Sandia National Laboratories

date: March 6, 2017

to: Records Center

from: Patricia Johnson, SNL Contractor

subject: 2016 Calculated Densities

The groundwater densities for the WIPP Culebra monitoring wells were calculated for 2016 as described in the Activity/Project Specific Procedure (SP) 9-11 *Calculation of Densities for Groundwater in WIPP Wells*. The derivation of the data is explained in the following sections and supporting data are attached.

1. Calculation Process:

As stated in SP 9-11, for each calculation the observed water pressure is divided by the height of the water column. Specifically, the measured pressure value minus the closest corresponding barometric pressure was divided by the pressure gauge depth minus the closest corresponding depth to water (from or adjusted to the same measurement point elevation), and that result was then divided by 0.4335 (psi to feet of water conversion at 4°C, at which temperature the density of pure water is 1.000 g/cm³). The individual calculated density results for each well were then averaged for a final density value.

The density data are included in the *2016 Calculated Densities.xlsx* spreadsheet file created in Excel. Within that spreadsheet, the worksheet *2016 Calc Dens* summarizes the resulting density values and supporting information for the calculated densities, and the worksheet *2016 Calc Dens Formulas* provides the formulas in the worksheet. In addition, the Excel file contains individual well worksheets that include the data used for the calculations and plots of the pressure gauge pressure data. The columns in the worksheets and their contents are described below:

- A – Monitor Well – Well name
- B – 2016 Avg Calc Dens (g/cm³) – Average calculated density value for 2016
- C – 2016 Specific Gravity (Reference: Freshwater at 70°F) – Average calculated density value for 2016 divided by 0.998 to represent specific gravity in reference to freshwater at 70°F
- D – 2015 Avg Calc Dens (g/cm³) – Average calculated density value for 2015
- E – 2015 Specific Gravity (Reference: Freshwater at 70°F) – Average calculated density value for 2016 divided by 0.998 to represent specific gravity in reference to freshwater at 70°F
- F – 2016 - 2015 Avg Calc Dens Difference (g/cm³) – Difference between 2016 and 2015 densities (Column B - Column D)
- G – # of Dens Averaged – number of density values averaged to get the final value
- H – 2016 Timeframe of Data – Time period for pressure data used in calculations
- I – Pressure Gauge File Name (Gauge SN) – File name for pressure data and INW or In-Situ gauge serial number

1

- I – Pressure Gauge File Name (Gauge SN) – File name for pressure data and INW or In-Situ gauge serial number
- J – Pressure Gauge Install Depth (ft BTOC/BTEC/BTOT) – Depth below primary measuring point at which the pressure gauge was installed
- K – Pressure Gauge Ideal Install Depth (ft BTOC/BTEC/BTOT) – Mid-Culebra depth below top of referenced casing
- L – Length Off Ideal Depth (ft) – Depth in feet that the pressure gauge is installed below or above the ideal (Column J - Column K)
- M – Date of Install – Date the pressure gauge was installed
- N – Installation Logbook Page – Reference to scientific notebook and page(s) where the pressure gauge installation is documented
- O – Comments/Explanations – Comments and/or explanations regarding data, as needed

The spreadsheet entries were verified by Michael Schuhen (6932) and Shelly Nielsen (6930).

2. Identification/Listing of Input, Input sources, and Output:
- Excel spreadsheet including the data – 2016 Calculated Densities.xls
  - Worksheet 1 – 2016 Calc Dens
  - Worksheet 2 – 2016 Calc Dens Formulas
  - Worksheet 3 – Baro Data
  - Worksheet 4 – AEC-7R
  - Worksheet 5 – C-2737
  - Worksheet 6 – ERDA-9
  - Worksheet 7 – H-2b2
  - Worksheet 8 – H-3b2
  - Worksheet 9 – H-4bR
  - Worksheet 10 – H-5b
  - Worksheet 11 – H-6bR
  - Worksheet 12 – H-7b1
  - Worksheet 13 – H-9bR
  - Worksheet 14 – H-10cR
  - Worksheet 15 – H-11b4R
  - Worksheet 16 – H-12R
  - Worksheet 17 – H-15R
  - Worksheet 18 – H-16
  - Worksheet 19 – H-17
  - Worksheet 20 – H-19b0
  - Worksheet 21 – IMC-461
  - Worksheet 22 – SNL-1
  - Worksheet 23 – SNL-2
  - Worksheet 24 – SNL-3
  - Worksheet 25 – SNL-5
  - Worksheet 26 – SNL-6
  - Worksheet 27 – SNL-8
  - Worksheet 28 – SNL-9
  - Worksheet 29 – SNL-10
  - Worksheet 30 – SNL-12
  - Worksheet 31 – SNL-13
  - Worksheet 32 – SNL-14
  - Worksheet 33 – SNL-15
  - Worksheet 34 – SNL-16
  - Worksheet 35 – SNL-17A
  - Worksheet 36 – SNL-18
  - Worksheet 37 – SNL-19
  - Worksheet 38 – WIPP-11
  - Worksheet 39 – WIPP-13
  - Worksheet 40 – WIPP-19

3. Data Qualification for Compliance Decision Analysis:
Data sources provided in Column I (Pressure Gauge File Name (Gauge SN)) and Column N (Installation Logbook Page), and in the References Section of this memorandum.

4. Software Used:
Lenovo, Intel® Core™ i7-4810MQ CPU, Windows 10 Pro, Microsoft Office 2016 Excel

5. Reviews:
Technical: Michael Schuhen, 6932

QA: Shelly Nielsen, 6930

6. References:

- Pressure gauge installation data and SNL water level data from the following scientific notebooks (package ERMS 543277):
  Long-Term Monitoring Notebook (LTM)-23
  Long-Term Monitoring Notebook (LTM)-24
  Long-Term Monitoring Notebook (LTM)-25
- RES Water Level Data submitted to SNL in monthly memoranda (package ERMS 525178)
- Johnson, Patricia B., Culebra Center Depths for Use in Calculating Equivalent Freshwater Heads of the Culebra Dolomite Member of the Rustler Formation near the WIPP Site, Revision 3, June 10, 2010 (ERMS 553781)

7. List of Attachments:

1. Printout of Excel file worksheet 2016 Calc Dens.xls
2. Printout of Excel file worksheet 2016 Calc Dens Formulas.xls
3. CD including the Excel file and memorandum

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Monitor Well	2016 Avg Calc Dens (g/cm³)	2016 Specific Gravity (Reference: Freshwater at 70°F)	2015 Avg Calc Dens (g/cm³)	2015 Specific Gravity (Reference: Freshwater at 70°F)	2016 - 2015 Avg Calc Dens Difference (g/cm³)	# of Dens Averaged	2016 Timeframe of Data	Pressure Gauge File Name (Gauge SN)	Pressure Gauge Install Depth (ft BTOC/BTEC/BTOT)	Pressure Gauge Ideal Install Depth (ft BTOC/BTEC/BTOT)	Length Off Ideal Depth (ft)	Date of Install	Installation Logbook Page	Comments/Explanations
	AEC-7R	1.058	=B4/0.998	1.056	=D4/0.998	=B4-D4	6	Aug - Oct	AEC-7R C11 072716 (21237053)	866	872.98	=J4-K4	42578	LTM-25, page 64	
	C-2737	1.021	=B5/0.998	1.021	=D5/0.998	=B5-D5	6	Aug - Oct	C-2737 C30 072116 (21225020)	688.85	689.78	=J5-K5	42572	LTM-25, page 59	
	ERDA-9	1.071	=B6/0.998	1.071	=D6/0.998	=B6-D6	6	Aug - Oct	ERDA-9 C22 080216 (21225018)	717.2	717.81	=J6-K6	42584	LTM-25, page 69	
	H-2b2	1.009	=B7/0.998	1.009	=D7/0.998	=B7-D7	6	Aug - Oct	H2b2 C14 120115 (21534013), H-2b2 C15 100516 (21237067)	635.5	635.5	=J7-K7	12/1/2015; 10/5/2016	LTM-24, page 33; LTM-25, page 108-	
	H-3b2	1.011	=B8/0.998	1.017	=D8/0.998	=B8-D8	6	Aug - Oct	H-3b2 C23 062916 (21225021)	670.6	687.1	=J8-K8	42550	LTM-25, page 42	
	H-4bR	1.021	=B9/0.998	1.027	=D9/0.998	=B9-D9	6	Aug - Oct	H-4bR C13 051016 (21237088)	507.9	507.54	=J9-K9	42500	LTM-24, page 144	
	H-5b	1.08	=B10/0.998	1.083	=D10/0.998	=B10-D10	4	Jun - Jul	H-5b C18 021616 (21237077)	909.22	909.22	=J10-K10	42416	LTM-24, page 87	
	H-6bR	1.036	=B11/0.998	1.036	=D11/0.998	=B11-D11	6	Aug - Oct	H-6bR C10 120105 (21534009), H-6bR C11 102516 (21237027)	616.6	616.58	=J11-K11	12/1/2015; 10/25/2016	LTM-25, page 31; LTM-25, page 130	
	H-7b1	1.006	=B12/0.998	1.007	=D12/0.998	=B12-D12	6	Aug - Oct	H-7b1 C21 120215 (21237010), H-7b1 C22 102416 (21237008)	269.9	269.13	=J12-K12	12/2/2015; 10/24/2016	LTM-24, page 34; LTM-25, page 128	
	H-9bR	1.002	=B13/0.998	1.002	=D13/0.998	=B13-D13	6	Aug - Oct	H-9bR C10 100615 (21534011), H-9bR C11 082516 (21237083)	660.54	660.54	=J13-K13	10/6/2015; 8/25/2016	LTM-23, page 125; LTM-25, page 87	
	H-10cR	1.103	=B14/0.998	1.095	=D14/0.998	=B14-D14		Jun - Aug	H-10cR C14 051716 2016-06-14 08.47.22.wsf (178126), H-10cR C05 061416_2016-08-29_14-17-24_062 (178135)	1358.39	1367.5	=J14-K14	42535	LTM-25, page 8; LTM-25, page 23	Well was being worked over and developed during the year. Density is not considered representative of formation water.
	H-11b4R	1.076	=B15/0.998	1.076	=D15/0.998	=B15-D15	6	Aug - Oct	H-11b4R C10 051016 (21237047)	735.85	735.85	=J15-K15	42500	LTM-24, page 142	5/10/16 depth noted as 759.56, which is the cable length and is incorrect
	H-12R	1.108	=B16/0.998	1.106	=D16/0.998	=B16-D16	6	Aug - Oct	H-12R C08 072716 (21237030)	835.8	837.67	=J16-K16	42578	LTM-25, page 63	
	H-15R	1.117	=B17/0.998	1.117	=D17/0.998	=B17-D17	6	Aug - Oct	H-15R C17 030816 (21237028), H-15R C18 082516 (21237040)	872.5	872.57	=J17-K17	3/8/2016, 8/25/2016	LTM-24, page 100; LTM-25, page 88	
	H-16	1.033	=B18/0.998	1.032	=D18/0.998	=B18-D18	6	Aug - Oct	H-16 C11 051116 (21237081)	715.1	715.1	=J18-K18	42501	LTM-24, page 145	
	H-17	1.131	=B19/0.998	1.131	=D19/0.998	=B19-D19	6	Aug - Oct	H-17 C16 120215 (21534014), H-17 C17 102516 (21237034)	719.93	719.93	=J19-K19	12/2/2015; 10/25/2016	LTM-24, page 34; LTM-25, page 131	
	H-19b0	1.064	=B20/0.998	1.064	=D20/0.998	=B20-D20	6	Aug - Oct	H-19b0 C22 072116 (21237048)	754	753.49	=J20-K20	42572	LTM-25, page 56	
	IMC-461	1	=B21/0.998	1.002	=D21/0.998	=B21-D21	6	Aug - Oct	IMC-461 C32 060916 (21237080)	376.5	376.1	=J21-K21	42530	LTM-25, page 20	
	SNL-1	1.029	=B22/0.998	1.028	=D22/0.998	=B22-D22	6	Aug - Oct	SNL-1 C29 061516 (21237051), SNL-1 C30 102416 (21534013)	612.9	612.23	=J22-K22	6/15/2016; 10/24/2016	LTM-25, page 25; LTM-25, page 127	6/15/16 depth is noted as 653.34, which is the cable length and is incorrect
	SNL-2	1.007	=B23/0.998	1.006	=D23/0.998	=B23-D23	6	Aug - Oct	SNL-2 C33 120115 (21237031), SNL-2 C34 102416 (21237036)	470.7	470.69	=J23-K23	12/1/2015; 10/24/2016	LTM-24, page 27; LTM-25, page 123	
	SNL-3	1.026	=B24/0.998	1.026	=D24/0.998	=B24-D24	6	Aug - Oct	SNL-3 C19 120115 (21237042), SNL-3 C20 102416 (21534012)	766.5	766.19	=J24-K24	12/1/2015; 10/24/2016	LTM-24, page 29; LTM-25, page 126	
	SNL-5	1.008	=B25/0.998	1.007	=D25/0.998	=B25-D25	6	Aug - Oct	SNL-5 C29 030816 (21237036), SNL-5 C30 081716 (21237066)	649	648.84	=J25-K25	3/8/2016; 8/17/2016	LTM-24, page 102; LTM-25, page 76	
	SNL-6	1.245	=B26/0.998	1.244	=D26/0.998	=B26-D26	6	Aug - Oct	SNL-6 C20 012116 (21238004)	1338.2	1338.03	=J26-K26	42725	LTM-24, page 49	1/21/16 was a test restart and not an install
	SNL-8	1.094	=B27/0.998	1.093	=D27/0.998	=B27-D27	6	Jul - Oct	SNL-8 C40 040716 (21237032), SNL-8 C41 090816 (21237032), SNL-8 C42 101916 (21237038)	969.7	969.7	=J27-K27	4/7/2016; 9/8/2016	LTM-24, page 122; LTM-25, page 91	
	SNL-9	1.016	=B28/0.998	1.016	=D28/0.998	=B28-D28	6	Aug - Oct	SNL-9 C30 061516 (21237067), SNL-9 C31 082416 (21237084)	567.2	567.2	=J28-K28	6/15/2016; 8/24/2016	LTM-25, page 26; LTM-25, page 86	6/15/16 iis noted as 922.18' (SNL-15 depth), which is incorrect
	SNL-10	1.008	=B29/0.998	1.008	=D29/0.998	=B29-D29	6	Aug - Oct	SNL-10 C23 030816 (21237038), SNL-10 C24 082416 (21237064)	613.5	613.46	=J29-K29	3/8/2016; 8/24/2016	LTM-24, page 103; LTM-25, page 85	
	SNL-12	1.004	=B30/0.998	1.005	=D30/0.998	=B30-D30	6	Aug - Oct	SNL-12 C22 062716 (21237076)	570.9	570.68	=J30-K30	42548	LTM-25, page 38	
	SNL-13	1.023	=B31/0.998	1.023	=D31/0.998	=B31-D31	6	Aug - Oct	SNL-13 C26 072816 (21225017)	401	400.62	=J31-K31	42579	LTM-25, page 66	
	SNL-14	1.043	=B32/0.998	1.042	=D32/0.998	=B32-D32	6	Aug - Oct	SNL-14 C31 120215 (21237069), SNL-14 C32 102516 (21237037)	668.95	668.95	=J32-K32	12/2/2015; 10/25/2016	LTM-24, page 35; LTM-25, page 131	
	SNL-15	1.23	=B33/0.998	1.229	=D33/0.998	=B33-D33	6	Aug - Oct	SNL-15 C28 062916 (21237073)	922.18	922.18	=J33-K33	42548	LTM-25, page 40	
	SNL-16	1.013	=B34/0.998	1.012	=D34/0.998	=B34-D34	6	Aug - Oct	SNL-16 C26 061516 (21237006), SNL-16 C27 102516 (21237009)	207.86	207.86	=J34-K34	6/15/2016; 10/25/2016	LTM-25, page 27; LTM-25, page 128	6/15/16 depth is noted as 257.15, which is the cable length and is not correct
	SNL-17A	1.006	=B35/0.998	1.007	=D35/0.998	=B35-D35	6	Aug - Oct	SNL-17 C24 072816 (21237005)	349.6	349.93	=J35-K35	42579	LTM-25, page 65	
	SNL-18	1.008	=B36/0.998	1.007	=D36/0.998	=B36-D36	6	Aug - Oct	SNL-18 C31 061416 (21237033), SNL-18 C32 091516 (21237033), SNL-18 C33 102416	549.3	549.3	=J36-K36	6/14/2016; 9/15/2016;	LTM-25, page 22; LTM-25, page 100;	
	SNL-19	1.004	=B37/0.998	1.003	=D37/0.998	=B37-D37	6	Aug - Oct	SNL-19 C20 061416 (21237029), SNL-19 C21 102416 (21237041)	355.1	354.19	=J37-K37	6/14/2016; 10/24/2016	LTM-25, page 21; LTM-25, page 122	6/14/16 depth noted as 354.19, which is the ideal depth and is not correct
	WIPP-11	1.036	=B38/0.998	1.036	=D38/0.998	=B38-D38	6	Aug - Oct	WIPP-11 C29 062716 (21237074)	857.8	857.41	=J38-K38	42548	LTM-25, page 40	
	WIPP-13	1.033	=B39/0.998	1.034	=D39/0.998	=B39-D39	6	Aug - Oct	WIPP-13 C22 030916 (21237041), WIPP-13 C23 081716 (21237062)	715.3	714.88	=J39-K39	3/9/2016; 8/17/2016	LTM-24, page 104; LTM-25, page 79	
	WIPP-19	1.05	=B40/0.998	1.048	=D40/0.998	=B40-D40	6	Aug - Oct	WIPP-19 C14 081315 (21237060), WIPP-19 C15 072816 (21237079)	770.2	769.5	=J40-K40	8/13/2015; 7/28/2016	LTM-23, page 91; LTM-25, page 67	

Notes:
ft BTOC = feet t
ft BTEC = feet b
ft BTOT = feet t
LTM = Long-Ter
NA = Not availa
The "SNL-17A"
Barometric dat
Mid Depths are

WIPP:4.4.2.3.1:TP:QA-L:RECERT:541153