20R	0.020204899	46.8765	
20S	0.034276055	78.5233	
21R	0.03467285	79.4041	
21S	0.013149377	30.7031	
blank	-0.000149217	-0.0353	
low level	0.002451254	0.5780	115.60
high level	0.109426719	23.4924	93.97
25R	0.009729601	22.7891	
25S	0.017200275	40.0143	
26R	0.030860459	70.9147	
26S	0.011533823	26.9706	
32R	0.008622248	20.2158	
32S	0.008079646	18.9530	
Spk2	0.088263015	192.9040	
Spk3	0.107151741	230.4782	
blank	0.000813219	0.1920	
low level	0.002066159	0.4874	97.47
high level	0.10694554	23.0074	92.03

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		
Sample ID	**Absorbance (Corr)**	**Conc (ug/L)**	**QC Recovery (%)**
blank	0.000259518		
1 ppb	0.001571383		
2 ppb	0.003705629		
5 ppb	0.012170606		
10 ppb	0.023490547		
25 ppb	0.061833449		
50 ppb	0.11307452		
Blank	0.000130387	0.0622	
low level	0.001700243	0.8100	81.00
high level	0.125251916	50.8903	101.78
2R	0.017887457	8.3328	

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Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
2R	0.042294616	19.0676	
2S	0.009001922	4.2450	
5R	0.021217985	9.8396	
5S	0.001784991	0.8502	
8R	0.02952803	13.5404	
8S	0.00417187	1.9805	
11R	0.011329553	5.3255	
11S	0.009130092	4.3047	
12R	0.013486987	6.3209	
12S	0.011622713	5.4611	
Blank	0.000176873	0.0844	
low level	0.002022556	0.9631	96.31
high level	0.130910423	52.8335	105.67
plantstd	0.060092694	26.4692	
14R	0.05107107	22.7604	
14S	0.007622652	3.6015	
18R	0.013043162	6.1166	
18S	0.005536992	2.6236	
20R	0.007771418	3.6710	
20S	0.002626617	1.2496	
21R	0.011207938	5.2692	
21S	0.001528462	0.7283	
25R	0.002616591	1.2449	
Blank	-0.000366492	-0.1751	
low level	0.002039643	0.9712	97.12
high level	0.133798611	53.8153	107.63
25S	0.004373988	2.0759	
26R	0.007032014	3.3251	
26S	0.004556726	2.1621	
32R	0.005484612	2.5990	
32S	0.179696435	68.5670	
32S	0.009925349	9.3490	
S1	0.001905883	0.9077	
S2	0.00166515	0.7933	
S3	0.002547492	1.2121	
B1	-0.000305232	≤0.68	
Blank	-0.000772525	-0.3693	
low level	0.002155311	1.0261	102.61
high level	0.133112707	53.5827	107.17
B2	-0.000775337	≤0.68	

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Casino Wetlands - Influent, Effluent, Substrates and Plants

Conditions	GF AAS	**Standards source**	SCP
Element/Wavelength	Se 196.03	**QC Source**	Perkin Elmer Mixed Std
Date	12/08/2014	**QC Frequency**	every 10 samples
Operator	IN	**QC Limits**	Low level: ±20%, High level: ±10%
Calibration equation	Nonlinear through zero	**Correlation coefficient**	0.9951
Detection Limit	0.68		

Sample ID	Absorbance (Corr)	Conc (ug/L)	QC Recovery (%)
B3	-0.000655707	≤0.68	
Std1	0.084597209	36.1204	
Std2	0.058146097	25.6763	
Std3	0.069860811	30.3887	
Spike1	0.05236324	23.2970	
Spike2	0.033792732	15.4078	
Spike3	0.0416624	18.7983	
Blank	-0.000284031	-0.1357	
low level	0.002023657	0.9636	96.36
high level	0.132026274	53.2136	106.43