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Sandia National Laboratories

Operated for the U.S. Department of Energy

by

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Carlsbad, New Mexico 88220

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to: Records Center

from: Patricia Johnson, SNL Contractor

subject: 2006 Calculated Densities

The groundwater densities for the WIPP Culebra monitoring wells were calculated for 2006 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 the 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 was divided by the Troll 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 fresh water conversion at 4°C, at which temperature the density of pure water is 1.000 g/cm^3). The individual calculated density results for each well were then averaged for a final density value.

The density data are included in the *2006 Calc Dens.xlsx* spreadsheet file created in Excel. Within that spreadsheet, the worksheet *2006 Calc Dens* summarizes the resulting density values and supporting information for the calculated densities, and the worksheet *2006 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 Troll pressure data. The columns in the worksheets and their contents are described below:

- A – Monitor Well – Well ID
- B – 2006 Avg Calc Dens (g/cm^3) – Average calculated density value for 2006
- C – 2005 Avg Calc Dens (g/cm^3) – Average calculated density value for 2005
- D – 2006 – 2005 Difference – Difference between 2006 and 2005 densities (Column B - Column C)
- E – # of Dens Averaged – Number of density values averaged to get the final value
- F – Troll – Mini/Level, Vented (v)/Non-Vented (nv) – Type of Troll and cable used to collect pressure measurements

WIPP:1.4.2.3:TD:QA-L:RECERT:541153

- G – Timeframe of Data – Time period for pressure data used in calculations
- H – Troll File Name(s) – File names for pressure data
- I – Troll Install Depth (ft BTOC/T) – Depth below primary measuring point at which the Troll was installed, below top of casing or tubing
- J – Troll Ideal Install Depth (ft BTOC/T) (ERMS 549564) – Mid-Culebra depth below top of casing/tubing
- K – Length Off Ideal Depth (ft) – Depth in feet that the Troll is installed below/above ideal (Column I - Column J)
- L – Date of Install – Date the Troll was installed into the well
- M – Installation Logbook Page – Reference to the logbook and page where the Troll installation was documented
- N – Comments/Explanations – Comments and/or explanations regarding data

The spreadsheet entries were verified by Dale O. Bowman II, Organization 6212.

2. Identification/Listing of Input, Input sources, and Output:

- Excel spreadsheet including the data – 2006 Calc Dens.xlsx
  - Worksheet 1 – 2006 Calc Dens (printed copy attached)
  - Worksheet 2 – 2006 Calc Dens Formulas (printed copy attached)
  - Worksheet 3 – C-2737
  - Worksheet 4 – DOE-1
  - Worksheet 5 – ERDA-9
  - Worksheet 6 – H-2b2
  - Worksheet 7 – H-3b2
  - Worksheet 8 – H-4b
  - Worksheet 9 – H-5b
  - Worksheet 10 – H-6b
  - Worksheet 11 – H-7b1
  - Worksheet 12 – H-9c
  - Worksheet 13 – H-10c
  - Worksheet 14 – H-11b4
  - Worksheet 15 – H-12
  - Worksheet 16 – H-15
  - Worksheet 17 – H-16
  - Worksheet 18 – H-17
  - Worksheet 19 – H-19b0
  - Worksheet 20 – IMC-461
  - Worksheet 21 – P-17
  - 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-12
- Worksheet 40 – WIPP-13
- Worksheet 41 – WIPP-19
- Worksheet 42 – WIPP-25
- Worksheet 43 – WIPP-26
- Worksheet 44 – WIPP-30

3. Data Qualification for Compliance Decision Analysis:
Data sources provided in Column H (Troll File Name(s)), Column M (Installation Logbook Page), and in the References Section.

4. Software Used:
Intel® Xeon® CPU, Microsoft Windows 7, Microsoft Office Professional Plus 2010 Excel

5. Reviews:
Technical: Dale O. Bowman II, 6212
QA: Shelly Nielsen, 6210

6. References:

- Troll installation data and SNL water level data from the following logbooks (package ERMS 543277):
  Troll Logbook 4 – Troll-4
  Troll Logbook 5 – Troll-5
  Long-Term Monitoring 1 – LTM-1
  Long-Term Monitoring 2 – LTM-2
  WIPP Site Well Testing 7 – WSWT-7
  WIPP Site Well Testing 9 – WSWT-9
- WRES 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 2006 Calc Dens.xlsx
    2. Printout of Excel file worksheet 2006 Calc Dens Formulas.xlsx
    3. CD including the Excel file and memorandum

2006 Calc Dens

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Monitor Well	2006 Avg Calc Dens (g/cm^3)	2005 Avg Calc Dens (g/cm^3)	2006 - 2005 Difference (g/cm^3)	# of Dens Averaged	Troll - Mini/Level, Vented (v)/Non-Vented (nv)	Timeframe of Data	Troll File Name(s)	Troll Install Depth (ft BTOC/T)	Troll Ideal Install Depth (ft BTOC/T) (ERMS 549564)	Length Off Ideal Depth (ft)	Date of Install	Installation Logbook Page	Comments/Explanations
C-2737	1.017	1.019	-0.002	4	Mini, vented	Sept - Nov	SN17333 2006-02-22 150000 C-2737(C11).bin	700.8	691.0	9.80	2/26/2006	LTM-1, 47	
DOE-1	1.091			5	Mini, vented	Mar - May	SN17764 2006-02-24 170000 DOE-1(C1).bin	600.0	831.6	-231.55	7/18/2005	WSWT-7, 91	Ideal depth is BGS
ERDA-9	1.046	1.066	-0.020	5	Mini, vented	Mar - May	SN14199 2006-03-31 120000 ERDA-9(C5).bin	475.8	716.8	-240.98	3/31/2006	LTM-1, 115	
H-2b2	NO TROLL DATA FOR 2006												
H-3b2	1.040	1.053	-0.013	5	Mini, vented	Mar - May	SN17386 2006-02-22 160000 H-3b2(C5).bin, SN17386 2006-06-28 110000 H-3b2(C6).bin	500.8	687.7	-186.90	2/22/2006	LTM-1, 49	
H-4b	1.015	1.015	0.000	8	Mini, vented	Aug - Dec	SN17334 2006-02-23 110000 H-4b(C3).bin, SN17310 2006-07-25 140000 H-4b(C4).bin	500.8	504.1	-3.30	7/25/2006	LTM-2, 68	
H-5b	1.092	1.097	-0.005	8	Mini, vented	Sept - Dec	SN08276 2006-03-02 140000 H-5b(C3).bin	600.8	910.3	-309.50	3/2/2006	LTM-1, 69	
H-6b	1.039	1.040	-0.001	8	Mini, vented	Aug - Nov	SN17400 2006-06-29 120000 H-6b (C9).bin, SN17400 2006-08-22 120000 H-6b(C10).bin	450.8	617.5	-166.70	6/29/2006	LTM-2, 36	
H-7b1	0.923	1.008	-0.085	6	Mini, vented	Sept - Nov	SN04580 2006-05-22 150000 H-7b1(C5).bin	275.8	269.9	5.92	5/22/2006	LTM-1, 155	
H-9c	1.022	1.028	-0.006	6	Mini, vented	Sept - Nov	SN11025 2006-09-06 160000 H-9C (C11).bin	500.1	663.5	-163.45	9/6/2006	LTM-2, 139	
H-10c	1.037			8	Mini, vented	Jul - Dec	SN13474 2006-03-03 170000 H-10C(C1).bin	679.8	1372.1	-692.30	3/3/2006	LTM-1, 73	
H-11b4	1.084	1.088	-0.004	8	Mini, vented	Sept - Dec	SN11231 2006-08-21 120000 H-11b4(C5).bin	500.0	736.2	-236.20	8/21/2006	LTM-2, 106	
H-12	1.096	1.106	-0.010	7	Mini, vented	Sept - Dec	SN14199 2006-08-21 130000 H-12(C7).bin	550.8	838.4	-287.60	8/21/2006	LTM-2, 108	
H-15	AVAILABLE TROLL DATA APPEARS TO HAVE FAILED - DENSITIES NOT REPRESENTATIVE												
H-16	NO TROLL DATA FOR 2006												
H-17	1.165	1.168	-0.003	7	Mini, vented	Feb - May	SN18758 2006-02-27 160000 H-17(C2).bin	500.0	720.4	-220.40	4/28/2005	Troll-4, 85	
H-19b0	1.067	1.067	0.000	8	Mini, vented	Sept - Dec	SN17334 2006-09-08 120000 H-19b0 (C6).bin	500.8	754.0	-253.20	8/21/2006	LTM-2, 104	
IMC-461	1.012	1.015	-0.003	5	Mini, vented	Oct - Dec	SN13485 2006-09-06 150000 IMC-461 (C11).bin	375.8	376.5	-0.70	9/6/2006	LTM-2, 137	
P-17	1.048	1.201	-0.153	5	Mini, vented	Mar - May	SN17400 2006-03-28 150000 P-17(C7).bin	550.8	570.5	-19.70	12/22/2005	Troll-5, 45	Ideal depth is BGS
SNL-1	1.075	1.032	0.043	5	Mini, vented	Sept - Nov	SN17764 2006-08-11 120000 SNL-1(C11).bin	610.8	612.9	-2.07	8/11/2006	LTM-2, 97	
SNL-2	0.989	1.001	-0.012	6	Mini, vented	Sept - Nov	SN13590 2006-03-29 140000 SNL-2(C17).bin	474.6	470.7	3.90	11/22/2005	Troll-5, 18	
SNL-3	1.024	1.029	-0.005	8	Mini, vented	Sept - Dec	SN16771 2006-08-09 120000 SNL-3(C6).bin	600.8	766.5	-165.70	8/9/2006	LTM-2, 92	
SNL-5	1.005	1.008	-0.003	7	Mini, vented	Sept - Dec	SN11306 2006-06-30 140000 SNL-5 (C6).bin	450.8	649.0	-198.20	6/30/2006	LTM-2, 50	
SNL-6	NO TROLL DATA FOR 2006												
SNL-8	1.031	1.039	-0.008	7	Mini, vented	Aug - Nov	SN18778 2006-08-21 140000 SNL-8(C10).bin	650.8	969.7	-318.90	8/21/2006	LTM-2, 109	
SNL-9	1.029	1.025	0.004	6	Mini, vented	Sept - Nov	SN18758 2006-05-23 130000 SNL-9(C12).bin	521.0	567.2	-46.20	5/23/2006	LTM-2, 7	
SNL-10	1.000			6	Mini, vented	Jul - Oct	SN17353 2006-07-25 150000 SNL-10(C1).bin, SN17353 2006-10-18 160000 SNL-10 (C2).bin	600.8	613.5	-12.66	7/25/2006	LTM-2, 70	
SNL-12	1.005	1.000	0.005	8	Mini, vented	Sept - Dec	SN17716 2006-07-25 120000 SNL-12(C8).bin	575.8	570.9	4.90	7/25/2006	LTM-2, 66	
SNL-13	1.015	1.035	-0.020	4	Mini, vented	Oct - Nov	SN18823 2006-07-25 130000 SNL-13(C11).bin	400.8	401.2	-0.36	7/25/2006	LTM-2, 67	
SNL-14	1.037	1.042	-0.005	8	Mini, vented	Jun - Sept	SN17359 2006-03-03 140000 SNL-14(C8).bin, SN17337 2006-08-21 120000 SNL-14(C9).bin	600.8	669.5	-68.70	10/25/05 8/21/2006	SNL-14, 153 LTM-2, 105	
SNL-15	1.482	1.233	0.249	2	Mini, vented	March	SN11358 2006-03-10 150000 SNL-15(C4).bin	800.8	922.8	-122.00	3/10/2006	LTM-1, 91	
SNL-16	0.925			8	Mini, vented	Sept - Dec	SN07861 2006-06-26 100000 SNL-16(C2).bin	207.5	206.3	1.20	5/2/2006	LTM-1, 147	
SNL-17A	1.000			5	Mini, vented	Oct - Dec	SN08268 2006-10-11 110000 SNL-17(C4).bin	350.8	349.6	1.24	8/23/2006	LTM-2, 121	
SNL-18	1.073			8	Mini, vented	Sept - Dec	SN12473 2006-09-06 100000 SNL-18 (C5).bin	539.6	551.2	-11.55	8/10/2006	WSWT-9, 40	
SNL-19	1.004			8	Mini, vented	Sept - Dec	SN17621 2006-08-10 110000 SNL-19(C5).bin	355.8	355.1	0.70	8/10/2006	WSWT-9, 36	
WIPP-11	1.031	1.042	-0.011	8	Mini, vented	Sept - Dec	SN11134 2006-08-11 130000 WIPP-11(C14).bin, SN13562 2006-09-18 150000 WIPP-11 (C15).bin	600.8	857.8	-257.00	8/11/2006	LTM-2, 98	
WIPP-12	NO WATER LEVELS OR TROLL DATA FOR 2006												
WIPP-13	1.033	1.038	-0.005	8	Mini, vented	Aug - Dec	SN11028 2006-06-29 130000 WIPP-13 (C5).bin	500.8	715.3	-214.50	6/29/2006	LTM-2, 37	
WIPP-19	NO TROLL DATA FOR 2006												
WIPP-25	NO CORRESPONDING WATER LEVEL AND TROLL DATA IN 2006												
WIPP-26	1.016	1.033	-0.017	8	Mini, vented	May - Sept	SN11336 2006-04-14 150000 WIPP-26(C5).bin	170.6	197.5	-26.90	4/14/2006	LTM-1, 142	Ideal depth is BGS
WIPP-30	0.997			6	Mini, vented	Sept - Nov	SN18823 2006-08-09 130000 WIPP-30	500.8	646.0	-145.24	8/9/2006	LTM-2, 94	

Notes:
ft BTOC = feet below top of casing
ft BTOT = feet below top of tubing
(v) = vented
(nv) = non-vented

2006 Calc Dens Formulas

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Monitor Well	2006 Avg Calc Dens (g/cm^3)	2005 Avg Calc Dens (g/cm^3)	2006 - 2005 Difference (g/cm^3)	# of Dens Averaged	Troll - Mini/Level, Vented (v)/Non-Vented (nv)	Timeframe of Data	Troll File Name(s)	Troll Install Depth (ft BTOC/T)	Troll Ideal Install Depth (ft BTOC/T) (ERMS [illegible])	Length Off Ideal Depth (ft)	Date of Install	Installation Logbook Page	Comments/Explanations
C-2737	1.017	1.019	=B4-C4	4	Mini, vented	Sept - Nov	SN17333 2006-02-22 150000 C-2737(C11).bin	700.8	691	=I4-J4	38774	LTM-1, 47	
DOE-1	1.091			5	Mini, vented	Mar - May	SN17764 2006-02-24 170000 DOE-1(C1).bin	600	831.55	=I5-J5	38551	WSWT-7, 91	Ideal depth is BGS
ERDA-9	1.046	1.066	=B6-C6	5	Mini, vented	Mar - May	SN14199 2006-03-31 120000 ERDA-9(C5).bin	475.8	716.78	=I6-J6	38807	LTM-1, 115	
H-2b2	NO TROLL DATA FOR 2006												
H-3b2	1.04	1.053	=B8-C8	5	Mini, vented	Mar - May	SN17386 2006-02-22 160000 H-3b2(C5).bin, SN17386 2006-06-28 110000 H-3b2(C6).bin	500.8	687.7	=I8-J8	38770	LTM-1, 49	
H-4b	1.015	1.015	=B9-C9	8	Mini, vented	Aug - Dec	SN17334 2006-02-23 110000 H-4b(C3).bin, SN17310 2006-07-25 140000 H-4b(C4).bin	500.8	504.1	=I9-J9	38923	LTM-2, 68	
H-5b	1.092	1.097	=B10-C10	8	Mini, vented	Sept - Dec	SN08276 2006-03-02 140000 H-5b(C3).bin	600.8	910.3	=I10-J10	38778	LTM-1, 69	
H-6b	1.039	1.04	=B11-C11	8	Mini, vented	Aug - Nov	SN17400 2006-06-29 120000 H-6b (C9).bin, SN17400 2006-08-22 120000 H-6b(C10).bin	450.8	617.5	=I11-J11	38897	LTM-2, 36	
H-7b1	0.923	1.008	=B12-C12	7	Mini, vented	Sept - Nov	SN04580 2006-05-22 150000 H-7b1(C5).bin	275.82	269.9	=I12-J12	38859	LTM-1, 155	
H-9c	1.022	1.028	=B13-C13	6	Mini, vented	Sept - Nov	SN11025 2006-09-06 160000 H-9C (C11).bin	500.05	663.5	=I13-J13	38966	LTM-2, 139	
H-10c	1.037			8	Mini, vented	Jul - Dec	SN13474 2006-03-03 170000 H-10C(C1).bin	679.8	1372.1	=I14-J14	38779	LTM-1, 73	
H-11b4	1.084	1.088	=B15-C15	8	Mini, vented	Sept - Dec	SN11231 2006-08-21 120000 H-11b4(C5).bin	500	736.2	=I15-J15	38950	LTM-2, 106	
H-12	1.096	1.106	=B16-C16	7	Mini, vented	Sept - Dec	SN14199 2006-08-21 130000 H-12(C7).bin	550.8	838.4	=I16-J16	38950	LTM-2, 108	
H-15	AVAILABLE TROLL DATA APPEARS TO HAVE FAILED - DENSITIES NOT REPRESENTATIVE												
H-16	NO TROLL DATA FOR 2006												
H-17	1.165	1.168	=B19-C19	7	Mini, vented	Feb - May	SN18758 2006-02-27 160000 H-17(C2).bin	500	720.4	=I19-J19	38470	Troll-4, 85	
H-19b0	1.067	1.067	=B20-C20	8	Mini, vented	Sept - Dec	SN17334 2006-09-08 120000 H-19b0 (C6).bin	500.8	754	=I20-J20	38950	LTM-2, 104	
IMC-461	1.012	1.015	=B21-C21	5	Mini, vented	Oct - Dec	SN13485 2006-09-06 150000 IMC-461 (C11).bin	375.8	376.5	=I21-J21	38966	LTM-2, 137	
P-17	1.065	1.201	=B22-C22	5	Mini, vented	Mar - May	SN17400 2006-03-28 150000 P-17(C7).bin	550.8	570.5	=I22-J22	38708	Troll-5, 45	Ideal depth is BGS
SNL-1	1.075	1.032	=B23-C23	5	Mini, vented	Sept - Nov	SN17764 2006-08-11 120000 SNL-1(C11).bin	610.8	612.87	=I23-J23	38940	LTM-2, 97	
SNL-2	0.989	1.001	=B24-C24	6	Mini, vented	Sept - Nov	SN13590 2006-03-29 140000 SNL-2(C17).bin	474.6	470.7	=I24-J24	38678	Troll-5, 18	
SNL-3	1.024	1.029	=B25-C25	8	Mini, vented	Sept - Dec	SN16771 2006-08-09 120000 SNL-3(C6).bin	600.8	766.5	=I25-J25	38938	LTM-2, 92	
SNL-5	1.005	1.008	=B26-C26	7	Mini, vented	Sept - Dec	SN11306 2006-06-30 140000 SNL-5 (C6).bin	450.8	649	=I26-J26	38898	LTM-2, 50	
SNL-6	NO TROLL DATA FOR 2006												
SNL-8	1.031	1.039	=B28-C28	7	Mini, vented	Aug - Nov	SN18778 2006-08-21 140000 SNL-8(C10).bin	650.8	969.7	=I28-J28	38950	LTM-2, 109	
SNL-9	1.029	1.025	=B29-C29	6	Mini, vented	Sept - Nov	SN18758 2006-05-23 130000 SNL-9(C12).bin	521	567.2	=I29-J29	38860	LTM-2, 7	
SNL-10	1			6	Mini, vented	Jul - Oct	SN17353 2006-07-25 150000 SNL-10(C1).bin, SN17353 2006-10-18 160000 SNL-10 (C2).bin	600.8	613.46	=I30-J30	38923	LTM-2, 70	
SNL-12	1.005	1	=B31-C31	8	Mini, vented	Sept - Dec	SN17716 2006-07-25 120000 SNL-12(C8).bin	575.8	570.9	=I31-J31	38923	LTM-2, 66	
SNL-13	1.015	1.035	=B32-C32	4	Mini, vented	Oct - Nov	SN18823 2006-07-25 130000 SNL-13(C11).bin	400.8	401.16	=I32-J32	38923	LTM-2, 67	
SNL-14	1.037	1.042	=B33-C33	8	Mini, vented	Jun - Sept	SN17359 2006-03-03 140000 SNL-14(C8).bin, SN17337 2006-08-21 120000 SNL-14(C9).bin	600.8	669.5	=I33-J33	10/25/05 8/21/2006	SNL-14, 153 LTM-2, 105	
SNL-15	1.482	1.233	=B34-C34	2	Mini, vented	March	SN11358 2006-03-10 150000 SNL-15(C4).bin	800.8	922.8	=I34-J34	38786	LTM-1, 91	
SNL-16	0.925			8	Mini, vented	Sept - Dec	SN07861 2006-06-26 100000 SNL-16(C2).bin	207.5	206.3	=I35-J35	38839	LTM-1, 147	
SNL-17A	1			5	Mini, vented	Oct - Dec	SN08268 2006-10-11 110000 SNL-17(C4).bin	350.8	349.56	=I36-J36	38952	LTM-2, 121	
SNL-18	1.073			8	Mini, vented	Sept - Dec	SN12473 2006-09-06 100000 SNL-18 (C5).bin	539.64	551.19	=I37-J37	38939	WSWT-9, 40	
SNL-19	1.004			8	Mini, vented	Sept - Dec	SN17621 2006-08-10 110000 SNL-19(C5).bin	355.8	355.1	=I38-J38	38939	WSWT-9, 36	
WIPP-11	1.031	1.042	=B39-C39	8	Mini, vented	Sept - Dec	SN11134 2006-08-11 130000 WIPP-11(C14).bin, SN13562 2006-09-18 150000 WIPP-11 (C15).bin	600.8	857.8	=I39-J39	38940	LTM-2, 98	
WIPP-12	NO WATER LEVELS OR TROLL DATA FOR 2006												
WIPP-13	1.033	1.038	=B41-C41	8	Mini, vented	Aug - Dec	SN11028 2006-06-29 130000 WIPP-13 (C5).bin	500.8	715.3	=I41-J41	38897	LTM-2, 37	
WIPP-19	NO TROLL DATA FOR 2006												
WIPP-25	NO CORRESPONDING WATER LEVEL AND TROLL DATA IN 2006												
WIPP-26	1.016	1.033	=B44-C44	8	Mini, vented	May - Sept	SN11336 2006-04-14 150000 WIPP-26(C5).bin	170.6	197.5	=I44-J44	38821	LTM-1, 142	Ideal depth is BGS
WIPP-30	0.997			6	Mini, vented	Sept - Nov	SN18823 2006-08-09 130000 WIPP-30	500.8	646.04	=I45-J45	38938	LTM-2, 94	

Notes:
ft BTOC = feet
ft BTOT = feet
(v) = vented
(v) = non-vente