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Bottom Ash Management Plan

Metro Vancouver Waste-to-Energy Facility

38968541

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1.0 INTRODUCTION

The purpose of this document is to define the requirements for management of Metro Vancouver's Waste-to-Energy Facility (WTEF) bottom ash in compliance with the Environmental Management Act. This Bottom Ash Management Plan defines requirements for beneficial use or disposal of bottom ash as municipal solid waste.

The Bottom Ash Management Plan presented herein provides a comprehensive set of procedures for sampling, data analysis, evaluation, beneficial use and disposal of bottom ash generated at the Metro Vancouver Waste-to-Energy Facility (WTEF), located in Burnaby. Bottom ash meeting the requirements in this plan is municipal solid waste and is not hazardous waste under the Ministry of Environment and Climate Change Strategy's (Ministry of Environment) *Hazardous Waste Regulation*. No additional testing or analysis beyond that included in this Bottom Ash Management Plan will be required to confirm the bottom ash is municipal solid waste.

1.1. Processed and Unprocessed Bottom Ash

Bottom ash from the WTEF is a residual from the incineration of municipal solid waste, largely comprised of slag, ceramic, glass, ferrous and non-ferrous metals, and un-combusted organics. To improve the characteristics of the bottom ash, and increase metals recycling, a non-ferrous metal recovery system was commissioned in 2018. Bottom ash processed through this system (Processed Bottom Ash) has different characteristics from bottom ash that has not been processed through the non-ferrous metal recovery system (Unprocessed Bottom Ash). These two bottom ash streams will now be managed separately.

Processed Bottom Ash testing shows more consistency and lower potential for individual sample results to exceed the *Hazardous Waste Regulation* Leachate Quality Standards (Attachment 1). As such, Processed Bottom Ash is suitable for beneficial use at a cement plant as an alternative to landfill disposal. Use of Processed Bottom Ash at a local cement plant will result in beneficial use of approximately 40,000 tonnes per year of material, offsetting raw material requirements, and reducing overall regional disposal requirements by approximately 5%.

Unprocessed Bottom Ash is a heterogeneous material, and although the majority of sample results are within regulated standards, sampling occasionally encounters material with high concentrations of contaminants of concern. Unprocessed Bottom Ash occurs when bottom ash bypasses the non-ferrous metal recovery system due to maintenance or operational issues.

This Bottom Ash Management Plan contains different sampling methodologies for Processed and Unprocessed Bottom Ash. Processed Bottom Ash currently represents approximately 95% of all bottom ash produced, with Unprocessed Bottom Ash only being produced during non-ferrous metal recovery system maintenance periods.

1.2. Bottom Ash Management Plan Summary

For Processed Bottom Ash, the updated Bottom Ash Management Plan) uses a rolling mean and a process control methodology to identify statistical outliers. The process control model was developed with assistance from Dr. Carl Schwarz, and is described in Section 2.

The Toxicity Characteristic Leaching Procedure (TCLP) cadmium data has been used for the examples in this evaluation as cadmium tends to have more outliers than other parameters analyzed; however, the procedure will be applied to all applicable TCLP parameters.

Unprocessed Bottom Ash will continue to be managed and stockpiled at the Vancouver Landfill until analytical results are received, as described in Section 3.

The Processed Bottom Ash will be managed and stockpiled per the Section 3: Bottom Ash Management Plan for Unprocessed Bottom Ash in the event the rolling mean and process control methodology show unfavourable changes in the characteristics of the Processed Bottom Ash.

1.3. Bottom Ash Management Plan for Processed Bottom Ash

The Bottom Ash Management Plan is shown graphically in the Flowchart (Attachment 2). Section 2 of the Bottom Ash Management Plan provides detailed methodology for Processed Bottom Ash:

- Step P-1 Processed Bottom Ash sample collection at the Waste-to-Energy Facility
- Step P-2 Weekly Processed Bottom Ash composite sample laboratory analysis
- Step P-3 Three-week rolling mean
- Step P-4 Process control model

1.4. Bottom Ash Management Plan for Unprocessed Bottom Ash

Section 3 of the Bottom Ash Management Plan provides detailed methodology for Unprocessed Bottom Ash which has bypassed the non-ferrous metal recovery system:

- Step U-1 Unprocessed Bottom Ash sample collection at the Waste-to-Energy Facility
- Step U-2 Weekly Unprocessed Bottom Ash composite sample laboratory analysis
- Step U-3 Statistical evaluation of weekly composite analytical data
- Step U-4 Daily bottom ash sample laboratory analysis
- Step U-5 Stockpile sampling

2.0 BOTTOM ASH MANAGEMENT PLAN FOR PROCESSED BOTTOM ASH

2.1. Step P-1: Processed Bottom Ash Sample Collection at the Waste-to-Energy Facility

Processed Bottom Ash is transported directly for beneficial use at a cement plant or disposal on a regular basis (up to 5 loads per day). Beneficial use at a cement plant involves preprocessing at the cement plant site or potentially another site. Preprocessing may include washing, grinding, screening and other similar unit processes. Additional recyclable metal is recovered and the residuals from preprocessing are disposed. The entity undertaking the preprocessing work is responsible for meeting all regulatory requirements with respect to receiving, processing and use of the Processed Bottom Ash. This includes meeting all regulatory requirements for using the preprocessed Processed Bottom Ash as a feedstock to the cement plant, disposal of any residuals from preprocessing activities and use of the cement. Processed Bottom Ash is sent to disposal in the event that beneficial use of the Processed Bottom Ash at cement plants is not available.

Waste-to-Energy Facility staff collect Processed Bottom Ash samples for testing on a daily basis, as the Processed Bottom Ash is loaded for transport. Some of these daily samples are combined to produce a weekly composite sample. The methodology for sample collection and handling at the WTEF is described in Covanta's Operational Procedure (Attachment 3). Daily and composite samples of Processed Bottom Ash are disposed of following delivery of the composite sample to the analytical laboratory.

After sampling, Processed Bottom Ash is hauled directly for beneficial use at a cement plant or disposal. Stockpiling of Processed Bottom Ash pending test results is not required for beneficial use or disposal.

2.2. Step P-2: Weekly Processed Bottom Ash Composite Sample Laboratory Analysis

Twelve sub-samples (the weekly processed composite sub-samples) are collected from the weekly processed composite sample, and sent to ALS Environmental (ALS) or equivalent for the following chemical analysis:

- Leachate analysis by Toxicity Characteristic Leaching Procedure (TCLP) Method 1311;
- pH analysis in accordance with "pH, Electrometric, Soil and Sediment – Prescriptive", as described in the British Columbia Ministry of Environment, 2009 British Columbia Environmental Laboratory Manual.

Laboratory results for the weekly processed composite sub-samples will be submitted annually to the Ministry of Environment as part of an annual update on implementation of the Bottom Ash Management Plan.

2.3. Step P-3: Three-Week Rolling Mean

The analytical results of the weekly processed composite sub-samples are combined with the results of the weekly processed composite sub-samples from the two (2) preceding weeks for a total sample size of 36 per 3-week period. The resulting upper bound of the 2-sided 95% confidence interval of the mean for the preceding three week's results are then compared to the Leachate Quality Standard. For the 3-week rolling average, 80% of the Leachate Quality Standard is set as the trigger for further analysis using a process control model to analyze the bottom ash (**Step P-4**). Statistical calculations will be performed on the logarithmic transformation of all sample results. Once calculated the statistical results will be back transformed for comparison with the Leachate Quality Standard.

The upper bound of the 95% two-sided confidence interval for the mean of the 36 samples (12 weekly composite sub-samples per week x 3 weeks of processed ash) will be incorporated into the statistical analysis procedure. The referenced statistic originates in the Ministry of Environment's *Technical Guidance 2: Statistical Criteria for Characterizing a Volume of Contaminated Material and the U.S. Environmental Protection Agency (USEPA) EPA530-R-95-036: Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for Toxicity Characteristic from the Office of Waste*.

Concentrations of chemicals below their detection limit will be set at the detection limit in performing this calculation.

If the upper bound of the 95% 2-sided confidence interval for the mean of the preceding 3-weeks' set of weekly processed composite sub-samples is below 80% of the TCLP standard, Processed Bottom Ash will continue to be hauled directly for beneficial use at a cement plant, or disposed directly at the Vancouver Landfill or sent elsewhere for beneficial use at a cement plant. See the Flow Chart.

2.4. Step P-4: Process Control Model

Process control models examine the mean of the Processed Bottom Ash analytical data on a continuous basis (i.e., not just using the preceding 3 weeks of data).

Control charts, also known as Shewhart charts or process-behavior charts, are a well-known statistical control tool used to determine if a process is in a state of control and to provide a defensible set of rules to decide when the process is out of control. Here, "out of control" implies that the current mean of a contaminant appears to be different than the long-term average.

Figure 1 shows seasonal trends exist in the mean, so an adjusted mean value is used to account for this seasonal pattern. The cause of this cyclical pattern is currently unknown but under investigation.

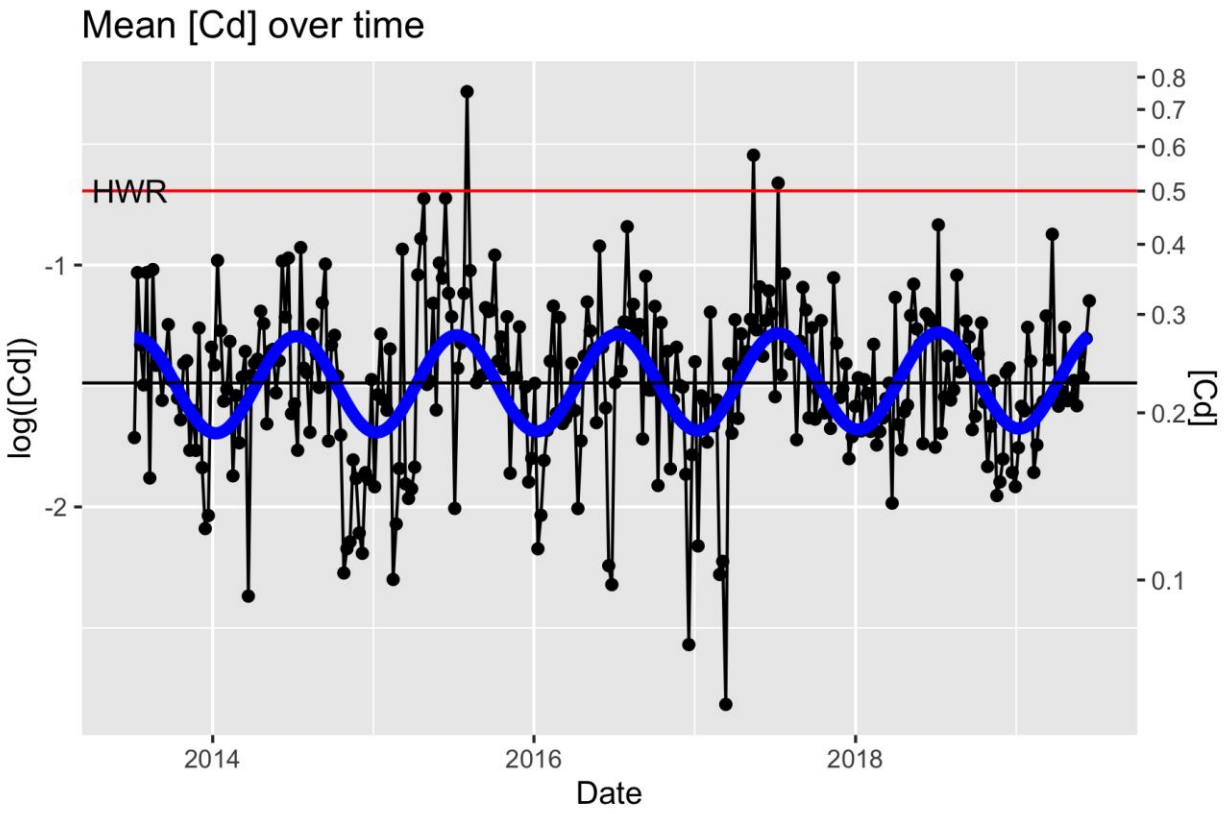


Figure 1: Mean log([Cd]) in bottom ash from the 12 composite samples measured each week vs. time

The *Hazardous Waste Regulations* limit for leachable cadmium (TCLP 1311) is 0.5 mg/L, is shown, along with the long-term average, and the cyclical pattern.

Because of skewness in the individual values, the mean log[Cd] is computed for each week as:

$$\overline{\log([Cd])}_w = \frac{\sum_{i=1}^{12} \log([Cd])_{wi})}{12}$$

where *w* refers to the week, and *i* refers to the samples within a week. [*i* = 12 samples.]

The cyclical pattern is fit using a regression model to the weekly mean of the form

$$\overline{\log([Cd])}_w = \beta_0 + \beta_1 \cos\left(\frac{2\pi StartDate_w}{365.25}\right) + \beta_2 \sin\left(\frac{2\pi StartDate_w}{365.25}\right) + error$$

The *sin* and *cos* terms represent the cyclical pattern expressed in years (*StartDate*/365.25). The *StartDate* is measured in days since some origin. The value of 365.25 accounts for leap years. The intercept represents the long-term average around which the mean log([Cd]) varies.

Once this equation is fit, predicted values ($\widehat{\overline{\log([Cd])}}_w$) are obtained for each start date representing the cyclical mean log([Cd]). The seasonally adjusted value is obtained as:

$$\log([Cd])_w^{SA} = \beta_0 + \overline{\log([Cd])}_w - \overline{\widehat{\log([Cd])}}_w$$

The long-term mean is added back to the seasonally adjusted values so that they vary around the grand mean (rather than 0). These seasonally adjusted values are then used for control chart plotting purposes. The seasonally adjusted values are shown in Figure 2.

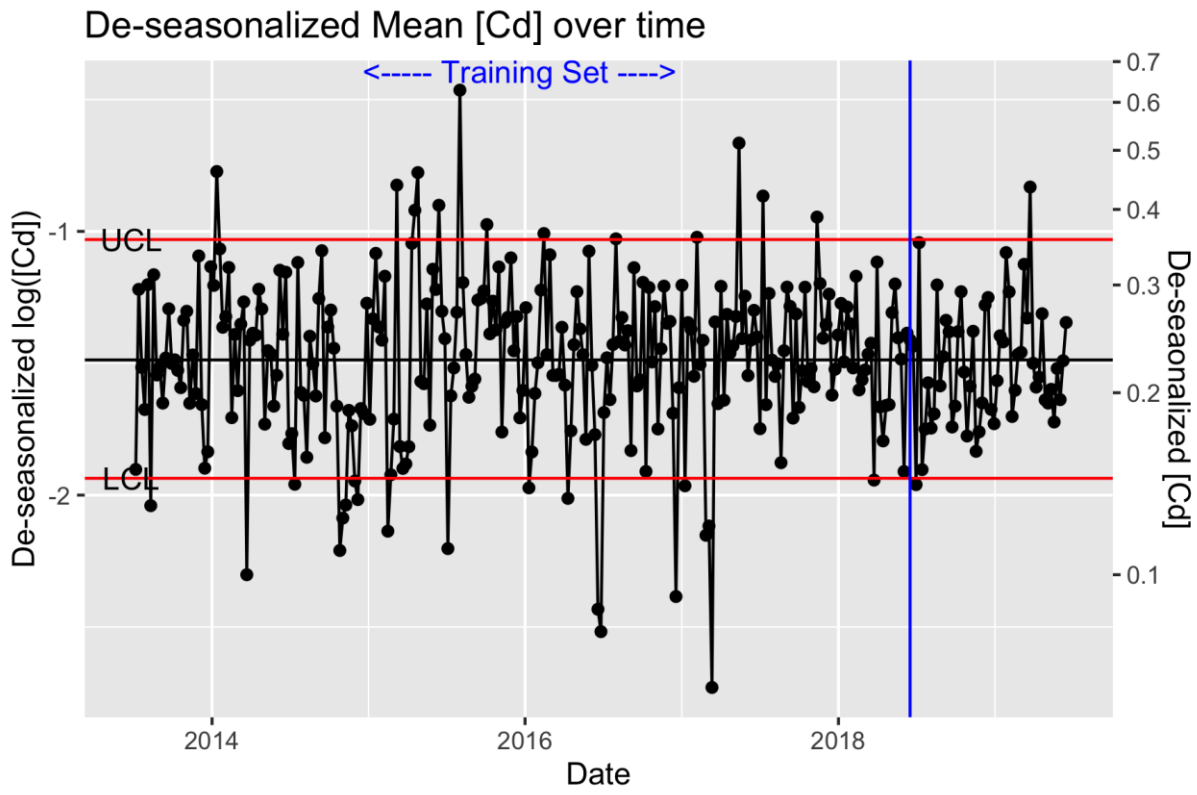


Figure 2: De-seasonalized mean log([Cd]) from the 12 weekly composite bottom ash sub-samples measured each week vs. time

The de-seasonalized log([Cd]) are determined by subtracting the seasonal trend from Figure 1 from each value of mean log([Cd]).

Next, upper and lower control limits (LCL and UCL) are constructed as

$$mean \pm 3 \times SD/\sqrt{12}$$

of the de-seasonalized values where the standard deviation (*SD)* is computed using the estimated pooled WITHIN week standard deviations and "12" represents the sample size taken each week. If the process is in control (and the process statistic is normal), 99.73% of the plotted points will fall between the control limits. The standard deviation from the de-seasonalized data is 0.53.
A set of standard decision rules are then applied to the control chart to determine if the process is moving out of control.

The following 3 rules will be used (using the seasonally adjusted values):

(a) **Rule 1.** If 2 successive seasonally adjusted mean log([Cd]) processed weekly composite subsamples fall above the upper control limit, the process is deemed out of control. Values below the lower control limit are not of interest – this would indicate that the seasonally adjusted mean is below what is expected but that is not a concern. Two successive points in a row would indicate that the randomness of the hotspots (see Figure 3) appears to be broken. At this point, Processed Bottom Ash should start to be stockpiled until further testing is done to determine if the high [Cd] is a one-off occurrence or continuing.

(b) **Rule 2.** If 9 or more points are on one side of the mean, the process is deemed out of control. Of most concern are 9 or more points above the mean, but still within the control limits indicating that the [Cd] appears to be shifting upwards. No immediate action is needed (i.e., it is not yet necessary to stockpile material) because the overall mean [Cd] is still well below the *Hazardous Waste Regulations*, but investigative actions are needed to understand the causes of this shift.

If 9 or more points are below the mean, this may be an indication that a management action (e.g., better battery recycling options) may be changing the process (for the better) and no action is needed at this time, but monitoring should continue.

(c) **Rule 3.** If 6 or more points in a row are continually increasing or decreasing, but still within the control limits, the process is deemed out of control. Of most concern are 6 points in an upwards trend indicating that the [Cd] appears to be shifting upwards. No immediate action is needed (i.e., it is not yet necessary to stockpile material) because the points are still within the control limits but investigative actions are needed to understand the causes of this shift.

As in rule 2, if the trend is downwards, this is not of concerns other than it is evidence that a management action may be changing the process (for the better).

These rules are illustrated in Figure 3.

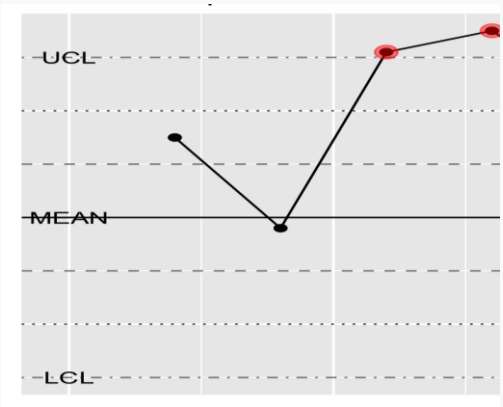
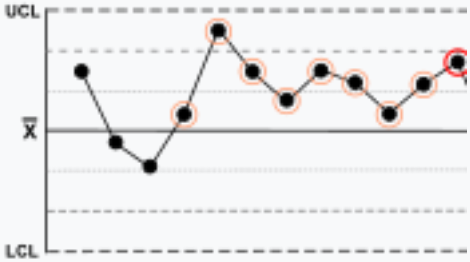
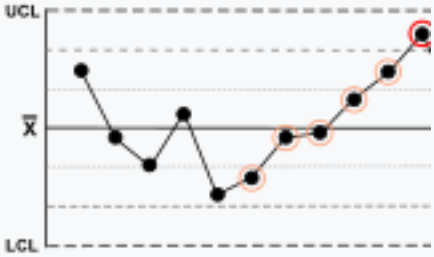
Rule 1	Two points in a row are above the Upper Control Limit		Two weeks in a row have [Cd] well above that expected from Figure 1. The *randomness* of hotspots is of concern.
Rule 2	Nine (or more) points in a row are on the same side of the mean.		Some prolonged bias exists.
Rule 3	Six (or more) points in a row are continually increasing (or decreasing).		A trend exists.

Figure 3: Process Control Rules

Control charts are a well-known statistical control tool used to determine if a process is in a state of control. In this instance, the control chart will use the seasonally adjusted mean of the logarithm of the weekly composite subsample concentrations.

If Rule 1 is exceeded, the Processed Bottom Ash will be stockpiled and further testing will be completed. If Rule 2 or 3 are exceeded, the Processed Bottom Ash will not be stockpiled, however, investigative actions will be undertaken to understand the cause of the shift.

If no process control rules are violated, Processed Bottom Ash will continue to be beneficially used at a cement plant, or sent to the Vancouver Landfill for disposal.

2.5. Stockpiling, Testing and Disposal of Processed Bottom Ash if Bottom Ash Management Plan Requirements Are Not Met

If the results from the previous rolling three week's set of processed samples exceeds a trigger point (**Step P-3**), and the process control model (see **Step P-4** Rule 1) has flagged a possibility that overall characteristics of the Processed Bottom Ash has changed, within 10 calendar days of receipt of the analytical results, temporary stockpiling of Processed Bottom Ash and landfill disposal of the Processed Bottom Ash under the protocols specified for Unprocessed Bottom Ash will be implemented until the rolling three week data drops below the trigger for three successive weeks.

3.0 BOTTOM ASH MANAGEMENT PLAN FOR UNPROCESSED BOTTOM ASH BYPASSING THE NON-FERROUS METAL RECOVERY SYSTEM

3.1. Step U-1: Unprocessed Bottom Ash Sample Collection at the Waste-to-Energy Facility

Unprocessed Bottom Ash generated at the WTEF that bypasses the non-ferrous metal recovery system is transported to the Vancouver Landfill, where it is offloaded in an approved designated bottom ash stockpile area. The bottom ash is deposited into segregated stockpiles, which are staked and labeled to identify the week number and day the load was received at the landfill.

Prior to transport, weekly composite and daily Unprocessed Bottom Ash samples are collected by WTEF staff. The methodology for sample collection and handling at the WTEF is described in Covanta's Operational Procedure (Attachment 3). Daily and weekly composite samples for Processed Bottom Ash and Unprocessed Bottom Ash will be maintained separately.

3.2. Step U-2: Weekly Unprocessed Bottom Ash Composite Sample Laboratory Analysis

Weekly Unprocessed Bottom Ash composite samples collected using the methods described in **Step U-1** are sent to ALS Environmental (ALS) or equivalent for the following chemical analysis:

- Leachate analysis by Toxicity Characteristic Leaching Procedure (TCLP) Method 1311;
- pH analysis in accordance with "pH, Electrometric, Soil and Sediment – Prescriptive", as prescribed in the British Columbia Ministry of Environment, 2009 British Columbia Environmental Laboratory Manual.

Refer to the flowchart for information on the protocol for the number of samples analyzed. Analytical data received from the laboratory is evaluated using the methodology detailed in the flowchart and below.

3.3. Step U-3: Statistical Evaluation of Weekly Composite Analytical Data

This weekly composite sampling and analysis process applies to Unprocessed Bottom Ash or Processed Bottom Ash that has been stockpiled due to the triggering of the Process Control Model as described in **Step P-4.** The Processed Bottom Ash and Unprocessed Bottom Ash stockpiles are segregated and are analyzed independently.

Bottom ash analytical data are statistically evaluated to assess the nature of the bulk material. The evaluation methodology has been developed utilizing the following guidance documents:

- Ministry of Environment, *Technical Guidance 1: Site Characterization and Confirmation Testing;*
- Ministry of Environment, *Technical Guidance 2: Statistical Criteria for Characterizing a Volume of Contaminated Material*;
- EPA530-R-95-036, *Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic, Office of Waste*, U.S. Environmental Protection Agency.

From these documents, the following criteria are utilized to determine parameter concentrations of the bottom ash and to evaluate the material relative to the Ministry of Environment's *Hazardous Waste Regulation*, including Schedule 4 Leachate Quality Standards:

- A minimum of 4 replicates must be submitted for analysis for any result that exceeded 2 X the Leachate Quality Standards in Schedule 4 of the *Hazardous Waste Regulation*. The average of the original result and replicates must be included in the statistical analysis ensuring the upper bound of the 95% confidence interval of the mean is below the applicable standard for the parameter;
- If a replicate of the weekly bottom ash sample also exceeds the 2 X criteria, the daily bottom ash samples for that week must be analyzed in accordance with **Step U-4**;
- Additional evaluation may be conducted on individual samples with concentrations greater than the standard. All replicates of samples exceeding the regulatory limit are included in the statistical analysis of the composite sample; and
- The upper bound of the 95% confidence interval of the mean is below the applicable standard for the parameter (see **Step U-4**).

Based on an evaluation of the weekly bottom ash composite sample analytical data against the criteria above, one of the two following scenarios will apply:

- Weekly bottom ash stockpiled at the Vancouver Landfill that meets the evaluation criteria above will be moved for disposal; or

- Weekly bottom ash stockpiled at the Vancouver Landfill that does not meet the evaluation criteria above will be subjected to further sampling and analysis utilizing the daily bottom ash samples retained at the WTEF. Stockpiled bottom ash from the corresponding week will remain segregated and intact at Vancouver Landfill while further characterization work is performed.

3.4. Step U-4: Daily Bottom Ash Sample Laboratory Analysis

The daily sampling and analysis process is the same for either Unprocessed Bottom Ash or Processed Bottom Ash that has been stockpiled due to the triggering of the Process Control Model as described in **Step P-4.** The Processed Bottom Ash and Unprocessed Bottom Ash are segregated and are analyzed independently.

In the event that the upper bound of the 95% confidence interval of the mean of the weekly bottom ash data is greater than the standard the following procedure will be conducted in concert with the previous actions.

The following procedure is based on the composite sampling procedure in the Ministry of Environment's *Technical Guidance 1*. As the weekly bottom ash composite samples are a composite of daily bottom ash samples, it is possible that there is one day that is causing the elevated results, an offending nugget in the aliquot selected by the lab, or an issue with the municipal solid waste delivered to the WTEF. Therefore, the following test procedures are recommended to further examine the material characterized for the week by the original composite sample:

1. Each of the daily composite sample buckets for the week will be processed at the WTEF in accordance with Covanta's Operational Procedure (see Attachment 3) to obtain twelve sub-samples for each day.
2. Individual daily composite sample buckets for the week are collected and maintained separately for Unprocessed Bottom Ash and Processed Bottom Ash. The analysis detailed below is applied to Unprocessed Bottom Ash exceeding the regulatory standard or Processed Bottom Ash being stockpiled due to triggering the Process Control Model in **Step P-4**.
3. Each day's sub-samples will be forwarded to ALS or equivalent for testing for the identified parameter(s).
4. Each day's sub-samples will be evaluated as follows:
    - For TCLP metals:
        - If the upper bound of the 95% confidence interval of the mean of the daily average values for the for the entire week is greater than the standard, the upper bound of the 95% confidence interval for the mean will be calculated for each day. If the upper bound of the 95% confidence interval for the mean for a specific day(s) is greater than the standard, the affected bottom ash loads will be flagged and additional investigation limited to the day(s) in question will occur, as described in **Step U-5.**
        - If the upper bound of the 95% confidence interval of the mean for the entire week are less than the standard, then the original weekly results will be

discarded as an error, no further action will be taken, and the weekly ash will be classified as non-hazardous (subject to confirmation of non-hazardous pH).

- If the upper bound of the 95% confidence interval for the entire week is greater than the standard or if at least one daily sub-sample value is greater than twice the standard, then the upper bound of the 95% confidence interval will be calculated for each day. If the upper bound of the 95% confidence interval for a specific day(s) is greater than the standard additional investigation limited to the day(s) in question will occur at Vancouver Landfill, as described in **Step U-5** below.

- For pH:
  - If any individual pH result is greater than 12.5 then a statistical analysis will be completed.
  - If the upper bound of the 95% confidence interval are less than the standard the result will be discarded as an error.
  - If the upper bound of the 95% confidence interval is greater than the standard additional investigation limited to the day(s) in question will occur at Vancouver Landfill.

3.5. Step U-5: Stockpile Sampling

The stockpile sampling and analysis procedure is the same for either Unprocessed Bottom Ash or Processed Bottom Ash stockpiles that requires additional investigation as per **Step U-4**. The Processed Bottom Ash and Unprocessed Bottom Ash loads are segregated and are analyzed independently.

The stockpile sampling procedure (see Attachment 4) has been derived according to the Ministry of Environment's *Technical Guidance 1.* This methodology was devised for conducting samples at a contaminated site rather than sampling an industrial waste stream. Under *Technical Guidance 1*, in-situ sampling is preferred and with material designated as suspect hazardous waste, the guidance indicates that one sample should represent 5 cubic meters (m^3) of in-situ material. In the case of bottom ash, the ash material is held in one specific area where the individual dump loads can be identified, however, a stockpile has not been formed. Therefore, *Technical Guidance 1*, Part II. Batch Testing of Suspect Material in Stockpile (ex-situ) is followed for sample collection at an in-situ sampling density.

In the following, each truckload or trailer load of ash material is referred to as a "load", and each load has a volume of approximately 8 to 10 m^3. Two samples will be obtained from each load, representing a "half-load" with a volume of 4 to 5 m^3. The combined loads from one day are referred to as a "stockpile" (even if they are not physically combined into one pile).

The sampling procedures for the characterization of ash are described in Attachment 4, Section 1.0. For the special situation of very small ash volumes (i.e., less than 5 truck or trailer loads), refer to Attachment 4, Section 2.0.

The results from each stockpile will be assessed as follows:

- Additional evaluation may be conducted on samples with concentrations greater than the standard. All replicates of samples exceeding the regulatory limit are included in the statistical analysis of the stockpile composite sample;
- The upper bound of the 95% of the confidence interval for the mean is below the applicable standard for the parameter.

In the event that the additional sampling results of a day's stockpiles meet the evaluation criteria the bottom ash will be landfilled or beneficially reused.

If a portion of stockpiled bottom ash goes through the additional characterization steps and does not meet the disposal criteria, the bottom ash will be disposed of at a suitable alternate disposal location.

3.6. Stockpile Management

Bottom ash stockpiled at Vancouver Landfill that meets the evaluation criteria will be moved for disposal.

Upon determination that a portion of stockpiled bottom ash does not meet the evaluation criteria, the offending portion of the bottom ash will be held until such time that the material is removed from Vancouver Landfill and disposed at a suitable alternate disposal location.

4.0 REPORTING REQUIREMENTS AND BOTTOM ASH MANAGEMENT PLAN REVIEW

4.1. Reporting Requirements

Metro Vancouver will submit an annual report on the bottom ash generated at the WTEF. The annual report will include:

- bottom ash sampling results for the previous four calendar years;
- bottom ash statistics for the previous four calendar year;
- quantities of Processed Bottom Ash and Unprocessed Bottom Ash produced for the preceding calendar year; and
- quantities of bottom ash beneficially used, landfilled, or disposed of at an alternate facility for the preceding calendar year.

Ministry of Environment staff would be advised if, based on statistical analysis, Processed Bottom Ash is temporarily stocked and disposed of under the Bottom Ash Management Plan for Unprocessed Bottom Ash. Ministry of Environment staff would also be advised if any Processed or Unprocessed Bottom Ash requires disposal at a facility other than the Vancouver Landfill as a result of failure to meet the requirements for landfill disposal of bottom ash.

4.2. Bottom Ash Management Plan Review

Metro Vancouver will engage a consultant to review the Bottom Ash Management Plan and data collected one year after the plan is approved.

Metro Vancouver will complete a full review of the Bottom Ash Management Plan five years after the plan is approved.

ATTACHMENT 1

2019 BOTTOM ASH MANAGEMENT PROGRAM

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

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Dear Mr. Lachance:

Metro Vancouver Waste-to-Energy Facility – Bottom Ash Update for 2019

This letter provides an update on bottom ash generated at the Metro Vancouver Waste-to-Energy Facility in Burnaby, B.C. In accordance with the B.C. Ministry of Environment and Climate Change Strategy's letter dated October 25, 2017, the bottom ash generated in 2019 was used at the Coquitlam Landfill as part of the landfill closure works until August 5, 2019. The bottom ash is currently being managed at the Vancouver Landfill.

Metro Vancouver has worked with B.C. Ministry of Environment and Climate Change Strategy to develop the existing Bottom Ash Management Plan, dated August 30, 2013 and amended October 21, 2013. Metro Vancouver submitted a draft updated Bottom Ash Management Plan to the B.C. Ministry of Environment and Climate Change Strategy on August 14, 2017. The B.C. Ministry of Environment and Climate Change Strategy retained a statistician to review the plan and a summary report was received on May 5, 2018. Metro Vancouver is now working directly with the statistician, Dr. Carl Schwartz, to develop an updated bottom ash management plan for submittal in 2020.

Bottom Ash Management Plan

The Bottom Ash Management Plan currently in place, provides a process to analyze bottom ash and confirm it is suitable for disposal. The plan provides detailed methodology on:

1. bottom ash sample collection at the Waste-to-Energy Facility;
2. weekly composite sample laboratory analysis;
3. statistical evaluation of analytical data;
4. daily sample laboratory analysis; and,
5. bottom ash sample collection at the disposal site.

As per the Bottom Ash Management Plan, a weekly bottom ash composite is produced. Each week's composite is processed into twelve (12) subsamples and sent to ALS Canada Ltd. for toxicity characteristic leaching procedure testing. The acceptance criteria are:

1. the 95th upper confidence limit of the mean for any regulated component of the bottom ash must be below the leachate quality standards of the Hazardous Waste Regulation;
2. the upper 90th percentile of the sample concentrations for any regulated component of the bottom ash must be below the leachate quality standards of the Hazardous Waste Regulation;
3. a minimum of four replicates must be submitted for analysis for any result that exceeded two times the leachate quality standards of the Hazardous Waste Regulation. The average of the original results and replicates must be included in the statistical analysis ensuring both the upper 90th percentile of the sample concentrations and the 95th upper confidence limit of the arithmetic mean concentrations are below the leachate quality standards of the Hazardous Waste Regulation; and,
4. should a replicate of the weekly sample also exceed the two times criteria, the daily samples for the week must be analyzed in accordance with the Bottom Ash Management Plan.

Bottom Ash Sampling Program Results

The following tables summarize the weekly cadmium and lead composite sample results for 2016 to 2020 year to date. The data show that the mean value, upper 95th confidence limit of the mean and 90th percentile for the bottom ash samples all meet the Leachate Quality Standards prescribed in the Hazardous Waste Regulation.

Tables 1 and 2 below show the changes in metal characteristics following implementation of the non-ferrous metal recovery system that began operating in late 2018. The weekly bottom ash results from 2018 onwards are shown in Figures 1 and 2. The project involves the recovery of non-ferrous and additional ferrous metal from the bottom ash. On average, the system recovers 50 tonnes per month of non-ferrous metal (mostly copper and aluminum). Ferrous metal recovery increased approximately 10%, or 50 tonnes per month, with the new system.

Removal of non-ferrous and additional ferrous metals from the bottom ash has improved the bottom ash quality as illustrated in Tables 1 and 2 and Figures 1 and 2. Average lead concentration in 2019 was 0.332 mg/L and year to date in 2020 is 0.272 mg/L, compared to an average of 0.437 mg/L between 2016 and 2018. Data variability for lead has improved dramatically as shown by both the 95th confidence limit of the mean and the 90th percentile.

Cadmium values have also shown improvement with the implementation of the non-ferrous recovery system. Average cadmium concentration in 2019 was 0.273 mg/L and year to date in 2020 is 0.279 mg/L, compared to an average of 0.292 mg/L between 2016 and 2018. Data variability has also improved.

Table 1: Bottom Ash Cadmium Toxicity Characteristic Leaching Procedure Summary

Bottom Ash Cadmium Toxicity Characteristic Leaching Procedure Summary (Original Samples – Replicates, Daily Composite and Landfill Samples Excluded)						
	Number of Samples	Maximum Value (mg/L)	Mean Value (mg/L)	Upper 95th Confidence Limit of Mean (mg/L)	90th Percentile (mg/L)	Leachate Quality Standard (mg/L)
2016	636	5.1	0.266	0.291	0.366	0.5
2017	636	5.7	0.315	0.355	0.411	0.5
2018	636	8.9	0.295	0.336	0.409	0.5
2019	636	7.8	0.273	0.303	0.369	0.5
2020 YTD	264	5.4	0.279	0.327	0.428	0.5

Table 2: Bottom Ash Lead Toxicity Characteristic Leaching Procedure Summary

Bottom Ash Lead Toxicity Characteristic Leaching Procedure Summary (Original Samples – Replicates, Daily Composite and Landfill Samples Excluded)						
	Number of Samples	Maximum Value (mg/L)	Mean Value (mg/L)	Upper 95th Confidence Limit of Mean (mg/L)	90th Percentile (mg/L)	Leachate Quality Standard (mg/L)
2016	636	6.0	0.411	0.451	0.665	5.0
2017	636	9.9	0.462	0.516	0.755	5.0
2018	636	15.8	0.438	0.506	0.645	5.0
2019	636	13.9	0.332	0.382	0.320	5.0
2020 YTD	264	1.6	0.272	0.286	0.250	5.0

Figure 1: Bottom Ash Leachable Cadmium Weekly Test Results

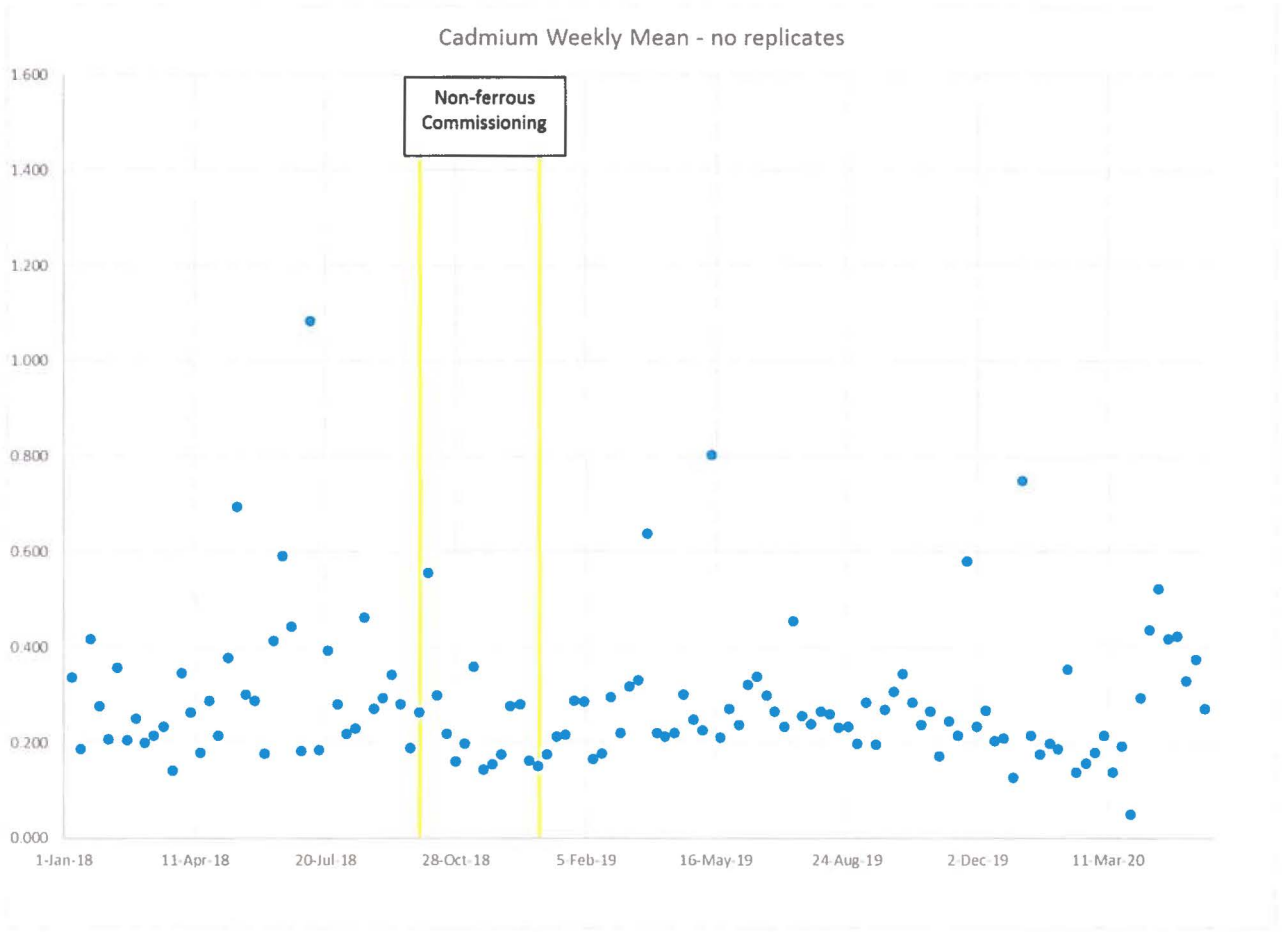
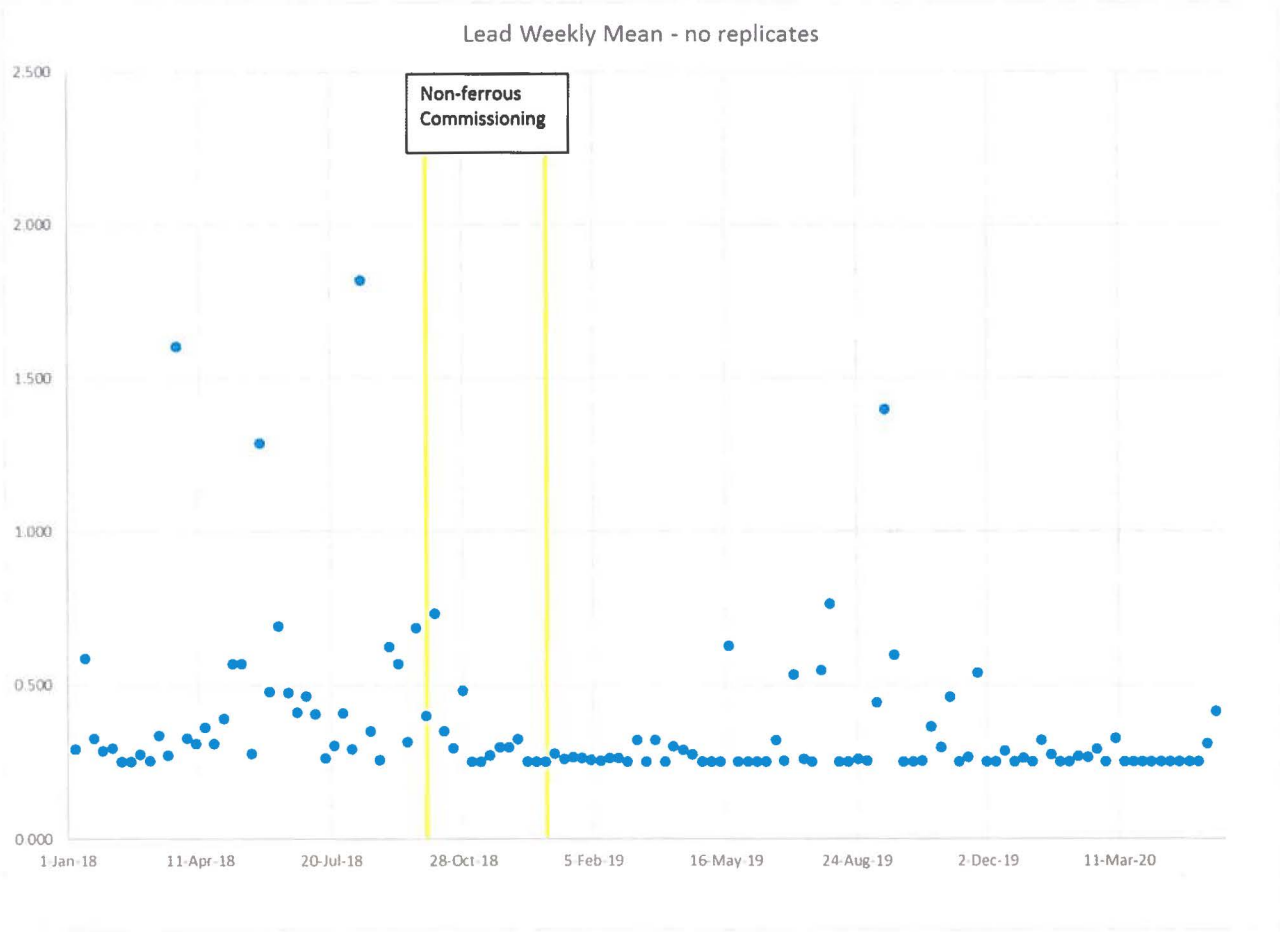


Figure 2: Bottom Ash Leachable Lead Weekly Test Results



Replicate Analysis

The bottom ash management plan includes a process where additional replicate samples are analyzed in the event original sample results do not meet the criteria for disposal of the bottom ash. Due to the heterogeneity of bottom ash, outliers are common and replicates provide a means to confirm if the outlier is indicative of the characteristics of the weekly or daily composite. Depending on the results of the replicate analysis, analysis of daily samples may be required.

Table 3 shows a dramatic difference in replicate analysis requirements following implementation of the non-ferrous recovery system. Total samples analyzed dropped from a high of 1,358 samples in 2016 to 674 samples in 2019. Daily sample analysis dropped from a high of 502 samples in 2017 to zero samples in 2019 and 2020 to date. These results demonstrate that the non-ferrous metal recovery system has improved bottom ash quality, and that any individual high sample results are non-reproducible indicating that they are truly outliers.

Table 3: Bottom Ash Sample Count

	Bottom Ash Samples					
	Weekly Composite		Daily Composite		Landfill Stockpile Samples	Total
Year	Original Results	Replicates	Original Results	Replicates		
2016	636	243	144	245	90	1,358
2017	636	194	300	202	0	1,320
2018	636	146	204	70	0	1,044
2019	636	48	0	0	0	674
2020	264	41	0	0	0	305

As shown in Table 4, since January 2019, more than 90% of the bottom ash generated has been processed through the non-ferrous recovery system.

Table 4: Non-ferrous Metal Recovery Project Monthly Ash Processing

	Non-Ferrous Metal Recovery Ash Processing Performance
Nov/Dec 2018	85%
2019	94%
2020 YTD	94%

Bottom Ash Beneficial Use

On March 13, 2020 Metro Vancouver posted a Request for Qualifications (RFQ) for bottom ash beneficial use. The RFQ close has been extended due to COVID-19 and currently is scheduled to close on June 21, 2020. The RFQ is seeking Proponents that can utilize the annual output of bottom ash for a beneficial purpose.

Please let us know if you have any questions.

Yours truly,

Paul Henderson, P.Eng.
General Manager, Solid Waste Services

PH/CA/bk

cc: Albert Shamess, City of Vancouver
Lynn Belanger, City of Vancouver
Mike Brotherston, Corporation of Delta
Jaime Boan, City of Coquitlam

Attachments: 2016 Weekly Composite, Daily Composite and Landfill Results Including Replicates
2017 Weekly Composite, Daily Composite and Landfill Results Including Replicates
2018 Weekly Composite, Daily Composite and Landfill Results Including Replicates
2019 Weekly Composite, Daily Composite and Landfill Results including Replicates
2020 Weekly Composite, Daily Composite and Landfill Results Including Replicates

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0 50 mg/L)			
2016 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
16-01	27-Dec-15	2-Jan-16	Weekly Composite	0.420	0.283	0.314	0.356	0.311	0.170	0.197	0.200
16-02	3-Jan-16	9-Jan-16	Weekly Composite	0.760	0.293	0.376	0.250	0.555	0.243	0.307	0.349
16-03	10-Jan-16	16-Jan-16	Weekly Composite	0.250	0.250	0.250	0.250	0.372	0.139	0.194	0.261
16-04	17-Jan-16	23-Jan-16	Weekly Composite	0.650	0.300	0.370	0.430	0.243	0.140	0.169	0.215
16-05	24-Jan-16	30-Jan-16	Weekly Composite	1.430	0.388	0.589	0.674	0.323	0.169	0.198	0.184
16-06	31-Jan-16	6-Feb-16	Weekly Composite	0.740	0.378	0.470	0.574	0.332	0.194	0.231	0.280
16-07	7-Feb-16	13-Feb-16	Weekly Composite	5.650	0.781	1.650	0.553	1.980	0.219	0.279	0.287
16-08	14-Feb-16	20-Feb-16	Weekly Composite	2.410	0.609	0.990	1.266	1.430	0.321	0.416	0.392
	15-Feb-16	15-Feb-16	Daily Composite Samples for Week 8 (Leachable Cadmium Only)					4.980	0.966	1.055	1.149
	16-Feb-16	16-Feb-16						1.080	0.202	0.246	0.298
	17-Feb-16	17-Feb-16						0.952	0.172	0.235	0.318
	18-Feb-16	18-Feb-16						0.281	0.170	0.198	0.227
	19-Feb-16	19-Feb-16						2.940	0.180	0.241	0.300
	20-Feb-16	20-Feb-16						32.000	0.682	1.432	0.412
	15-Feb-16	15-Feb-16	Landfill Stock Pile Samples					0.942	0.290	0.400	0.660
	20-Feb-16	20-Feb-16						0.349	0.190	0.230	0.280
16-09	21-Feb-16	27-Feb-16	Weekly Composite	1.960	0.479	0.762	0.839	0.286	0.202	0.224	0.247
16-10	28-Feb-16	5-Mar-16	Weekly Composite	1.820	0.573	0.870	1.397	0.709	0.285	0.336	0.402
16-11	6-Mar-16	12-Mar-16	Weekly Composite	0.410	0.286	0.318	0.359	0.535	0.211	0.275	0.281
16-12	13-Mar-16	19-Mar-16	Weekly Composite	0.660	0.313	0.391	0.524	5.110	0.196	0.313	0.291
16-13	20-Mar-16	26-Mar-16	Weekly Composite	5.770	0.821	1.712	0.992	0.781	0.181	0.220	0.287
16-14	27-Mar-16	2-Apr-16	Weekly Composite	0.440	0.266	0.297	0.250	1.380	0.224	0.291	0.342
16-15	3-Apr-16	9-Apr-16	Weekly Composite	1.000	0.329	0.452	0.414	0.440	0.214	0.264	0.325
16-16	10-Apr-16	16-Apr-16	Weekly Composite	0.490	0.293	0.336	0.386	0.247	0.152	0.195	0.245
16-17	17-Apr-16	23-Apr-16	Weekly Composite	1.030	0.412	0.578	0.968	0.319	0.185	0.216	0.242
16-18	24-Apr-16	30-Apr-16	Weekly Composite	0.270	0.253	0.256	0.259	0.888	0.225	0.259	0.322
16-19	1-May-16	7-May-16	Weekly Composite	0.610	0.383	0.445	0.508	0.585	0.288	0.332	0.380
16-20	8-May-16	14-May-16	Weekly Composite	0.540	0.296	0.348	0.418	0.665	0.254	0.281	0.318
16-21	15-May-16	21-May-16	Weekly Composite	5.230	1.027	1.826	1.932	0.370	0.264	0.293	0.323
16-22	22-May-16	28-May-16	Weekly Composite	1.500	0.387	0.586	0.357	0.227	0.193	0.207	0.219
16-23	29-May-16	4-Jun-16	Weekly Composite	1.380	0.353	0.536	0.340	2.900	0.349	0.396	0.457
16-24	5-Jun-16	11-Jun-16	Weekly Composite	0.250	0.250	0.250	0.250	0.660	0.278	0.348	0.306
16-25	12-Jun-16	18-Jun-16	Weekly Composite	2.120	0.511	0.815	0.738	0.258	0.205	0.217	0.217
16-26	19-Jun-16	25-Jun-16	Weekly Composite	0.250	0.250	0.250	0.250	0.232	0.124	0.164	0.223
16-27	26-Jun-16	2-Jul-16	Weekly Composite	0.330	0.258	0.272	0.268	0.270	0.116	0.156	0.202
16-28	3-Jul-16	9-Jul-16	Weekly Composite	0.490	0.308	0.358	0.468	0.435	0.234	0.274	0.278
16-29	10-Jul-16	16-Jul-16	Weekly Composite	0.520	0.292	0.337	0.357	1.320	0.239	0.270	0.315
16-30	17-Jul-16	23-Jul-16	Weekly Composite	1.080	0.427	0.603	1.017	0.354	0.241	0.270	0.325
16-31	24-Jul-16	30-Jul-16	Weekly Composite	0.490	0.308	0.355	0.434	0.788	0.315	0.407	0.407
16-32	31-Jul-16	6-Aug-16	Weekly Composite	1.090	0.651	0.799	0.989	1.310	0.370	0.401	0.442
	1-Aug-16	1-Aug-16	Daily Composite Samples for Week 32 (Leachable Cadmium Only)					1.580	0.238	0.296	0.359
	2-Aug-16	2-Aug-16						0.507	0.262	0.314	0.364
	3-Aug-16	3-Aug-16						0.830	0.274	0.375	0.296
	4-Aug-16	4-Aug-16						0.534	0.317	0.362	0.397
	5-Aug-16	5-Aug-16						2.900	0.592	0.687	0.740
	6-Aug-16	6-Aug-16						5.710	0.357	0.433	0.418
	5-Aug-16	5-Aug-16	Landfill Stock Pile Samples					1.410	0.530	0.600	0.660
16-33	7-Aug-16	13-Aug-16	Weekly Composite	0.670	0.330	0.400	0.417	0.597	0.300	0.356	0.355
16-34	14-Aug-16	20-Aug-16	Weekly Composite	2.670	0.679	1.083	1.324	1.870	0.276	0.308	0.338
16-35	21-Aug-16	27-Aug-16	Weekly Composite	0.900	0.422	0.539	0.668	1.580	0.250	0.287	0.325
16-36	28-Aug-16	3-Sep-16	Weekly Composite	0.950	0.376	0.493	0.565	2.780	0.271	0.339	0.398
16-37	4-Sep-16	10-Sep-16	Weekly Composite	0.830	0.373	0.470	0.506	0.239	0.181	0.197	0.211
16-38	11-Sep-16	17-Sep-16	Weekly Composite	1.470	0.604	0.839	1.148	0.668	0.360	0.417	0.373
16-39	18-Sep-16	24-Sep-16	Weekly Composite	0.700	0.338	0.421	0.544	0.339	0.223	0.247	0.260
16-40	25-Sep-16	1-Oct-16	Weekly Composite	0.510	0.297	0.343	0.386	0.327	0.226	0.259	0.316
16-41	2-Oct-16	8-Oct-16	Weekly Composite	0.790	0.384	0.475	0.553	2.250	0.268	0.314	0.327
16-42	9-Oct-16	15-Oct-16	Weekly Composite	0.530	0.301	0.360	0.491	0.257	0.164	0.205	0.256
16-43	16-Oct-16	22-Oct-16	Weekly Composite	0.390	0.277	0.303	0.344	0.798	0.311	0.400	0.348
16-44	23-Oct-16	29-Oct-16	Weekly Composite	0.860	0.411	0.529	0.704	0.503	0.231	0.292	0.347
16-45	30-Oct-16	5-Nov-16	Weekly Composite	0.520	0.373	0.419	0.484	0.547	0.275	0.336	0.347
16-46	6-Nov-16	12-Nov-16	Weekly Composite	1.220	0.470	0.627	0.728	0.301	0.166	0.198	0.222
16-47	13-Nov-16	19-Nov-16	Weekly Composite	6.040	0.857	1.789	0.944	0.626	0.231	0.306	0.305
16-48	20-Nov-16	26-Nov-16	Weekly Composite	0.830	0.379	0.486	0.615	0.566	0.275	0.335	0.356
16-49	27-Nov-16	3-Dec-16	Weekly Composite	0.890	0.381	0.487	0.581	0.416	0.230	0.267	0.261
16-50	4-Dec-16	10-Dec-16	Weekly Composite	2.830	0.465	0.886	0.250	0.337	0.226	0.253	0.288
16-51	11-Dec-16	17-Dec-16	Weekly Composite	0.390	0.262	0.285	0.250	0.302	0.160	0.187	0.180
16-52	18-Dec-16	24-Dec-16	Weekly Composite	0.250	0.250	0.250	0.250	0.597	0.111	0.198	0.128
16-53	25-Dec-16	31-Dec-16	Weekly Composite	2.190	0.553	0.900	1.329	0.234	0.171	0.190	0.210

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0.50 mg/L)			
2017 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
17-01	1-Jan-17	7-Jan-17	Weekly Composite	0.480	0.269	0.307	0.250	4.960	0.258	0.379	0.384
17-02	8-Jan-17	14-Jan-17	Weekly Composite	0.250	0.250	0.250	0.250	0.233	0.120	0.143	0.159
17-03	15-Jan-17	21-Jan-17	Weekly Composite	2.710	0.583	1.014	1.415	0.388	0.227	0.275	0.355
17-04	22-Jan-17	28-Jan-17	Weekly Composite	0.370	0.261	0.280	0.259	0.651	0.229	0.305	0.245
17-05	29-Jan-17	4-Feb-17	Weekly Composite	1.480	0.498	0.759	1.333	0.274	0.181	0.205	0.244
17-06	5-Feb-17	11-Feb-17	Weekly Composite	0.910	0.468	0.618	0.873	1.030	0.358	0.502	0.632
	5-Feb-17	5-Feb-17	Daily Composite Samples for Week 6 (Leachable Cadmium Only)					0.495	0.192	0.249	0.216
	6-Feb-17	6-Feb-17						0.280	0.215	0.229	0.228
	7-Feb-17	7-Feb-17						0.174	0.143	0.154	0.169
	8-Feb-17	8-Feb-17						0.352	0.219	0.246	0.242
	9-Feb-17	9-Feb-17						1.070	0.245	0.281	0.326
	10-Feb-17	10-Feb-17						0.885	0.187	0.258	0.333
	11-Feb-17	11-Feb-17						0.268	0.101	0.147	0.230
17-07	12-Feb-17	18-Feb-17	Weekly Composite	0.910	0.305	0.413	0.250	0.247	0.193	0.216	0.235
17-08	19-Feb-17	25-Feb-17	Weekly Composite	2.070	0.496	0.797	0.850	0.479	0.224	0.278	0.326
17-09	26-Feb-17	4-Mar-17	Weekly Composite	0.250	0.250	0.250	0.250	0.177	0.105	0.121	0.131
17-10	5-Mar-17	11-Mar-17	Weekly Composite	0.250	0.250	0.250	0.250	0.211	0.113	0.135	0.136
17-11	12-Mar-17	18-Mar-17	Weekly Composite	0.250	0.250	0.250	0.250	0.105	0.062	0.073	0.098
17-12	19-Mar-17	25-Mar-17	Weekly Composite	9.940	0.741	1.193	2.035	3.270	0.236	0.308	0.401
17-13	26-Mar-17	1-Apr-17	Weekly Composite	0.680	0.312	0.383	0.409	0.401	0.197	0.244	0.313
17-14	2-Apr-17	8-Apr-17	Weekly Composite	1.530	0.605	0.808	0.965	4.000	0.273	0.351	0.389
17-15	9-Apr-17	15-Apr-17	Weekly Composite	0.980	0.406	0.553	0.856	0.687	0.223	0.311	0.301
17-16	16-Apr-17	22-Apr-17	Weekly Composite	0.520	0.323	0.384	0.504	5.730	0.274	0.385	0.388
17-17	23-Apr-17	29-Apr-17	Weekly Composite	2.620	0.514	0.894	0.554	0.440	0.254	0.297	0.342
17-18	30-Apr-17	6-May-17	Weekly Composite	6.880	1.038	2.107	1.675	0.346	0.260	0.283	0.333
17-19	7-May-17	13-May-17	Weekly Composite	1.240	0.365	0.524	0.407	0.645	0.311	0.380	0.389
17-20	14-May-17	20-May-17	Weekly Composite	0.800	0.323	0.415	0.445	3.260	0.383	0.474	0.615
	15-May-17	15-May-17	Daily Composite Samples for Week 20 (Leachable Cadmium Only)					0.568	0.268	0.326	0.329
	16-May-17	16-May-17						0.945	0.317	0.440	0.476
	17-May-17	17-May-17						1.200	0.298	0.337	0.363
	18-May-17	18-May-17						0.914	0.308	0.419	0.362
	19-May-17	19-May-17						0.487	0.332	0.396	0.471
	20-May-17	20-May-17						1.110	0.282	0.356	0.434

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0 50 mg/L)			
2017 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
17-21	21-May-17	27-May-17	Weekly Composite	2.970	0.954	1 411	1 956	0.494	0.293	0.348	0.433
17-22	28-May-17	3-Jun-17	Weekly Composite	2.790	0.761	1.210	1.763	2.350	0.304	0.390	0.380
	29-May-17	29-May-17	Daily Composite Samples for Week 22 (Leachable Cadmium Only)					0.292	0.215	0.236	0.254
	30-May-17	30-May-17						1.160	0.244	0.293	0.381
	31-May-17	31-May-17						2.800	0.384	0.467	0.439
	1-Jun-17	1-Jun-17						0.792	0.254	0.309	0.315
	2-Jun-17	2-Jun-17						1.760	0.351	0.418	0.481
	3-Jun-17	3-Jun-17						0.266	0.188	0.221	0.258
17-23	4-Jun-17	10-Jun-17	Weekly Composite	3.060	0.528	0.982	0.497	0.301	0.254	0.269	0.295
17-24	11-Jun-17	17-Jun-17	Weekly Composite	3.290	0.732	1.228	1.303	0.573	0.302	0.353	0.320
17-25	18-Jun-17	24-Jun-17	Weekly Composite	0.370	0.277	0.304	0.358	0.836	0.286	0.321	0.389
17-26	25-Jun-17	1-Jul-17	Weekly Composite	0.520	0.315	0.369	0.482	0.762	0.272	0.319	0.391
17-27	2-Jul-17	8-Jul-17	Weekly Composite	0.550	0.303	0.356	0.419	1.320	0.215	0.277	0.334
17-28	9-Jul-17	15-Jul-17	Weekly Composite	1.130	0.544	0.676	0.677	3.610	0.456	0.503	0.472
	10-Jul-17	10-Jul-17	Daily Composite Samples for Week 28 (Leachable Cadmium Only)					0.617	0.294	0.377	0.495
	11-Jul-17	11-Jul-17						2.070	0.231	0.292	0.386
	12-Jul-17	12-Jul-17						4.600	0.805	1.022	1.275
	13-Jul-17	13-Jul-17						1.440	0.327	0.390	0.480
	14-Jul-17	14-Jul-17						1.300	0.739	0.835	0.849
	15-Jul-17	15-Jul-17						0.783	0.268	0.362	0.321
	12-Jul-17	12-Jul-17	Landfill Stock Pile Samples					1.180	0.343	0.489	0.583
	14-Jul-17	14-Jul-17						3.280	0.629	0.970	0.992
17-29	16-Jul-17	22-Jul-17	Weekly Composite	3.170	0.528	1.000	0.437	0.728	0.262	0.353	0.346
17-30	23-Jul-17	29-Jul-17	Weekly Composite	0.900	0.408	0.550	0.840	0.611	0.364	0.416	0.463
17-31	30-Jul-17	5-Aug-17	Weekly Composite	2.620	0.448	0.835	0.250	1.430	0.261	0.317	0.404
17-32	6-Aug-17	12-Aug-17	Weekly Composite	1.220	0.473	0.665	1.057	0.382	0.258	0.286	0.296
17-33	13-Aug-17	19-Aug-17	Weekly Composite	0.250	0.250	0.250	0.250	0.808	0.288	0.382	0.304
17-34	20-Aug-17	26-Aug-17	Weekly Composite	0.340	0.258	0.272	0.250	0.234	0.180	0.193	0.202
17-35	27-Aug-17	2-Sep-17	Weekly Composite	0.930	0.444	0.578	0.709	0.354	0.271	0.295	0.342
17-36	3-Sep-17	9-Sep-17	Weekly Composite	2.700	0.618	1.018	1.108	3.650	0.298	0.391	0.398
17-37	10-Sep-17	16-Sep-17	Weekly Composite	0.360	0.263	0.282	0.295	0.873	0.332	0.434	0.408
17-38	17-Sep-17	23-Sep-17	Weekly Composite	2.430	0.590	0.940	0.965	0.282	0.200	0.227	0.279
17-39	24-Sep-17	30-Sep-17	Weekly Composite	1.350	0.450	0.637	0.734	0.551	0.306	0.380	0.491
17-40	1-Oct-17	7-Oct-17	Weekly Composite	0.790	0.382	0.483	0.596	0.235	0.196	0.209	0.228
17-41	8-Oct-17	14-Oct-17	Weekly Composite	0.310	0.255	0.265	0.250	0.813	0.248	0.351	0.282
17-42	15-Oct-17	21-Oct-17	Weekly Composite	1.280	0.465	0.689	1.183	0.911	0.334	0.452	0.490
17-43	22-Oct-17	28-Oct-17	Weekly Composite	1.250	0.497	0.697	1.076	0.337	0.205	0.236	0.265
17-44	29-Oct-17	4-Nov-17	Weekly Composite	0.360	0.266	0.287	0.322	0.886	0.184	0.218	0.259
17-45	5-Nov-17	11-Nov-17	Weekly Composite	0.650	0.333	0.410	0.548	0.322	0.192	0.221	0.248
17-46	12-Nov-17	18-Nov-17	Weekly Composite	2.730	0.629	1.064	1.500	5.740	0.343	0.474	0.363
17-47	19-Nov-17	25-Nov-17	Weekly Composite	0.570	0.308	0.360	0.366	0.939	0.252	0.301	0.361
17-48	26-Nov-17	2-Dec-17	Weekly Composite	0.690	0.293	0.364	0.288	0.516	0.238	0.309	0.404
17-49	3-Dec-17	9-Dec-17	Weekly Composite	2.880	0.635	1.069	1.200	0.924	0.257	0.378	0.299
17-50	10-Dec-17	16-Dec-17	Weekly Composite	1.830	0.568	0.831	1.006	1.230	0.219	0.261	0.269
17-51	17-Dec-17	23-Dec-17	Weekly Composite	0.640	0.342	0.422	0.582	0.803	0.200	0.309	0.197
17-52	24-Dec-17	30-Dec-17	Weekly Composite	1.350	0.342	0.521	0.250	0.327	0.185	0.212	0.201

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0.50 mg/L)			
2018 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
18-01	31-Dec-17	6-Jan-18	Weekly Composite	0.250	0.250	0.250	0.250	0.259	0.207	0.224	0.249
18-02	7-Jan-18	13-Jan-18	Weekly Composite	0.620	0.293	0.354	0.353	1.710	0.223	0.290	0.420
18-03	14-Jan-18	20-Jan-18	Weekly Composite	2.210	0.587	0.915	1.018	0.265	0.187	0.203	0.200
18-04	21-Jan-18	27-Jan-18	Weekly Composite	1.190	0.328	0.482	0.250	2.950	0.231	0.322	0.283
18-05	28-Jan-18	3-Feb-18	Weekly Composite	0.550	0.286	0.337	0.367	1.010	0.226	0.298	0.426
18-06	4-Feb-18	10-Feb-18	Weekly Composite	0.600	0.296	0.358	0.422	0.639	0.207	0.286	0.233
18-07	11-Feb-18	17-Feb-18	Weekly Composite	0.250	0.250	0.250	0.250	1.140	0.243	0.305	0.409
18-08	18-Feb-18	24-Feb-18	Weekly Composite	0.250	0.250	0.250	0.250	0.582	0.205	0.290	0.423
18-09	25-Feb-18	3-Mar-18	Weekly Composite	0.450	0.274	0.307	0.307	1.290	0.189	0.253	0.219
18-10	4-Mar-18	10-Mar-18	Weekly Composite	0.310	0.255	0.265	0.250	0.304	0.199	0.224	0.260
18-11	11-Mar-18	17-Mar-18	Weekly Composite	1.270	0.335	0.502	0.250	0.291	0.216	0.239	0.261
18-12	18-Mar-18	24-Mar-18	Weekly Composite	0.330	0.272	0.287	0.308	0.340	0.233	0.269	0.334
18-13	25-Mar-18	31-Mar-18	Weekly Composite	15.800	0.567	1.076	0.814	0.215	0.142	0.162	0.187
18-14	1-Apr-18	7-Apr-18	Weekly Composite	0.720	0.328	0.414	0.511	0.729	0.349	0.471	0.424
18-15	8-Apr-18	14-Apr-18	Weekly Composite	0.450	0.308	0.350	0.406	1.380	0.182	0.227	0.229
18-16	15-Apr-18	21-Apr-18	Weekly Composite	1.460	0.361	0.557	0.309	0.368	0.180	0.219	0.238
18-17	22-Apr-18	28-Apr-18	Weekly Composite	0.520	0.311	0.364	0.457	1.610	0.191	0.239	0.206
18-18	29-Apr-18	5-May-18	Weekly Composite	0.960	0.392	0.544	0.900	0.456	0.215	0.260	0.238
18-19	6-May-18	12-May-18	Weekly Composite	1.930	0.568	0.878	1.221	1.260	0.273	0.331	0.381
18-20	13-May-18	19-May-18	Weekly Composite	1.820	0.570	0.855	1.017	5.040	0.313	0.438	0.350
18-21	20-May-18	26-May-18	Weekly Composite	0.480	0.278	0.315	0.308	0.697	0.301	0.377	0.390
18-22	27-May-18	2-Jun-18	Weekly Composite	8.140	1.287	2.642	3.586	0.789	0.287	0.378	0.277
18-23	3-Jun-18	9-Jun-18	Weekly Composite	1.430	0.479	0.706	1.127	0.230	0.178	0.194	0.225
18-24	10-Jun-18	16-Jun-18	Weekly Composite	1.320	0.693	0.935	1.230	1.570	0.276	0.350	0.478
18-25	17-Jun-18	23-Jun-18	Weekly Composite	1.370	0.475	0.665	0.750	4.390	0.295	0.441	0.291
18-26	24-Jun-18	30-Jun-18	Weekly Composite	1.580	0.411	0.625	0.479	1.990	0.538	1.115	0.549
	25-Jun-18	25-Jun-18	Daily Composite					4.350	0.234	0.368	0.225
	26-Jun-18	26-Jun-18	Daily Composite					0.582	0.300	0.356	0.379
	27-Jun-18	27-Jun-18	Daily Composite					2.110	0.184	0.251	0.172
	28-Jun-18	28-Jun-18	Daily Composite					0.313	0.207	0.239	0.302
	29-Jun-18	29-Jun-18	Daily Composite					0.493	0.272	0.324	0.321
	30-Jun-18	30-Jun-18	Daily Composite					0.613	0.231	0.307	0.331
18-27	1-Jul-18	7-Jul-18	Weekly Composite	2.180	0.463	0.774	0.469	0.286	0.184	0.216	0.243
18-28	8-Jul-18	14-Jul-18	Weekly Composite	1.420	0.405	0.592	0.500	8.860	1.083	2.474	0.858
	9-Jul-18	9-Jul-18	Daily Composite					0.368	0.273	0.301	0.333
	10-Jul-18	10-Jul-18	Daily Composite					0.796	0.188	0.299	0.256
	11-Jul-18	11-Jul-18	Daily Composite					0.413	0.208	0.249	0.257
	12-Jul-18	12-Jul-18	Daily Composite					2.090	0.455	0.533	0.604
	13-Jul-18	13-Jul-18	Daily Composite					0.297	0.208	0.232	0.262
	14-Jul-18	14-Jul-18	Daily Composite					1.180	0.205	0.244	0.254
	12-Jul-18	12-Jul-18	Landfill Stockpile Samples					5.850	0.291	0.504	0.367
18-29	15-Jul-18	21-Jul-18	Weekly Composite	0.360	0.263	0.282	0.295	0.214	0.184	0.194	0.208
18-30	22-Jul-18	28-Jul-18	Weekly Composite	0.610	0.303	0.373	0.494	2.840	0.213	0.298	0.201
18-31	29-Jul-18	4-Aug-18	Weekly Composite	0.750	0.408	0.518	0.675	0.750	0.280	0.373	0.404
18-32	5-Aug-18	11-Aug-18	Weekly Composite	0.680	0.293	0.363	0.322	0.406	0.218	0.257	0.282
18-33	12-Aug-18	18-Aug-18	Weekly Composite	9.340	1.820	3.452	4.990	0.446	0.231	0.281	0.367
18-34	19-Aug-18	25-Aug-18	Weekly Composite	0.830	0.352	0.456	0.570	1.630	0.304	0.367	0.484
18-35	26-Aug-18	1-Sep-18	Weekly Composite	0.350	0.258	0.275	0.250	0.706	0.241	0.313	0.324
18-36	2-Sep-18	8-Sep-18	Weekly Composite	3.520	0.624	1.146	0.600	0.775	0.293	0.393	0.429
18-37	9-Sep-18	15-Sep-18	Weekly Composite	2.160	0.569	0.900	1.102	1.030	0.338	0.513	0.333
	10-Sep-18	10-Sep-18	Daily Composite					1.050	0.194	0.237	0.311
	12-Sep-18	12-Sep-18	Daily Composite					0.429	0.218	0.258	0.240
	13-Sep-18	13-Sep-18	Daily Composite					2.500	0.266	0.341	0.464
	14-Sep-18	14-Sep-18	Daily Composite					1.010	0.382	0.418	0.480
	15-Sep-18	15-Sep-18	Daily Composite					0.901	0.285	0.361	0.434
18-38	16-Sep-18	22-Sep-18	Weekly Composite	0.920	0.317	0.426	0.367	0.492	0.280	0.321	0.332
18-39	23-Sep-18	29-Sep-18	Weekly Composite	1.520	0.687	0.929	1.264	0.249	0.188	0.205	0.242
18-40	30-Sep-18	6-Oct-18	Weekly Composite	0.990	0.399	0.546	0.809	1.320	0.196	0.253	0.237
18-41	7-Oct-18	13-Oct-18	Weekly Composite	3.870	0.734	1.312	1.044	4.410	0.273	0.412	0.388
18-42	14-Oct-18	20-Oct-18	Weekly Composite	0.670	0.349	0.424	0.496	0.582	0.300	0.354	0.340
18-43	21-Oct-18	27-Oct-18	Weekly Composite	0.630	0.296	0.358	0.329	0.478	0.219	0.267	0.263
18-44	28-Oct-18	3-Nov-18	Weekly Composite	1.940	0.483	0.756	0.723	0.202	0.161	0.171	0.183
18-45	4-Nov-18	10-Nov-18	Weekly Composite	0.250	0.250	0.250	0.250	0.438	0.198	0.243	0.219
18-46	11-Nov-18	17-Nov-18	Weekly Composite	0.280	0.253	0.257	0.250	1.560	0.204	0.261	0.358
18-47	18-Nov-18	24-Nov-18	Weekly Composite	0.380	0.271	0.298	0.358	0.188	0.143	0.155	0.168
18-48	25-Nov-18	1-Dec-18	Weekly Composite	0.790	0.298	0.385	0.269	0.281	0.155	0.180	0.184
18-49	2-Dec-18	8-Dec-18	Weekly Composite	0.550	0.299	0.353	0.405	0.382	0.175	0.216	0.231
18-50	9-Dec-18	15-Dec-18	Weekly Composite	0.880	0.324	0.426	0.358	0.755	0.242	0.315	0.347
18-51	16-Dec-18	22-Dec-18	Weekly Composite	0.250	0.250	0.250	0.250	0.920	0.281	0.402	0.363
18-52	23-Dec-18	29-Dec-18	Weekly Composite	0.250	0.250	0.250	0.250	0.258	0.163	0.193	0.245

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0.50 mg/L)			
2019 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
19-01	30-Dec-18	5-Jan-19	Weekly Composite	0.250	0.250	0.250	0.250	0.263	0.151	0.174	0.179
19-02	6-Jan-19	12-Jan-19	Weekly Composite	0.420	0.275	0.308	0.367	0.241	0.175	0.193	0.207
19-03	13-Jan-19	19-Jan-19	Weekly Composite	0.320	0.260	0.273	0.295	0.350	0.213	0.248	0.287
19-04	20-Jan-19	26-Jan-19	Weekly Composite	0.360	0.266	0.287	0.322	0.443	0.217	0.272	0.378
19-05	27-Jan-19	2-Feb-19	Weekly Composite	0.340	0.264	0.280	0.290	0.396	0.288	0.318	0.380
19-06	3-Feb-19	9-Feb-19	Weekly Composite	0.320	0.256	0.267	0.250	1.000	0.286	0.415	0.309
19-07	10-Feb-19	16-Feb-19	Weekly Composite	0.300	0.254	0.262	0.250	0.391	0.166	0.209	0.217
19-08	17-Feb-19	23-Feb-19	Weekly Composite	0.420	0.264	0.292	0.250	0.231	0.177	0.194	0.211
19-09	24-Feb-19	2-Mar-19	Weekly Composite	0.380	0.261	0.282	0.250	1.650	0.195	0.246	0.233
19-10	3-Mar-19	9-Mar-19	Weekly Composite	0.250	0.250	0.250	0.250	0.481	0.222	0.274	0.309
19-11	10-Mar-19	16-Mar-19	Weekly Composite	1.110	0.322	0.462	0.250	0.697	0.318	0.397	0.444
19-12	17-Mar-19	23-Mar-19	Weekly Composite	0.280	0.253	0.257	0.250	1.580	0.239	0.295	0.351
19-13	24-Mar-19	30-Mar-19	Weekly Composite	0.520	0.321	0.378	0.481	3.780	0.398	0.509	0.487
	25-MAR-19	25-Mar-19	Daily Composite					0.419	0.240	0.276	0.279
	26-Mar-19	26-Mar-19	Daily Composite					5.050	0.318	0.457	0.466
	27-Mar-19	27-Mar-19	Daily Composite					0.392	0.212	0.246	0.254
	28-Mar-19	28-Mar-19	Daily Composite					0.613	0.254	0.319	0.281
	29-Mar-19	29-Mar-19	Daily Composite					0.566	0.264	0.337	0.479
	30-Mar-19	30-Mar-19	Daily Composite					0.794	0.317	0.400	0.490
19-14	31-Mar-19	6-Apr-19	Weekly Composite	0.250	0.250	0.250	0.250	0.252	0.220	0.231	0.248
19-15	7-Apr-19	13-Apr-19	Weekly Composite	0.600	0.299	0.364	0.458	0.338	0.212	0.247	0.317
19-16	14-Apr-19	20-Apr-19	Weekly Composite	0.600	0.290	0.347	0.327	0.263	0.220	0.236	0.253
19-17	21-Apr-19	27-Apr-19	Weekly Composite	0.450	0.274	0.307	0.299	0.471	0.301	0.363	0.444
19-18	28-Apr-19	4-May-19	Weekly Composite	0.250	0.250	0.250	0.250	0.859	0.249	0.364	0.340
19-19	5-May-19	11-May-19	Weekly Composite	0.250	0.250	0.250	0.250	0.542	0.226	0.286	0.269
19-20	12-May-19	18-May-19	Weekly Composite	0.250	0.250	0.250	0.250	7.770	0.262	0.445	0.255
19-21	19-May-19	25-May-19	Weekly Composite	2.240	0.627	0.988	1.547	0.354	0.210	0.240	0.247
19-22	26-May-19	1-Jun-19	Weekly Composite	0.250	0.250	0.250	0.250	0.523	0.269	0.325	0.373
19-23	2-Jun-19	8-Jun-19	Weekly Composite	0.250	0.250	0.250	0.250	0.368	0.237	0.269	0.295
19-24	9-Jun-19	15-Jun-19	Weekly Composite	0.270	0.252	0.255	0.250	0.991	0.321	0.456	0.498
19-25	16-Jun-19	22-Jun-19	Weekly Composite	0.250	0.250	0.250	0.250	0.797	0.338	0.426	0.428
19-26	23-Jun-19	29-Jun-19	Weekly Composite	1.120	0.323	0.465	0.250	0.809	0.299	0.404	0.498
19-27	30-Jun-19	6-Jul-19	Weekly Composite	0.280	0.254	0.260	0.268	0.467	0.266	0.314	0.400
19-28	7-Jul-19	13-Jul-19	Weekly Composite	3.550	0.532	1.070	0.314	0.599	0.233	0.300	0.259
19-29	14-Jul-19	20-Jul-19	Weekly Composite	0.360	0.259	0.277	0.250	2.780	0.298	0.414	0.462
19-30	21-Jul-19	27-Jul-19	Weekly Composite	0.250	0.250	0.250	0.250	0.459	0.256	0.303	0.346
19-31	28-Jul-19	3-Aug-19	Weekly Composite	2.420	0.548	0.911	1.067	0.319	0.238	0.260	0.291
19-32	4-Aug-19	10-Aug-19	Weekly Composite	6.390	0.764	1.767	0.277	0.448	0.264	0.303	0.316
19-33	11-Aug-19	17-Aug-19	Weekly Composite	0.250	0.250	0.250	0.250	0.644	0.259	0.331	0.306
19-34	18-Aug-19	24-Aug-19	Weekly Composite	0.250	0.250	0.250	0.250	0.297	0.231	0.251	0.274
19-35	25-Aug-19	31-Aug-19	Weekly Composite	0.360	0.259	0.277	0.250	0.378	0.233	0.271	0.345
19-36	1-Sep-19	7-Sep-19	Weekly Composite	0.310	0.255	0.265	0.250	0.271	0.198	0.218	0.252
19-37	8-Sep-19	14-Sep-19	Weekly Composite	2.110	0.444	0.751	0.673	0.908	0.285	0.400	0.373
19-38	15-Sep-19	21-Sep-19	Weekly Composite	13.900	0.488	0.933	0.319	0.272	0.196	0.215	0.236
19-39	22-Sep-19	28-Sep-19	Weekly Composite	1.390	0.599	0.845	1.345	0.372	0.269	0.302	0.329
19-40	29-Sep-19	5-Oct-19	Weekly Composite	0.250	0.250	0.250	0.250	1.480	0.224	0.273	0.254
19-41	6-Oct-19	12-Oct-19	Weekly Composite	0.250	0.250	0.250	0.250	0.681	0.345	0.424	0.486
19-42	13-Oct-19	19-Oct-19	Weekly Composite	0.300	0.254	0.262	0.250	0.403	0.284	0.322	0.377
19-43	20-Oct-19	26-Oct-19	Weekly Composite	1.640	0.366	0.593	0.250	0.298	0.238	0.251	0.259
19-44	27-Oct-19	2-Nov-19	Weekly Composite	0.540	0.299	0.355	0.448	0.556	0.266	0.324	0.325
19-45	3-Nov-19	9-Nov-19	Weekly Composite	2.780	0.461	0.874	0.250	0.201	0.171	0.183	0.199
19-46	10-Nov-19	16-Nov-19	Weekly Composite	0.250	0.250	0.250	0.250	0.576	0.244	0.306	0.294
19-47	17-Nov-19	23-Nov-19	Weekly Composite	0.450	0.267	0.299	0.250	0.441	0.216	0.263	0.314
19-48	24-Nov-19	30-Nov-19	Weekly Composite	1.820	0.540	0.824	1.230	2.390	0.331	0.390	0.465
19-49	1-Dec-19	7-Dec-19	Weekly Composite	0.250	0.250	0.250	0.250	0.445	0.233	0.282	0.347
19-50	8-Dec-19	14-Dec-19	Weekly Composite	0.260	0.251	0.252	0.250	0.500	0.268	0.319	0.365
19-51	15-Dec-19	21-Dec-19	Weekly Composite	0.430	0.285	0.322	0.378	0.284	0.203	0.223	0.241
19-52	22-Dec-19	28-Dec-19	Weekly Composite	0.270	0.252	0.255	0.250	0.552	0.209	0.285	0.388

Week Number	Start Date	End Date	Sample Analyzed	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile	Maximum Value	Mean	Upper 95th Confidence Limit of Mean	90th Percentile
				Leachable Lead, mg/L (LQS limit = 5.0 mg/L)				Leachable Cadmium, mg/L (LQS = 0.50 mg/L)			
2020 Weekly Composite, Daily Composite and Landfill Sample Results Including Replicates											
20-01	29-Dec-19	4-Jan-20	Weekly Composite	0.400	0.263	0.287	0.250	0.283	0.127	0.165	0.175
20-02	5-Jan-20	11-Jan-20	Weekly Composite	0.260	0.252	0.254	0.259	5.400	0.324	0.469	0.427
20-03	12-Jan-20	18-Jan-20	Weekly Composite	0.740	0.323	0.419	0.592	0.414	0.216	0.267	0.316
20-04	19-Jan-20	25-Jan-20	Weekly Composite	0.480	0.273	0.311	0.295	0.195	0.176	0.183	0.195
20-05	26-Jan-20	1-Feb-20	Weekly Composite	0.250	0.250	0.250	0.250	0.345	0.199	0.239	0.302
20-06	2-Feb-20	8-Feb-20	Weekly Composite	0.250	0.250	0.250	0.250	0.360	0.187	0.225	0.276
20-07	9-Feb-20	15-Feb-20	Weekly Composite	0.480	0.269	0.307	0.250	2.190	0.220	0.286	0.242
20-08	16-Feb-20	22-Feb-20	Weekly Composite	0.450	0.267	0.299	0.250	0.233	0.139	0.167	0.221
20-09	23-Feb-20	29-Feb-20	Weekly Composite	0.760	0.293	0.376	0.259	0.326	0.158	0.193	0.214
20-10	1-Mar-20	7-Mar-20	Weekly Composite	0.250	0.250	0.250	0.250	0.259	0.179	0.203	0.222
20-11	8-Mar-20	14-Mar-20	Weekly Composite	0.760	0.328	0.432	0.637	0.462	0.215	0.281	0.412
20-12	15-Mar-20	21-Mar-20	Weekly Composite	0.250	0.250	0.250	0.250	0.215	0.138	0.155	0.166
20-13	22-Mar-20	28-Mar-20	Weekly Composite	0.250	0.250	0.250	0.250	0.269	0.192	0.212	0.241
20-14	29-Mar-20	4-Apr-20	Weekly Composite	0.250	0.250	0.250	0.250	0.050	0.055	0.063	0.071
20-15	5-Apr-20	11-Apr-20	Weekly Composite	0.250	0.250	0.250	0.250	0.405	0.292	0.325	0.372
20-16	12-Apr-20	18-Apr-20	Weekly Composite	0.250	0.250	0.250	0.250	0.580	0.425	0.453	0.490
20-17	19-Apr-20	25-Apr-20	Weekly Composite	0.250	0.250	0.250	0.250	1.380	0.456	0.487	0.479
20-18	26-Apr-20	2-May-20	Weekly Composite	0.250	0.250	0.250	0.250	1.100	0.347	0.399	0.461
20-19	3-May-20	9-May-20	Weekly Composite	0.250	0.250	0.250	0.250	2.170	0.300	0.381	0.408
20-20	10-May-20	16-May-20	Weekly Composite	0.270	0.252	0.255	0.250	0.584	0.330	0.399	0.487
20-21	17-May-20	23-May-20	Weekly Composite	0.970	0.310	0.428	0.250	1.150	0.317	0.361	0.446
20-22	24-May-20	30-May-20	Weekly Composite	1.580	0.414	0.630	0.585	0.408	0.270	0.305	0.333

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ATTACHMENT 2

BOTTOM ASH MANAGEMENT PLAN FLOWCHART

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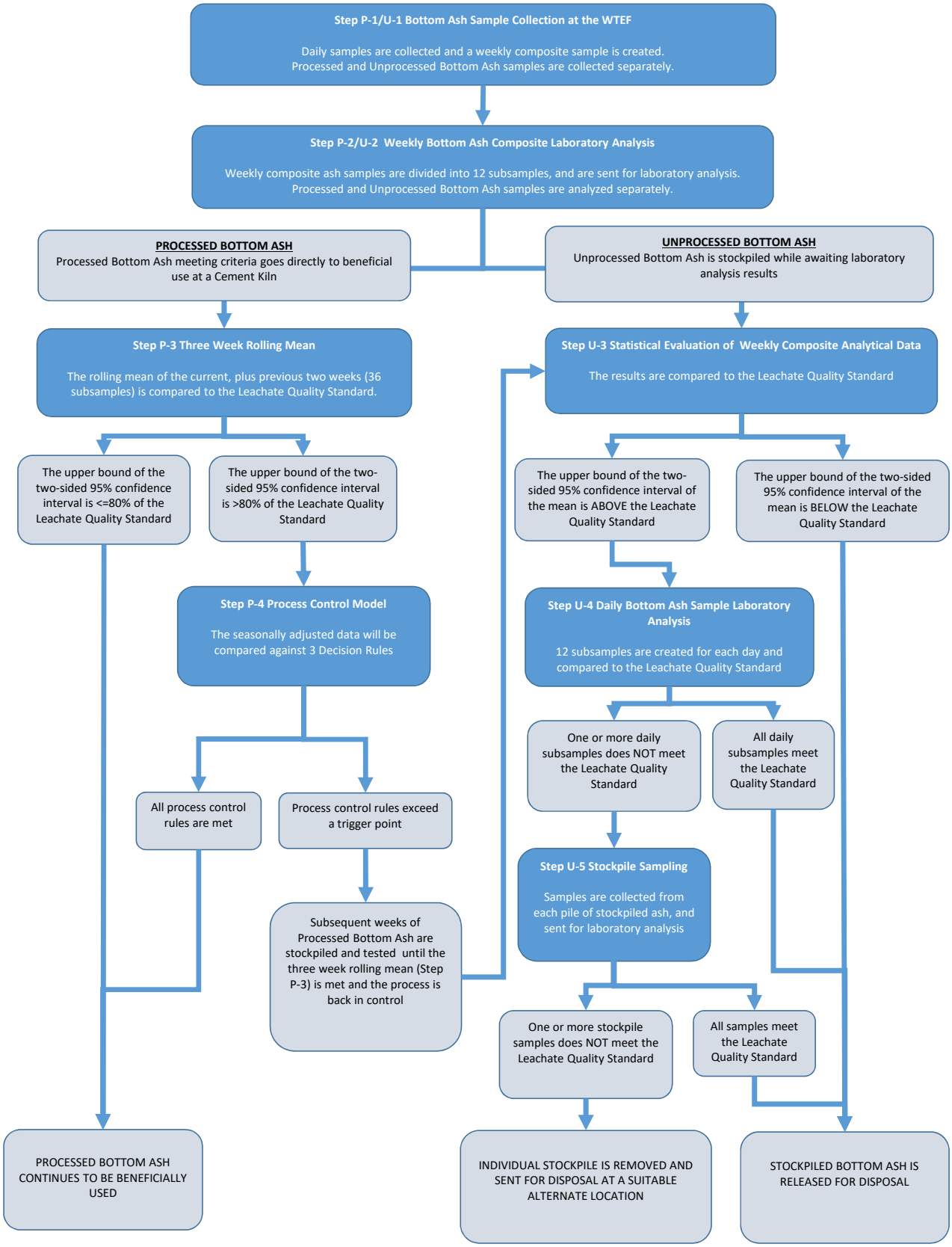
Bottom Ash Management Plan Flowchart



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ATTACHMENT 3

ENVIRONMENTAL MANAGEMENT SYSTEM OPERATIONAL PROCEDURE – BOTTOM ASH SAMPLING

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Bottom Ash Sampling

I PURPOSE

The purpose of this procedure is to:

1. Define the steps necessary to create and process a representative bottom ash weekly composite suitable for laboratory TCLP testing.
2. Define the steps to be taken to create a representative bottom ash daily composite sample
3. Minimize employee exposure to the bottom ash and to the dust generated by the bottom ash during sampling.

II REFERENCES

1. Bottom Ash and Treated Bottom Ash Safety Data Sheet
2. Directive D0001 – Routine Duties to be Performed Each Shift
3. Directive D0002 – Routine Duties to be Performed Each Week
4. Directive D0005 – Plant Housekeeping Duties
5. EMS Book 2 - Training Module #5 - Sewer & Storm Water Discharges.
6. US EPA Method 1311
7. All related JSA's

III GENERAL & DEFINITIONS

As per the BC Hazardous Waste Regulation, the toxicity characteristic of bottom ash is determined using an extraction procedure described in US EPA Method 1311. If this test produces an extract with a contaminant concentration is equal to or greater than those prescribed in Table 1 of Schedule 4 of the Regulations, the waste is considered to be hazardous. US EPA Method 1311 is commonly called the Toxicity Characteristic Leaching Procedure (TCLP).

There are 92 potential contaminates listed in Table 1 of Schedule 4. However, contaminants that are not present in the waste, or are present in such low concentrations that the regulatory limits could not be exceeded, need not be included in the TCLP test. An example of this is volatile organics; these are not expected to be found in the bottom ash since furnace temperatures exceed the boiling points of the compounds. 12 metals are regulated by Schedule 4 and are TCLP tested. Historically, in this facility and similar facilities worldwide, the bottom ash contaminants of most concern are lead and cadmium.

The TCLP test uses a minimum of 100 grams of sample; therefore, the sampling plan is a critical component in accurately determining the toxicity characteristic of the bottom ash. The objective of the sampling plan is to obtain a representative sample of the ash which exhibits the average properties of the ash as a whole. Composite sampling is used as it provides a good characterization of the variability in the bottom ash.

In this procedure, composite sampling is defined as the collection of a defined number of daily samples at a specified frequency. These samples are mixed together to form a single weekly composite. This single sample is then analyzed at the lab using the TCLP. Sampling procedures are used to describe the specific details of the different types of composite samples that may be collected. In all cases, the objective is to ensure enough samples are collected over a suitable period of time to represent the variability in the bottom ash. A suitable sampling plan will allow measurements that are both accurate and precise (repeatable).

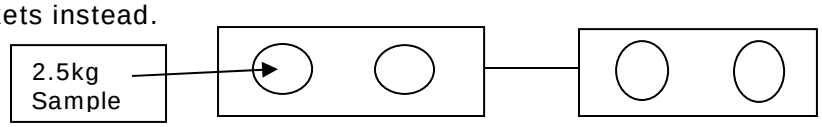
IV PROCEDURES

This procedure defines the methods used to collect both a weekly (defined as 12:00am Sunday to 12:00 midnight the following Saturday) and daily composite bottom ash sample:

DAILY COMPOSITE SAMPLE

i. Daily samples are to only be created from material loaded to the ash trucks. They are meant to be a one to one correspondence to material that is deposited in the landfill. No daily composite sample to be taken if no bottom ash truck is loaded and transported to the landfill on a particular day. While rare, there are days where no bottom ash is transported to the landfill.

ii. For each truck loaded collect a total of 10kg of Bottom Ash. Take 2 samples 2.5kg from each truck; including the truck or (pup) (total sample collected will be 10kg). Ensure you collect a minimum of 24kg in total for the day; if only 1 truck will be loaded in the day take 30kg of ash from that truck. Place the sample in a clean 5-gallon container. If there are no 5-gallon buckets, then use 2 2.5-gallon buckets instead.



iii. At the end of each day shift remove a total of 6kg from the daily samples and collect it for the weekly composite.

iv. Put a lid on the remaining daily samples, label the bucket as “Bottom Ash Daily Sample” and the date the sample was created. The labeled daily sample buckets are to be temporarily stored at the ash station in the Turbine Hall basement. At the end of the week, the daily samples are to be archived in the blue shipping container located on the apron.

WEEKLY COMPOSITE SAMPLE

i. Take the 6kg sample that was collected at the end of each day shift and deposit into the wagon located in the Turbine Hall basement.

ii. At the end of 7 days of sampling, the wagon will contain approximately 42 kg of material, ready for processing.

iii. After the weekly wagon storage pile is complete (7 days of samples), place the entire sample on a sheet of plywood and mix thoroughly. Do not discard any ash.

iv. Take a sub-sample of the weekly storage pile and, using the Sample Processing Procedure (see Section V below), process enough bottom ash to fill twelve (12) equal sized samples of approximately 2000 grams each. Use the plastic bags supplied by ALS (Lab used for testing). Fill a 2.5 gallon pail to the top with the remaining place a lid on it label as “Bottom Ash Weekly Composite Sample” and the date range for the week. Archive this sample in the TG basement until

instructed to dispose. The left over material after the 2.5 gallon pail has been filled can be disposed of.

V SAMPLE PROCESSING PROCEDURE

Refer to the attached "Bottom Ash Sampling Worksheet" to record weights

i. All the ash from the week should be in one wagon and shall be weighed prior to mixing.

ii. All ash should first be passed over a 3/8" (9.5 mm) screen.

iii. Material that does not pass through the screen is to be subjected to a particle size reduction step. Make sure to weigh the amount of >3/8" material prior to size reduction and record on the worksheet.

a. In particle size reduction, materials are reduced in size by mechanical crushing and then passed over the 3/8" screen again by using the 4 pound hammer. Do not work the material excessively (i.e. do not over crush and create a lot of fines)

Bottom Ash Sampling

iv. Material (including metal) that does not pass through the 3/8" screen and cannot be reduced in size is discarded. Ensure the weight of this material is noted on the worksheet.

v. Mix all the material that has passed through the 3/8" screen thoroughly on a piece of plywood. Ensure large and small material on the plywood is mixed thoroughly for at least three minutes.

vi. Cone and divide the pile into 4 equal portions (quarters).

vii. Place this ash into twelve (12) separate bags (supplied by ALS) by scooping material from each quarter. Use the plastic bags supplied by ALS (Lab used for testing). Put small scoops into each bag and alternate all bags until they are full (to ensure the sampling procedures are maintained as uniform as possible and result in as near-replicated samples as possible). Label the sample bags with "Bottom Ash" and the date when the sample was collected (ie; Bottom Ash from June 9-15, 2013). Put the remaining material into a 2.5 gallon bucket and seal with a lid. Note the contents of the bucket and the date when sample collected. (ie; Bottom ash from June 9-15 2013)

viii. Bring the sample containers (bags) and Bottom Ash Worksheet to the Front Desk for further labeling and shipment to the laboratory for TCLP testing.

ix. Clean the sampling equipment and wagon. Ensure the ash testing area is tidied up.

Bottom Ash Worksheet

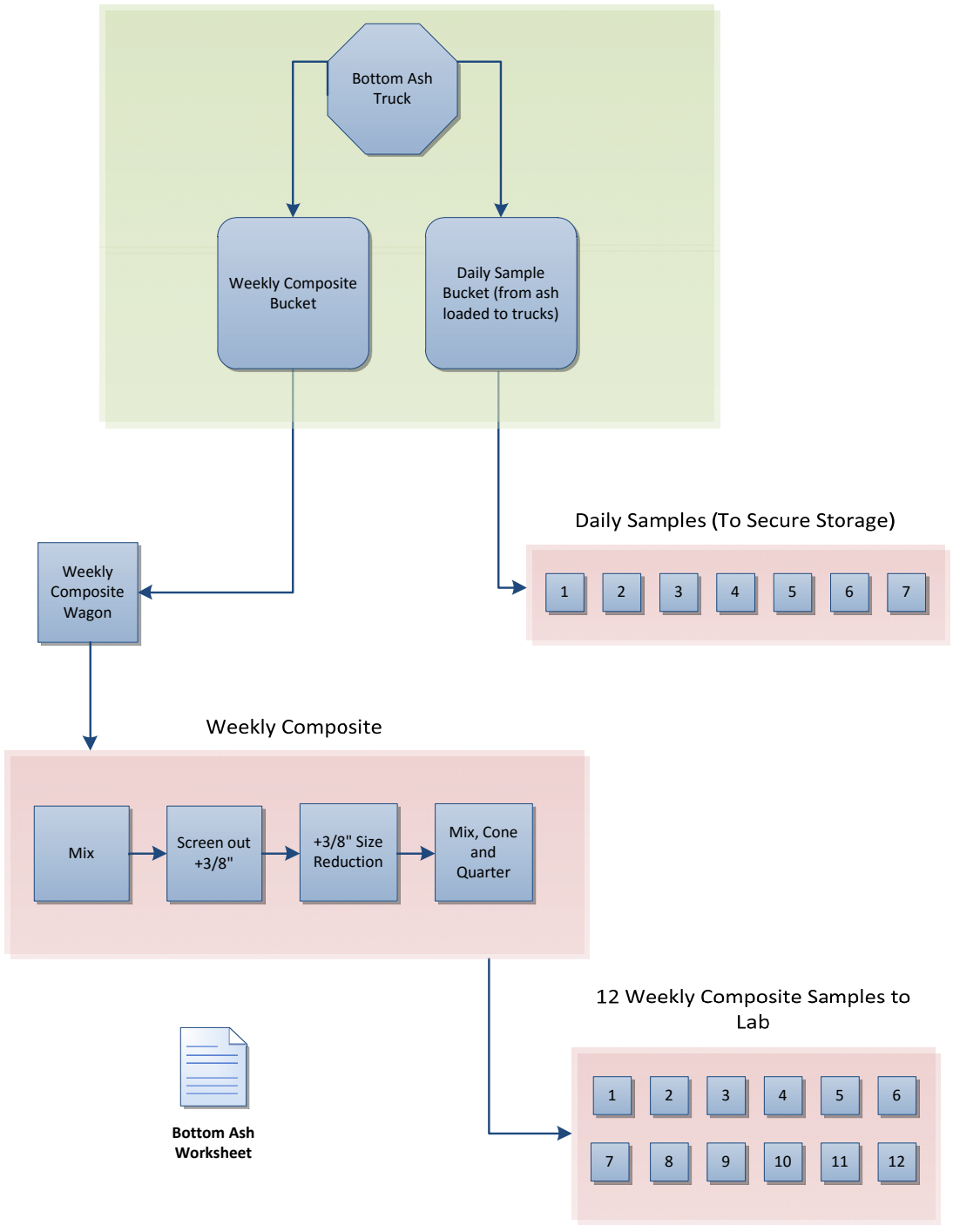
Date sample composited (DD/MM/YYYY)	
Person doing the sampling	
Total Sample Weight before processing, kg	
Weight of Material >3/8", kg	
Weight of Material that cannot be processed to <3/8" (metal, wood, etc), kg	
Final Total weight of Processed Bottom Ash, kg	

Return this form with the filled Weekly Bottom Ash Composite Sample containers

Fill twelve bags with approximately 2000g of mixed bottom ash and label each with "Bottom Ash" and the week the ash composite is from, i.e. "June 9-15, 2019"

October 1, 2018

Bottom Ash Sampling Procedure Flowchart



Revisions and Edits Log:

1. **Aug 15, 2013** – V.iii.a Removed reference to using a hammer drill and special bit for size reduction and associated photo. Added "Do not work the material excessively (i.e. do not over crush and create a lot of fines)".
2. **Aug 16, 2013** – IV section i, ii, iii and iv: Clarified daily sampling methodology. Daily samples are to be created from material loaded to the ash trucks. They are meant to be a one to one correspondence to material that is deposited in the landfill. No daily composite sample to be taken if no bottom ash is loaded and transported to the landfill on a particular day. Sampling procedures separated into "Weekly Composite" and "Daily Composite" for clarity.
3. **Aug 27, 2013** – IV section i: changed sampling material from the ash crane bucket in equal proportions of fine and larger material to take samples approximately in proportion of fine and larger material (i.e. not "equal"). Added reference to storage in a 2.5 gal container, cleaned prior to use. V section iiii: added requirement to record +3/8 material prior to size reduction. V section vi: added to ensure large and small material on the plywood is mixed thoroughly for at least three minutes. Daily Composite Sample section iii: added place sample into a clean 2.5 gallon container. Daily Composite Sample, section i: added "while rare, there are days where no bottom ash is transported to the landfill". Removed for clarity - Daily Composite Sample, section ii: "The daily sample bucket is to be filled with bottom ash sampled from the grapple that is being loaded onto a truck"; added clarification to take a 1kg sample from each pit, total of 3 kg. V section vii: Added labeling instruction for sample bottles. Added "Put small scoops in each container and alternate all containers until they are full (to ensure the sampling procedures are maintained as uniform as possible and result in as near-replicated samples as possible)". Added "dust" to Purpose, Section 3, minimizing employee exposure.
4. **Aug 28, 2013** – Purpose, section 3: Deleted reference to fumes and vapours. IV Procedures: clarified sampling period for the weekly bottom ash composite. Weekly Composite, (i): Clarified representative sample to mean collecting material from the ash bucket in the same proportion as observed in the bucket (i.e. proportion of fines to larger particles).
5. **Feb 17, 2014** – Changed all references of 500 ml bottles to @ 1000 grams sample containers. As of Feb 7, 2014 ALS supplies Covanta Burnaby with plastic bags used for sampling instead of using the 500 ml bottles. Also changed the amount of Daily bottom ash collected from one full 2.5 gallon bucket to 2 full 2.5 gallon buckets.
6. **June 19, 2014**- Removed all references to 500 ml bottles and replace with the word bags. Changed the section "Weekly Composite Sample" and changed to portions of bottom ash required for the sampling process.
7. **Dec 23, 2016**- Added procedure approval signature space.
8. **Oct 1, 2018** – Revised the "Daily Composite Sample" and 'Weekly Composite Sample" sections.

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ATTACHMENT 4

STOCKPILE SAMPING PROCEDURE

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Detailed Sampling Instructions

1.0 Stockpile Sampling Procedure

For the characterization of stockpiled bottom ash, the following site procedure will be utilized (for small stockpiles, please refer to Section 2.0):

1. Each day's ash will be considered to be a stockpile and will be assessed separately.
2. The individual truck or trailer loads will be surveyed and two labeled stakes will be placed in each individual pile; each stake will represent the respective load.
    I. The stakes will be labeled A and B.
3. A sample will be obtained from each load by the following:
    I. Obtain a minimum of three (ideally five) equally sized aliquots from three different areas of the A side by excavating at least 20cm into the face of the pile. Each aliquot should be a minimum of approximately 250mL in volume.
    II. Place all the aliquots into a clean sediment bag.
    III. Seal the sediment bag and label as "BA-LF-YY-WW-DD-A-X", where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day of the wee (1 to 7, Sunday is 1), A = A or B identifying the A or B side of the load, X = sequential number from 1 to n (where n is the number of loads included in the stockpile).
    IV. At a suitable location, process the material to create a composite sample for the load as follows:
        a. Place material from the bucket onto a sheet of plywood or into a suitable sized stainless steel bowl and mix thoroughly for 1 minute.
        b. Pass the material over a 3/8" (9.5mm) screen.
        c. Material that does not pass through the screen is to be subjected to a particle size reduction step. Make sure to weigh the amount of >3/8" material prior to size reduction and record on a worksheet.
            - In particle size reduction step, material reduced in size by mechanical crushing are passed over the 3/8" screen again. Do not work the material excessively (i.e. do not over crush and create a lot of fines).
            - Material (including metals) that do not pass through the 3/8" screen and cannot be reduced in size is discarded. Ensure the weight of this material is noted on the worksheet.
        d. Mix all the material that has passed through the 3/8" screen thoroughly on a piece of plywood or into a suitable sized stainless steel bowl. Ensure large and small material is mixed thoroughly for at least 3 minutes.
        e. Cone and divide the composited material into 4 equal portions (quarters).
        f. Place this ash into clean sample containers by scooping material from each quarter. Put small scoops into the containers until they are full. Ensure each sample container is filled to the top and at a minimum 1 kg of sample is in the containers. Discard the remaining material back to the stockpile from which the material was collected.
        g. Label the sample containers "BA-LF-YY-WW-DD-A-X", where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day of the week (1

to 7, Sunday is 1), A = A or B identifying the A or B side of the load, X = sequential number from 1 to n (where n is the number of loads for the day).

V. For one in ten samples (or a portion of 10), a duplicate sample will be prepared and analyzed as a blind duplicate and will be prepared as follows:
    a. When a duplicate sample is to be prepared, then step 3.iv.f is amended as follows: fill the original and duplicate containers by putting scoops into the containers by alternating between the containers (i.e. do not fill them sequentially; alternating between containers will ensure the sampling procedures are maintained as uniform as possible and result in as near-replicated samples as possible).
    b. Label the duplicate sample containers with "BA-LF-YY-WW-DD-A-X+100", where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day (1 to 7, Sunday is 1), A = A or B, X+100 = the number of the identifying the load (same number as the original sample) plus 100. For example, the duplicated for BA-LF-16-38-02-A-3 would be BA-LF-16-38-02-A-103.

4. Based on this procedure, for analysis of bottom ash from one day, a minimum of six aliquots per load will be obtained for two laboratory samples (a minimum of three aliquots will be composited from each of the A and B side). Therefore, for example, for a day with 5 loads (trucks with trailer - there will be 10 loads), a minimum of 60 aliquots will be obtained and composited into 20 samples for the stockpile.
5. All samples will be submitted to ALS or equivalent for analysis for TCLP metals and/or pH (2:1) for the identified parameter(s).

2.0 Special Consideration for Small Stockpiles

If only a small amount of bottom ash (i.e. fewer than 5 loads, i.e fewer than 3 haul trips of truck and trailer combination) was delivered for a given day, the procedure under 5.1.1 is modified as follows:

1. Each day's ash will be considered to be a stockpile and will be assessed separately.
2. The individual truck or trailer loads will be visually surveyed and a sufficient number of labeled stakes will be placed in each individual load to obtain a minimum of 10 samples. For example, if there is 1 load, then 10 stakes will be placed into that load. If there are 2 loads, then each load will be subdivided into 5 equal parts and staked. If there are 3 loads, each load will be divided into 4 equal parts and staked. If there are 4loads, each will be subdivided into 3 equal parts and staked.
    I. The stakes will be labeled A, B, C…..as required.
3. A sample will be obtained from each staked portion by the following:
    I. Obtain a minimum of three (ideally five) equally sized aliquots from three different areas of the A staked portion by excavating at least 20cm into the face of the pile. Each aliquot should be a minimum of approximately 250mL in volume.
    II. Place all the aliquots into a clean sediment bag.
    III. Seal the sediment bag and label as "BA-LF-YY-WW-DD-A-X", where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day of the wee (1 to 7, Sunday is 1), A = A or B identifying the A or B side of the load, X = sequential number from 1 to n (where n is the number of loads included in the stockpile).

IV. At a suitable location, process the material to create a composite sample as described in Section 5.1.1. Label the sample containers “BA-LF-YY-WW-DD-A-X”, where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day of the wee (1 to 7, Sunday is 1), A = A or B identifying the A or B side of the load, X = sequential number from 1 to n (where n is the number of loads for the day).

V. For one in ten samples (or a portion of 10), a duplicate sample will be prepared and analyzed as a blind duplicate and will be prepared as described in Section 5.1.1. Label the duplicate sample containers with “BA-LF-YY-WW-DD-A-X+100”, where BA = bottom ash, LF = Landfill, YY = year, WW = week (1 to 52), DD = day (1 to 7, Sunday is 1), A = A or B, X+100 = the number of the identifying the load (same number as the original sample) plus 100. For example, the duplicated for BA-LF-16-38-02-A-3 would be BA-LF-16-38-02-A-103.

VI. Decontaminate all sampling equipment.

4. All samples will be submitted to ALS or equivalent for analysis for TCLP metals and/or pH (2:1) for the identified parameter(s).


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