Appendix E: Supplemental Technical Memoranda

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Appendix E1: Leachate Lagoon Air Quality Impacts Memorandum

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Memo

HDR

To:	**Eric Mead**	**Date:**	**August 14, 2009**
From:	**M. Kirk Dunbar**	**Project:**	**King County Cedar Hills Regional Landfill**
cc:	**Karissa Kawamoto**	**Job No.:**	**83825**
Subject:	**Leachate Lagoons Air Quality Impacts**		

Introduction

The Cedar Hills Regional Landfill (CHRLF) uses two lagoons in series to aerate leachate collected from the landfill prior to sending the leachate to the anitary sewer system for treatment. In response to CHRLF Site Development Plan Draft Environmental Impact (EIS) scoping comments with regard to the human health impacts of leachate aeration, an ambient air quality impact analysis was conducted for the existing leachate lagoons. This analysis focused on a number of compounds contained in the leachate that are classified as toxic air contaminants (TACs) by the Puget Sound Clean Air Agency (PSCAA) and Washington State Department of Ecology (Ecology).

PSCAA and Ecology have rules that require the review of TACs from new sources of toxic air pollutants. One aspect of this review is a demonstration that the impacts of the new source of TACs are less than Acceptable Source Impact Levels (ASILs) that PSCAA and Ecology have developed for each TAC. As existing sources, the leachate lagoons are not subject to these requirements, which include a demonstration of impacts below applicable ASILs. However, to address the scoping comments, air dispersion modeling was used to determine whether or not the leachate lagoons would cause an exceedance of any ASIL at any existing nearby residence.

Emissions Estimation

CHRLF conducts routine sampling of the leachate that is collected and sent to the leachate lagoons (influent), as well as the aerated leachate that is pumped to the sanitary sewer system (effluent) for disposal. The samples are analyzed to determine the concentrations of several compounds, a number of which are TACs. The sampling results were reviewed by HDR and those compounds that are TACs were identified for evaluation.

In addition to routine leachate sampling, the facility monitors the amount of influent and effluent pumped into and out of the leachate lagoons on a daily basis. The results of the influent sampling were averaged and multiplied by the influent pumping rate, on both an annual and an average daily basis, to estimate the mass of each TAC in the influent. The mass of each TAC in the effluent was estimated in a similar way. The leachate lagoon emission rate for each TAC was then estimated by subtracting the effluent mass from the influent mass. In the event that the influent results for a given compound were below detection limits in all samples, emissions for that compound were assumed to be 100% of the average level of the compound in the effluent. A similar approach was used for compounds that were below detection limit in the effluent.

Modeling Methodology

The current version of the USEPA-approved AERMOD dispersion model (version 07026) was used to estimate pollutant concentrations. Bee-Line Software's BEEST version of the AERMOD model was used in the dispersion analysis. The model was run with the regulatory default options recommended in the current version of USEPA's "Guideline on Air Quality Models" (40 CFR 51, Appendix W, July 1, 2007).

The two leachate lagoons were characterized in the model as two volume sources, each modeled with an emission rate of 0.5 lb/hr (for a total leachate lagoons emission rate of 1 lb/hr). AERMOD is capable of producing concentration predictions for various averaging times. The model was run to calculate 24-hour and annual (as applicable based on the ASILs) average concentrations. Use of this modeling approach results in AERMOD concentration values per lb/hr emissions for each averaging period. These values were then multiplied by the leachate aeration emission rate to determine the ambient impact for the averaging period(s) applicable to that constituent. The resulting values were compared to ASILs as specified in PSCAA's current Regulation III (dated April 13, 2000) and WAC 173-460-150 (last updated May 20, 2009).

The meteorological data used for this analysis consisted of five years, 1986, 1987, 1988, 1989, and 1991 meteorological data. The surface data was recorded by the National Weather Service (NWS) at the Seattle-Tacoma International Airport (Station Number 24233), and the upper-air (mixing height) meteorological data was recorded by the NWS at the Salem, Oregon Airport (Station Number 24232). These data were processed using the EPA-approved AERMET software (version 06341).

To use the AERMET software, a number of land use-related parameters must be calculated. Per current USEPA guidance, the AERSURFACE software package (version 08009) was used to calculate the land-use parameters used by AERMET.

Receptors (indicated as yellow dots in Figure 1) were placed at nearby residences. The highest concentration at any residence for a given averaging period was used to calculate emissions for comparison to the applicable ASILs.

Results

The results of the modeling, along with a comparison to the applicable PSCAA and WAC ASILs, are presented in Table 1.

Conclusions

Based on the above data, the following conclusions can be made:

- Based on the modeling results being below all applicable ASILs, the leachate aeration system is not expected to result in adverse impacts to human health.

Figure 1 – Receptor Placement and Site Layout

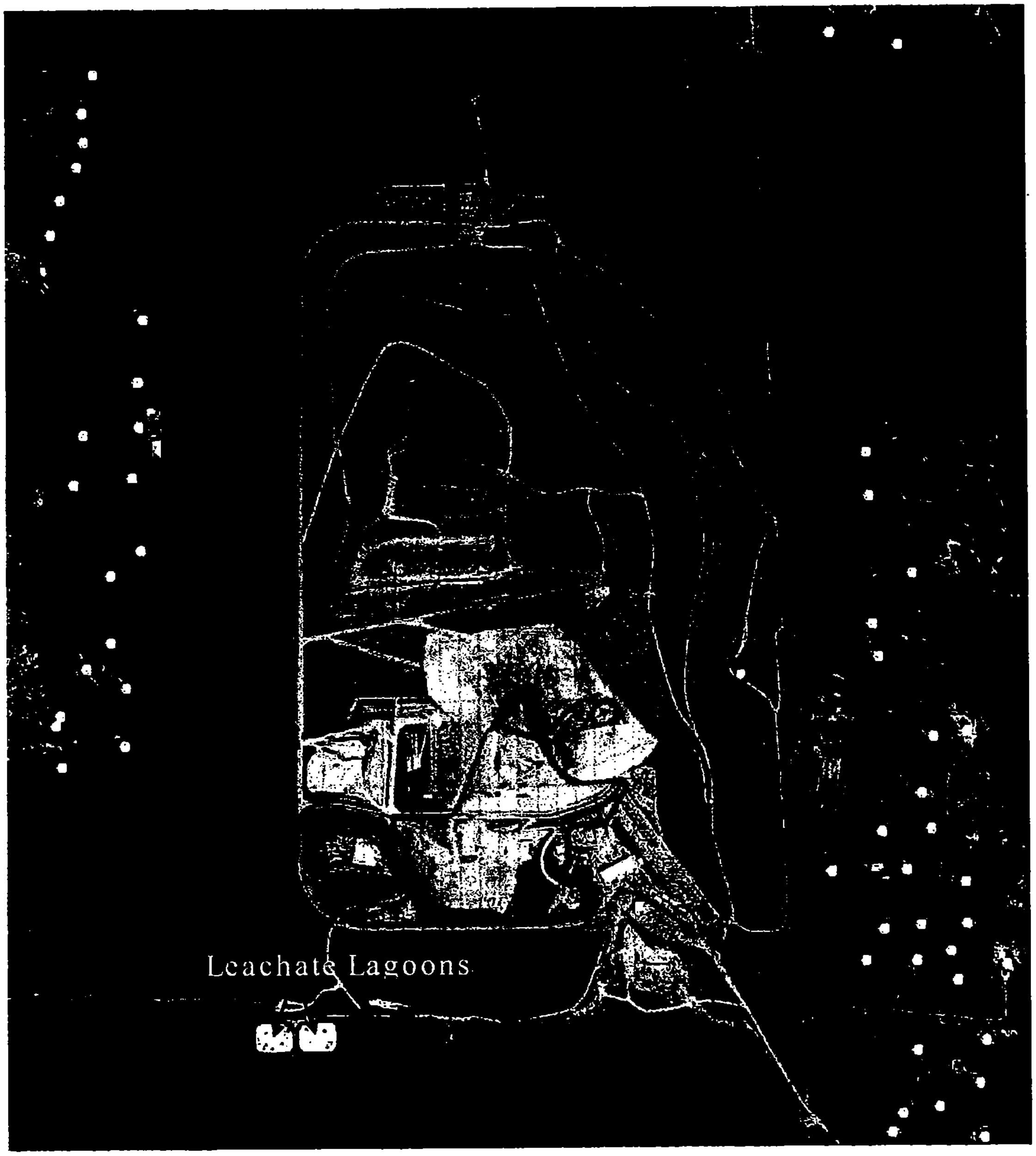

Table 1 - Summary of Modeled Results for Leachate Aeration

Modeling Results for 1 lb/hr emission rate

Maximum 24-hr Impact (μg/m³) 1.70

Maximum Annual Impact (μg/m³) 0.15

Compound	CAS #	Calculated Leachate Pond Emissions		Modeled Hourly Emission Rates for Specified Averaging		PSCAA ASIL (μg/m³)		173-460 WAC ASIL (μg/m³)		Modeled Impact for Specified Averaging Period	
		lb/day	lb/yr	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual
1,1,1-TRICHLOROETHANE (methyl chloroform)	71-55-6	0.003		1.16E-04		6400		1000		0	
1,1-DICHLOROETHANE (ethylidene dichloride)	75-34-3	0.002	0.71	8.01E-05	8.16E-05	2700			0.625	0	0.000
1,1-DICHLOROETHENE (vinylidene chloride)	75-35-4	0.002		7.29E-05		67		200		0	
1,2-DICHLOROBENZENE (o-dichlorobenzene)	95-50-1	0.0006		2.51E-05		1000				0	
1,2-DICHLOROETHANE (ethylene dichloride)	107-06-2		1.5		1.71E-04		0.038		0.0385		0.0000
1,4-DICHLOROBENZENE (p-dichlorobenzene)	106-46-7		1.1		1.29E-04		1.5		0.0909		0.0000
2,4,5-T	93-76-5	0.012		4.96E-04		33				0	
2,4-D (2,4-dichlorophenoxy acetic acid)	94-75-7	0.09		3.87E-03		33				0	
2-BUTANONE (methyl ethyl ketone)	78-93-3	8		3.17E-01		1000		5000		1	
2-HEXANONE (methyl butyl ketone)	591-78-6	0.02		7.47E-04		67				0	
2-METHYL-1-PROPANOL (isobutyl alcohol)	78-83-1	3		1.14E-01		510				0	
4-METHYL-2-PENTANONE (methyl isobutyl ketone)	108-10-1	0.10		4.11E-03		680		3000		0	
ACETONE	67-64-1	5		1.95E-01		5900				0	
ACETONITRILE	75-05-8	0.7	277	3.11E-02	3.17E-02	220			60	0	0
ALDRIN	309-00-2		0.036		4.13E-06		0.0002		0.000204		0.000001
ALPHA BHC (alpha lindane, alpha-hexachlorocyclohexane)	319-84-6	0.00005	0.019	2.13E-06	2.17E-06	1.7			0.0013	0.0	0.0000
AMMONIA	7664-41-7	514		2.14E+01		100		70.8		36.4	
BENZENE	71-43-2		0.2		2.38E-05		0.12		0.0345		0.0000
BETA BHC (beta lindane, beta-hexachlorocyclohexane)	319-85-7	0.0003	0.11	1.18E-05	1.20E-05	1.7			0.00233	0.0	0.00000
BROMOFORM	75-25-2		1.4		1.58E-04		0.91		0.909		0.000
CARBON DISULFIDE	75-15-0	0.0014		5.92E-05		100		800		0	
CHLOROBENZENE	108-90-7	0.0009		3.95E-05		150		1000		0	
CHLOROETHANE (ethyl chloride)	75-00-3	0.0014		5.89E-05		10000		30000		0	
CHLOROFORM	67-66-3		1.6		1.82E-04		0.043		0.0435		0.0000
CHLOROMETHANE (methyl chloride)	74-87-3	0.0011		4.63E-05		340		90		0	
ETHYLBENZENE	100-41-4	0.01	2.9	3.25E-04	3.31E-04	1000			0.4	0	0.0
HEPTACHLOR	76-44-8		0.040		4.57E-06		0.00077		0.0000769		0.0000007
MERCURY	7439-97-6	0.0012		4.89E-05		0.17		0.09		0.00	
METHACRYLONITRILE	126-98-7	0.5		2.04E-02		9				0	
METHYL METHACRYLATE	80-62-6	0.006		2.39E-04		1400		700		0	
METHYLENE CHLORIDE (dichloromethane)	75-09-2		24		2.78E-03		0.56		1		0.00
STYRENE	100-42-5	0.008		3.41E-04		1000		900		0	
TETRACHLOROETHENE (perchloroethylene)	127-18-4		0.67		7.63E-05		1.1		0.169		0.000
TOLUENE	108-88-3	0.06		2.53E-03		400		5000		0	
TRICHLOROETHENE (trichloroethylene)	79-01-6		7.5		8.60E-04		0.59		0.5		0.00
TRICHLOROFLUOROMETHANE	75-69-4	0.002		7.89E-05		19000				0	
VINYL CHLORIDE	75-01-4		0.68		7.72E-05		0.012		0.0128		0.000
XYLENES, TOTAL	1330-20-7	0.04		1.67E-03		1500		221		0	

Appendix E2: North Flare Station Supplemental Noise Study

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Memo

HDR

To:	Eric Mead P.E.	Date:	September 10, 2009
From:	Tim Casey	Project:	King County Cedar Hills Landfill
cc:	Karissa Kawamoto	Job No.:	83825
Subject:	North Flare Station Supplemental Noise Study		

Introduction

HDR evaluated noise emissions associated with the north flare station to assess the potential effects to residences in the project area. Residents in the project area commented during the Cedar Hills Landfill 2009 Site Development Plan, Environmental Impact Study (EIS) scoping meeting about low frequency noise emissions and high frequency noise emissions from the North Flare Station.

Field Work

Noise emissions levels from the existing blowers and flares at the station were observed during site visits on July 20, 2009, and July 21, 2009. During the site visits, HDR determined that the source of the low frequency noise is the 40-feet tall flare towers, each with 12-feet diameter. HDR also determined that the source of the high frequency noise is the blowers that move gas from the landfill to the flares.

Fundamentals of Environmental Acoustics

Noise is defined as unwanted sound. Sound is made up of tiny fluctuations in air pressure. Sound, within the range of human hearing, can vary in intensity by over one million units. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound intensity and to compress the scale to a more manageable range.

Sound is characterized by both its amplitude (how loud it is) and frequency (or pitch). The human ear does not hear all frequencies equally. In fact the human hearing organs of the inner ear deemphasize very low and very high frequencies. The A-weighted scale (dBA) is used to reflect this selective sensitivity of human hearing. This scale puts more weight on the range of frequencies that the average human ear perceives, and less weight on those frequencies we do not hear as well. The human range of hearing extends from approximately 3 dBA to around 140 dBA. Table 1 shows a range of typical noise levels from common activities.

Table 1
Common Noise Sources and Levels

Sound Pressure Level (dBA)	Typical Sources
90	Motorcycle at 25 feet Gas lawn mower at 3 feet
80	Garbage disposal
70	City street corner
60	Conversational speech
50	Typical office
40	Living room (without TV)
30	Quiet bedroom at night

SOURCE: Environmental Impact Analysis Handbook, ed. by Rau and Wooten, 1980

Using the decibel scale, sound levels from two or more noise sources cannot be arithmetically added together to determine the overall sound level. Rather, the combination of two sounds, at the same level, yields an increase of 3–dB. On average, a 3-dB change in the A-weighted sound level is generally considered a noticeable change in loudness, whereas a 5-dB increase is clearly noticeable. A 10-dB change is perceived by most people as a doubling or halving of the perceived loudness.

The sounds that we hear are a combination of many sounds of different pitches. It is possible to use a frequency analyzer, and separate sound into its different frequency components. The frequency ranges are called octave bands; frequency is measured in Hertz (Hz), or cycles per second. Data that have been sorted into its octave bands is called spectral data. Data that has not been sorted into its octave bands is called broadband – this is what we hear. Noise sources can emit broadband noise or tonal noise. The human ear has the ability to identify a tone in the presence of background broadband noise. In some cases the presence of a tone can be annoying because it is perceived as something standing out among the background, broadband noise.

Environmental noise is often expressed as a sound level occurring over a stated period of time, typically one hour. When the acoustic energy is averaged over the stated period of time, the resulting equivalent sound level represents the energy-based average sound level. This is called the equivalent level, or L_{eq}. Therefore, the L_{eq} represents a constant sound that, over the specified period, has the same acoustic energy as the time-varying sound.

Environmental noise is often also expressed as a sound level occurring over the period of 24-hours. The L_{dn} is a noise weighted descriptor created to quantify the manner in which sound is perceived over a 24 hour period. The L_{dn} is equivalent to the $L_{eq(24)}$ with 10 decibels of the A-weighted scale (dBA) added to nighttime sound levels between the hours of 10:00 PM and 7:00 AM to account for people's greater sensitivity to sound during nighttime hours.

Methodology

Noise emissions from the existing blowers and flares at the station were observed during the site visits on July 20, 2009, and July 21, 2009. During the noise survey it was noted that audible high-frequency tones were emitted from existing blowers and horizontal piping. The landfill gas flares emit a distinct low frequency tone.

To evaluate the high frequency tone, HDR evaluated the blade frequency noise and pipe resonance associated with the blowers. HDR determined the number of blades in each blower, and the rate of rotation, then calculated the blade pass frequency. Blade frequency noise, commonly referred to as the blade pass frequency, is created by repeated impulses of air that result from the passing of a blade. The frequency of the tone is dependent on the number of blades and the operating speed of the machinery. The calculated blade pass frequency matched the frequency of the high-frequency noise measured during the site visit. This match provides confirmation that the blowers are the source of the high frequency noise emissions. The high frequency noise emitted by the blowers radiates both upstream and downstream in the gas collection and distribution pipes. This explains why the noise is so prevalent at the North Flare Station.

Additionally, using the dimensions of the flare towers, HDR calculated the resonance frequency associated with the flares themselves. The calculated frequency matched the frequency measured during the site visit. This match provides confirmation that the blowers are the source of the high frequency noise emissions.

Results

Low frequency noise

The noise emitted by flares at the North Flare Station is dominated by low frequency energy. Through modal analysis HDR determined that the low frequency noise emitted by the flare stacks is created by the resonance of the flare stack. Resonance refers to the tendency of a system, in this situation a flare, to vibrate at larger amplitudes at particular frequencies than at others when excited by an equal force.

High frequency noise

The noise emitted by the gas collection and distribution system at the North Flare Station was dominated by mid frequency energy, around the 1 kHz band. The increase in sound pressure level at this frequency indicates tonal noise emissions from one of the system components. To identify the exact source of the 1 kHz tone the blade pass frequency of the blower system and motor fan were examined. Results of the blade pass frequency study are presented in Table 2.

Table 2
Blade Pass Frequency

Equipment	Operating Frequency, RPM	Number of Blades	Blade Pass Frequency, Hz
Lamson Blower	3545	17	1004
Toshiba Motor	3545	12	709

The blade pass frequency calculated for the blower coincides with elevated spectral noise measurements made in the 1 kHz band.

Breakout noise, noise emitted by blowers and motors which is transmitted through the fiberglass pipes into open air, is caused by the use of relatively lightweight materials in the piping. Fiberglass piping currently used in North Flare Station lacks the necessary mass to create high levels of transmission loss and block the 1 kHz tone from being emitted into the ambient acoustic environment.

Conclusions

Low frequency noise

The low frequency resonance created by the flares at the North Flare Station is difficult to attenuate because the resonance is a function of the physical dimensions of the 40-feet tall, 12-feet wide flares. There are no practical source or path mitigation[1] options to abate the low frequency noise from the north station flares. A standard "rule of thumb" for attenuation due to long, wide regions of heavy, non-deciduous woods and undergrowth is 5 dBA for the 1st 30 meters, 5 additional dBA for the 2nd 30 meters, to a 10 dBA maximum attenuation. The North Flare Station is separated by at least 1,000 feet of densely vegetated, non-deciduous buffer from the nearest residential structure.

Use of the North Flare Station is now diminished due to the new landfill gas to energy system. When the landfill gas to energy system becomes fully operational, the North Flare Station will serve as a back-up system, and only be used in emergency or maintenance conditions, effectively eliminating the low frequency noise emissions.

High frequency noise

Using measurements performed with a real-time analyzer during the site visit and blade pass frequency calculations HDR determined that the 1 kHz tonal noise was caused by the blade pass frequency of the Lamson blowers used in the gas transfer system. Breakout noise from the north flare station gas collection system is caused by noise emitted by blowers and motors which is transmitted through the fiberglass pipes into

[1] Typical path mitigation, such as sound barriers and partial enclosures are ineffective at low frequencies due to diffraction and ground borne propagation.

open air. This breakout noise is caused by the use of relatively lightweight materials in the pipes.

To mitigate noise transmitted through the existing fiberglass piping (plenum) it is recommended that the plenum is retrofitted using pipe lagging. The acoustical cladding should consist of a decoupling material and mass loaded barrier overwrap. A common decoupling material is light density fiberglass (minimum of 1"), which serves as an airspace between the pipes and barrier material. The acoustic barrier material improves the transmission loss of the piping by adding a mass barrier.

A product similar or equivalent to KNM-100ALQ manufactured by Kinetics is suggested. Acoustical characteristics of the KNM-100ALQ are presented in Table 3.

Table 3
Kinetics KNM-100ALQ Insertion Loss

Frequency, Hz	63	125	250	500	1000	2000	4000
Insertion Loss, dB	2	10	16	27	35	34	33

Appendix E3: Fugitive Dust Air Quality Impacts

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Memo

HDR

To:	**Eric Mead**	**Date:**	**September 23, 2009**
From:	**M. Kirk Dunbar**	**Project:**	**King County Cedar Hills Regional Landfill**
cc:	**Karissa Kawamoto**	**Job No.:**	**83825**
Subject:	**Fugitive Dust Air Quality Impacts**		

Introduction

A number of operations associated with the Cedar Hills Regional Landfill (CHRLF) generate fugitive dust. The ambient air impacts of this fugitive dust were determined using USEA-approved dispersion modeling.

Emissions Estimation

Truck and Other Traffic on Public Roads

HDR Engineering conducted a traffic survey at three intersections near CHRLF between June 9 and June 18, 2009. The results of this traffic study, detailed in a memo dated July 10, 2009 (see Attachment 1), were used to determine traffic levels on the roads for particulate matter calculation purposes.

Emission factors for PM_{10} and $PM_{2.5}$ were developed using the methodology from EPA's Fifth Edition AP-42, Section 13.2.1. PM_{10} is particulate matter (both solid particles and liquid droplets) that have an aerodynamic diameter of less than 10 micrometers, while $PM_{2.5}$ is particulate matter with an aerodynamic diameter of less than 2.5 micrometers. The range of particles with diameters larger than 2.5 micrometers and smaller than 10 micrometers are commonly referred to as "inhalable coarse particles", while $PM_{2.5}$ is commonly referred to as "fine particles".

Based on the results of the traffic study, a paved road silt loading of 0.20 gram/m^2 was used. The emission factors were used in combination with the traffic count information to estimate particulate matter emissions for the paved public roads. The traffic on public road emission calculations were based on trucks operating 15 hours per day. The traffic on public roads emission calculations are presented in Attachment 2.

Landfill Fugitive Dust Sources

The modeling included fugitive dust generated by haul-truck traffic on-site and daily cover operations (including dozers and scrapers). The emission calculations for these operations are presented in Attachment 3. As a note, the main difference between the calculation methodology for truck traffic on-site versus on public roads is the silt loading used. A silt loading value of 7.4 g/m_2, which corresponds to USEPA's average silt loading for landfills, was used for the on-site truck traffic emission calculations.

Modeling Methodology

Modeling

The current version of the USEPA-approved AERMOD dispersion model (version 07026) was used to estimate pollutant concentrations. Bee-Line Software's BEEST version of the AERMOD model was used in the dispersion analysis. The model was run with the regulatory default options recommended in the current version of USEPA's "Guideline on Air Quality Models" (40 CFR 51, Appendix W, July 1, 2007).

The truck traffic (both on-site and public roads) was input to AERMOD as volume sources that were placed along the roads. The other on-site sources of fugitive dust were input to the model as area sources, located in the general location in which they occur.

Receptor Locations

Receptors were placed along the CHRLF's property line and at nearby residences. The highest concentration at any receptor for a given averaging period was used to calculate emissions for comparison to the applicable ambient air quality standards.

Meteorological Conditions

The meteorological data used for this analysis consisted of five years, 1986, 1987, 1988, 1989, and 1991 meteorological data. The surface date was recorded by the National Weather Service (NWS) at the Seattle-Tacoma International Airport (Station Number 24233), and the upper-air (mixing height) meteorological data was recorded by the NWS at the Salem, Oregon Airport (Station Number 24232). These data were processed using the EPA-approved AERMET software (version 06341). To use the AERMET software, a number of land use-related parameters must be calculated. Per current USEPA guidance, the AERSURFACE software package (version 08009) was used to calculate the land-use parameters used by AERMET.

Other Assumptions

Several other assumptions and parameters were included in the dispersion modeling, including:

- The future fugitive dust generated by haul-truck traffic on-site and on the public roads leading to the CHRLF was calculated based on a ratio of current CHRLF haul traffic and future combined CHRLF haul traffic and action alternative construction truck traffic. The future fugitive dust emissions from daily cover operations (including dozers and scrapers), and other traffic on the public roads leading to the CHRLF were assumed to be the same as existing conditions.

- The fugitive dust modeling was based on traffic and landfill sources operating between the hours of 5:00 AM and 9:00 PM.

- The fugitive dust modeling was performed for the facility operating 7 days per week, 365 days per year.

- There are a number of other sources of fugitive dust at the facility such as wind erosion from exposed surfaces, miscellaneous vehicular traffic, etc. As with the 1996 analysis, these sources were not included in the present inventory because they are expected to be of less magnitude than the major sources discussed above. On occasion, wind erosion may be a larger source, typically during high wind events, when the action of the wind on exposed surfaces is more pronounced. However, peak modeled particulate concentrations typically occur during low wind events, when atmospheric dilution is poorest and wind erosion emissions are minimal. Thus, even though high wind events cause more movement of particulate matter, they are not the peak periods of concern for purposes of modeling facility impacts.

- Local traffic on the public roads during the time period of 9:00 PM to 5:00 AM were not included in the model. Any impacts from this type of activity is included in the background concentration added to the model results to estimate total ambient air impacts.

- A background concentration of 62 µg/m^3 for PM_{10} was obtained from EPA's AIRSDATA, corresponding to the most recent three years of available data (2005-2007) for a monitor located at 4401 E Marginal Way in Seattle, Washington. The use of a monitor located in an urban area of King County is expected to yield conservatively high background concentration values for PM_{10}. The average 24-hour background PM_{10} is the average of the 2nd high means for the three years.

- Background concentrations of $PM_{2.5}$ were obtained from PSCAA, corresponding to the most recent three years of available data (2005-2007) for a monitor located at 42404 SE North Bend Way in North Bend, Washington. The use of a monitor located in a rural area of King County near the landfill is expected to yield representative background concentration values for $PM_{2.5}$. The 24-hour background of 15 µg/m^3 is the average of the 98th percentile values for the three years and the annual background of 5.0 µg/m^3 is the average of the annual mean values for the three years.

Results

No Build Scenario

The peak 24-hour PM_{10} concentration associated with existing operations was computed to be 32 µg/m^3. Summing the CHRLF modeled value and the background concentration results in a predicted existing maximum 24-hour PM_{10} of 94 µg/m^3. This concentration is well below the 24-hour PM_{10} ambient air quality standard of 150 µg/m^3.

The peak 24-hour and annual $PM_{2.5}$ concentrations associated with existing conditions were computed to be 2 µg/m^3 and 0.6 µg/m^3, respectively. Summing the CHRLF modeled values and the background concentrations results in a predicted existing maximum 24-hour $PM_{2.5}$ of 17 µg/m^3 and a maximum predicted existing annual $PM_{2.5}$ of 5.6 µg/m^3. These concentrations are well below the 24-hour and annual $PM_{2.5}$ ambient air quality standards of 35 µg/m3 and 15.0 µg/m^3, respectively.

Build Scenario

The future peak 24-hour PM_{10} concentration was computed to be 53 µg/m^3 for all of the action alternatives. Summing the CHRLF modeled value and the background concentration results in a predicted existing maximum 24-hour PM_{10} of 115 µg/m^3. This concentration is well below the 24-hour PM_{10} ambient air quality standard of 150 µg/m^3.

The future peak 24-hour and annual $PM_{2.5}$ concentrations were computed to be 4 μg/m^3, and 1.0 μg/m^3, respectively. Summing the future CHRLF modeled values and the background concentrations results in a predicted future maximum 24-hour $PM_{2.5}$ impact of 19 μg/m^3 and a maximum predicted future annual $PM_{2.5}$ impact of 6.0 μg/m^3. These concentrations are well below the 24-hour and annual $PM_{2.5}$ ambient air quality standards of 35 μg/m3 and 15.0 μg/m^3, respectively.

Conclusions

Based on the above data, the following conclusions can be made:

- The existing CHRLF operations, including traffic on public roads, currently meet all applicable particulate matter ambient air quality standards.
- The CHRLF operations, including traffic on public roads, will continue to meet all applicable particulate matter ambient air quality standards under each of the five action alternatives.

ATTACHMENT 1

July 10, 2009 Traffic Study Memo

Memo

To:	**Jim Jordan**	**Date:**	**July 10, 2009**
From:	**Tony Wang**	**Project:**	**King County Cedar Hills Landfill Truck Study**
cc:	**WD Baldwin**	**Job No.:**	**83825**
Subject:	**Truck Survey Summary**		

Introduction

There are several truck traffic generators along Cedar Grove Road including King County (KC) Cedar Hills Regional Landfill, Cedar Grove Composting Inc, Stoneway Rock&Recycle, Quality Aggregates and Pacific Top Soils. This study collected hourly truck counts on individual access roadways to the truck traffic generators. This study also investigated truck traffic and general traffic patterns along Cedar Grove Road between SE Lake Francis Road and 228th Avenue SE from 6:00am to 9:00pm during the weekday.

Location Map

The three study intersections are highlighted on the location map as shown in **Figure 1.**

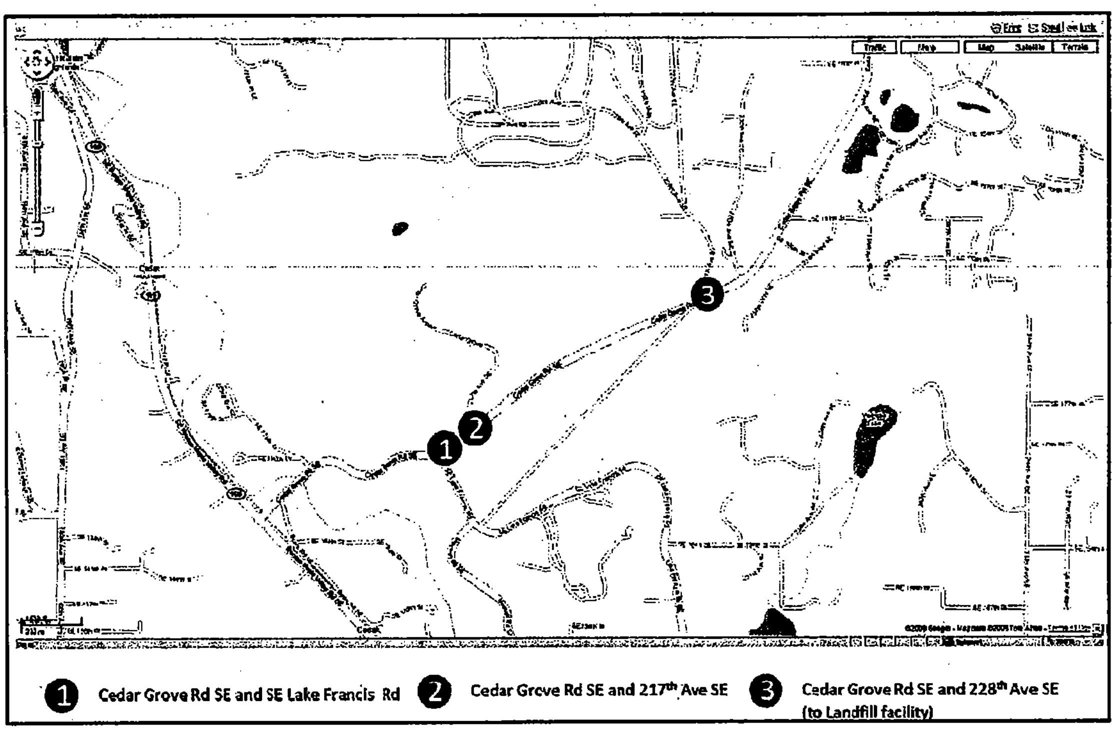

Figure 1. Location Map

Methodology

Field videos were collected from 6:00 am to 9:00pm for three days at each intersection between June 9 and June 18, 2009. No Monday or Friday was selected. No holiday or special events happened during the days when the videos were captured. The dates used for data collection are listed in **Table 1**.

Table 1 Traffic Survey Dates

Dates	Location 1	Location 2	Location 3
Tuesday	6/16/2009	6/16/2009	6/9/2009
Wednesday	6/10/2009	6/17/2009	6/17/2009
Thursday	6/11/2009	6/18/2009	6/11/2009

The devices used are similar to the one shown in **Figure 2.** A video camera was set up on a 26-foot tall pole temporarily attached to a tree or sign post.

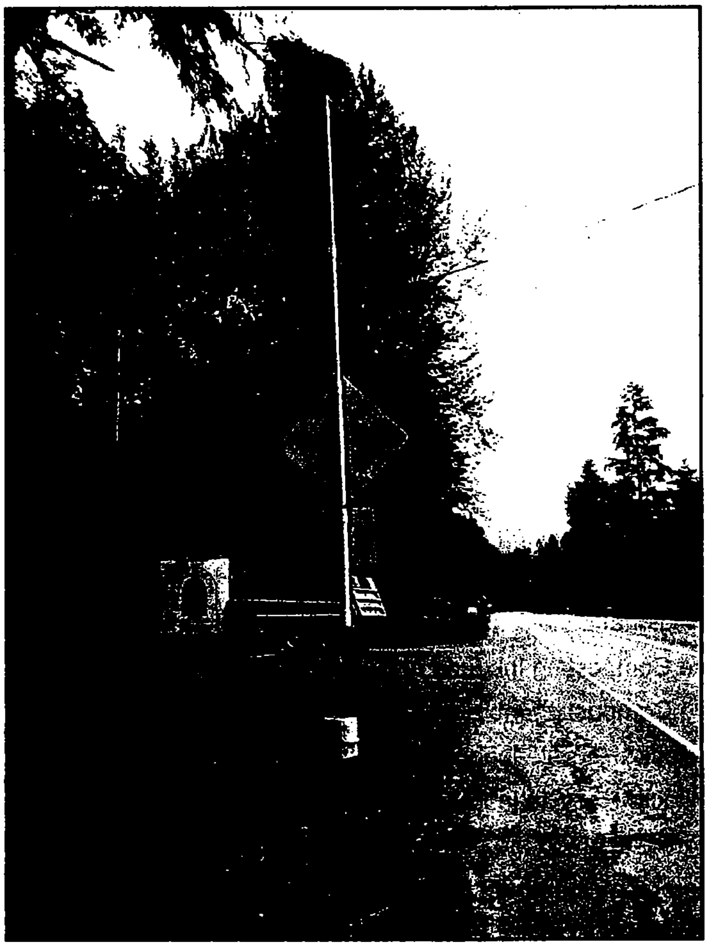

Figure 2. Video Camera Setup

Camera views used are presented on **Figure 3**. At Location 2, the camera setup was changed during the three-day of data collection to obtain a better view point.

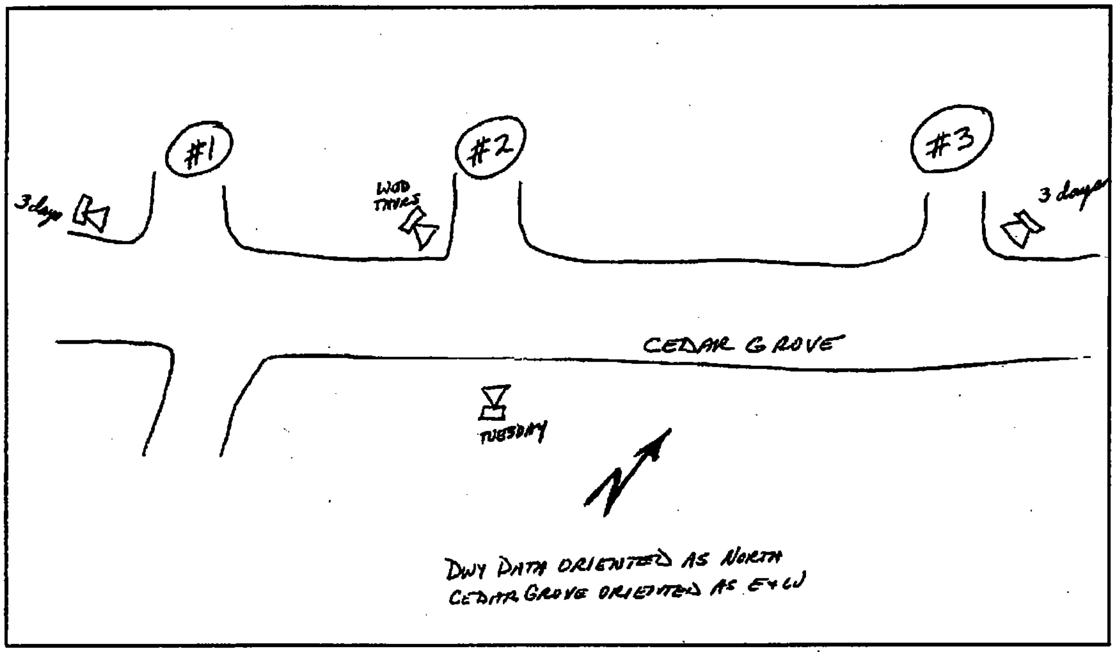

Figure 3. Camera View Diagram

Results

The videos were manually reviewed and counted. The vehicle classifications were (1) King County Haul Truck, (2) Other Truck, (3) Other Vehicle. The traffic patterns were summarized into individual diagrams and charts by the following categories.

(1) 15-Hour Total Intersection Turning Movement Counts by Classifications

(2) AM Peak Hour Intersection Turning Movement Counts by Classifications

(3) PM Peak Hour Intersection Turning Movement Counts by Classifications

(4) Mid-day Intersection Turning Movement Counts by Classifications

(5) Cedar Hill Regional Landfill Inbound and Outbound Hourly KC Haul Trucks

(6) Cedar Hill Regional Landfill Inbound and Outbound Hourly Traffic by Classifications

(7) Cedar Grove Composting Inbound and Outbound Hourly Truck Traffic

(8) Cedar Grove Composting Inbound and Outbound Hourly Traffic by Classifications

(9) Stoneway Rock&Recycle Inbound and Outbound Hourly Truck Traffic

(10) Stoneway Rock&Recycle Inbound and Outbound Hourly Traffic by Classifications

(11) Quality Aggregates Inbound and Outbound Hourly Truck Traffic

(12) Quality Aggregates Inbound and Outbound Hourly Traffic by Classifications

(13) Cedar Grove Road Traffic Variations Between 217th Avenue and 228th Avenue

(14) Cedar Grove Road Traffic Variations Between 228th Avenue and 230th Avenue

(15) Cedar Grove Road Traffic Variations Between Lake Francis Road and 217th Avenue

(16) Cedar Grove Road Traffic Variations Between SR 169 and Lake Francis Road

(17) Truck Percentage Tables of each sections along Cedar Grove Road

All the diagrams were included in the PDF files. The diagrams will be included in the appendix for the Cedar Hills Landfill EIS.

Conclusions

Based on the above data, the following conclusions can be made:

- No King County Haul Trucks used Cedar Grove Road north/east of 228th Avenue.
- King County Haul Truck and other truck operations peak was different from general traffic peaks. King County Haul Truck traffic had peaks from 11:00am and 2:00pm while other traffic had AM peak from 6:00am to 7:00am and PM peak from 4:00pm to 5:00pm.

ATTACHMENT 2

Public Road Fugitive Dust Emission Calculations

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 1	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	EB	King County Haul	0.20	27	136		0.019							
	EB	Other Truck		17	344	6.12		0.001	0.052	0.0004	0.009	0.428	0.0034	Intersection of Cedar Grove Rd and Renton Maple Valley Rd to Location 1
	EB	Other Vehicle		3	2107									
	WB	King County Haul		27	150									
	WB	Other Truck		17	281	6.07		0.001	0.048	0.0004	0.009	0.401	0.0032	Halfway between Location 1 and Location 2 to Location 1
	WB	Other Vehicle		3	2025									
	NB	King County Haul		27	0									
	NB	Other Truck		17	32	3.59		0.000	0.004	0.0000	0.004	0.053	0.00042	Intersection of SE Lake Francis Rd and Maxwell Rd to Location 1
	NB	Other Vehicle		3	726									
	SB	King County Haul		27	0									
	SB	Other Truck		17	160	13.87		0.004	0.017	0.0001	0.031	0.120	0.0009	Bottom of Gravel Pit to Location 1
	SB	Other Vehicle		3	46									
Departure	EB	King County Haul		27	136									
	EB	Other Truck		17	295	6.15		0.001	0.047	0.0004	0.009	0.391	0.0031	Location 1 to halfway between Location 1 and Location 2
	EB	Other Vehicle		3	1916									
	WB	King County Haul		27	150									
	WB	Other Truck		17	347	6.20		0.001	0.054	0.0004	0.009	0.446	0.0035	Location 1 to intersection of Cedar Grove Rd and Renton Maple Valley Rd
	WB	Other Vehicle		3	2146									
	NB	King County Haul		27	0									
	NB	Other Truck		17	148	13.85		0.004	0.016	0.0001	0.031	0.111	0.0009	Location 1 to Bottom of Gravel Pit
	NB	Other Vehicle		3	43									
	SB	King County Haul		27	0									
	SB	Other Truck		17	27	3.46		0.000	0.004	0.00003	0.003	0.054	0.0004	Location 1 to intersection of SE Lake Francis Rd and Maxwell Rd
	SB	Other Vehicle		3	799									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42

[2] Equation AP-42 13.2.1 (2)

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 2	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	EB	King County Haul	0.20	27	148	6.37	0.019	0.001	0.051	0.0004	0.009	0.416	0.0033	Halfway between Location 1 and Location 2 to Location 2
	EB	Other Truck		17	314									
	EB	Other Vehicle		3	1898									
	WB	King County Haul		27	157	5.97		0.001	0.041	0.0003	0.008	0.345	0.0027	Halfway between Location 2 and Location 3 to Location 2
	WB	Other Truck		17	191									
	WB	Other Vehicle		3	1824									
	SB	King County Haul		27	0	10.37		0.003	0.014	0.0001	0.020	0.099	0.0008	Intersection of Cedar Grove Airport Rd and unnamed road (east) to Location 2
	SB	Other Truck		17	139									
	SB	Other Vehicle		3	125									
Departure	EB	King County Haul		27	148	5.82		0.001	0.039	0.0003	0.008	0.331	0.0026	Location 2 to halfway between Location 2 and Location 3
	EB	Other Truck		17	183									
	EB	Other Vehicle		3	1835									
	WB	King County Haul		27	157	6.37		0.001	0.051	0.0004	0.009	0.412	0.0032	Location 2 to halfway between Location 1 and Location 2
	WB	Other Truck		17	294									
	WB	Other Vehicle		3	1891									
	NB	King County Haul		27	0	11.14		0.003	0.017	0.0001	0.022	0.121	0.0010	Location 2 to intersection of Cedar Grove Airport Rd and unnamed road (east)
	NB	Other Truck		17	168									
	NB	Other Vehicle		3	121									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42
[2] Equation AP-42 13.2.1 (2)

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 3	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	EB	King County Haul	0.20	27	155	5.84	0.019	0.001	0.040	0.0003	0.008	0.333	0.0026	Halfway between Location 2 and Location 3 to Location 3
	EB	Other Truck		17	174									
	EB	Other Vehicle		3	1836									
	WB	King County Haul		27	0	3.61		0.000	0.010	0.0001	0.004	0.122	0.0010	Intersection of Cedar Grove Rd and 230th Avenue to Location 3
	WB	Other Truck		17	75									
	WB	Other Vehicle		3	1660									
	SB	King County Haul		27	162	12.66		0.004	0.042	0.0003	0.027	0.302	0.0024	Intersection of 228th Avenue and unnamed road (east) to Location 3
	SB	Other Truck		17	132									
	SB	Other Vehicle		3	300									
Departure	EB	King County Haul		27	0	3.50		0.000	0.009	0.0001	0.004	0.119	0.0009	Location 3 to intersection of Cedar Grove Rd and 230th Avenue
	EB	Other Truck		17	63									
	EB	Other Vehicle		3	1711									
	WB	King County Haul		27	162	5.99		0.001	0.041	0.0003	0.008	0.346	0.0027	Location 3 to halfway between Location 2 and Location 3
	WB	Other Truck		17	184									
	WB	Other Vehicle		3	1814									
	NB	King County Haul		27	155	12.99		0.004	0.042	0.0003	0.028	0.296	0.0023	Location 3 to intersection of 228th Avenue and unnamed road (east)
	NB	Other Truck		17	134									
	NB	Other Vehicle		3	271									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42
[2] Equation AP-42 13.2.1 (2)

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 1	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM10 Emission Rate (ton/yr per 100')	Total Distance Traveled (mi)	Description
Approach	EB	King County Haul	0.20	27	230	6.86	0.019	0.001	0.067	0.0005	0.010	0.530	0.0042	0.10	0.65	Intersection of Cedar Grove Rd and Renton Maple Valley Rd to Location 1
	EB	Other Truck		17	344											
	EB	Other Vehicle		3	2107											
	WB	King County Haul		27	254	6.92		0.001	0.065	0.0005	0.011	0.513	0.0040	0.09	0.07	Halfway between Location 1 and Location 2 to Location 1
	WB	Other Truck		17	281											
	WB	Other Vehicle		3	2025											
	NB	King County Haul		27	0	3.59		0.000	0.004	0.0000	0.004	0.053	0.00042	0.01	0.30	Intersection of SE Lake Francis Rd and Maxwell Rd to Location 1
	NB	Other Truck		17	32											
	NB	Other Vehicle		3	726											
	SB	King County Haul		27	0	13.87		0.004	0.017	0.0001	0.031	0.120	0.0009	0.02	0.13	Bottom of Gravel Pit to Location 1
	SB	Other Truck		17	160											
	SB	Other Vehicle		3	46											
Departure	EB	King County Haul		27	230	6.95		0.001	0.062	0.0005	0.011	0.493	0.0039	0.09	0.07	Location 1 to halfway between Location 1 and Location 2
	EB	Other Truck		17	295											
	EB	Other Vehicle		3	1916											
	WB	King County Haul		27	254	6.99		0.001	0.071	0.0006	0.011	0.559	0.0044	0.10	0.65	Location 1 to intersection of Cedar Grove Rd and Renton Maple Valley Rd
	WB	Other Truck		17	347											
	WB	Other Vehicle		3	2146											
	NB	King County Haul		27	0	13.85		0.004	0.016	0.0001	0.031	0.111	0.0009	0.02	0.13	Location 1 to Bottom of Gravel Pit
	NB	Other Truck		17	148											
	NB	Other Vehicle		3	43											
	SB	King County Haul		27	0	3.46		0.005	0.086	0.0007	0.003	0.054	0.0004	0.01	0.30	Location 1 to intersection of SE Lake Francis Rd and Maxwell Rd
	SB	Other Truck		17	27											
	SB	Other Vehicle		3	799											

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42

[2] Equation AP-42 13.2.1 (2)

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 2	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	EB	King County Haul	0.20	27	250	7.22	0.019	0.001	0.067	0.0005	0.011	0.528	0.0042	Halfway between Location 1 and Location 2 to Location 2
	EB	Other Truck		17	314									
	EB	Other Vehicle		3	1898									
	WB	King County Haul		27	265	6.96		0.001	0.058	0.0005	0.011	0.462	0.0036	Halfway between Location 2 and Location 3 to Location 2
	WB	Other Truck		17	191									
	WB	Other Vehicle		3	1824									
	SB	King County Haul		27	0	10.37		0.003	0.014	0.0001	0.020	0.099	0.0008	Intersection of Cedar Grove Airport Rd and unnamed road (east) to Location 2
	SB	Other Truck		17	139									
	SB	Other Vehicle		3	125									
Departure	EB	King County Haul		27	250	6.78		0.001	0.055	0.0004	0.010	0.440	0.0035	Location 2 to halfway between Location 2 and Location 3
	EB	Other Truck		17	183									
	EB	Other Vehicle		3	1835									
	WB	King County Haul		27	265	7.28		0.001	0.068	0.0005	0.011	0.531	0.0042	Location 2 to halfway between Location 1 and Location 2
	WB	Other Truck		17	294									
	WB	Other Vehicle		3	1891									
	NB	King County Haul		27	0	11.14		0.003	0.017	0.0001	0.022	0.121	0.0010	Location 2 to intersection of Cedar Grove Airport Rd and unnamed road (east)
	NB	Other Truck		17	168									
	NB	Other Vehicle		3	121									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42

[2] Equation AP-42 13.2.1 (2)

Estimation of Emissions from Public Paved Roads Including King County Haul Trucks

	Location 3	Vehicle	Average Suface Silt Loading (g/m^2)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	EB	King County Haul	0.20	27	262	6.84	0.019	0.001	0.056	0.0004	0.010	0.447	0.0035	Halfway between Location 2 and Location 3 to Location 3
	EB	Other Truck		17	174									
	EB	Other Vehicle		3	1836									
	WB	King County Haul		27	0	3.61		0.000	0.010	0.0001	0.004	0.122	0.0010	Intersection of Cedar Grove Rd and 230th Avenue to Location 3
	WB	Other Truck		17	75									
	WB	Other Vehicle		3	1660									
	SB	King County Haul		27	274	14.93		0.005	0.066	0.0005	0.034	0.461	0.0036	Intersection of 228th Avenue and unnamed road (east) to Location 3
	SB	Other Truck		17	132									
	SB	Other Vehicle		3	300									
Departure	EB	King County Haul		27	0	3.50		0.000	0.009	0.0001	0.004	0.119	0.0009	Location 3 to intersection of Cedar Grove Rd and 230th Avenue
	EB	Other Truck		17	63									
	EB	Other Vehicle		3	1711									
	WB	King County Haul		27	274	7.03		0.001	0.059	0.0005	0.011	0.467	0.0037	Location 3 to halfway between Location 2 and Location 3
	WB	Other Truck		17	184									
	WB	Other Vehicle		3	1814									
	NB	King County Haul		27	262	15.24		0.005	0.064	0.0005	0.036	0.449	0.0035	Location 3 to intersection of 228th Avenue and unnamed road (east)
	NB	Other Truck		17	134									
	NB	Other Vehicle		3	271									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

[1] Silt Loading value taken from Table 13.2.1-3 in AP-42
[2] Equation AP-42 13.2.1 (2)

ATTACHMENT 3

Landfill Operations Fugitive Dust Emission Calculations

Estimation of Emissions from On-Site Paved Roads

		Vehicle	Average Suface Silt Loading (g/m²)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	SB	King County Haul	7.40	27	162	27.00	0.019	0.133	0.407	0.00320526	0.886	2.719	0.0214093	Intersection of 228th Avenue and unnamed road (east) to Location 3
	SB	Other Truck		17	0									
	SB	Other Vehicle		3	0									
Departure	NB	King County Haul		27	155	27.00		0.133	0.389	0.0030668	0.886	2.601	0.020484	Location 3 to intersection of 228th Avenue and unnamed road (east)
	NB	Other Truck		17	0									
	NB	Other Vehicle		3	0									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	PM2.5	PM10
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

Silt Loading value taken from Table 13.2.1-3 in AP-42

Estimation of Emissions from Unpaved Landfill Roads

$$E = k\,(s/12)^a (W/3)^b$$

$$E_{ext} = E\,[(365 - P)/365]$$

Eqs. 1a and 2, AP-42 13.2.2

Haul Trucks Section

k_{PM10}	1.5 lb/VMT
$k_{PM2.5}$	0.15 lb/VMT
s	6.4 % silt
W	27 tons
a	0.9
b	0.45
P	180
E_{ext}	1.16 lb PM_{10}/VMT
E_{ext}	0.116 lb $PM_{2.5}$/VMT

Trips per Day	317
Volume Source Spacing	0.019 miles
Daily Hours of Operation	16 hours
Emissions	6.9679247 lbs PM_{10}/day per 100'
	0.055 g PM_{10}/s
	0.70 lbs $PM_{2.5}$/day per 100'
	0.0055 g $PM_{2.5}$/s

Scraper Section

k_{PM10}	1.5 lb/VMT
$k_{PM2.5}$	0.15 lb/VMT
s	6.4 % silt
W	53.8 tons
a	0.9
b	0.45
P	180
E_{ext}	1.58 lb PM_{10}/VMT
E_{ext}	0.158 lb $PM_{2.5}$/VMT

Trips per Day	21
Volume Source Spacing	0.019 miles
Daily Hours of Operation	16 hours
Emissions	9.5025853 lbs PM_{10}/day per 100'
	0.075 g PM_{10}/s
	0.95 lbs $PM_{2.5}$/day per 100'
	0.0075 g $PM_{2.5}$/s

Estimation of Emissions from Compactor and Bulldozer Area Sources

PM_{10}[1]

$E = [1.0(s)^{1.5} / (M)^{1.4}] \times (\%PM_{10})$

M	7.9 % moisture
s	6.9 % silt
$\%PM_{10}$	0.75 %
Emissions (E)	0.75 lb/hr
	0.095 g/s

$PM_{2.5}$[2]

$E = [5.7(s)^{1.2} / (M)^{1.3}] \times (\%PM_{2.5})$

M	7.9 % moisture
s	6.9 % silt
$\%PM_{2.5}$	0.105
Emissions (E)	0.11 lb/hr
	0.013 g/s

[1] AP-42 Table 11.9-1, Bulldozer, Overburden, PM_{15} Corrected to PM_{10}

[2] AP-42 Table 11.9-1, Bulldozer, Overburden, TSP Corrected to $PM_{2.5}$

Compactor

Working Area	979 m^2
PM_{10}	9.7E-05 g/s-m^2
$PM_{2.5}$	1.4E-05 g/s-m^2

Bulldozer

Working Area	5463 m^2
PM_{10}	1.7E-05 g/s-m^2
$PM_{2.5}$	2.4E-06 g/s-m^2

Estimation of Emissions from On-Site Paved Roads

		Vehicle	Average Suface Silt Loading (g/m²)[1]	Vehicle Weight (tons)	Trips/Day	Fleet Average Vehicle Weight (tons)	Distance Traveled (100' VMT)	Fugitive $PM_{2.5}$ Emission Factor (lb/VMT)[2]	Fugitive $PM_{2.5}$ Emission Rate (lb/day per 100')	Fugitive $PM_{2.5}$ Emission Rate Based on Daily Hours of Operation (g/s per 100')	Fugitive PM_{10} Emission Factor (lb/VMT)[2]	Fugitive PM_{10} Emission Factor (lb/day per 100')	Fugitive PM_{10} Emission Rate Based on Daily Hours of Operation (g/s per 100')	Description
Approach	SB	King County Haul	7.40	27	274	27.00	0.019	0.133	0.688	0.00542124	0.886	4.598	0.0362107	Intersection of 228th Avenue and unnamed road (east) to Location 3
	SB	Other Truck		17	0									
	SB	Other Vehicle		3	0									
Departure	NB	King County Haul		27	262	27.00		0.133	0.658	0.0051838	0.886	4.397	0.034625	Location 3 to intersection of 228th Avenue and unnamed road (east)
	NB	Other Truck		17	0									
	NB	Other Vehicle		3	0									

P (# of "wet" days)	180	
Daily Hours of Operation	16	
Constant	PM2.5	PM10
k (lb/VMT)	0.0024	0.016
C (lb/VMT)	0.00036	0.00047

Silt Loading value taken from Table 13.2.1-3 in AP-42

Estimation of Emissions from Unpaved Landfill Roads

$$E = k\,(s/12)^a (W/3)^b$$

$$E_{ext} = E\,[(365 - P)/365]$$

Eqs. 1a and 2, AP-42 13.2.2

Haul Trucks Section

k_{PM10}	1.5 lb/VMT
$k_{PM2.5}$	0.15 lb/VMT
s	6.4 % silt
W	27 tons
a	0.9
b	0.45
P	180
E_{ext}	1.16 lb PM_{10}/VMT
E_{ext}	0.116 lb $PM_{2.5}$/VMT

Trips per Day	536
Volume Source Spacing	0.019 miles
Daily Hours of Operation	16 hours
Emissions	11.78173 lbs PM_{10}/day per 100'
	0.093 g PM_{10}/s
	1.18 lbs $PM_{2.5}$/day per 100'
	0.0093 g $PM_{2.5}$/s

Scraper Section

k_{PM10}	1.5 lb/VMT
$k_{PM2.5}$	0.15 lb/VMT
s	6.4 % silt
W	53.8 tons
a	0.9
b	0.45
P	180
E_{ext}	1.58 lb PM_{10}/VMT
E_{ext}	0.158 lb $PM_{2.5}$/VMT

Trips per Day	21
Volume Source Spacing	0.019 miles
Daily Hours of Operation	16 hours
Emissions	16.06746 lbs PM_{10}/day per 100'
	0.127 g PM_{10}/s
	1.61 lbs $PM_{2.5}$/day per 100'
	0.0127 g $PM_{2.5}$/s

Estimation of Emissions from Compactor and Bulldozer Area Sources

PM_{10}[1]

$E = [1.0(s)^{1.5} / (M)^{1.4}] \times (\%PM_{10})$

M	7.9 % moisture
s	6.9 % silt
$\%PM_{10}$	0.75 %
Emissions (E)	0.75 lb/hr
	0.095 g/s

$PM_{2.5}$[2]

$E = [5.7(s)^{1.2} / (M)^{1.3}] \times (\%PM_{2.5})$

M	7.9 % moisture
s	6.9 % silt
$\%PM_{2.5}$	0.105
Emissions (E)	0.11 lb/hr
	0.013 g/s

[1] AP-42 Table 11.9-1, Bulldozer, Overburden, PM_{15} Corrected to PM_{10}

[2] AP-42 Table 11.9-1, Bulldozer, Overburden, TSP Corrected to $PM_{2.5}$

Compactor

Working Area	979 m^2
PM_{10}	9.7E-05 g/s-m^2
$PM_{2.5}$	1.4E-05 g/s-m^2

Bulldozer

Working Area	5463 m^2
PM_{10}	1.7E-05 g/s-m^2
$PM_{2.5}$	2.4E-06 g/s-m^2

Appendix E4: Truck Traffic and Landfill Activity Supplemental Vibration Study

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Memo

HDR

To:	Eric Mead P.E.	Date:	September 10, 2009
From:	Tim Casey	Project:	King County Cedar Hills Regional Landfill
cc:	Karissa Kawamoto	Job No.:	83825
Subject:	Truck Traffic and Landfill Activity Supplemental Vibration Study		

Introduction

HDR performed a vibration analysis to assess the potential impact of ground-borne vibration associated with typical landfill activities at the Cedar Hills Regional Landfill (CHRLF). Residents in the project area commented during the Cedar Hills Landfill 2009 Site Development Plan, Environmental Impact Study (EIS) scoping meeting about structural effects due to vibration generated by the landfill. The analysis evaluated ground-borne vibration associated with transfer truck traffic off-site and landfill activities on-site to assess the potential impact to residences and structures in the vicinity.

Human Perception of Vibration

The effects of ground-borne vibration include perceptible movement of building floors, interference with vibration sensitive instruments, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. Vibration consists of rapidly fluctuating motions. However, human response to vibration is a function of the average motion over a longer (but still short) time period, such as one second. The root mean square (RMS) amplitude of a motion over a one second period is commonly used to predict human response to vibration.

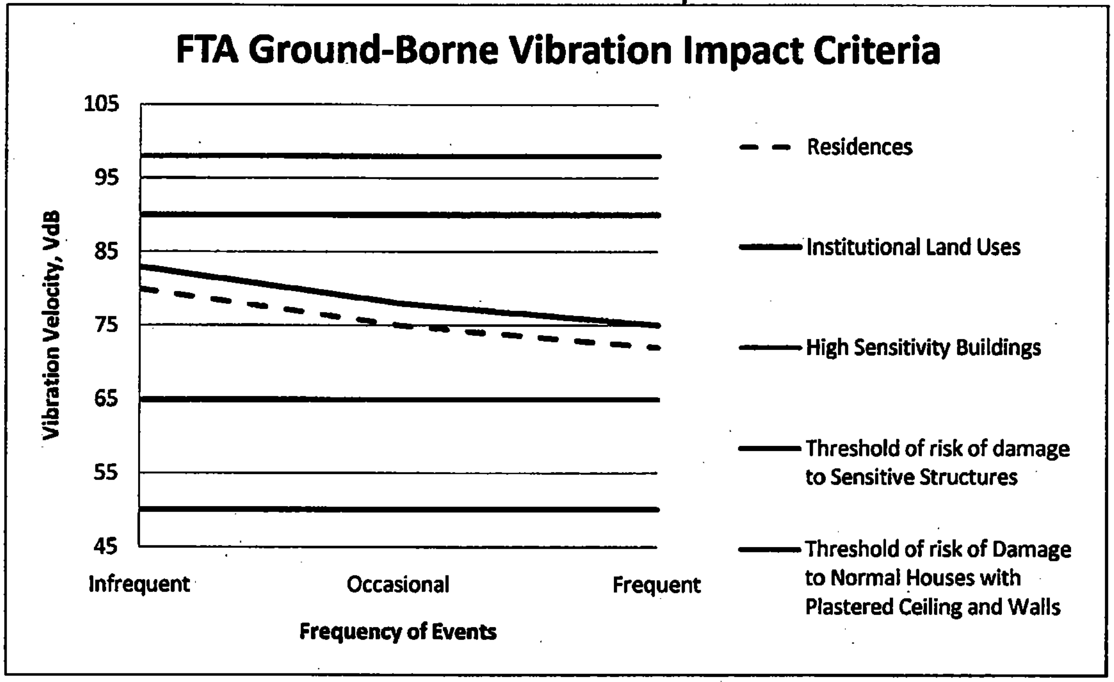
For convenience, decibel notation is used to describe vibration velocities and acceleration relative to a reference level. In this memorandum, vibration velocity is reported in decibels (VdB) relative to a reference of 10^{-6} inches per second (1 µin/sec). Vibration acceleration is reported using a reference of $1g_{rms}$ (9.807 m/s^2).

In contrast to airborne noise, ground-borne vibration is not a phenomenon that most people experience everyday. The background vibration level in residential areas is usually 50 VdB or lower—well below the threshold of perception for humans, which is around 65 VdB. Most perceptible indoor vibration is caused by sources within a building such as the operation of mechanical equipment, movement of people, or slamming of doors. Typical outdoor sources of perceptible ground-borne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads.

Vibration Criteria

The vibration criteria used in the analysis of on-site landfill activities are consistent with FTA guidelines published in the "Transit Noise and Vibration Impact Assessment". Figure 1 depicts the FTA ground-borne vibration impact criteria used in general vibration assessment and construction vibration damage criteria. Frequent events are defined as more than 70 events per day. Activities at CHRLF, such as the operation of earthmoving equipment and heavy truck movement, fall under this category. Occasional events are defined as 30 to 70 events per day. Infrequent events are defined as fewer than 30 vibration events per day.

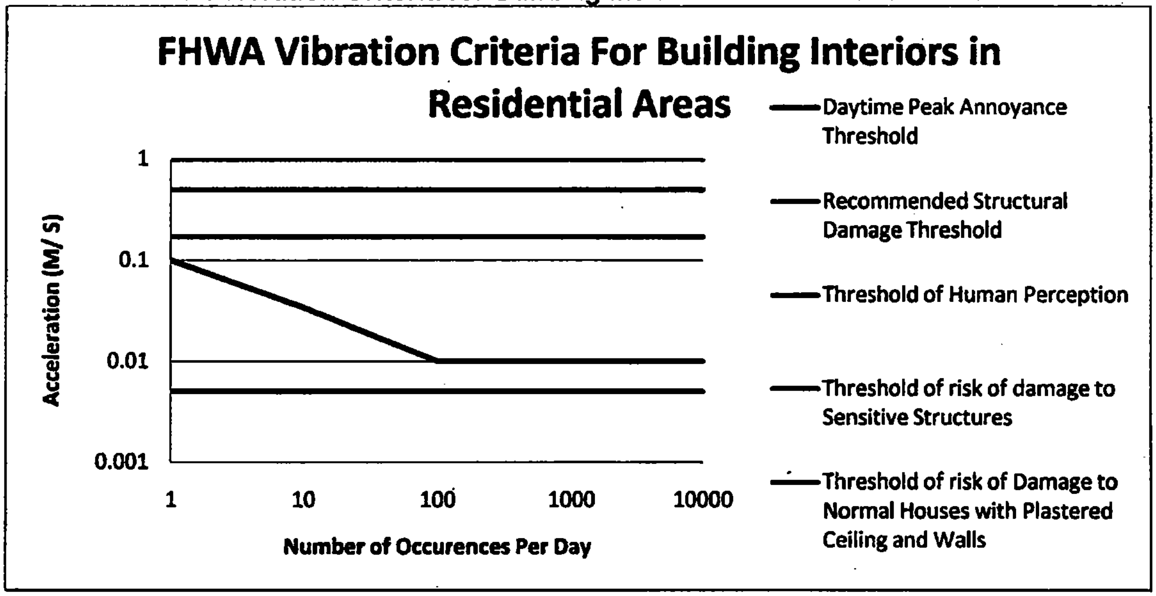
Figure 1
FTA Ground-borne Vibration Impact Criteria



The vibration criteria used in the analysis of off-site traffic activities are based on the FHWA vibration assessment guidelines. Figure 2 depicts the FHWA ground-borne vibration impact criteria for building interiors in residential areas. The threshold for human perception (annoyance) is based on both the frequency and magnitude of vehicle pass-by events.[1]

[1] Based on the CHLF Truck Study, the traffic associated with the CHRLF is approximately 150-160 during a 15-hour operational period.

Figure 2
FHWA Vibration Criteria for Building Interiors in Residential Areas



Methodology

Potential ground-borne vibration associated with activities on-site at the CHRLF was assessed using methods published by FTA for construction-related vibration analyses. FTA methods were selected because the types of mobile equipment operated at the landfill are comparable to the types of equipment used on a transportation-related construction project. Therefore, FTA methods for evaluating construction-related vibration provide a convenient estimate of ground-borne vibrations due to daily material handling activities at the landfill.[2] Ground-borne vibrations associated with transfer truck traffic were assessed using FHWA methodologies published in the "Engineering Guidelines for the Analysis of Traffic-Induced Vibration".[3]

Vibration producing activities associated with the Cedar Hills Regional Landfill site include the movement of large bulldozers, small bulldozers, and loaded trucks. The vibration producing on-site activities are limited to areas of the facility inside the facility's 1,000 foot buffer area. Other vibration producing activities that occur off-site include the hauling of gravel and heavy truck traffic.

Table 1 presents vibration source levels for several pieces of common construction-related equipment that are comparable to the equipment used at a landfill. All vibration source levels used in the CHRLF ground-borne vibration analysis utilize FTA vibration source levels.

[2] FTA, "Transit Noise and Vibration Impact Assessment" (May 2006) (FTA-VA-90-1103-06).
[3] FHWA. "Engineering Guidelines for the Analysis of Traffic-Induced Vibration" (February 1978) (FHWA-RD-78-166).

CHRLF induced vibration levels were evaluated at several distances including the property line, 500 feet beyond the property line, and at the nearest residence. Due to a lack of site specific data, normal propagation conditions were assumed. Calculated ground-borne vibration levels were compared with thresholds for human perception, annoyance, cosmetic impact, and structural damage to buildings.

Table 1[4]
Vibration Source Levels for Construction Equipment

Equipment	PPV at 25 feet (in/sec)	Approximate Lv at 25 ft
Large bulldozer	0.089	87
Loaded trucks	0.076	86
Small bulldozer	0.003	58

The FHWA methodology accounts for pavement condition, gross vehicle weight, distance to receptor, and building amplification. Calculated traffic induced ground-borne vibration levels were compared with thresholds for human perception, annoyance, cosmetic impact and structural damage to buildings to assess impact to nearby residences.

Analysis Results

The vibration associated with on-site activities are predicted to reach a maximum level of 39 VdB at 1,000 feet from the work zone and 34 VdB at 1,500 feet from the work zone. The nearest residences, located approximately 1,300 feet from the work zone, are predicted to experience a maximum vibration level of 36 VdB. A vibration velocity of 36 VdB is approximately 30 dB below the threshold of human perception and 54 dB below the threshold for structural damage to fragile buildings.

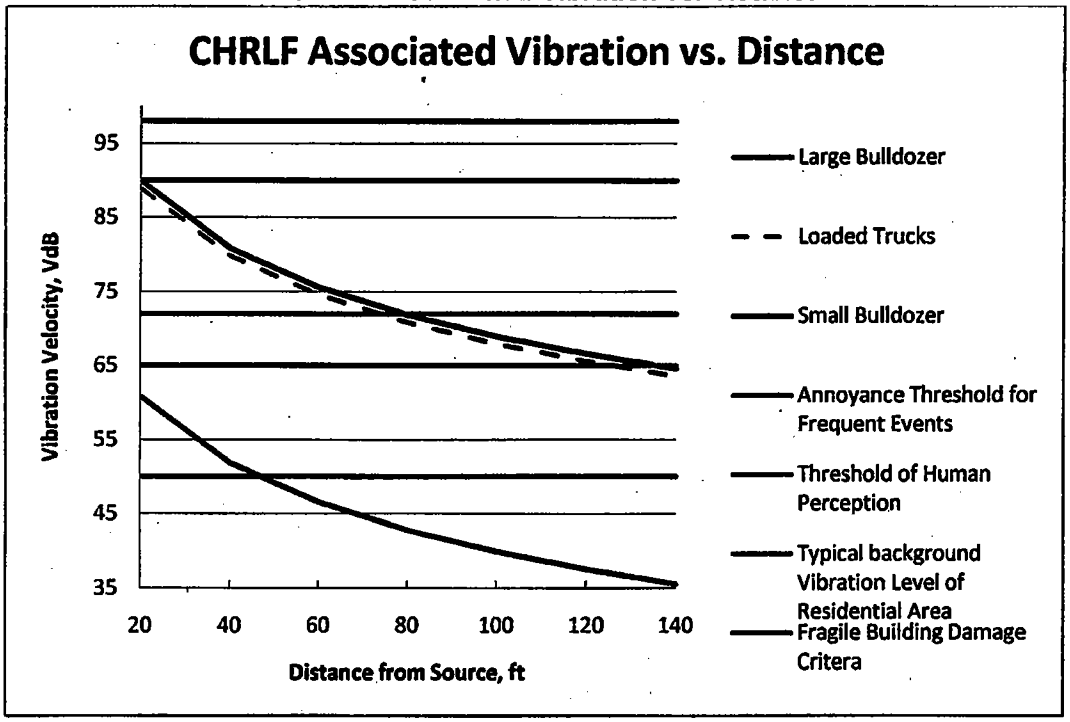
Figure 3 depicts the CHRLF work zone and the evaluated vibration thresholds. The 72 VdB contour defines the area in which ground-borne vibration will exceed the threshold of human annoyance. The 65 VdB contour defines the area in which CHRLF vibration will exceed the threshold of human perception. The 50 VdB contour outlines the area in which vibration will exceed the ambient vibration associated with residential areas.

[4] FTA, "Transit Noise and Vibration Impact Assessment" (May 2006) (FTA-VA-90-1103-06), page 12-12.

FIGURE 3
Cedar Hills Regional Landfill
Vibration Contours
Large Bulldozers
and Loaded Trucks

Results of the on-site ground-borne vibration analysis are summarized in Figure 4. Figure 4 depicts the propagation of several types of vibration producing equipment, including large bulldozers, small bulldozers, and loaded trucks.

Figure 4
CHRLF Associated Vibration vs. Distance

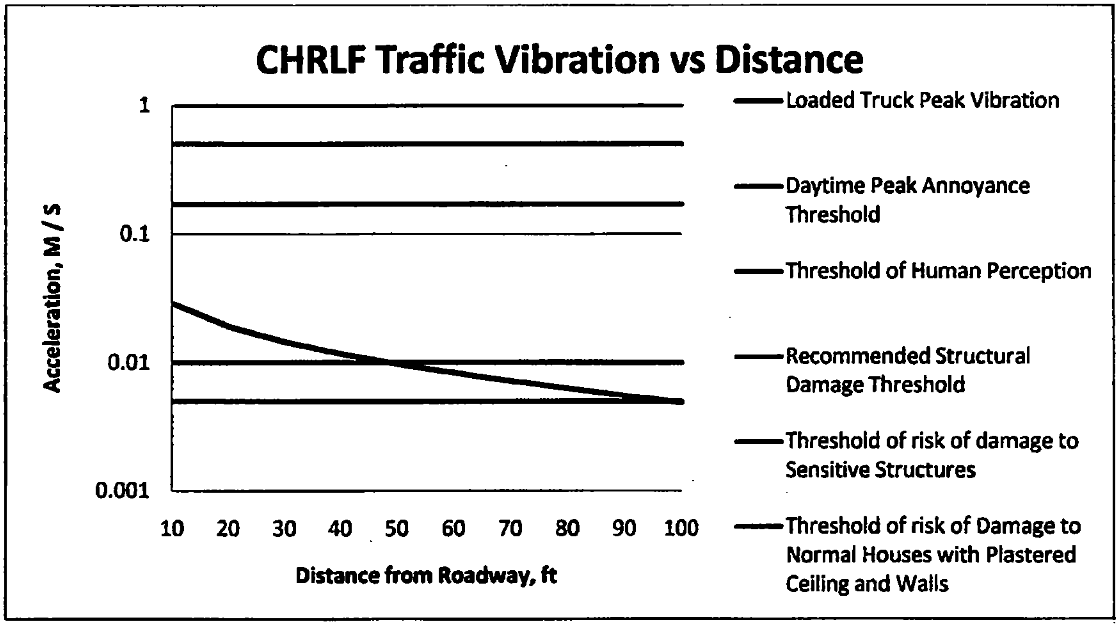


HDR's vibration analysis demonstrates that all ground-borne vibration associated with on-site activities will be below the human threshold of perception at a distance of 140 feet from the work zone[5]. This indicates that ground-borne vibration will neither be perceptible nor structurally harm residences located beyond the property line.

Results of the traffic induced, ground-borne vibration analysis are summarized in Figure 5. Figure 5 depicts the propagation of heavy truck induced vibration into homes. The values presented include a building amplification factor of +5 dB.

[5] CHRLF work zone is approximately 1,000 feet from the property line.

Figure 5
CHRLF Traffic Vibration vs. Distance



Calculated vibration levels associated with CHRLF traffic are not predicted to exceed the annoyance threshold at any nearby residences. The nearest residence, located 60 feet from the roadway, will experience a maximum vibration acceleration of 0.008 $m/s^2 \approx -61.5$ dB, which is below the threshold of annoyance[6]. Additionally maximum traffic induced vibration levels are approximately 35 dB below the FHWA threshold for structural damage.

Conclusions

The results of HDR's ground-borne vibration analysis demonstrate that vibration levels associated with on-site landfill activities and off-site hauling traffic associated with the CHRLF are not predicted to impact the nearest residences when compared to thresholds for human annoyance and structural damage. Calculated vibration levels associated with CHRLF work on-site are not predicted to exceed typical ambient vibration levels beyond the property line and will be imperceptible to the nearest residences. The 1,000 foot buffer zone provides sufficient distance to protect nearby residences from structural damage and annoyance.

Results from the ground-borne vibration analysis demonstrate that vibration levels associated with heavy truck traffic activities near the CHRLF are not predicted to impact nearby residences when compared to thresholds for human annoyance. Project-related, traffic-induced, ground-borne vibration is predicted to not cause structural or cosmetic damage to residences.

[6] Based on the FHWA peak annoyance threshold of 0.01 m/s^2.

Appendix E5: Greenhouse Gas Emissions Calculation Spreadsheet

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Solid Waste Forecast - King County Cedar Hills Landfill, GHG

Old Forecast		New Forecast (1/27/09)				
Year	Forecast Tonnage	Years	Total Tons (without yards)	Delta (tons)	Delta (%)	
2008	1,050,800	2008	930,200	120,600	0.89	
2009	1,080,800	2009	895,000	185,800	0.83	
2010	1,115,200	2010	905,000	210,200	0.81	
2011	1,133,800	2011	910,000	223,800	0.80	
2012	1,160,200	2012	910,000	250,200	0.78	
2013	1,178,800	2013	930,000	248,800	0.79	
2014	1,210,200	2014	965,000	245,200	0.80	
2015	1,242,100	2015	990,391	251,709	0.80	
2016	1,264,900	2016	994,497	270,403	0.79	
2017	1,295,700	2017	1,013,460	282,240	0.78	
2018	1,327,700	2018	1,033,022	294,678	0.78	
2019	1,353,800	2019	1,047,805	305,995	0.77	
2020	1,388,500	2020	1,068,941	319,559	0.77	
2021	1,402,500	2021	1,073,949	328,551	0.77	
2022	1,436,400	2022	1,093,972	342,428	0.76	
2023	1,442,300	2023	1,092,424	349,876	0.76	
2024	1,478,500	2024	1,113,660	364,840	0.75	
2025	1,515,900	2025	1,135,415	380,485	0.75	
2026	1,524,400	2026	1,135,402	388,998	0.74	
2027	1,563,400	2027	1,157,693	405,707	0.74	
2028	1,588,100	2028	1,169,382	418,718	0.74	
2029	1,628,700	2029	1,192,627	436,073	0.73	
2030	1,670,300	2030	1,216,257	454,043	0.73	
2031	1,670,300	2031	1,216,257	454,043	0.73	Estimated number based on previous year.

Method 1

Alternative	Added Capacity (cubic yards)	Years of Extended Landfill Life	Estimated Closure Date	Dates of Transport	Years of Transport Required	Tons Transported	Ton Miles [1]	Fuel Consumed (gallons) [2,3]	Nitrous Oxide (NO_x)[4] (Metric ton)	PM-10[4] (Metric ton)	PM-2.5[4] (Metric ton)	SO2[4] (Metric ton)	VOC[4] (Metric ton)	NH3[4] (Metric ton)	CO2[4] (Metric ton)	CH4[4] (Metric ton)	N2O[4] (Metric ton)
Alternative 1	7,700,000	3.00	12/31/2021	1/1/2022 to 1/1/2032	10.00	11,523,088	4,033,080,650	9,588,736	1,234	32	28	121	44	NA	47,167	NA	NA
Alternative 2	11,300,000	5.00	12/31/2023	1/1/2024 to 1/1/2032	8.00	9,336,692	3,267,842,300	7,769,366	1,000	26	23	98	36	NA	38,217	NA	NA
Alternative 3	14,800,000	9.00	12/31/2027	1/1/2028 to 1/1/2032	4.00	4,794,523	1,678,083,043	3,989,679	513	13	12	50	18	NA	19,625	NA	NA
Alternative 4	17,800,000	11.00	12/31/2029	1/1/2030 to 1/1/2032	2.00	908,086	317,830,164	755,648	97	3	2	10	3	NA	3,717	NA	NA
Alternative 5	18,800,000	13.00	12/31/2031	Not Applicable	0.00	0	0	0	0	0	0	0	0	NA	0	NA	NA
No Build	0	0	12/31/2018	1/1/2018 to 1/1/2032	13.00	15,746,805	5,511,381,686	13,103,429	1,686	44	39	165	61	NA	64,456	NA	NA

[1] Assumes transport distance of 350 miles. The Columbia Ridge Landfill And Recycling Center, Roosevelt Regional Landfill, and the Finley Buttes Regional Landfill are located within 350 miles of Cedar Hills.
[2] Based on an average freight rail energy intensity of 330 Btus per ton per mile. This is the current (2006) average for Class I freight railroads in the United States.
[3] Based on a conversion factor of 138,800 Btus per gallon of diesel fuel.
[4] Emission factors are based on the CCAP Guidebook Emissions Calculator for freight trains.

Alternative Method

Alternative	Added Capacity (cubic yards)	Years of Extended Landfill Life	Estimated Closure Date	Dates of Transport	Years of Transport Required	Tons Transported	Ton Miles [1]	Fuel Consumed (gallons) [2,3]	Energy Used (Mbtu)	Emission Factor Diesel Fuel Input (lbs/Mbtu)	CO2[4] (Metric ton)	From CSX	From CSX (Metric ton)
Alternative 1	7,700,000	3.00	12/31/2021	1/1/2022 to 1/1/2032	10.00	11,523,088	4,033,080,650	9,588,736	1,330,917	164	109,135	124,619	112,964
Alternative 2	11,300,000	5.00	12/31/2023	1/1/2024 to 1/1/2032	8.00	9,336,692	3,267,842,300	7,769,366	1,078,388	164	88,428	100,893	91,530
Alternative 3	14,800,000	9.00	12/31/2027	1/1/2028 to 1/1/2032	4.00	4,794,523	1,678,083,043	3,989,679	553,767	164	45,409	51,810	47,002
Alternative 4	17,800,000	11.00	12/31/2029	1/1/2030 to 1/1/2032	2.00	908,086	317,830,164	755,648	104,884	164	8,600	9,813	8,902
Alternative 5	18,800,000	13.00	12/31/2031	Not Applicable	0.00	0	0	0	0	164	0	0	0
No Build	0	0	12/31/2018	1/1/2018 to 1/1/2032	13.00	15,746,805	5,511,381,686	13,103,429	1,818,756	164	149,138	170,181	154,370

[1] Assumes transport distance of 350 miles. The Columbia Ridge Landfill And Recycling Center, Roosevelt Regional Landfill, and the Finley Buttes Regional Landfill are located within 350 miles of Cedar Hills.
[2] Based on an average freight rail energy intensity of 330 Btus per ton per mile. This is the current (2006) average for Class I freight railroads in the United States.
[3] Based on a conversion factor of 138,800 Btus per gallon of diesel fuel.
[4] Emission factors are based on the CCAP Guidebook Emissions Calculator for freight trains.

NOTE: FUEL CONSUMPTION FOR THE RETURN TRIP BACK TO KING COUNTY WAS INCLUDED AFTER THIS ESTIMATE WAS PREPARED AND FUEL CONSUMPTION WAS ADJUSTED ACCORDINGLY.