ENG.20070814.0034

LBSC	**Design Calculation or Analysis Cover Sheet** *Complete only applicable items.*	1. QA: N/A 2. Page 1

3. System Subsurface Ventilation and Mining Systems	4. Document Identifier 800-KVC-VU00-00700-000-00A

5. Title
Natural Ventilation Pressure

6. Group
Subsurface Mining, Ventilation

7. Document Status Designation
☐ Preliminary ☒ Committed ☐ Confirmed ☐ Cancelled/Superseded

8. Notes/Comments
The responsible DEM approved the use of EGS as the checker for this document (Email from R. Saunders to H. Hang on 07/31/2007, 02:05 pm.)

Attachments		Total Number of Pages
Attachment A		1
Attachment B		1
Attachment C		1
Attachment D		1
Attachment E	Electronic Files (includes one CD)	1

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/ Accepted (Print/Sign/Date)
00A	Initial Issue JS 8/20/07	27 (incl. 1 cd)	E-1	Jeff Steinhoff Jeff Steinhoff 8/13/2007	Hang Yang Hang Yang 08-13-2007	Hang Yang Hang Yang 08-13-2007	Robert Saunders Robert S. Saunders 8/13/07

DISCLAIMER

CONTENTS

FIGURES

TABLES

ABBREVIATIONS

(With readily available conversions as appropriate)

A	area (ft^2 or m^2)
cfm	volume flow, cubic feet per minute (1 cfm = 0.000472 m^3/s)
dhh	decay heat history (kW/m)
ft	length, feet (1 foot = 0.3048 m)
ft^2	area, square feet (1 ft^2 = 0.0929 m^2)
in	inch (1 inch = 25.4 mm)
in. w.g.	inches water gauge (pressure) (1 in. w.g. = 249.089 Pa)
Pa	pressure unit in Pascals
psi	pounds per square inch (1 psi = 6894.8 Pa)
k	Atkinson's friction factor (kg/m^3) ($lbfmin^2/ft^4 \times 10^{10}$)
kcfm	volume flow, 1000 cubic feet per minute (1 kcfm = 1000 cfm = 0.472 m^3/s)
L	length
m	length, meters (1 m = 3.2808 ft)
m^2	area, square meters (10.764 ft^2)
m^3/s	volume flow, cubic meters per second (1 m^3/s = 2119 ft^3/min)
P	pressure
Q	air volumetric flow rate
R	airflow resistance (Ns^2/m^8) or (PU), (PU = 1.1183 Ns^2/m^8) (Ref.2.2.12, Table I)
R_{shock}	airflow shock loss resistance (Ns^2/m^8) or (PU)
ρ	density (kg/m^3) or (lb/ft^3)

1. PURPOSE

The purpose of the calculation is to determine the Natural Ventilation Pressure (NVP) based upon different periods of forced ventilation in the emplacement drifts; and, different heat histories. The software, DriftFlow v. 1.0 will be used to determine the natural ventilation pressure and flow rate in the emplacement drifts.

2. REFERENCES

2.1 PROJECT PROCEDURES/DIRECTIVES

2.1.1 EG-PRO-3DP-G04B-00037, Rev 009, *Calculations and Analyses*

2.2 DESIGN INPUTS

2.2.1 BSC 2002. *Software Definition Report for DriftFlow v. 1.0, Revision 01.* 10722-SDR-1.0-01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021105.0366. [DIRS 161000]

2.2.2 BSC 2003. *Natural Ventilation Pressure Calculation.* 800-M0C-VU00-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030714.0002; ENG.20050817.0004. [DIRS 164316]

2.2.3 BSC 2003. *Underground Layout Configuration.* 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007; ENG.20050817.0005. [DIRS 165572]

2.2.4 BSC 2005. *IED Waste Package Decay Heat Generation* [Sheet 1 of 1]. 800-IED-WIS0-00701-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050406.0006.

2.2.5 BSC 2006. *Basis of Design for the TAD Canister-Based Repository Design Concept*. 000-3DR-MGR0-00300-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061023.0002 [DIRS 177636]

2.2.6 BSC (Bechtel SAIC Company) 2007. *Underground Layout Configuration for LA*. 800-KMC-SS00-00200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070727.0004.[DIRS 179640]

2.2.7 BSC 2006. *Ventilation Network Model Parameters for LA.* 800-KVC-VUE0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061117.0006. [DIRS 178337]

2.2.8 BSC 2007. *Ground Support Materials and Concrete Inverts - Committed and Non-Committed*. 800-K0C-SSD0-00300-000-00A Las Vegas, Nevada. Bechtel SAIC Company, ACC: 20070627.0001

2.2.9 BSC 2007. *Subsurface Air Properties Entering Emplacement Drifts*. 800-KVC-VU00-00200-000-00A. Las Vegas, Nevada. Bechtel SAIC Company, ACC: ENG.20070306.0001

2.2.10 BSC 2007. *Subsurface Ventilation Network Model for LA.* 800-KVC-VUE0-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070123.0008. [DIRS 179520]

2.2.11 Hartman, H.L.; Mutmansky, J.M.; Ramani, R.V.; and Wang, Y.J. 1997. *Mine Ventilation and Air Conditioning.* 3rd Edition. New York, New York: John Wiley & Sons. TIC: 236391. [ISBN: 0-471-11635-1] [DIRS 101877]

2.2.12 McPherson, M.J. 1993. *Subsurface Ventilation and Environmental Engineering.* New York, New York: Chapman & Hall. TIC: 215345. [ISBN 0 412 35300 8]

2.3 DESIGN CONSTRAINTS

None

2.4 DESIGN OUTPUTS

The output of the document will be used for reference as an input to the current development of the "Subsurface Construction and Emplacement Ventilation" calculation.

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

3.1.1 Determining the Decay Heat History for DriftFlow

The decay heat history for waste streams averaging more than 1.45 kW/m can be estimated by factoring the values found in Ref. 2.2.4.(*IED Waste Package Decay Heat Generation* [Sheet 1 of 1]). Scaling the values will produce decay heat curves that are parallel to the curve produced by the plotting values from Ref. 2.2.4)

Rationale: The decay heat history for waste in a particular emplacement drift may not be represented by a curve parallel to curve defined by the data in Ref. 2.2.4. However, the estimate is adequate for use in this calculation of natural ventilation pressure using DriftFlow.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

None.

4. QUALITY ASSURANCE

This calculation was prepared in accordance with EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Ref. 2.1.1). The shafts (non emplacement openings) and subsurface ventilation system, which consists of the emplacement ventilation subsystem and development ventilation subsystem, are classified as a non-Safety Category item in the *Basis of Design* (Ref. 2.2.5, Section 22.1.2). Therefore, the approved version is designated as QA:N/A.

This calculation is intended to support the License Application.

4.1 USE OF SOFTWARE

4.1.1 DriftFlow Version 1.0

The DriftFlow Version 1.0 (Software Tracking Number 10722-1.0-00) program (Ref. 2.2.1) is designed to calculate the thermal conditions in the repository. The software program was properly added to the software baseline on October 24, 2002.

DriftFlow approximates the ventilation system by the analysis of a single emplacement drift, which is then extrapolated to reflect the rest of the ventilation system. The waste packages are simplified by representing them as a single homogeneous heat-generating cylinder (Ref. 2.2.1, Section 1.2.1).

Driftflow is intended to calculate thermal conditions within the proposed repository during the forced ventilation, natural ventilation, and post-closure periods (Ref. 2.2.1, Section 1.2.1). Inspection of the code shows that DriftFlow uses the entire repository layout filled with waste packages for analysis. It cannot analyze only a portion of the repository or a repository that is partially filled with waste packages. The calculation in this document is fully within the validation range of DriftFlow. Inputs to DriftFlow and output files are included on a CD, as identified in Attachment E.

The computer used to run the software is described as follows:

- Full Computer Name: QNW-150619.ymservices.ymp.gov
- System: Microsoft Windows 2000, 5.00.2195, Service Pack 4

4.1.2 Microsoft Excel

The standard graphing feature of Excel is used to present the data generated by DriftFlow Version 1.0. The graphical representation is verified by visual inspection.

The computer used to run the software is described as follows:

- Full Computer Name: CDB-150635.ymservices.ymp.gov
- System: Microsoft Windows 2000, 5.00.2195, Service Pack 4

4.2 METHODOLOGY DESCRIPTION

The following steps were used to determine the natural ventilation pressure for various conditions:

- Determine input values
- Use DriftFlow v.1 to determine natural ventilation pressure and airflow in the emplacement drifts under various conditions
- Graph results using Microsoft Excel

4.2.1 Interfaces

None.

5. LIST OF ATTACHMENTS

	Title	Number of Pages
Attachment A	Calculation of Resistance for DriftFlow	1
Attachment B	Average Intake and Exhaust Shaft Depth	1
Attachment C	Absolute Pressure at Exhaust Shaft Collar	1
Attachment D	Average Shaft Diameter	1
Attachment E	Electronic Files (Includes 1 CD)	1

6. BODY OF ANALYSIS

6.1 DETERMINATION OF INPUT VALUES

Table 1 is a summary of the Base Case input values used in this calculation.

Table 1 - Base Case Input Values

Input Description	Base Case Input Values	Comments and References
Drift spacing (m)	81 m	Ref. 2.2.5, Section 8.2.1.8
Total system flow resistance ($Pa{\cdot}s^2/m^6$ or Ns^2/m^8)	7.06 Ps^2/m^6	See Attachment A for calculation and references.
Inlet shaft length (m)	326 m	See Attachment B for calculation and reference.
Exhaust shaft length (m)	354 m	See Attachment B for calculation and reference .
Average Inlet and exhaust shaft diameter (m)	6.8 m	DriftFlow assumes that the intake and exhaust opening diameters are equal. See Attachment D
Net cross-sectional area for airflow in drift (m^2)	16.7 m^2	180.07 ft^2 (Ref. 2.2.7, Table 8) or 16.7 m^2
Waste package diameter (m)	2.1	6.98 ft (Ref 2.2.7. Table 8) or 2.1 m
Waste package surface emissivity	.87	Use default value (Ref. 2.2.1, page 35).
Drift diameter (m)	5.5	Use the excavated diameter of the emplacement drifts (Ref. 2.2.1, page 35).
Drift wall emissivity	.92	Use Default value (Ref. 2.2.1, page 35).
Decay heat history	Use the option identified as "Other Option" in DriftFlow	Use the "Other Option" available in DriftFlow by pasting the decay history values from the *IED Waste Package Decay Heat Generation (*Ref. 2.2.4).
Average drift volumetric flowrate (m^3/s) during forced ventilation period	0	The value is 0 when there is no forced ventilation.
Forced ventilation period duration (years)	0 years	Varies. The value of 0 is used to simulate no forced ventilation prior to fan shutdown.

Input Description	Base Case Input Values	Comments and References
Natural ventilation period duration (years)	years	The value is an input variable for the number of years of natural ventilation.
Heat load ramping factor	0	Default factor used. (Ref. 2.2.1, Table 2)
Inlet air temperature (°C)	28.53 °C	The summer average temperature is used. See Table 2
Initial drift wall temperature (°C)	27.6 °C	Use default setting (Ref 2.2.1, Page 37).
Absolute air pressure at exhaust (Pa)	85250 Pa	Based on average elevation of collar of Exhaust Shafts (See Attachment C).
Choice of convection coefficient option A or B		Use the default option FEA. (Ref. 2.2.1, page 35, Parameter Ani_Ans).
Option variants for each scalar and exponential coefficient in the Dittus-Boelter and Knudsen j-factor correlations		Use the default option Dittus-Boelter (Ref. 2.2.1, Table 2 page 35).
Number of drift segments	6	Use default value (Ref. 2.2.1, page 36).

6.1.1 Inlet Air Temperature

The seasonal average temperature of the air entering the emplacement drift is summarized in Table 2:

Table 2 - Seasonal Average Temperature

Seasonal Average	Dry Bulb Temp ^{0}F (^{0}C)	Barometric Pressure (in-HG)	Relative Humidity (%)	Wet Bulb Temp ^{0}F
Overall annual average	75 (23.82)	26.3252	19.22	51.7
Winter average	65 (18.10)	26.3252	21.66	45.8
Spring average	69 (20.65)	26.3252	20.84	48.6
Summer average	83 (28.53)	26.3252	18.61	56.8
Fall average	80 (26.40)	26.3252	16.59	53.4

Ref. 2.2.9, Table 17

The summer average temperature was selected for the base case because it results in a more conservative natural ventilation pressure than using the cooler seasonal temperatures. The effect of the seasonal and overall annual average temperature on natural ventilation are evaluated in Case 3.

6.2 Description of Cases

6.2.1 General Description of Input and Output Values

The output values used in this calculation are the time in years, temperature in degrees Celsius, natural ventilation head in Pascals, and flowrate in the emplacement drifts in cubic meters per second. Although the annual values for decay heat in Watts per meter are inputs to DriftFlow, they are listed with the output values for comparison.

Output values are listed in tabular and graphic form. Table 3 through Table 5 are summaries of the input and output values for the various cases discussed. The top portion of the tables, labeled Input Description, lists the input values used for each case. The bottom portion of the table, labeled Results, contain the DriftFlow output values.

The first column contains the years. The Drift flow output is given for years 1, 5, 10, 20, etc. It also lists annual results so that a specific year can be presented. For example, year 73 is shown in Table 3 for comparison purposes.

The second column lists the Natural Ventilation Head. This column only has meaning when there is natural ventilation. See Section 6.2.2 for details.

The third column lists the airflow in the emplacement drifts. During forced ventilation, the value will be equal to the input value (15 or 16 m^3/s). During natural ventilation, the number is calculated by DriftFlow.

The graphical presentation of data in Section 7 are summaries of the data presented in the tables. They are not produced by DriftFlow.

6.2.2 Case 1

The input and output values for Case 1 are shown in Table 3.

The column on Table 3 labled Inputs shows the input values used in a 2003 calculation (Ref. 2.2.2) to estimate natural ventilation pressure and flowrate in the emplacement drifts after 73 years of forced ventilation. Natural ventilation starts in year 74.

Inspection of the DriftFlow code indicates that the pressure values shown during forced ventilation do not represent the contribution of natural ventilation to fan performance. This is not an unexpected result. The same pressure and volume relationships are shown in the *Software Definition Report* (Ref. 2.2.1, Attachment I, page 1).

In column 2 the same input data is used except forced ventilation is zero. As a result, all of the pressures and flowrates shown are the result of natural ventilation. The first two columns demonstrate the effect of reducing the forced ventilation period, all other things being equal.

Column 3 is the same as column 2 except the input values were developed from information contained in recent calculations. The natural ventilation pressure is still very close to the 2003 value. There is a slight reduction in flowrate in the emplacement drifts due to an increase in the total system flow resistance value.

6.2.3 Case 2

Case 2, as summarized in Table 4, shows the natural ventilation after 1, 5, 10, 20 and 30 years of forced ventilation. The natural ventilation flow starts in year 2, 6, 11, 21 and 31 as illustrated in the table. Only the pressure during natural ventilation is shown, as explained in Section 6.2.2.

Table 4 also shows that years of forced or natural ventilation does not seem to impact the airflow caused by decay heat. For example, the airflow in the emplacement drifts that occurs in year 50 when the decay heat is 592 W/m is always 7.5 m^3/s regardless of the number of years of forced or natural ventilation preceding it.

6.2.4 Case 3

Table 5 summarizes the natural ventilation pressure and airflow in the emplacement drifts that occurs when average seasonal temperatures are considered. As can be seen in the table, the variation of natural ventilation pressure and airflow with seasonal temperature is small.

6.2.5 Case 4

Table 6 summarizes the natural ventilation pressure and airflow in the emplacement drifts when the thermal load is varied from 1.45 kW/m to 1.8 kW/m and to 2.0 kW/m. To simulate a thermal loading of 1.8 kW/m, annual decay heat history values from Ref 2.2.4 (*IED Waste Package Decay Heat Generation [Sheet 1 of 1]*) were multiplied by a factor of 1.24 (1.8 kW/m/1.45 kW/m). To simulate a loading of 2.0 kW/m, the values were multiplied by a value of 1.38 (2.0 kW/m / 1.45 kW/m). Plots of the factored values form decay heat history curves parallel to the original Ref. 2.2.4 data curves. DriftFlow uses the factored histories to calculate the natural ventilation pressure and airflow in the emplacement drifts at different thermal loadings. (Assumption 3.1.1)

Table 6 shows that with an increase in heat of approximately 38% ($\frac{2.0kW/m - 1.45kW/m}{1.45kW/m}$ *100%), the increase in natural ventilation flow is about 11% ($\frac{10.1kW/m - 9.1kW/m}{9.1kW/m}$ *100%).

Table 3 - Case 1 Summary

Input Description	Natural Ventilation Pressure Calculation Values, 2003	Natural Ventilation Pressure Calculation Values, 2003 Data with 0 yrs. Forced Vent.	Base Case with 0 yrs. Forced Vent. For Comparison
Drift spacing (m)	81	81	81
Total system flow resistance (Pa×s^2/m^6 or Ns^2/m^8)	5.5664	5.5664	7.06
Inlet shaft length	260.42	260.42	326
Exhaust shaft length (m)	371.78	371.78	354
Inlet and exhaust shaft diameter (m)	7.3	7.3	6.8
Net cross-sectional area for airflow in drift (m^2)	12.31	12.31	16.7
Waste package diameter (m)	1.564	1.564	2.1
Waste package surface emissivity	0.87	0.87	0.87
Drift diameter (m)	5.5	5.5	5.5
Drift wall emissivity	0.92	0.92	0.92
Decay heat history			See Table 1
Average drift volumetric flowrate (m^3/s) during forced ventilation period	**16**	**0**	**0**
Forced ventilation period duration (years)	**73**	**0**	**0**
Natural ventilation period duration (years)	100	100	100
Heat load ramping factor	0	0	0
Inlet air temperature (°C)	28.53	28.53	28.53
Initial drift wall temperature (°C)	27.6	27.6	27.6
Absolute air pressure at exhaust (Pa)	84867	84867	85250
Choice of convection coefficient option A or B	A	A	
Option variants for each scalar and exponential coefficient in the Dittus-Boelter and Knudsen j-factor correlations	D-B AND FEA	D-B AND FEA	
Number of drift segments	6	6	6

Results	Decay Heat History (W/m) Yr. 0 = 1450	Nat. Vent. Head (Pa)	Ave. Flowrate (m3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)
Year 1	1399	428.43	16.0	569.3	10.1	578	9.1
Year 5	1259	434.63	16.0	593.6	10.3	601	9.2
Year 10	1135	404.22	16.0	568.3	10.1	578	9.0
Year 20	944	344.38	16.0	511.2	9.6	525	8.6
Year 30	799	296.19	16.0	462.4	9.1	478	8.2
Year 40	684	258.79	16.0	423.3	8.7	437	7.9
Year 50	592	229.49	16.0	389.9	8.4	403	7.6
Year 60	518	206.17	16.0	363.4	8.1	373	7.3
Year 70	459	187.78	16.0	341.1	7.8	346	7.0
Year 73	443	182.99	16.0	335.6	7.8	339	6.9
Year 74	438	298.74	7.33	333.8	7.7	337	6.9
Year 80	410	306.83	7.4	323.2	7.6	324	6.8
Year 90	371	295.36	7.3	307.7	7.4	306	6.6
Year 100	340	283.83	7.1	294.0	7.3	290	6.4

1 Ref. 2.2.2, Table 6 contains input values in the 1973 Calculation

Table 4 - Case 2 Summary

Input Description		Base Case, Forced Vent. 1 yr.		Base Case, Forced Vent. 5 yrs.		Base Case, Forced Vent. 10 yrs.		Base Case, Forced Vent. 20 yrs.		Base Case, Forced Vent. 30 yrs.	
Drift spacing (m)		81		81		81		81		81	
Total system flow resistance (Pa×s^2/m^6 or Ns^2/m^8)		7.06		7.06		7.06		7.06		7.06	
Inlet shaft length		326		326		326		326		326	
Exhaust shaft length (m)		354		354		354		354		354	
Inlet and exhaust shaft diameter (m)		6.8		6.8		6.8		6.8		6.8	
Net cross-sectional area for airflow in drift (m^2)		16.7		16.7		16.7		16.7		16.7	
Waste package diameter (m)		2.1		2.1		2.1		2.1		2.1	
Waste package surface emissivity		0.87		0.87		0.87		0.87		0.87	
Drift diameter (m)		5.5		5.5		5.5		5.5		5.5	
Drift wall emissivity		0.92		0.92		0.92		0.92		0.92	
Decay heat history										See Table 1	
Average drift volumetric flowrate (m^3/s) during forced ventilation period		15		15		15		15		15	
Forced ventilation period duration (years)		**1**		**5**		**10**		**20**		**30**	
Natural ventilation period duration (years)		100		100		100		100		100	
Heat load ramping factor		0		0		0		0		0	
Inlet air temperature (°C)		28.53		28.53		28.53		28.53		28.53	
Initial drift wall temperature (°C)		27.6		27.6		27.6		27.6		27.6	
Absolute air pressure at exhaust (Pa)		85250		85250		85250		85250		85250	
Choice of convection coefficient option A or B											
Option variants for each scalar and exponential coefficient in the Dittus-Boelter and Knudsen j-factor correlations											
Number of drift segments		6		6		6		6		6	
Results	Decay Heat History (W/m) Yr. 0 = 1450	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)
Year 1	1399		15.0		15.0		15.0		15.0		15.0
Year 5	1259	599	9.2		15.0		15.0		15.0		15.0
Year 10	1135	577	9.0	572	9.0		15.0		15.0		15.0
Year 20	944	524	8.6	523	8.6	520	8.6		15.0		15.0
Year 30	799	478	8.2	477	8.2	475	8.2	470	8.2		15.0
Year 40	684	437	7.9	436	7.9	435	7.8	431	7.8	426	7.8
Year 50	592	402	7.5	402	7.5	400	7.5	398	7.5	395	7.5
Year 60	518	372	7.3	372	7.3	371	7.2	368	7.2	366	7.2
Year 70	459	346	7.0	345	7.0	345	7.0	343	7.0	340	6.9
Year 80	410	324	6.8	324	6.8	323	6.8	321	6.7	319	6.7
Year 90	371	305	6.6	305	6.6	304	6.6	303	6.5	301	6.5
Year 100	340	290	6.4	289	6.4	289	6.4	287	6.4	286	6.4

Table 5 - Case 3 Summary

Input Description		Base Case, Overall avg Inlet temp.		Base Case, avg Winter Inlet temp.		Base Case, avg Spring Inlet temp.		Base Case, avg Summer Inlet temp.		Base Case, avg Fall Inlet temp.	
Drift spacing (m)		81		81		81		81		81	
Total system flow resistance (Pa×s^2/m^6 or Ns^2/m^8)		7.06		7.06		7.06		7.06		7.06	
Inlet shaft length		326		326		326		326		326	
Exhaust shaft length (m)		354		354		354		354		354	
Inlet and exhaust shaft diameter (m)		6.8		6.8		6.8		6.8		6.8	
Net cross-sectional area for airflow in drift (m^2)		16.7		16.7		16.7		16.7		16.7	
Waste package diameter (m)		2.1		2.1		2.1		2.1		2.1	
Waste package surface emissivity		0.87		0.87		0.87		0.87		0.87	
Drift diameter (m)		5.5		5.5		5.5		5.5		5.5	
Drift wall emissivity		0.92		0.92		0.92		0.92		0.92	
Decay heat history		Used		Used		Used		Used		Used	
Average drift volumetric flowrate (m^3/s) during forced ventilation period		15		15		15		15		15	
Forced ventilation period duration (years)		1		1		1		1		1	
Natural ventilation period duration (years)		100		100		100		100		100	
Heat load ramping factor		0		0		0		0		0	
Inlet air temperature (°C)		**23.82**		**18.1**		**20.65**		**28.53**		**26.4**	
Initial drift wall temperature (°C)		27.6		27.6		27.6		27.6		27.6	
Absolute air pressure at exhaust (Pa)		85250		85250		85250		85250		85250	
Choice of convection coefficient option A or B											
Option variants for each scalar and exponential coefficient in the Dittus-Boelter and Knudsen j-factor correlations											
Number of drift segments		6		6		6		6		6	
Results	Decay Heat History (W/m) Yr. 0 = 1450	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m^3/sec)
Year 1	1399	602	9.2	631	9.5	618	9.4	578	9.1	589	9.1
Year 5	1259	620	9.4	643	9.5	633	9.5	601	9.2	610	9.3
Year 10	1135	595	9.2	617	9.3	607	9.3	578	9.0	586	9.1
Year 20	944	542	8.8	560	8.9	552	8.8	525	8.6	532	8.7
Year 30	799	493	8.4	511	8.5	503	8.4	478	8.2	485	8.3
Year 40	684	451	8.0	469	8.2	461	8.1	437	7.9	444	7.9
Year 50	592	416	7.7	432	7.8	425	7.8	403	7.6	409	7.6
Year 60	518	385	7.4	401	7.5	394	7.5	373	7.3	378	7.3
Year 70	459	359	7.1	375	7.3	368	7.2	346	7.0	352	7.1
Year 80	410	336	6.9	351	7.1	345	7.0	324	6.8	330	6.8
Year 90	371	317	6.7	332	6.9	325	6.8	306	6.6	311	6.6
Year 100	340	301	6.5	316	6.7	309	6.6	290	6.4	295	6.5

Table 6 - Case 4 Summary

Input Description	Base Case with 0 yrs. Forced Vent. And 1.45 kW Decay Heat HistoryFor	Base Case with 1.8 kW Decay Heat History	Base Case with 2.0 kW Decay Heat History
Drift spacing (m)	81	81	81
Total system flow resistance (Pa×s^2/m^6 or Ns^2/m^8)	7.06	7.06	7.06
Inlet shaft length	326	326	326
Exhaust shaft length (m)	354	354	354
Inlet and exhaust shaft diameter (m)	6.8	6.8	6.8
Net cross-sectional area for airflow in drift (m^2)	16.7	16.7	16.7
Waste package diameter (m)	2.1	2.1	2.1
Waste package surface emissivity	0.87	0.87	0.87
Drift diameter (m)	5.5	5.5	5.5
Drift wall emissivity	0.92	0.92	0.92
Decay heat history	**See Table 1.**	**Table 1. Values Multiplied by 124%**	**Table 1. Values Multiplied by 138%**
Average drift volumetric flowrate (m^3/s) during forced ventilation period	**0**	**0**	**0**
Forced ventilation period duration (years)	**0**	**0**	**0**
Natural ventilation period duration (years)	100	100	100
Heat load ramping factor	0	0	0
Inlet air temperature (°C)	28.53	28.53	28.53
Initial drift wall temperature (°C)	27.6	27.6	27.6
Absolute air pressure at exhaust (Pa)	85250	85250	85250
Choice of convection coefficient option A or B			
Option variants for each scalar and exponential coefficient in the Dittus-Boelter and Knudsen j-factor correlations	Default	Default	Default
Number of drift segments	6	6	6

Results	Decay Heat History (W/m) Yr. 0 = 1450	Decay Heat History (W/m) Yr. 0 = 1800	Decay Heat History (W/m) Yr. 0 = 2000	Nat. Vent. Head (Pa)	Ave. Flowrate (m3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m3/sec)	Nat. Vent. Head (Pa)	Ave. Flowrate (m3/sec)
Year 1	1399	1736	1929	578	9.1	669	9.7	718	10.1
Year 5	1259	1563	1737	601	9.2	693	9.9	742	10.2
Year 10	1135	1409	1565	578	9.0	666	9.7	713	10.0
Year 20	944	1172	1302	525	8.6	606	9.3	649	9.6
Year 30	799	992	1102	478	8.2	552	8.8	592	9.2
Year 40	684	849	943	437	7.9	505	8.5	544	8.8
Year 50	592	735	816	403	7.6	466	8.1	499	8.4
Year 60	518	643	715	373	7.3	431	7.8	463	8.1
Year 70	459	569	633	346	7.0	401	7.5	430	7.8
Year 80	410	509	566	324	6.8	376	7.3	404	7.6
Year 90	371	461	512	306	6.6	354	7.1	381	7.3
Year 100	340	422	468	290	6.4	336	6.9	361	7.1

7. RESULT AND CONCLUSIONS

7.1 Result

7.1.1 Case 1

The conclusions drawn from Table 3 are:

- During forced ventilation, DriftFlow reports natural ventilation pressures. These values are meaningless and are not to be interpreted as the natural ventilation head contributing to fan performance.
- Minor changes to the layout since 2003 have not significantly changed the natural ventilation airflow in the emplacement drifts.

7.1.2 Case 2

Figure 1 and Figure 2 summarize the tabular data presented in Section 6.2.2. The section concluded that the number of years of forced ventilation or natural ventilation preceding a particular year does not impact the airflow in the emplacement drifts. The airflow is determined by the heat emitted from the waste packages in that particular year.

Figure 1 - Case 2 Natural Ventilation Head Varied by Years of Forced Ventilation

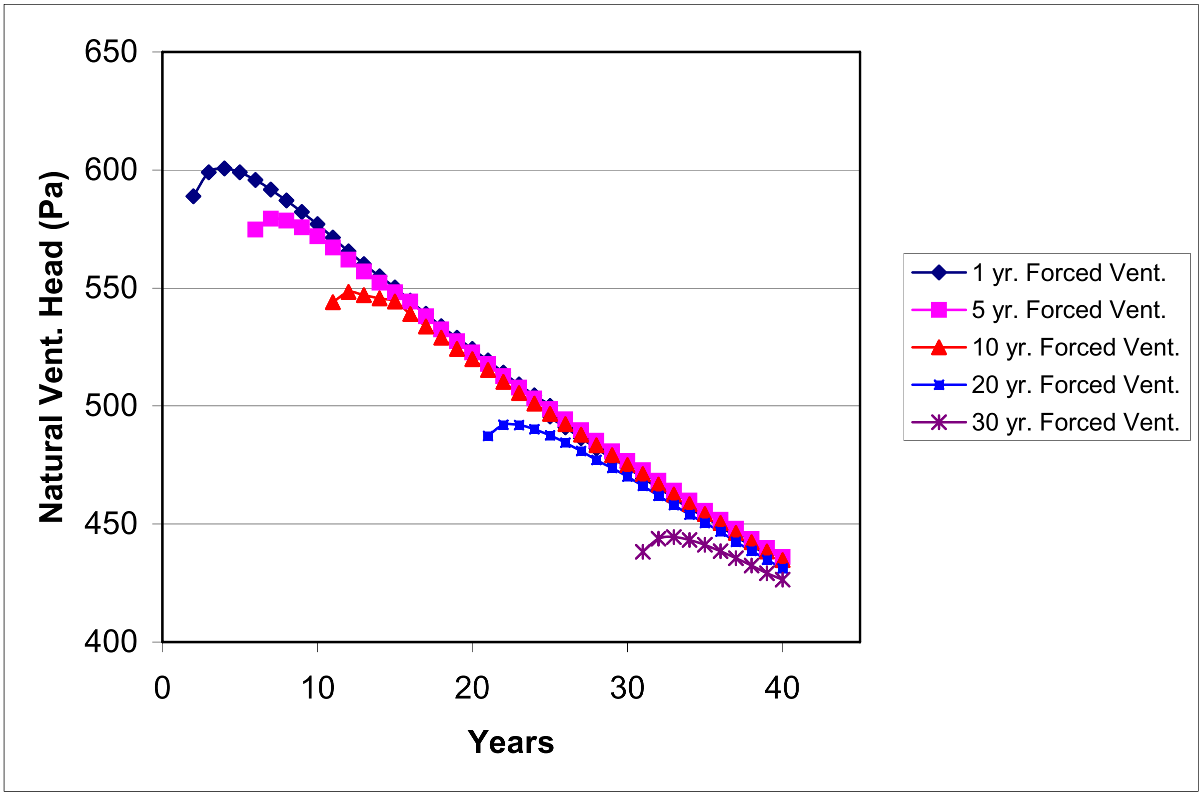
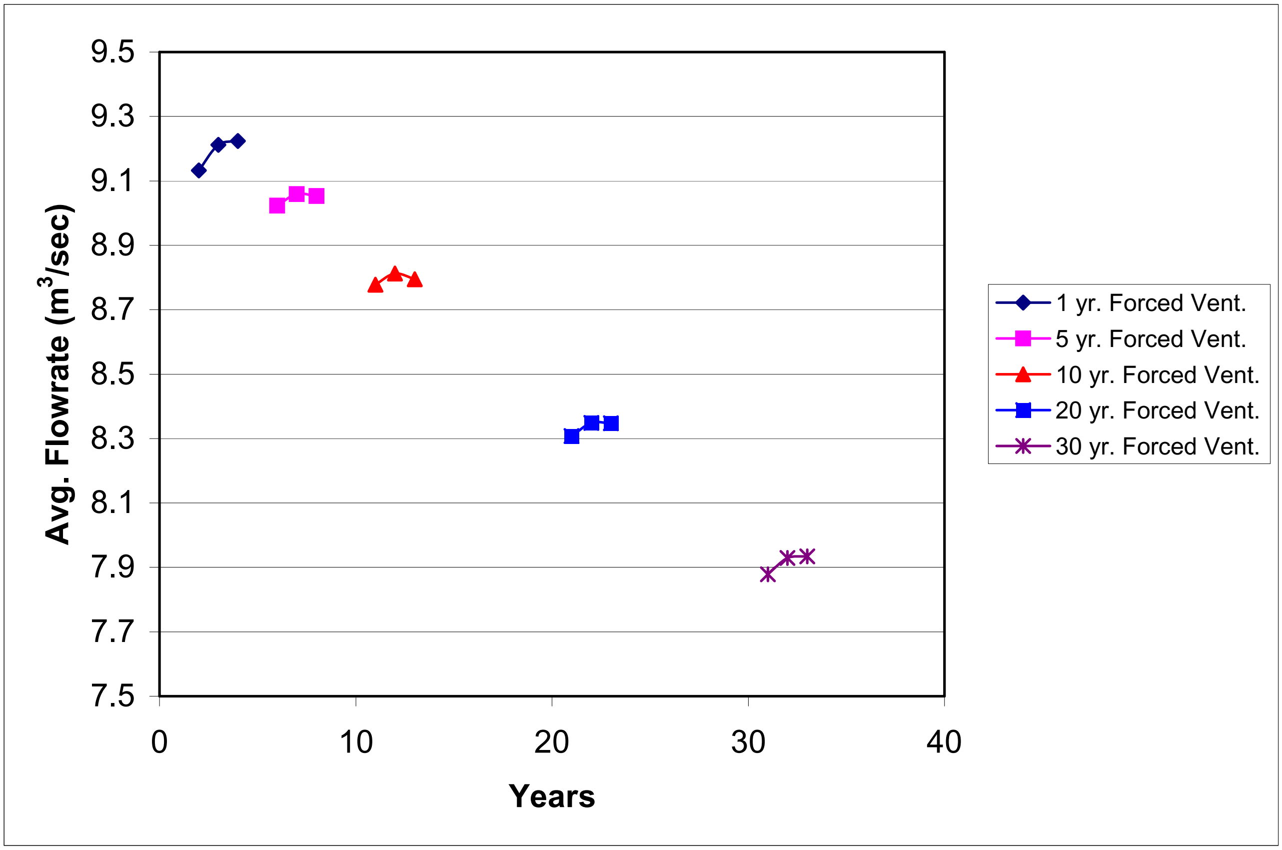


Figure 2 - Case 2 Avg. Flowrate Varied by Years of Forced Ventilation



7.1.3 Case 3

Figure 3 and Figure 4 summarize the output values from Section 6.2.4. The conclusion from the output values is that the seasonal average temperature change does not have a large impact on the natural ventilation airflow in the drifts.

Figure 3 - Natural Ventilation Head Variation with Seasonal Average Temperature

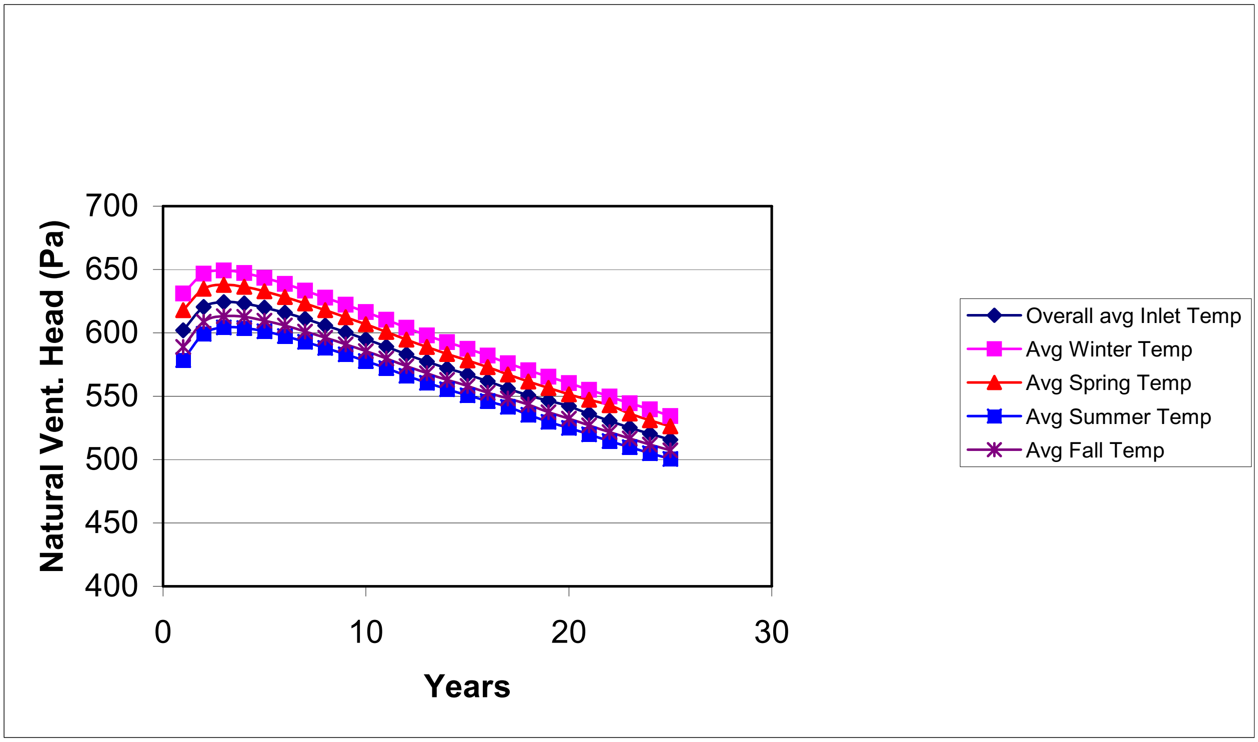
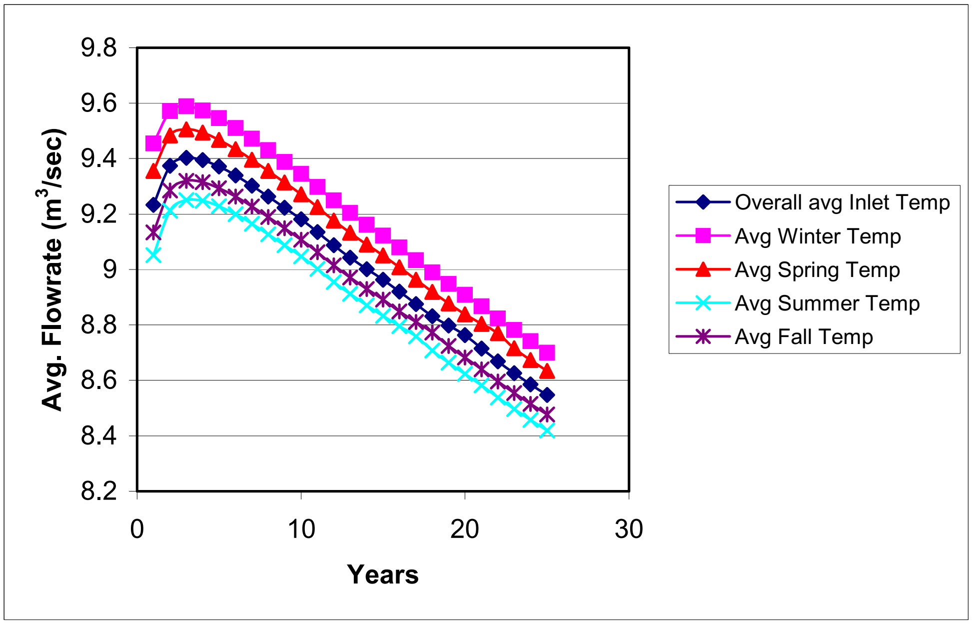


Figure 4 - Natural Ventilation Variation with Seasonal Average Temperature



7.1.4 Case 4

Figures 5 and 6 summarize the output values from Section 6.2.5. The conclusion from the outputs is that the increase from 1.45 kW/m to 2.0 kW/m (approximately 38%) causes a relatively small change in natural ventilation airflow in the emplacement drifts.

Figure 5 - Natural Ventilation Pressure with Varying Decay Heat History (DHH) kW/m

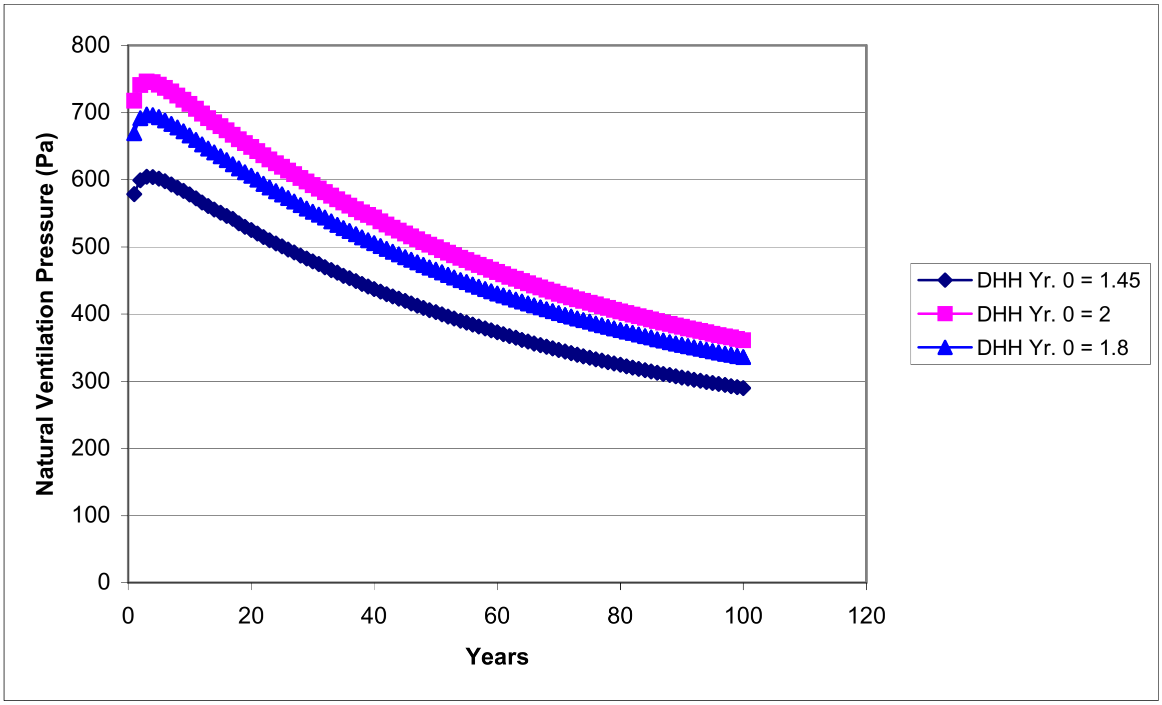
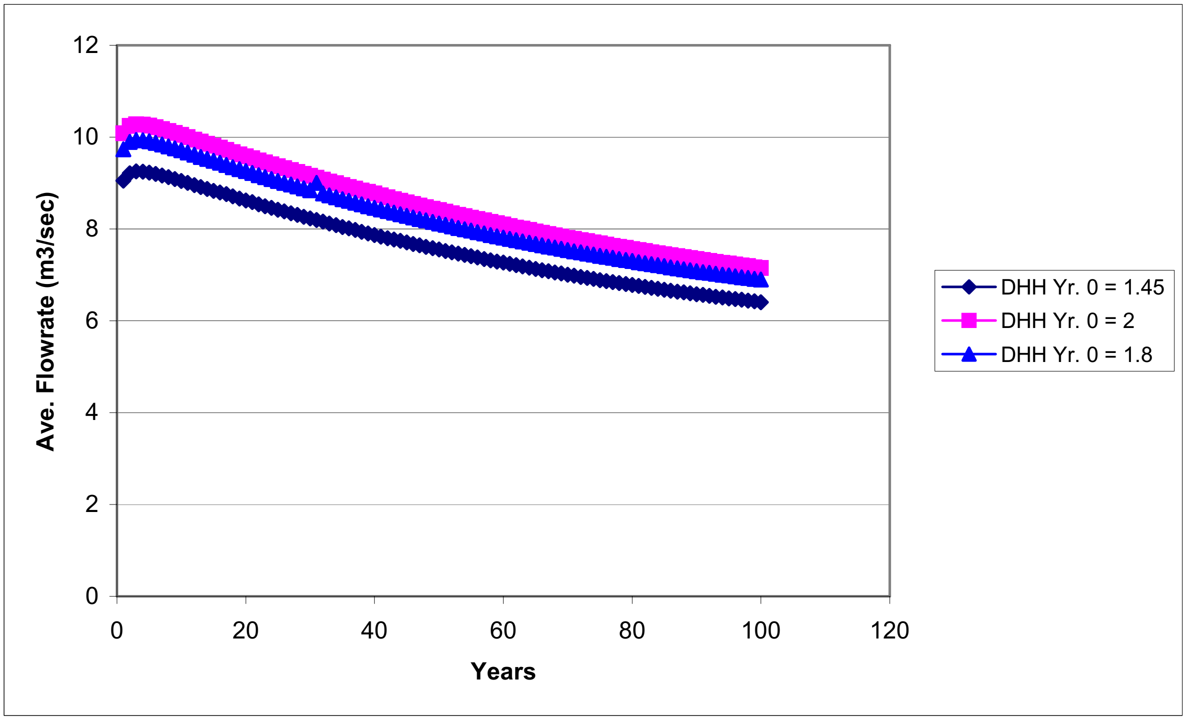


Figure 6 - Average Flowrate with Varying Decay Heat History (DHH) kW/m



Attachment A

Calculation of Resistance for DriftFlow

Fan Location [1]	Pressure (in. wg.) [1]			
ECRB Exhaust Fan	6.15			
Exhaust Shaft 1	6.59			
Exhaust Shaft 2	6.77			
Exhaust Shaft 3N	6.24			
Exhaust Shaft 3S	6.76			
Exhaust Shaft 4	5.75			
Average Pressure, H	6.37667			
Conversion wg. To Pa	249.08900	(1 in.w.g.= 249.089 Pa)		
Average Pressue in Pa	1588.358	Pa		
Design Volume per Emplacement Drift, Q m^3/s [3]	15.000	m^3/s		
R factor = H/Q^2 [2]	7.059	Pa s^2/m^6	Use 7.06 $^2/m^6$ for DriftFlow	

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[1] Ref. 2.2.10, Table 1

[2] Ref. 2.2.1, Equation 5 The total system flow resistance for DriftFlow is defined as the pressure drop provided by each fan divided by the volumetric flowrate in each emplacement drift squared. (Ref 2.2.1., Equation 5)

[3] The design flowrate in the emplacement drifts that results in the average pressure shown in the table is 32,000 cfm. (15 m^3/s) (Ref. 2.2.10, Section 4.3.5).

Attachment B

Average Intake and Exhaust Shaft Depth

Location	Shaft Depth (ft)	Shaft Depth (m)
Intake Shaft 4	1240 ft	
Intake Shaft 3	1150 ft	
Intake Shaft 2	814 ft	
Average Intake Shaft	1068 ft	326 m
Exhaust Shaft 1	1167 ft	
Exhaust Shaft 3S	1404 ft	
Exhaust Shaft 4	958 ft	
Exhaust Shaft 3N	1217 ft	
Exhaust Shaft 2	915 ft	
ECRB Shaft	1306 ft	
Average Exhaust Shaft	1161 ft	354 m

Ref. 2.2.10, Table 6

Attachment C

Absolute Pressure at Exhaust Shaft Collar

1. Determine Average Shaft Collar Elevation

LA Shaft Name (1)	Shaft Name (2)	Collar Elevation (2)	
		meters	feet
	Intake		
	Exhaust		
Exhaust Shaft 1	Exhaust Raise 1	1435	4707.996
Exhaust Shaft 3 South	Exhaust Raise 2	1340	4396.317
Exhaust Shaft 4	Exhaust Shaft 1	1470	4822.825
Exhaust Shaft 3 North	Exhaust Shaft 2	1450	4757.208
Exhaust Shaft 2	Exhaust Shaft 3	1400	4593.167
ECRB Exhaust Shaft	ECRB Exhaust Shaft	1475	4839.229
	Average	1428.333	4686.124

(1) Ref.2.2.6, Table 8, *Shaft Nomenclature*

(2) Ref. 2.2.3, Table 7 *Shaft Locations*

2. Interpolation to Determine Absolute Pressure at Average Exhaust elevation of Shaft Collar.

Elevation above Sea Level (ft) (1)	Atmospheric Pressure (psi) (1)
4500	12.45
4686.124	12.3644
5000	12.22

Ref. 2.2.11, Table A-1

General Note: The interpolated value is 12.3644 psi.

3. Convert PSI to Pa (1 psi = 6894.8 Pa)

The absolute pressure at the exhaust shaft collar is 85250 Pa (12.36 psi * 6894.8 = 85250 Pa).

Attachment D

Average Shaft Diameter

Underground Layout for LA Nomenclature [1]	Excavated Diameter (m)	Excavated Diameter (ft)	Reference Table as Noted [1]	Liner Thickness [2] (m)	Inside Diameter (m)
Exhaust Shaft #1	5	16	Table 3, Panel 1	0.25	4.5
Exhaust Shaft 2	8	26	Table 4, Panel 2	0.3	7.4
ECRB Exhaust Shaft	8	26	Table 4, Panel 2	0.3	7.4
Exhaust Shaft #3S	5	16	Table 5 Panel 3	0.25	4.5
Intake Shaft 4	8	26	Table 5, Panel 3	0.3	7.4
Intake Shaft #2	8	26	Table 4, Panel 2	0.3	7.4
Exhaust Shaft #4	8	26	Table 5 Panel 3	0.3	7.4
Intake Shaft 3	8	26	Table 5, Panel 3	0.3	7.4
Exhaust Shaft #3N	8	26	Table 5, Panel 3	0.3	7.4
Average Diameter (m)					6.8

[1] Ref. 2.2.6, Table as noted

[2] Ref. 2.2.8, Table 2

Attachment E

Electronic Files

The output tables from DriftFlow v.1 are contained on a non-rewritable CD that has been included in the record package. The files on the CD are as follows:

File	Description	File Size	Date & Time
Case 1.1.xls	Natural Ventilation Pressure Calculation Values 2003 data 73 years forced ventilation, Case 1.2	2199 kb	7/31/2007 @ 4:01 PM
Case 1.2.xls	Natural Ventilation Pressure Calculation Values 2003 Data with 0 yrs. Forced Ventilation	2189 kb	7/31/2007 @ 4:01 PM
Case 1.3.xls	Base Case with 0 Yrs. Forced Ventilation for Comparison	2189 kb	7/31/2007 @ 4:03 PM
Case 2.1.xls	Base Case, Forced Ventilation for 1 year	2189 kb	7/31/2007 @ 4:04 PM
Case 2.2.xls	Base Case, Forced Ventilation for 5 years	2190 kb	7/31/2007 @ 4:04 PM
Case 2.3.xls	Base Case, Forced Ventilation for 10 years	2190 kb	7/31/2007 @ 4:06 PM
Case 2.4.xls	Base Case, Forced Ventilation for 20 years	2192 kb	7/31/2007 @ 4:06 PM
Case 2.5.xls	Base Case, Forced Ventilation for 30 year	2193 kb	7/31/2007 @ 4:07 PM
Case 3.1	Base Case, Overall Average Inlet Temperature	2189 kb	7/31/2007 @ 4:08 PM
Case 3.2	Base Case, Average Winter Inlet Temperature	2189 kb	7/31/2007 @ 4:09 PM
Case 3.3	Base Case, Average Spring Inlet Temperature	2189 kb	7/31/2007 @ 4:10 PM
Case 3.4	Base Case, Average Summer Inlet Temperature	2189 kb	7/31/2007 @ 4:08 PM
Case 3.5	Base Case, Average Fall Inlet Temperature	2189 kb	7/31/2007 @ 4:10 PM
Case 4.1.xls	Base Case with 1.8 kW/m Decay Heat History	2190 kb	8/7/2007@ 10:51 AM
Case 4.2.xls	Base Case with 2.1 kW/m Decay Heat History	2191 kb	8/7/2007@ 10:53 AM
Readme	Description of files on CD.	1 kb	8/7/2007@ 10:55 AM