TECHNICAL MEMORANDUM

DATE	October 14, 2014	**PROJECT No.**	1114220046-553-TM-Rev0
TO	Derek Holmes BURNCO Rock Products Ltd		
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BURNCO AGGREGATE PROJECT AT MCNAB CREEK/HOWE SOUND, BC – SOURCE MEASUREMENT PROGRAM FOR BURNCO SPRINGBANK AGGREGATE PIT IN ALBERTA

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by BURNCO Rock Products Ltd. (BURNCO) to conduct an Environmental Impact Assessment (EIA) for the BURNCO Aggregate Project in Howe Sound, BC (the Project). The focus of this technical memorandum is potential project-related noise effects and computer generated noise model that will include representations of source acoustics of proposed Project equipment. Sound sources of comparable or similar scale aggregate operation equipment to that proposed for the Project were measured at BURNCO and third-party and processing facilities in Alberta (AB), British Columbia (BC), and Manitoba (MB) during the summer of 2012. These source acoustic data will be used as input into the modelled conditions for the proposed Project. This technical memorandum presents results from sound source measurements conducted at the BURNCO Springbank Operation Site (Springbank) near Calgary, AB.

As described in the Environmental Assessment Project Description (Golder 2011), major sound sources associated with the Project will include aggregate crushing and screening equipment. The crushing and screening equipment at Springbank is consistent or comparable to the equipment being proposed for use with the Project. The results of the sound source measurements at Springbank aggregate site are included in this Technical Memorandum. These measurements, scaled appropriately for actual Project operations, will serve as inputs to the computer noise model used to assess noise impacts in the Project Noise Impact Assessment (NIA).

2.0 SOUND SOURCES AT SPRINGBANK OPERATION SITE

Operation at Springbank was divided among three areas including:

- Crush plant,
- Wash plant, and
- Sorting and storage area.

The aggregate operation at Springbank comprised the following general process and facility components.

a) Aggregate material extracted from the Springbank pit was transported by truck to the crush plant;

b) Crushed and screened material was transported via a conveyor system, dump trucks, and front end loaders to the wash plant; and

c) Screened and washed material was transported via a conveyor system to the sorting and storage area.

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Major sound sources located within the crush plant included:

- Dump trucks depositing aggregate material into one hopper;
- Two electric motor powered crushers in canvas sheds;
- Two electric motor powered screens in canvas sheds;
- One conveyor system consisting of about 240 metres (m) of conveyor for aggregate transport, connecting crushers, screens and wash plant;
- Aggregate material falling from crushers and screens onto conveyors; and
- Two trailer-mounted generator sets (gensets) and associated coolers.

Major sound sources located within the wash plant included:

- One front end loader depositing aggregate material into one hopper;
- One outdoor electric motor powered screen;
- One electric motor powered washer unit;
- One electric motor powered washer pump;
- One trailer-mounted genset and associated cooler;
- One conveyor system consisting of about 200 m of conveyor for aggregate transport, connecting washer, screen and sorting and storage area; and
- One cement truck being loaded on the periphery of the wash plant area.

During the measurement program there were no major sound sources within the sorting and storage area except the dump trucks and front end loaders transporting material to/from the crush plant and wash plant.

Photos from the site identify the location and spacing of equipment measured as sound sources.

- Photo 1 shows some of the equipment associated with the crush plant; canvas sheds for two crushers and two screens, the hopper that serves as the front end of the crush plant, and several conveyors.
- Photo 2 shows some of the equipment associated with the wash plant; one outdoor screen, one trailer-mounted genset, several aggregate stockpiles, one office trailer, one front end loader, and several conveyors.

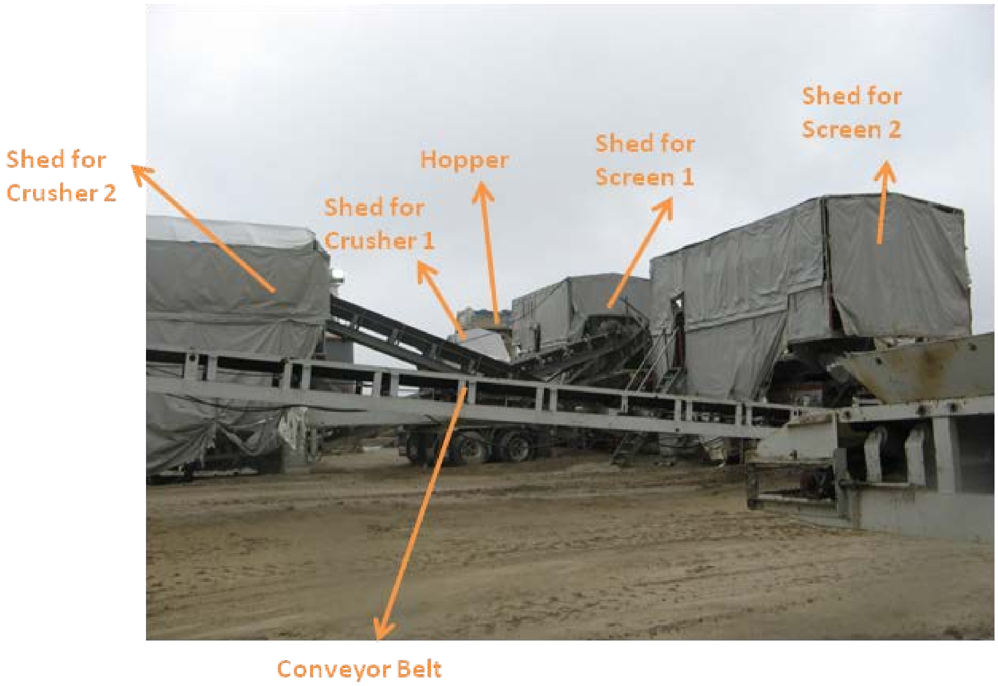

Photo 1: Some of the Equipment Associated with the Crush Plant

Photo 2: Some of the Equipment Associated with the Wash Plant

3.0 SOUND SOURCE MEASUREMENT METHODS AND RESULTS

The envelope and the concentrated source methods were used to measure sound pressure levels and calculate sound power levels (PWLs) for individual pieces of equipment. The concentrated source method was also used to estimate the total PWL of the crush plant as a whole and the wash plant as a whole (i.e., treating the crush plant as a single source and the wash plant as a single source). The specific measurement and calculation techniques associated with both the envelope and concentrated source methods are described in detail in the document *BURNCO Aggregate Project at McNab Creek / Howe Sound, BC – Source Measurement Program for Pine Ridges Inland Clamshell Operation* (Golder 2012). The results of the Springbank source measurements are presented in the following sub-sections.

3.1 Envelope Method

The envelope method was used to measure sound pressure for:

- crushers and electric motors,
- screens and electric motors,
- conveyors and motors,
- gensets,
- falling sand and gravel,
- washer unit and electric motors, and
- washer pump and motor

Measurement contamination from nearby equipment can be neglected based on what was audible in the field at the measurement location and the distance of less than 0.5 m between the measurement points and the surface of the equipment, and a spacing distance of at least 2 m between other equipment sound sources.

The results of sound measurements for the above equipment using the envelope method are presented in Sections 3.1.1 to 3.1.9.

3.1.1 Crushers in the Crush Plant

As shown in Photo 1, within the crush plant were two crushers (Crusher 1 and Crusher 2) housed inside canvas sheds. Photo 3 shows the inside of the canvas shed housing Crusher 1. Photo 4 shows the inside of the canvas shed housing Crusher 2.

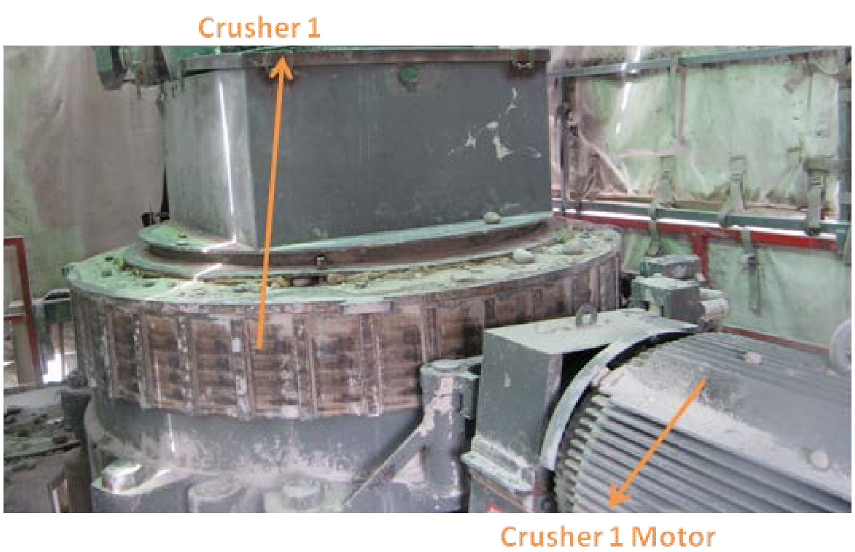

Photo 3: Inside the Canvas Shed Housing Crusher 1 and its Motor

Photo 4: Inside the Canvas Shed Housing Crusher 2 and its Motor

For each crusher, L_{eq} was measured on the surface of an assumed envelope surrounding the equipment. In this case, the envelope was defined to surround only the crushers themselves – the crusher motors were characterized using a separate measurement (see Section 3.1.2). The measured L_{eq} values were then used to calculate the PWL for each crusher. The measurement surface areas were 30.8 square metres (m^2) and 47.4 m^2 for Crusher 1 and Crusher 2, respectively.

For the following reasons, the sound reduction associated with the walls and roofs of the canvas sheds is assumed to be zero:

- Canvas is known to have a low sound transmission loss;
- There were large openings in the walls of each canvas shed to accommodate conveyors transporting aggregate material to and from the crushers, and to accommodate access by workers;
- There were considerable gaps between the canvas walls and roofs; and
- Housing the crushers inside canvas sheds was primarily a dust control strategy – not a noise control strategy.

Table 1 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for Crusher 1 and Crusher 2.

Table 1: Measured L_{eq} and Calculated PWLs for Crushers

Equipment	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Crusher 1	L_{eq} [dBA]	60.1	75.6	88.0	93.6	92.6	96.1	95.2	94.3	86.5	101.8
	PWL [dBA]	77.8	93.3	105.7	111.3	110.3	113.8	112.9	112.0	104.2	119.5
Crusher 2	L_{eq} [dBA]	46.4	56.3	78.1	79.9	85.9	90.6	91.9	89.9	89.8	97.1
	PWL [dBA]	67.7	77.6	99.4	101.2	107.2	111.9	113.2	111.2	111.1	118.4

3.1.2 Crusher Motors in the Crush Plant

There was one large motor associated with Crusher 1 and one large motor associated with Crusher 2. The motors for Crusher 1 and Crusher 2 are shown in Photo 3 and Photo 4, respectively. For each crusher motor, L_{eq} was measured on the surface of an assumed enveloped surrounding the equipment. The measured L_{eq} values were then used to calculate PWL for each crusher motor. The measurement surface areas were 9.5 m^2 and 9.4 m^2 for Crusher 1 motor and Crusher 2 motor, respectively.

Table 2 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for the motors associated with Crusher 1 and Crusher 2.

Table 2: Measured L_{eq} and Calculated PWLs for Crusher Motors

Equipment	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Crusher 1 Motor	L_{eq} [dBA]	51.9	64.0	79.0	88.9	96.0	101.0	100.7	95.0	91.1	105.3
	PWL [dBA]	61.7	73.8	88.8	98.7	105.8	110.8	110.5	104.8	100.9	115.1
Crusher 2 Motor	Leq [dBA]	51.2	62.5	77.9	88.6	94.6	99.4	99.7	93.8	89.4	104.0
	PWL [dBA]	61.0	72.3	87.7	98.4	104.3	109.1	109.5	103.6	99.2	113.7

3.1.3 Vibrating Screens with Motors in the Crush and Wash Plant

As shown in Photo 1, within the crush plant were two vibrating screens (Screen 1 and Screen 2) housed inside canvas sheds. Because the screens took up almost all of the space inside their respective canvas sheds, it was not possible to take any useful photos of Screen 1 or Screen 2 showing the equipment in close-up. The maximum dimension of an average piece of aggregate material associated with Screen 1 was observed to be between 10 centimetres (cm) and 20 cm. The maximum dimension of an average piece of aggregate material associated with Screen 2 was observed to be between 7 cm and 10 cm.

Photo 2 shows one outdoor vibrating screen (Screen 3) within the wash plant Screen 3 is shown in more detail in Photo 5. The aggregate material associated with Screen 3 was observed to be much finer (i.e., more highly refined) than the aggregate material associated with the screens in the crush plant; the maximum dimension of an average piece of aggregate material associated with Screen 3 was observed to be between 2 cm and 5 cm.

Photo 5: Screen 3 in the Wash Plant

For each screen, L_{eq} was measured on the surface of an assumed envelope surrounding the equipment – both the vibrating screen and its associated motor. The measured L_{eq} values were then used to calculate PWL for each screen. The measurement surface areas were 48.0 m^2 for Screen 1, 57.4 m^2 for Screen 2, and 32.3 m^2 for Screen 3.

Table 3 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for Screen 1, Screen 2, and Screen 3, along with their associated motors.

Table 3: Measured L_{eq} and Calculated PWLs for Vibrating Screens and Associated Motors

Equipment	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Screen 1 in Crush Plant	L_{eq} [dBA]	64.7	69.1	76.8	83.0	94.4	98.5	100.9	99.96	95.5	105.5
	PWL [dBA]	84.2	88.6	96.3	102.5	113.9	118.0	120.4	119.5	115.0	125.1
Screen 2 in Crush Plant	L_{eq} [dBA]	54.1	60.2	74.4	82.5	90.8	94.1	96.8	97.6	94.7	102.4
	PWL [dBA]	74.7	80.8	95.0	103.1	111.4	114.7	117.4	118.2	115.3	123.0
Screen 3 in Wash Plant	L_{eq} [dBA]	55.8	78.0	78.9	93.3	83.0	75.2	75.3	61.5	73.7	94.1
	PWL [dBA]	70.9	93.1	94.0	108.4	98.1	90.3	90.4	76.6	88.8	109.2

3.1.4 Conveyors in the Crush and Wash Plant

The conveyor system at Springbank included:

- Several interconnected conveyors,approximately 210 m long, operating in the crush plant; and
- Several interconnected conveyors, approximately 240 m long, operating in the wash plant.

The PWLs of the individual conveyors were observed to depend primarily on the size of the aggregate material being transported: smaller, more refined aggregate material tended to result in a lower PWL than coarser, less refined aggregate material. For example, the crush plant conveyor (shown in Photo 1 and Photo 6) that was used to transport relatively coarse aggregate material from Screen 1 to Screen 2 was observed to be louder than the wash plant conveyor (shown in Photo 2 and Photo 7) that was used to transport relatively fine aggregate material from Screen 3 to the washer unit.

Photo 6: Crush Plant Conveyors

Photo 7: Wash Plant Conveyors

L_{eq} for these two conveyors, which are believed to be representative of the other conveyors in use at Springbank, were measured on the surface of assumed envelopes around each conveyor. These measured L_{eq} values were then used to calculate corresponding PWLs. The measurement surface area was 31.9 m^2 for the crush plant conveyor and was 33.0 m^2 for the wash plant conveyor.

Table 4 presents the measured L_{eq} and calculated PWLs per meter in octave bands (31.5 Hz - 8000 Hz) for each of the conveyors.

Table 4: Measured L_{eq} and Calculated PWLs for Conveyors

Equipment	Measured L_{eq} /Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Crush Plant Conveyor	L_{eq} [dBA]	44.9	63.0	81.7	80.6	87.1	79.2	76.3	76.0	73.1	89.8
	PWL/m [dBA]	45.3	63.4	82.1	81.0	87.5	79.6	76.7	76.4	73.5	90.2
Wash Plant Conveyor	L_{eq} [dBA]	41.5	52.3	64.5	66.8	70.8	71.7	70.4	65.6	60.4	77.0
	PWL/m [dBA]	41.9	52.7	64.9	67.2	71.2	72.1	70.8	66.0	60.8	77.4

3.1.5 Conveyor Motors in the Crush and Wash Plant

The conveyor motors in use at Springbank can be broadly divided into two types. One type of conveyor motor (Conveyor Motor 1) was located at the ends of various outdoor conveyors within the crush plant and wash plant; photo 8 shows this type of conveyor motor. The second type of conveyor motor (Conveyor Motor 2) was located inside the canvas sheds housing crushers and screens in the crush plant; photo 9 shows this type of conveyor motor.

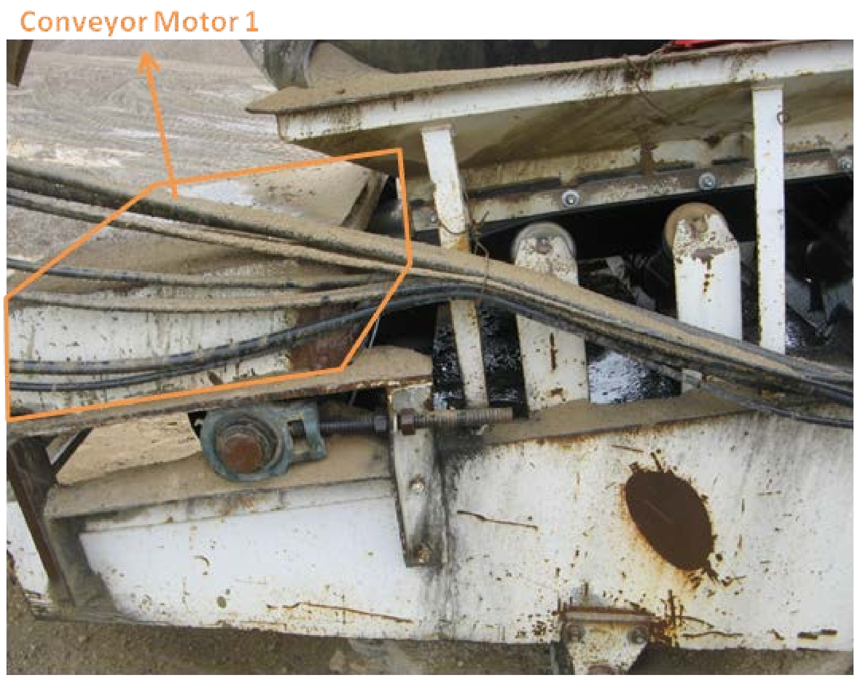

Photo 8: Conveyor Motor 1

Photo 9: Conveyor Motor 2

For each type of conveyor motor, L_{eq} was measured on the surface of an assumed envelope surrounding the motor itself, as well as the associated gear box and adjacent belt rollers. These measured L_{eq} values were then used to calculate corresponding PWLs. The measurement surface area was 5.3 m^2 for Conveyor Motor 1 and 5.8 m^2 for Conveyor Motor 2.

Table 5 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for both types of conveyor motor.

Table 5: Measured L_{eq} and Calculated PWLs for Conveyor Motors

Equipment	Measured L_{eq} / Calculated PWLs	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Conveyor Motor 1	L_{eq} [dBA]	44.1	59.7	69.3	77.3	81.9	83.1	80.3	78.1	69.3	87.8
	PWL [dBA]	51.3	66.9	76.5	84.5	89.1	90.3	87.5	85.3	76.5	95.0
Conveyor Motor 2	L_{eq} [dBA]	41.5	52.6	64.8	77.0	83.4	87.8	89.2	85.3	78.7	93.3
	PWL [dBA]	49.1	60.2	72.4	84.6	91.0	95.4	96.8	92.9	86.3	100.9

3.1.6 Generator Sets in the Crush Plant and the Wash Plant

There were two gensets (Genset 1 and Genset 2) side by side in the crush plant. As shown in Photo 10, Genset 1 and Genset 2 were mounted on separate trailers with their coolers oriented to point out the open end. There was one genset (Genset 3) in the wash plant. Genset 3 was mounted on a trailer with its cooler oriented to point out the open trailer end (see photos 2 and 11). For all three gensets the cooler was observed to be the most dominant sound source.

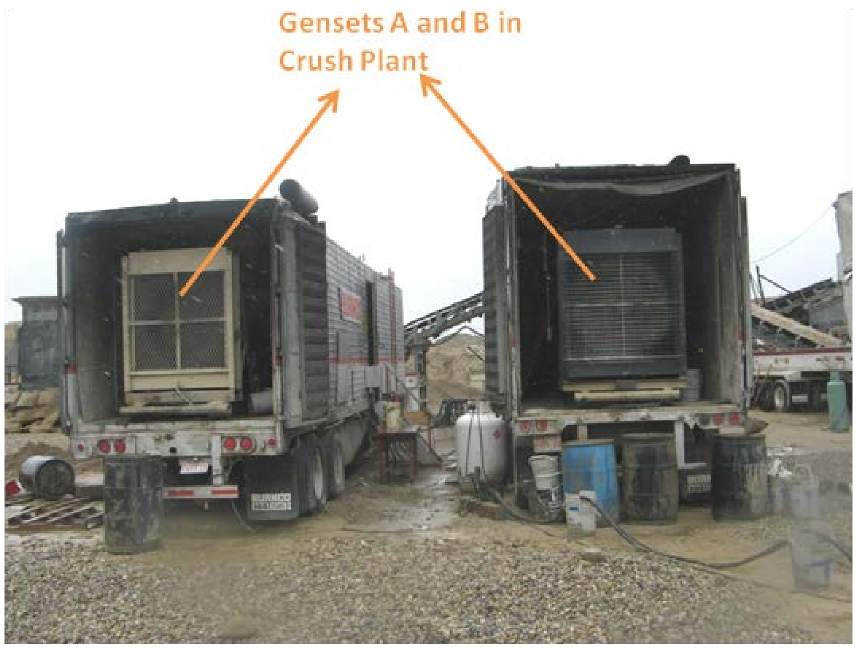

Photo 10: Genset 1 and Genset 2 in the Crush Plant

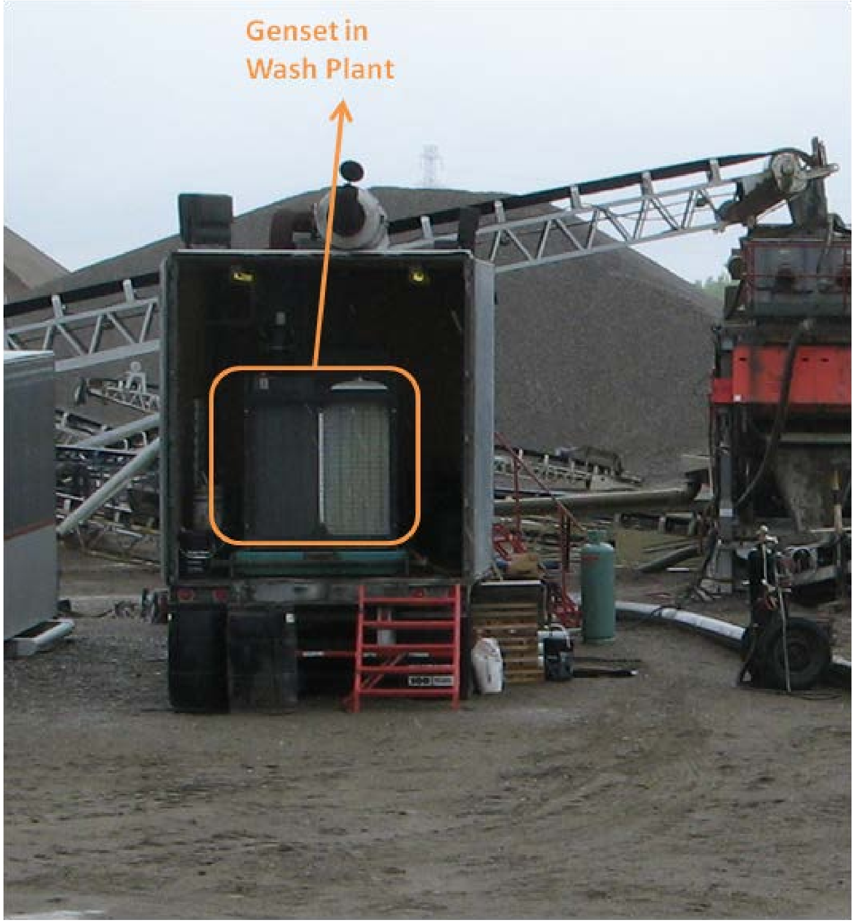

Photo 11: Genset 3 in the Wash Plant

For each genset, L_{eq} was measured on the surface of an assumed envelope surrounding the cooler. The measured L_{eq} values were then used to calculate the corresponding PWLs. The measurement surface area was 1.8 m^2 for Genset 1, 2.0 m^2 for Genset 2, and 2.4 m^2 for Genset 3.

Table 6 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for Genset 1, Genset 2, and Genset 3.

Table 6: Measured L_{eq} and Calculated PWLs for Gensets

Equipment	Measured L_{eq} / Calculated PWLs	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Genset 1 (Crush Plant)	L_{eq} [dBA]	57.5	71.2	89.6	99.5	100.5	103.6	103.3	98.3	90.1	108.7
	PWL [dBA]	60.1	73.8	92.2	102.1	103.1	106.2	105.9	100.9	92.7	111.2
Genset 2 (Crush Plant)	Leq [dBA]	55.4	67.3	85.2	93.5	94.7	95.3	97.0	93.8	88.1	102.3
	PWL [dBA]	58.3	70.2	88.1	96.4	97.6	98.2	99.9	96.7	91.0	105.2
Genset 3 (Wash Plant)	Leq [dBA]	52.0	68.8	86.4	99.3	98.6	98.9	98.4	95.9	90.3	105.6
	PWL [dBA]	54.6	71.4	89.0	101.9	101.2	101.5	101.0	98.5	92.9	108.1

3.1.7 Falling Sand and Gravel in the Crush and Wash Plant

In both the crush and the wash plant sand and gravel falling from conveyors was observed to be a major sound source. A single measurement intended to characterize all instances of falling aggregate material was conducted near Crusher 1. The falling aggregate near Crusher 1 is assumed to be representative of falling aggregate at other locations around Springbank. The maximum range in dimension of aggregate material observed at Crusher 1 was 5 to 7 centimetre (cm) in diameter. L_{eq} was measured on the surface of an assumed envelope surrounding the falling aggregate material. The measured L_{eq} value was then used to calculate PWL. The measurement surface area was 2 m^2.

Table 7 presents the measured L_{eq} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) for falling aggregate material near Crusher 1.

Table 7: Measured L_{eq} and Calculated PWL for Falling Aggregate Material near Crusher 1

Equipment	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Aggregate Material Falling from Crusher 1	L_{eq} [dBA]	47.1	61.0	76.5	89.5	96.0	100.3	100.6	95.9	93.4	105.2
	PWL [dBA]	50.1	64.0	79.5	92.5	99.0	103.3	103.6	98.9	96.4	108.2

3.1.8 Washer Unit with Motors in the Wash Plant

There was one two-level washer unit located in the wash plant, which is shown in Photo 12. Individual sound sources associated with the washer unit included small motors, moving/falling aggregate and moving/falling water. L_{eq} for the washer unit as a whole was measured on the surface of an assumed envelope large enough to surround each of the individual sources. The measured L_{eq} value was then used to calculate PWL. The measurement surface area was 86.5 m^2.

Photo 12: Washer Unit in the Wash Plant

Table 8 presents the measured L_{eq} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) of the washer unit including associated motors.

Table 8: Measured L_{eq} and Calculated PWL of Washer Unit

Equipment	Recorded L_{eq} / Calculated PWLs	Central Frequencies of Octave Bands [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Washer Unit	L_{eq} [dBA]	50.7	61.6	78.2	82.2	73.7	87.0	71.8	82.4	74.2	89.9
	PWL [dBA]	70.1	81.0	97.6	101.6	93.1	106.4	91.2	101.8	93.6	109.3

3.1.9 Washer Pump with Motor in the Wash Plant

Adjacent to the washer unit, but separate from the measurement described in Section 3.1.9, was an electric motor powered pump that supplied water to the washer unit. The washer pump is pictured in Photo 13. L_{eq} for the washer pump including its associated motor was measured on the surface of an assumed envelope. The measured L_{eq} value was then used to calculate the PWL. The measurement surface area was 7.4 m^2.

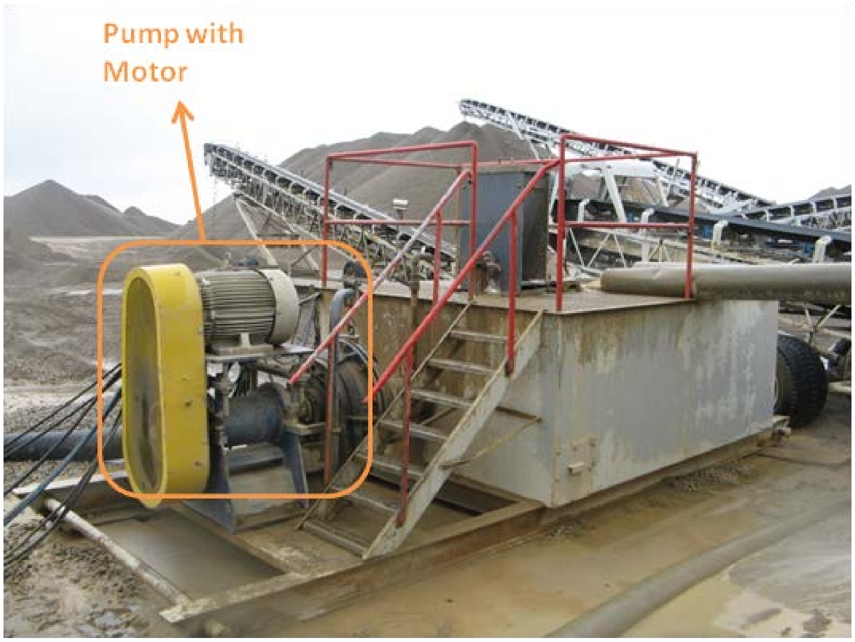

Photo 13: Washer Pump with Motor in the Wash Plant

Table 9 presents the measured L_{eq} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) for the washer pump including its motor.

Table 9: Measured L_{eq} and Calculated PWL for Washer Pump with Motor

Equipment	Measured L_{eq} / Calculated PWLs	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Washer Pump with Motor	L_{eq} [dBA]	42.3	55.3	70.6	77.4	79.7	81.4	83.3	84.2	82.8	89.9
	PWL [dBA]	51.0	64.0	79.3	86.1	88.4	90.1	92.0	92.9	91.5	98.5

3.2 Concentrated Source Measurement Method

Dump trucks depositing aggregate material into the hopper feeding the crush plant, front end loaders depositing material into the hopper feeding the wash plant, loading of a cement truck on the periphery of the wash plant, and a dump truck hauling aggregate material were all characterized using the concentrated source method. In addition, for the purposes of calibration and confirmation:

- One measurement for Genset 1 and Genset 2 was conducted using the concentrated source method and compared to the envelope method results presented in Table 6;
- One measurement for Genset 3 was conducted using the concentrated source method and compared to the envelope method results presented in Table 6;
- One measurement for the washer unit was conducted using the concentrated source method and compared to the envelope method results presented in Table 8;
- Two measurements for the crush plant as a whole were conducted using the concentrated source method and compared to the sum of the measurement results for relevant pieces of equipment; and
- Two measurements for the wash plant as a whole were conducted using the concentrated source method and compared to the sum of the measurement results for relevant pieces of equipment.

Because the propagation distance between source and measurement point is greater in the concentrated source method than in the envelope method, there is greater potential for contamination of the measurement by sources other than the equipment being studied. However, because the concentrated source method does not rely on an envelope, the concentrated source method does not require accurate knowledge of source dimensions. Although it is usually easy enough to measure equipment dimensions, it is not always obvious which part(s) of the equipment are actually radiating sound and this uncertainty can lead to inaccuracies in PWL values obtained via the envelope method – inaccuracies that are absent from the concentrated source method.

The results of sound measurements for the above equipment using the concentrated source method are presented in Sections 3.2.1 to 3.2.8.

3.2.1 Dump Truck Filling Hopper in the Crush Plant

The concentrated source method was used to determine the PWL of a dump truck depositing material into the hopper that served as the front end of the crush plant. The crush plant hopper is shown in Photo 1 and again in Photo 14.

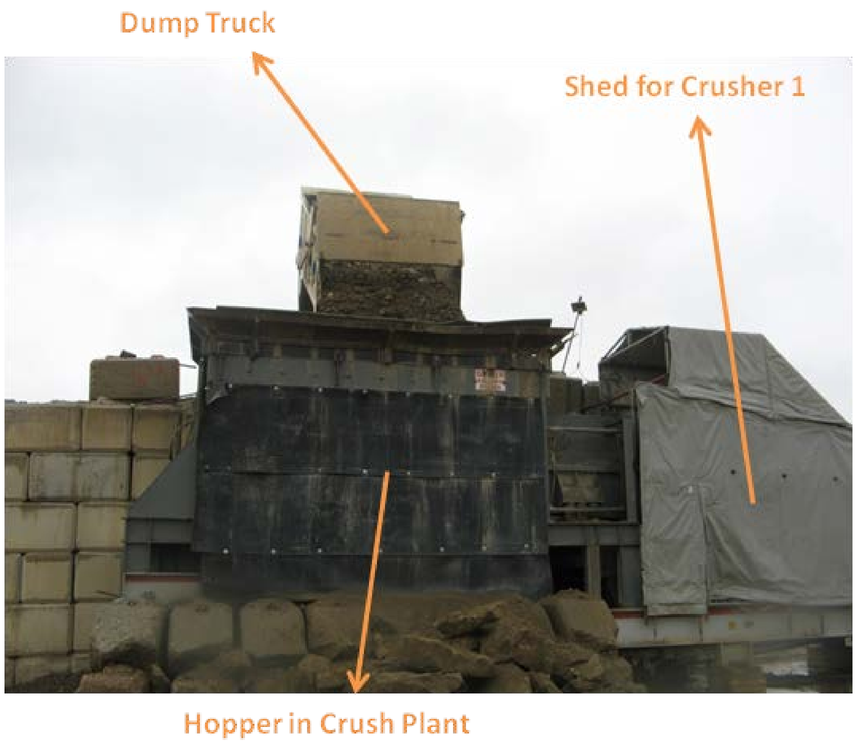

Photo 14: Dump Truck Filling Hopper in Crush Plant

The average measurement distance was 14 m and there was an unobstructed line of sight between the measurement location and the hopper loading activities. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The distance between the measurement location and other crush plant sound sources (i.e., potential sources of measurement contamination) was estimated to be greater than 30 m. Based on envelope measurements of Crusher 1, this equipment was estimated to contaminate the measurement of hopper loading activities by about 1 dB. Contamination from other sources was considered to be negligible.

Table 10 presents the measured L_{eq} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) for the dump truck depositing aggregate material in the crush plant hopper. Note that L_{eq} shown in Table 10 are adjusted sound levels by subtracting 1 dB from the raw measurement data by to account for measurement contamination by Crusher 1.

Table 10: Measured L_{eq} and Calculated PWL for Dump Truck Filling Crush Plant Hopper

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Dump Truck Filling Crush Plant Hopper	L_{eq} [dBA]	54.9	60.3	69.6	80.1	81.9	82.0	79.7	77.0	68.9	88.6
	PWL [dBA]	82.8	88.2	101.5	112.0	113.8	113.9	111.6	108.9	100.8	120.5

3.2.2 Front End Loader Filling Hopper in the Wash Plant

The concentrated source method was used to determine the PWL of a front end loader depositing material into the hopper that served as the front end of the wash plant. The filling of the wash plant hopper is shown in Photo 15.

Photo 15: Front End Loader Filling Wash Plant Hopper

The average measurement distance was 20 m and there was an unobstructed line of sight between the measurement location and the hopper loading activities. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The distance between the measurement location and other wash plant sound sources (i.e., potential sources of contamination) was estimated to be greater than 50 m and, as a result, sound from the hopper filling activities was observed to be dominant at the measurement location. Therefore, contamination from other sound sources was considered to be negligible.

Table 11 presents the measured L_{eq} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) for the front end loader filling the wash plant hopper.

Table 11: Measured L_{eq} and Calculated PWL for Front End Loader Filling Wash Plant Hopper

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Front End Loader Filling Wash Plant Hopper	L_{eq} [dBA]	32.5	64.7	66.6	59.7	64.8	64.4	61.4	57.6	51.0	72.2
	PWL [dBA]	63.5	95.7	101.6	94.7	99.8	99.5	96.5	93.0	87.4	106.7

3.2.3 Cement Truck near the Wash Plant

At the time of the measurement program there was a large cement truck being loaded at the edge of the wash plant area. As shown in Photo 16, while being loaded the cement truck was parked partially inside a metal building – the back end of the truck was entirely within the building and the front end of the truck protruded from the building.

Photo 16: Cement Truck loading near the Wash Plant

The concentrated source method was used to determine the PWL of cement truck at two points during the loading process: when the truck first arrived at the loading building and was almost empty, and when the truck was just about to leave the loading building and was almost full. Both measurements were conducted from a distance of 14 m with an unobstructed line of sight between source and measurement location. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The distance between the measurement location and other wash plant equipment (i.e., potential sources of measurement contamination) was estimated to be greater than 70 m and, as a result, sound from the cement truck loading activities was observed to be dominant at the measurement location. Therefore, contamination from other sound sources was considered to be negligible.

Table 12 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for the cement truck during two points in the loading process.

Table 12: Measured L_{eq} and Calculated PWLs for Cement Truck Loading

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Cement Truck Upon Arrival at Loading Building	L_{eq} [dBA]	24.5	42.5	60.7	63.1	70.0	75.0	72.8	71.0	67.8	79.2
	PWL [dBA]	52.4	70.4	92.6	95.1	101.9	106.9	104.7	102.9	99.7	111.1
Cement Truck Immediately Before Leaving Loading Building	L_{eq} [dBA]	24.4	46.9	66.1	63.9	76.5	80.7	77.3	74.6	65.7	84.1
	PWL [dBA]	52.3	74.8	98.0	95.8	108.4	112.6	109.2	106.5	97.6	116.0

3.2.4 Dump Truck Hauling Aggregate Material

The concentrated source method was used to determine the PWL of a loaded dump truck hauling material between the crush and the wash plant. The maximum L_{eq} value (L_{max}) was noted as the dump truck drove by the measurement location and was then used to calculate the corresponding PWL. The minimum measurement distance (corresponding to the noted L_{max} was estimated to be 17 m, and there was an unobstructed line of sight between the source and the measurement location. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The distance between the measurement location and other crush and wash plant equipment (i.e., potential sources of measurement contamination) was estimated to be greater than 100 m and, as a result, sound from the dump truck was observed to be dominant at the measurement location. Therefore, contamination from other sound sources was considered to be negligible.

Table 13 presents the measured L_{max} and calculated PWL in octave bands (31.5 Hz - 8000 Hz) for the dump truck hauling aggregate material.

Table 13: Measured L_{max} and Calculated PWL of Dump Truck Hauling Aggregate Material

Sound Source	Measured L_{max} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Dump Truck Hauling Aggregate Material	L_{max} [dBA]	56.3	60.8	70.1	77.2	79.1	80.1	78.8	74.4	67.0	85.5
	PWL [dBA]	85.9	90.4	103.7	110.8	112.7	113.7	112.4	108.0	100.6	119.1

3.2.5 Generator Sets in the Crush Plant and the Wash Plant

As described in Section 3.1.6, the envelope method was used to obtain separate PWLs for Genset 1, Genset 2, and Genset 3. For the purposes of calibration and confirmation (i.e., as a check on the validity of PWLs obtained via the envelope method), the concentrated source method was also used to determine a single PWL for both Genset 1 and Genset 2 (a PWL value that can be compared to the sum of the individual envelope-based PWLs) and a PWL for Genset 3 (a PWL value that can be compared directly to the envelope-based PWL).

When applying the concentrated source method, the average measurement distance to Genset 1 and Genset 2 was 6 m and there was an unobstructed line of sight between the measurement point and both gensets. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The closest other piece of crush plant equipment (i.e., the closest source of potential measurement contamination) was Crusher 2, which was located approximately 20 m from the measurement location. Based on envelope measurements of Crusher 2, this piece of equipment was estimated to contaminate the concentrated source measurement of Genset 1 and Genset 2 by about 2 dB. Contamination from other sources was considered to be negligible.

When applying the concentrated source method, the average measurement distance to Genset 3 was 7 m and there was an unobstructed line of sight between the measurement point and Genset 3. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. All other wash plant equipment was substantially farther from the measurement point than Genset 3, and contamination from other sources was considered to be negligible.

The measurement location was further away from all the other sound sources except the shed for Crusher 2. The distance between shed for Crusher 2 and the measurement location was about 20 m. Contamination from Crusher 2 was estimated to be 2 dB based on the measured PWL of Crusher 2 using envelope method. Contamination from other sound sources could be negligible.

The concentrated source method was used to determine the PWLs of the genset (Genset 3) in the wash plant for the purpose of calibration and confirmation. The measurement distance was 7 m. The measurement location was far enough away from other sound sources that contamination was estimated to be negligible. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere.

For Genset 1 and 2, Table 14 presents the measured L_{eq} obtained via the concentrated source method along with the PWLs in octave bands (31.5 Hz - 8000 Hz) calculated using both the concentrated source and envelope methods. In Table 14, the envelope based PWL is obtained by summing the Genset 1 and Genset 2 PWLs presented in Table 6. In Table 14, 2 dB has been subtracted from the PWL obtained using the concentrated source method to account for measurement contamination by Crusher 2. The two PWL estimates presented in Table 14 are separated by only 0.2 dB; this is considered to be good agreement for a field measurement.

Table 14: Measured L_{eq} and Calculated PWLs for Crush Plant Gensets

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Genset 1 and Genset 2 (Crush Plant)	L_{eq} [dBA]	40.8	55.3	67.6	75.8	80.6	80.6	81.2	75.6	66.6	86.5
	Concentrated Source PWL [dBA]	62.7	77.2	93.5	101.7	106.5	106.5	107.1	101.5	92.5	112.4
	Envelope PWL[(a)] [dBA]	62.3	75.4	93.6	103.1	104.2	106.8	106.9	102.3	94.9	112.2

(a) See Table 6

For Genset 3, Table 15 presents the measured L_{eq} obtained via the concentrated source method along with the PWLs in octave-bands (31.5 Hz – 8000 Hz) calculated using both the concentrated source and envelope methods. The two PWL estimates presented in Table 15 are separated by only 0.4 dB; this is considered to be good agreement for a field measurement.

Table 15: Measured L_{eq} and Calculated PWLs for Wash Plant Genset

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Genset 3 (Wash Plant)	L_{eq} [dBA]	36.1	52.4	65.9	71.6	76.9	77.3	75.8	72.6	65.3	82.6
	Concentrated Source PWL [dBA]	58.0	74.3	91.8	97.5	102.8	103.2	101.7	98.5	91.2	108.5
	Envelope PWL[(a)] [dBA]	54.6	71.4	89.0	101.9	101.2	101.5	101.0	98.5	92.9	108.1

(a) See Table 6

3.2.6 Washer Unit with Motors in the Wash Plant

As described in Section 3.1.8, the envelope method was used to obtain PWL for the washer unit including motors. For the purposes of calibration and confirmation (i.e., as a check on the validity of the PWL obtained via the envelope method), the concentrated source method was also used to determine the PWL of the electric motor powered washer unit. The measurement distance was 19 m and there was an unobstructed line of sight between the measurement point and the washer unit. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. All other wash plant equipment was substantially farther from the measurement point than was the washer unit (e.g. Screen 3 was 60 m away), and so contamination from other sources was considered to be negligible.

For the washer unit, Table 16 presents the measured L_{eq} obtained via the concentrated source method along with PWLs in octave bands (31.5 Hz - 8000 Hz) calculated using both the concentrated source and envelope methods. The two PWL estimated are separated by only 0.1 dB; this is considered to be good agreement for a field measurement.

Table 16: Measured L_{eq} and Calculated PWLs for Washer Unit

Sound Source	Measured L_{eq} / Calculated PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Washer Unit	L_{eq} [dBA]	31.8	50.6	59.1	62.3	67.6	68.9	69.2	65.3	60.1	74.6
	Concentrated Source PWL [dBA]	62.4	81.1	93.7	96.9	102.2	103.5	103.8	99.8	94.6	109.2
	Envelope PWL[(a)] [dBA]	70.1	81.0	97.6	101.6	93.1	106.4	91.2	101.8	93.6	109.3

(a) See Table 8

3.2.7 Crush Plant as a Single Source

Two measurements that treated the crush plant as a single source were conducted using the concentrated source method. The purpose of these measurements was to confirm the accuracy of the measurements of the individual pieces of equipment located in the crush plant.

The acoustic centre of the crush plant was assumed to coincide with Screen 1. The first measurement was conducted from a distance of 84 m from this acoustic centre and the second measurement was conducted from a distance of 82 m. These two measurements were made in different directions to the crush plant. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The closest sources of potential measurement contamination were located at the wash plant, more than 200 m away, and so contamination from sources outside the crush plant was assumed to be negligible.

Table 17 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for the crush plant as a whole. Table 17 also presents the sum of the PWLs for the individual pieces of equipment operating at the time of these measurements (i.e., the sum of the relevant measurements of individual pieces of crush plant equipment – screens with motors, crushers with motors, conveyors with motors, falling aggregate material, and a dump truck filling the hopper). Individual crush plant screens were not operating over the entire measurement period and their PWLs have been scaled by 80% when calculating the PWL sum in Table 17.

Table 17: Measured L_{eq} and Calculated PWLs of the Crush Plant as a Single Source and Comparison with Sum of Individual PWLs for Relevant Equipment

Whole Crush Plant	Measured L_{eq} / PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Measurement 1	L_{eq} [dBA]	44.2	50.3	65.0	65.7	67.7	69.3	68.8	64.1	55.1	75.0
	PWL [dBA]	87.7	93.8	112.5	113.2	115.3	117.0	116.8	113.2	108.2	123.0
Measurement 2	L_{eq} [dBA]	41.4	52.2	64.8	68.9	68.4	72.1	69.0	63.5	54.5	76.5
	PWL [dBA]	84.7	95.5	112	116.2	115.8	119.6	116.7	112.3	107.3	124.1
Sum of PWLs of Operating Equipment Based on Individual Measurements	PWL [dBA]	82.0	91.3	104.0	110.5	115.1	119.1	120.4	119.2	115.4	125.5

The PWL values meant to characterize the crush plant as a single source are found to be 1.4-2.5 dB lower than the sum of estimated PWLs for the individual pieces of operating equipment. This is considered to be a good agreement in light of uncertainty inherent in field measurements. One reason the measurements of the crush plant as a whole are slightly lower than the sum of the individual pieces of equipment is likely due to screening – i.e., the physical presence of one piece of equipment partially blocks the sound energy from another piece of equipment from reaching the measurement location.

3.2.8 Wash Plant as a Single Source

Two measurements that treated the wash plant as a single source were conducted using the concentrated source method. The purpose of these measurements was to confirm the accuracy of the measurements of the individual pieces of equipment located in the wash plant.

The acoustic centre of the wash plant was assumed to coincide with Screen 3. The first measurement was conducted from a distance of 55 m from this acoustic centre and the second was conducted from a distance of 56 m. These two measurements were made in different directions to the wash plant. Because the source and measurement heights were small compared to the distance between source and measurement point, geometric spreading of sound was assumed to be consistent with a half sphere. The closest sources of potential measurement contamination were located at the crush plant, more than 200 m away, and so contamination from sources outside the wash plant was assumed to be negligible.

Table 18 presents the measured L_{eq} and calculated PWLs in octave bands (31.5 Hz - 8000 Hz) for the wash plant as a whole. Table 18 also presents the sum of the PWLs for the individual pieces of equipment operating at the time of these measurements (i.e., the sum of the relevant measurements of individual pieces of wash plant equipment – screen with motor, washer unit with motors, washer pump with motor, conveyors with motors, and a front end loader filling the hopper).

Table 18: Measured L_{eq} and Calculated PWLs of the Wash Plant as a Single Source and Comparison with Sum of Individual PWLs for Relevant Equipment in Wash Plant

Whole Wash Plant	Measured L_{eq} / PWL	Octave Band Centre Frequency [Hz]									Overall
		31.5	63	125	250	500	1000	2000	4000	8000	
Measurement 1	L_{eq} [dBA]	31.2	40.6	56.2	62.3	64.1	63.2	60.0	54.5	48.1	69.1
	PWL [dBA]	71.0	80.4	100.0	106.1	107.9	107.2	104.1	99.4	95.6	113.1
Measurement 2	L_{eq} [dBA]	24.9	41.5	53.6	57.9	61.9	65.2	62.4	58.2	55.3	69.3
	PWL [dBA]	64.9	81.4	97.6	101.9	106.0	109.4	106.7	103.3	103.0	113.7
Sum of PWLs of Operating Equipment Based on Individual Measurements	PWL [dBA]	74.2	97.8	104.5	110.3	106.8	108.5	103.5	104.4	98.8	115.0

The PWL values meant to characterize the wash plant as a single source are found to be less than 2 dB lower than the sum of estimated PWLs for the individual pieces of operating equipment. This is considered to be a good agreement in light of uncertainty inherent in field measurements. One reason the measurements of the wash plant as a whole is slightly lower than the sum of the individual pieces of equipment is likely due to screening – i.e., the physical presence of one piece of equipment partially blocks the sound energy from another piece of equipment from reaching the measurement location.

4.0 DISCUSSION AND SUMMARY

The equipment in operation at Springbank was measured and their PWLs were determined by the envelope method and/or the concentrated source method. The PWLs of the Springbank crush plant and wash plant as single sources were determined by the concentrated source method. Within the uncertainty bounds inherent in field measurements the sum of the relevant individual measurements and the overall crush plant and wash plant measurements were found to be consistent and in agreement, which indicates that the field measurements are accurately characterizing the acoustic properties of the Springbank equipment.

As part of the NIA for the Project, the sound source measurement data obtained at Springbank (scaled appropriately for actual Project operations) will be used to develop a computer noise model.

5.0 CLOSURE

We trust that the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

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