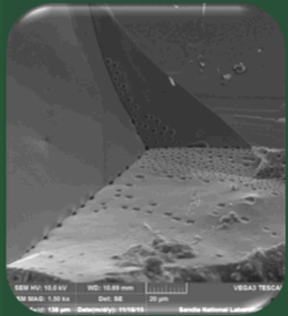

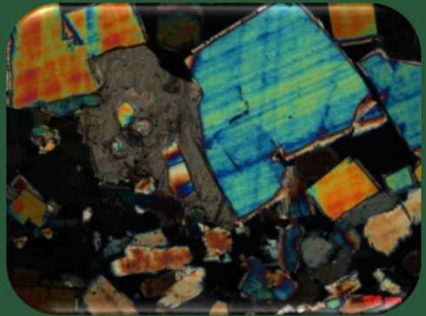

SAND2016-8665C

Parameter Selections Associated with Modeling WIPP's ROM Salt Panel Closure System

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Washington, DC

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Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. This research is funded by WIPP programs administered by the Office of Environmental Management (EM) of the U.S. Department of Energy.

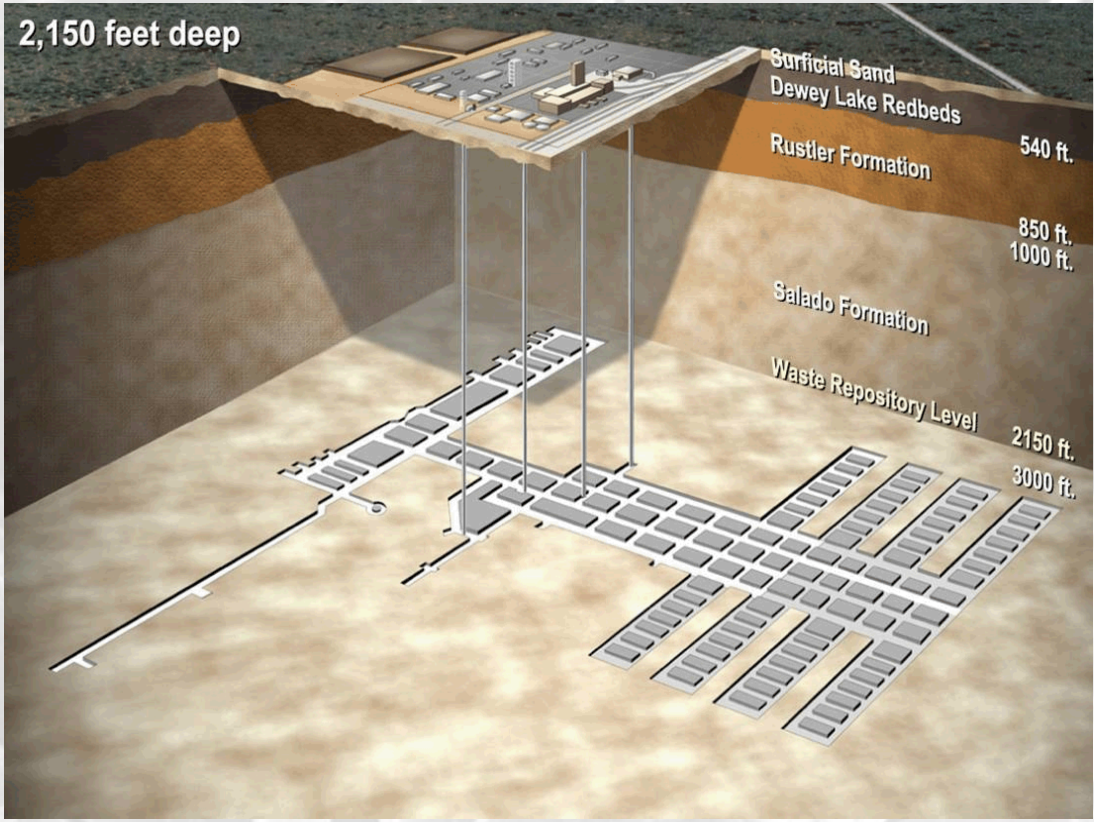
SAND2016-XXXX.

Outline

- WIPP background, panel closure history
  - Option D
  - Panel closure design elements
- WIPP ROM (Run-of-Mine) Salt Panel Closure System
- Construction attempts at ROM Salt Panel Closures
  - Three scenarios
- Parameters and their evaluation to use the “WIPP Crushed Salt Model” (Callahan, 1999)
  - Geometry
  - Initial density
  - Moisture content
  - Particle size

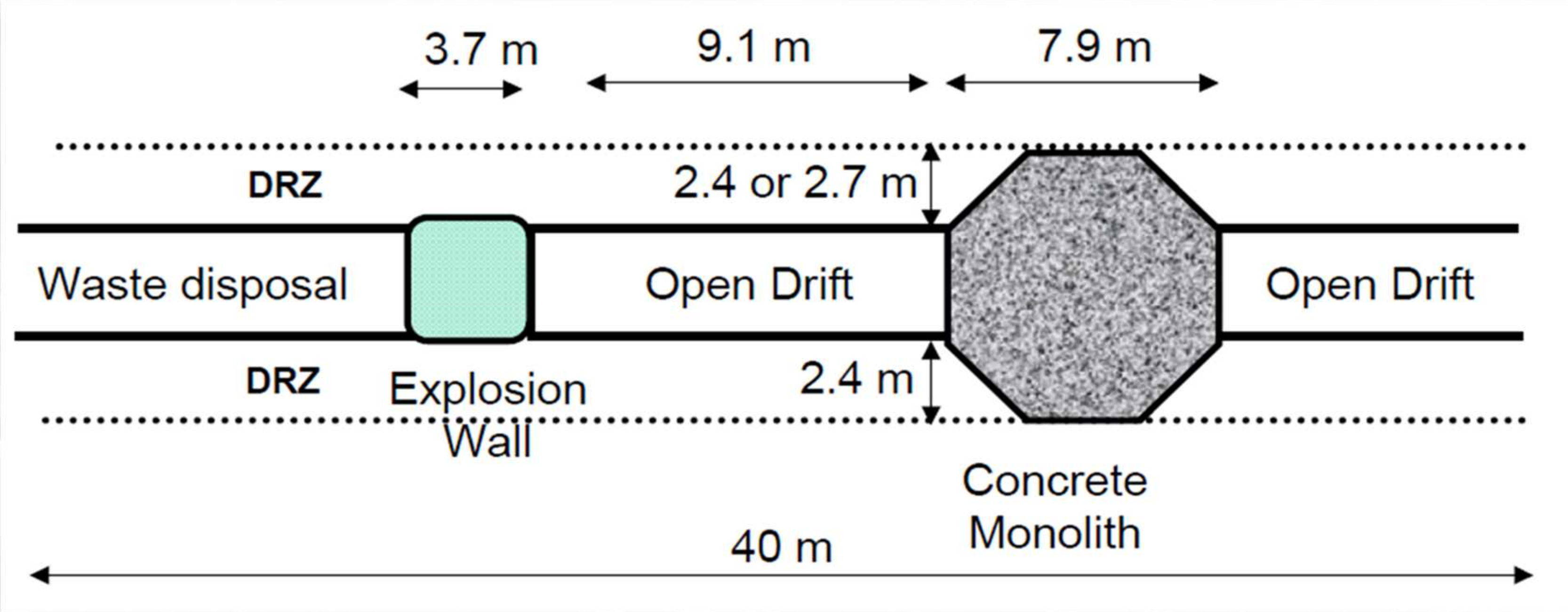
WIPP Background

- Deep Geologic Repository in Bedded Salt
- Disposal of U.S. defense related Transuranic and Transuranic Mixed waste
- Repository Design consists of:
  - Ten panels
  - Each panel has seven rooms
  - Two access drifts per panel
    - Intake
    - Exhaust
- Five Options for Panel Closures were submitted. Option D was chosen by the EPA



Option D Panel Closure

- 1998: EPA's Certification decision identified Option D with Salado Mass Concrete (salt-based concrete) as the mandated panel closure design. **Long-term repository performance 10,000 yrs**.
- 1999: NMED agreed with EPA's mandated design and incorporated Option D with Salado Mass Concrete into the Hazardous Waste Facility Permit. **Short-term repository performance ≈30 yrs**.



Problems with Options D

DOE identified issues with construction of Option D:

- Cannot manufacture Salado mass concrete to the specifications in the compliance application while meeting the design requirements of the Option D design
- Option D design is very complex to implement and impacts waste handling operations
- Hydrogen and Methane monitoring data shows no need for explosion wall

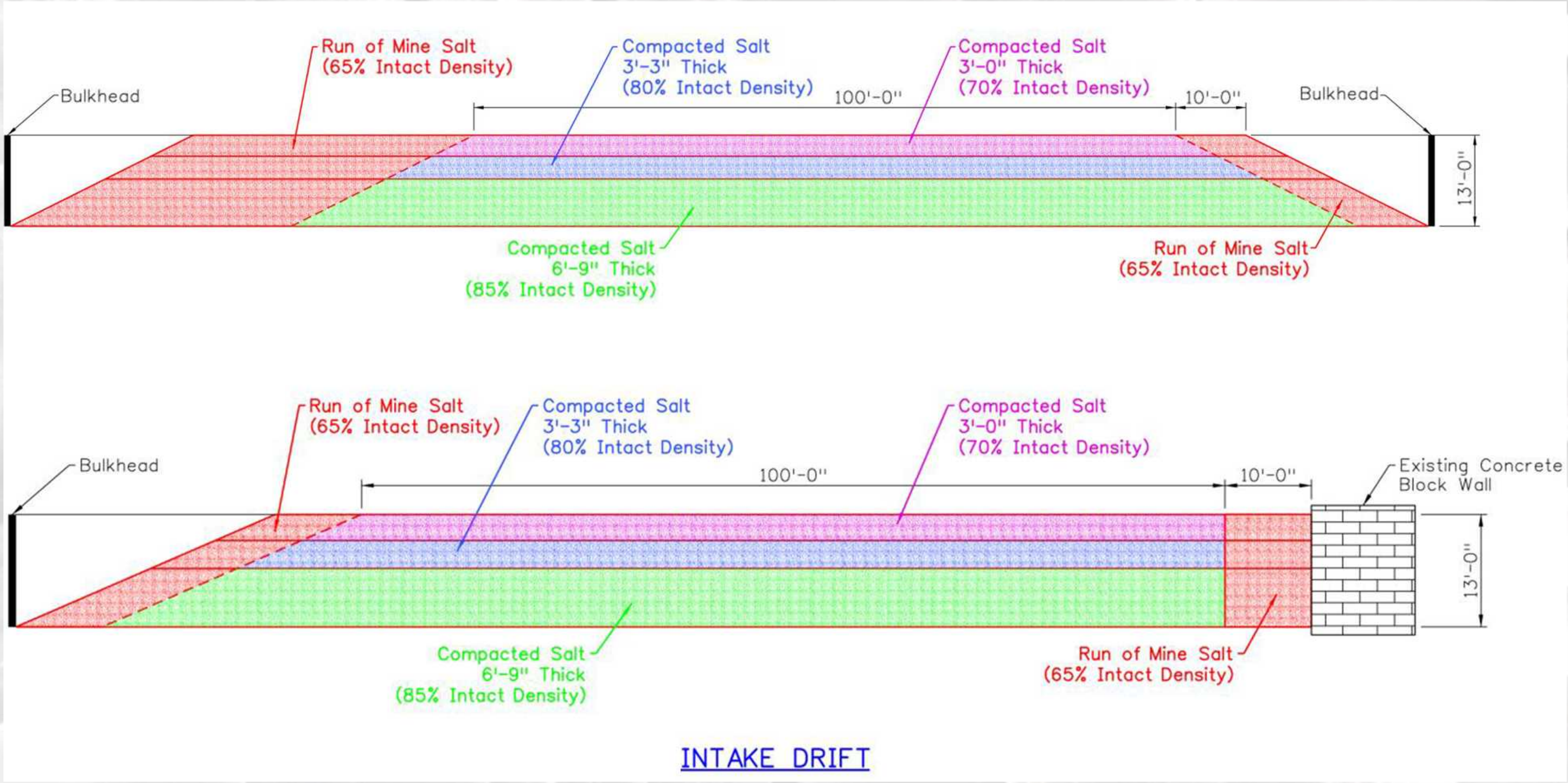
Panel Closure Redesign Criteria

- The panel closure system design shall limit VOC migration from a closed panel consistent with the limits found in the Hazardous Waste Permit
- The panel closure system shall consider potential flow of VOCs through the disturbed rock zone (DRZ) in addition to flow through the closure components
- The panel closure system shall perform its intended functions under loads generated by creep closure of the drifts
- The nominal operational life of the closure system is thirty-five (35) years
- The panel closure system shall address the most severe ground conditions expected in the waste disposal area
- The panel closure system shall be built to generally accepted national design and construction standards

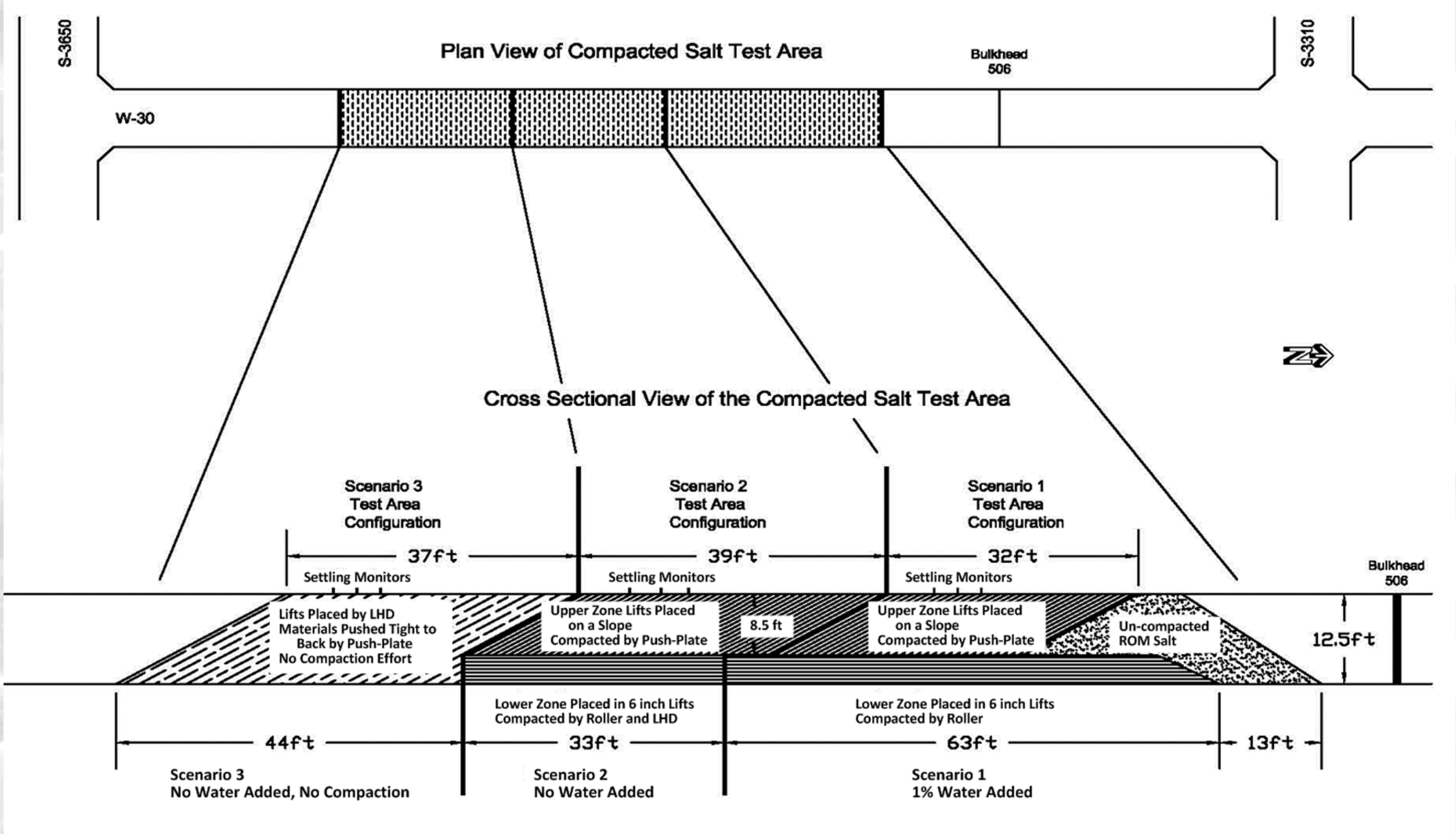
Redesign Criteria Cont.

- The design and construction shall follow conventional mining practices
- Structural analysis shall use data acquired from the WIPP underground
- Materials shall be compatible with the emplacement environment and function
- Treatment of surfaces in the closure areas shall be considered in the design
- During construction, a Quality Assurance/Quality Control (QA/QC) program shall be established to verify material properties and construction practices
- Construction of the panel closure system shall consider shaft and underground access and services for materials handling

The Original WIPP Panel Closure (WPC) Design



Nuclear Waste Partnership's (NWP) Construction Attempts



Modified from Klein, T., Patterson, R., Camphouse, C., et al. (2013.) In-Situ Testing and Performance Assessment of a Redesigned WIPP Panel Closure. Paper 13192. WM2013 Conference, 24-28 Feb 2013, Phoenix, Arizona.

Construction Techniques

Load-Haul-Dump
Truck Placing
ROM Salt

Walk Behind
Roller Compactor

Fletcher with
Push-Plate
Attachment

Numerical Modeling

- Our numerical modeling intention was always to use the “WIPP Crushed Salt Model” developed by Gary Callahan

  Callahan, G.D. (1999.) Crushed Salt Constitutive Model. SAND98-2680. Sandia National Laboratories, Albuquerque, New Mexico.

- The model is dependent on:
  - Grain size
  - Moisture content
  - Temperature

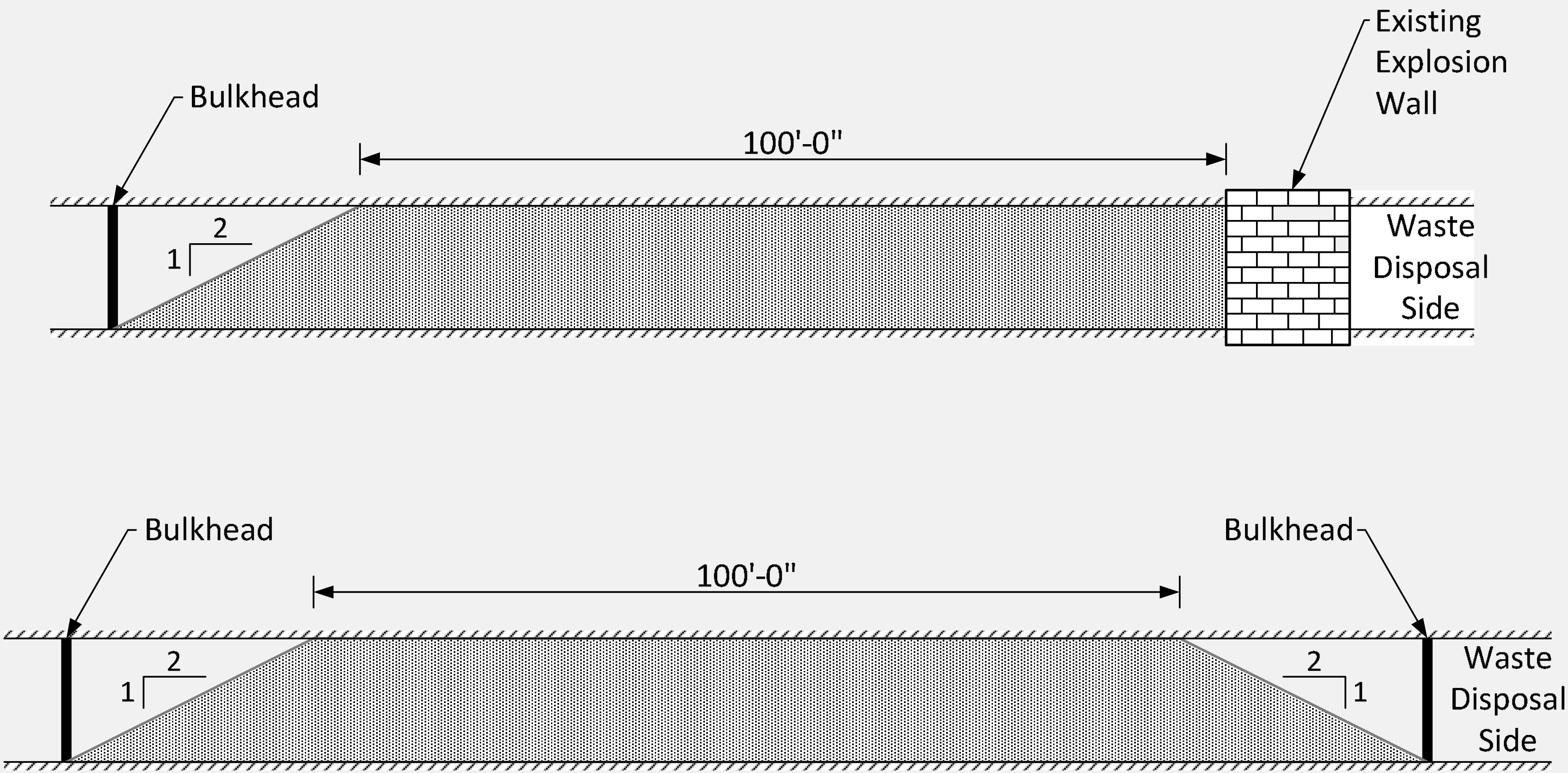
Scenario Summaries (Averages)

	Scenario 1	Scenario 2	Scenario 3
Lower Level Compaction (% Intact Salt Density)	74.5	74.4	–
Lower Level Moisture Content (%)	1.57	0.31	–
Upper Level Compaction (% Intact Salt Density)	63.2	62.5	66.8
Upper Level Moisture Content (%)	1.30	0.40	0.43

It was decided that the addition of 1% moisture by weight (Scenario 1) and performing initial compaction to 75% (Scenarios 1 and 2) resulted in fractional densities that were only 10% greater than the simpler ROM salt emplacement of Scenario 3 and does not support the cost of the increased effort involved.

Zimmerly, B., Moffat, T., and Zavicar IV, J. (2012.) Construction Methods Assessment for Compacted Salt Panel Closure. Nuclear Waste Partnership LLC, Carlsbad, New Mexico

Final WPC Design



Modified from Klein, T., Patterson, R., Camphouse, C., et al. (2013.) In-Situ Testing and Performance Assessment of a Redesigned WIPP Panel Closure. Paper 13192. WM2013 Conference, 24-28 Feb 2013, Phoenix, Arizona.

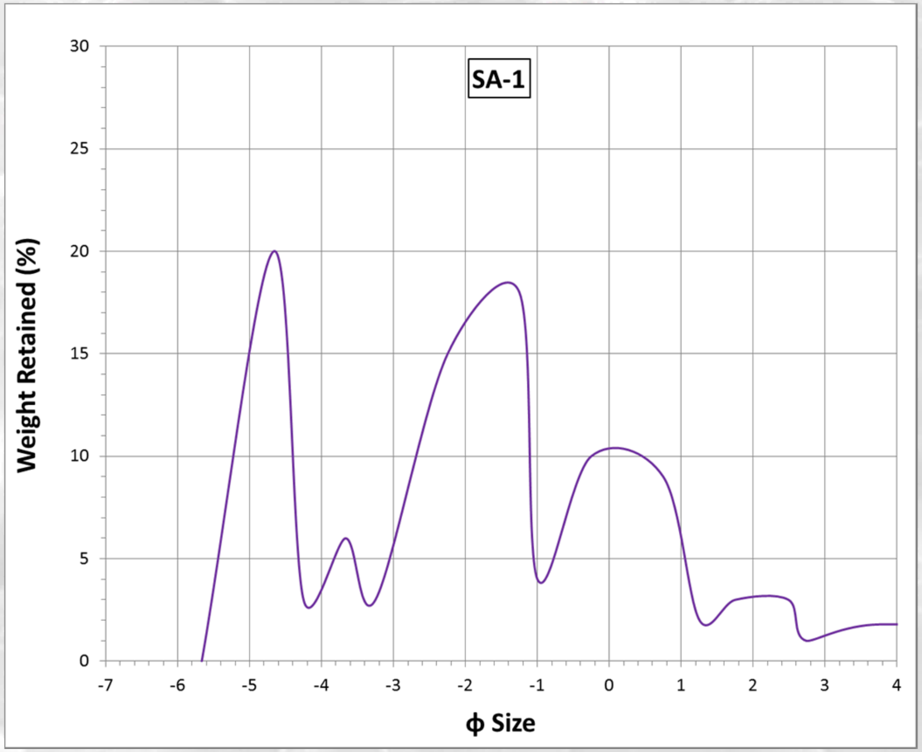
Character of ROM Salt

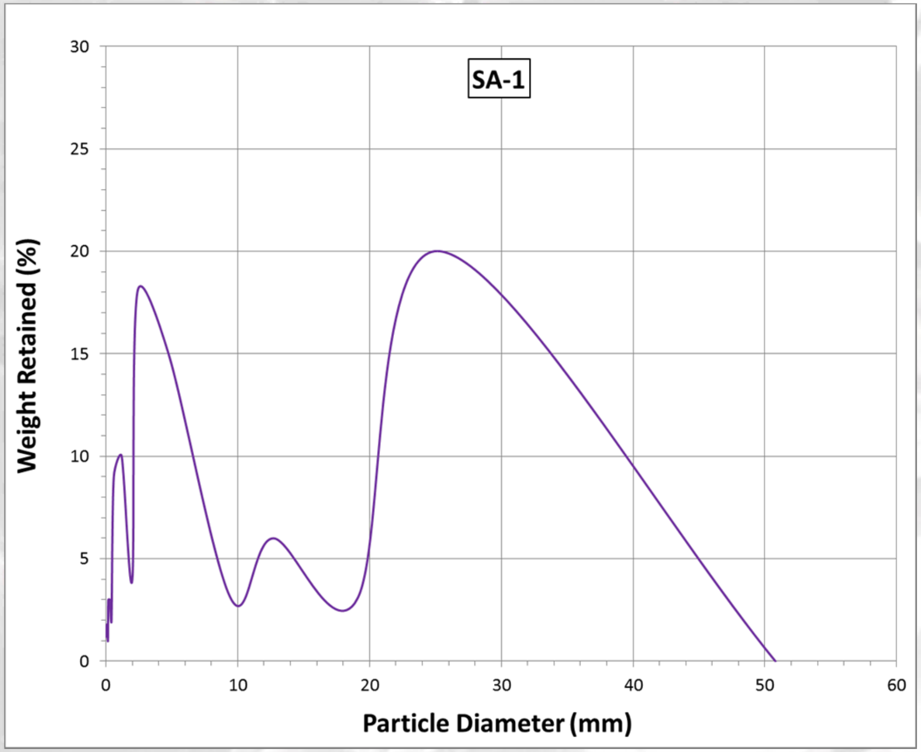
- Large Range of Sizes – Boulders to Silt

Prototype Panel Closure ROM Salt Sieve Analysis

Screen Size	Particle size	% Passing
75.0 mm	3”	91 ←
63.0 mm	2½”	85
50.0 mm	2”	82
37.5 mm	1½”	80
31.5 mm	1¼”	78
25.0 mm	1”	76
19.0 mm	¾”	74
12.5 mm	½”	71
9.5 mm	3/8”	67
4.75 mm	#4 sieve	52
2.0 mm	#10 sieve	32
425 µm	#40 sieve	13
180 µm	#80 sieve	7
75 µm	#200 sieve	3.1

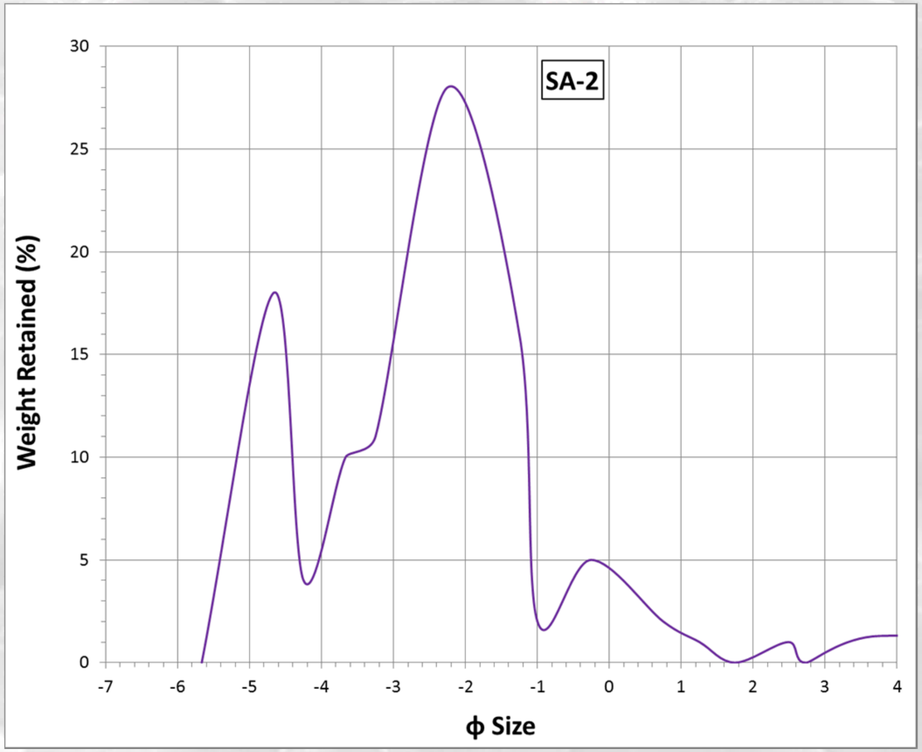
ROM Grain Size Distribution SA-1

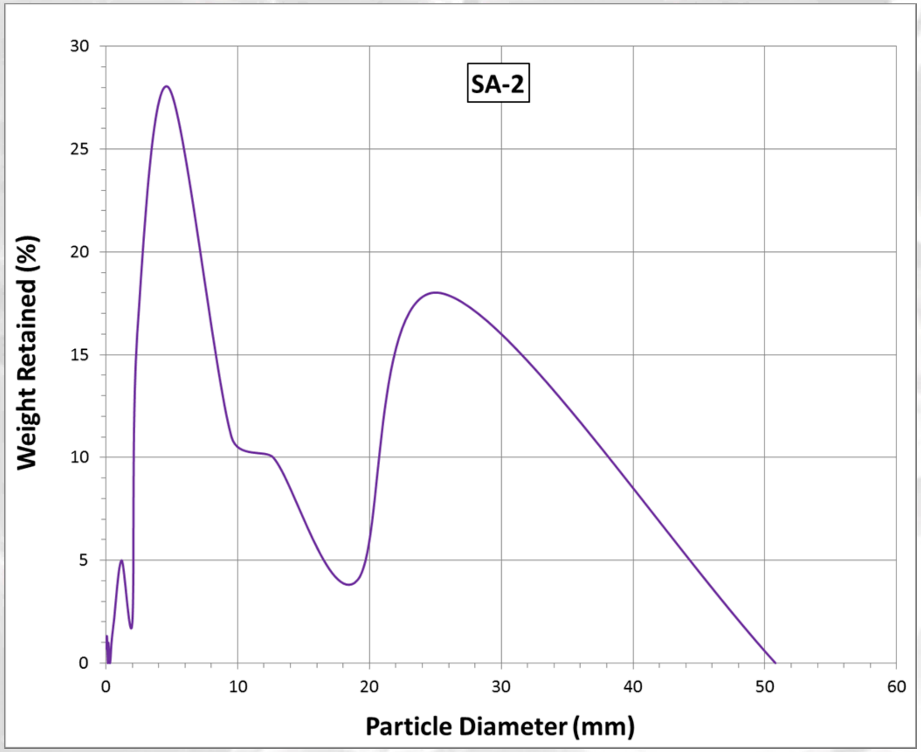




Material used for Proctor tests; boulders greater than 3 inch in diameter discarded prior to test

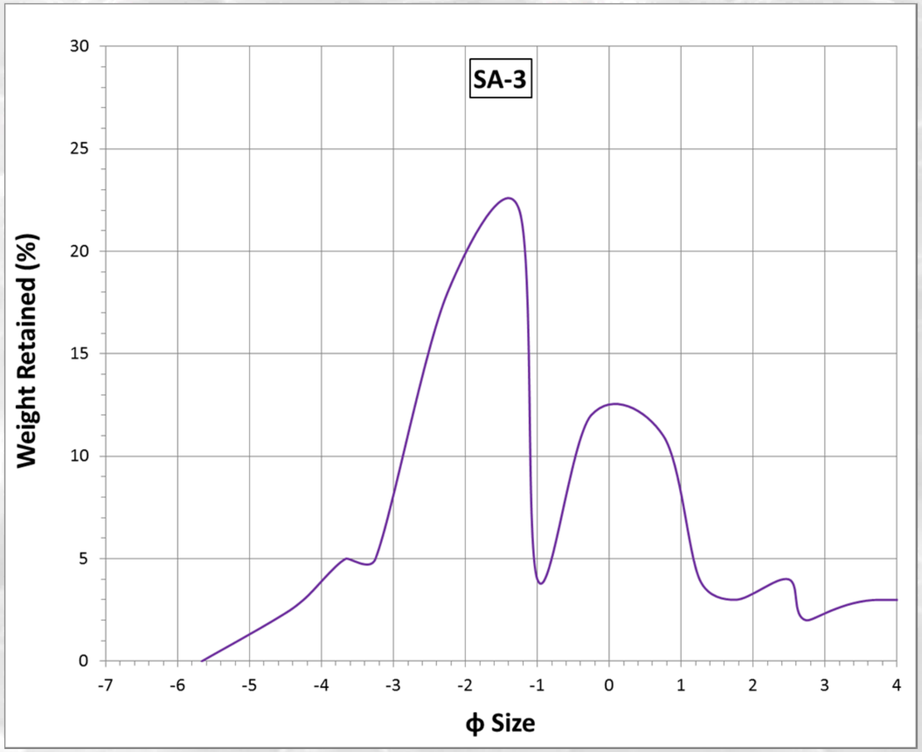
ROM Grain Size Distribution SA-2

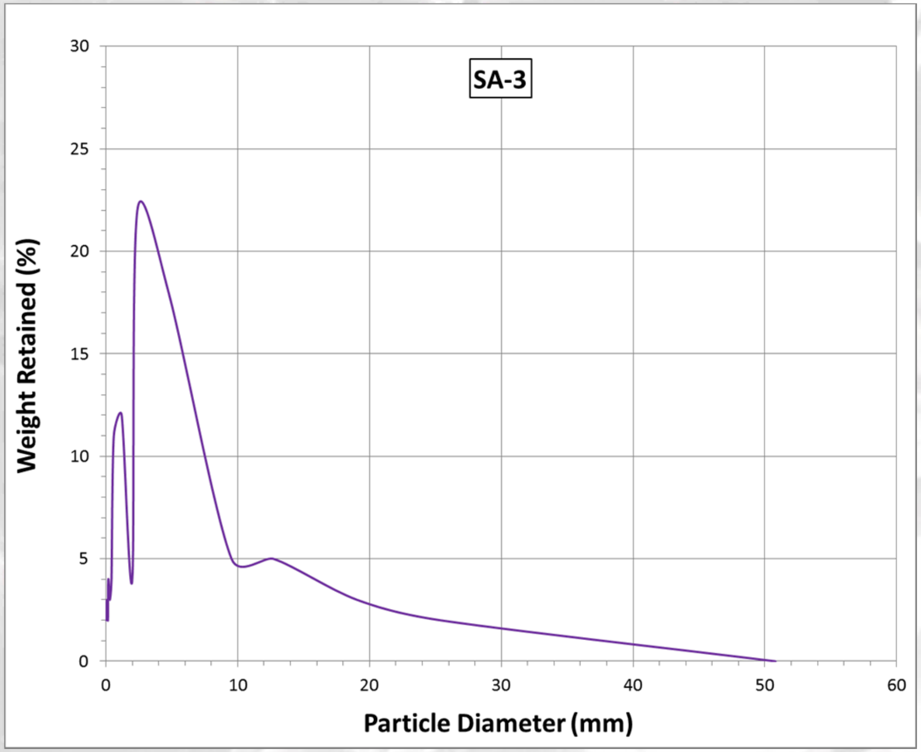




Material used for Proctor tests; boulders greater than 3 inch in diameter discarded prior to test

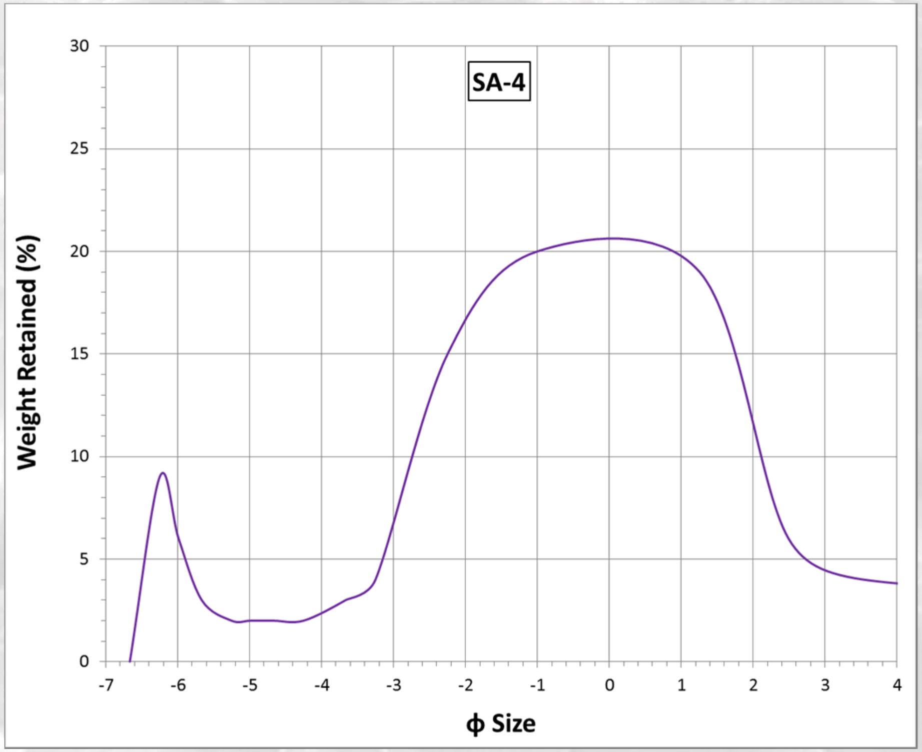
ROM Grain Size Distribution SA-3

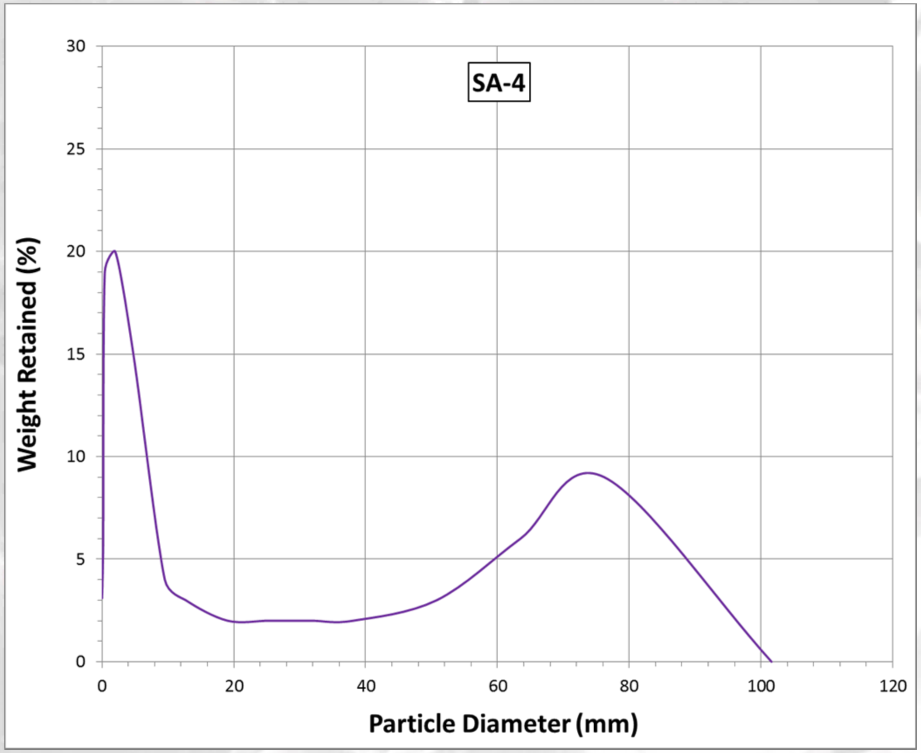




Material used for Proctor tests; boulders greater than 3 inch in diameter discarded prior to test

ROM Grain Size Distribution SA-4





Material used for panel closure demonstration (Slide 15). Distribution of boulders greater than 3 inch in diameter not analyzed (9% of total)

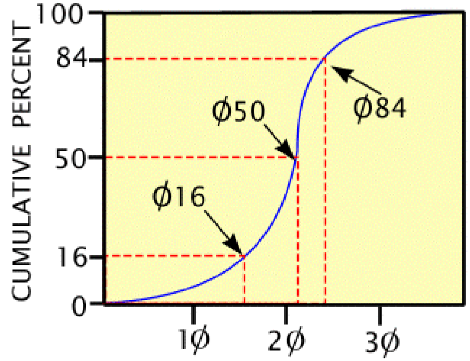
Comments on Grain Sizes Analyses

- This ROM salt grain size distributions are not normal or theoretically expected lognormal curves under grinding and crushing, but are generally polymodal
- Sedimentologists have developed a number of graphic and moment measures to determine grain size statistics
- The WIPP ROM salt data is already skewed because most labs, apparently including the lab which performed the gradation tests for NWP, cannot accommodate the boulders found in the material
  - Large sieves
  - Large sample (6 inch sieve → recommended minimum sample size of 1,250 lbs / 575 kg) (extrapolated from ASTM D6913-04, Table 2)

Inclusive Graphics

INCLUSIVE GRAPHIC STATISTICS

(FOLK, 1974)



MEDIAN

$$Md_{\phi} = \phi 50$$

GRAPHIC MEAN

$$M_Z = \frac{\phi 16 + \phi 50 + \phi 84}{3}$$

INCLUSIVE GRAPHIC STANDARD DEVIATION

$$\sigma_I = \frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

σ_I < .35Ø, VERY WELL SORTED
.35-.50Ø, WELL SORTED
.50-.71Ø, MODERATELY WELL SORTED
.71-1.0Ø, MODERATELY SORTED
1.0-2.0Ø, POORLY SORTED
2.0-4.0Ø, VERY POORLY SORTED
> 4.0Ø, EXTREMELY POORLY SORTED

INCLUSIVE GRAPHIC SKEWNESS

$$SK_I = \frac{\phi 16 + \phi 84 - 2\phi 50}{2(\phi 84 - \phi 16)} + \frac{\phi 5 + \phi 95 - 2\phi 50}{2(\phi 95 - \phi 5)}$$

SK_I 1.0 TO 0.30, STRONGLY FINE SKEWED
0.30 TO 0.10, FINE SKEWED
0.10 TO -0.10, NEARLY SYMMETRICAL
-0.10 TO -0.30, COARSE SKEWED
-0.30 TO -1.0, STRONGLY COARSE SKEWED

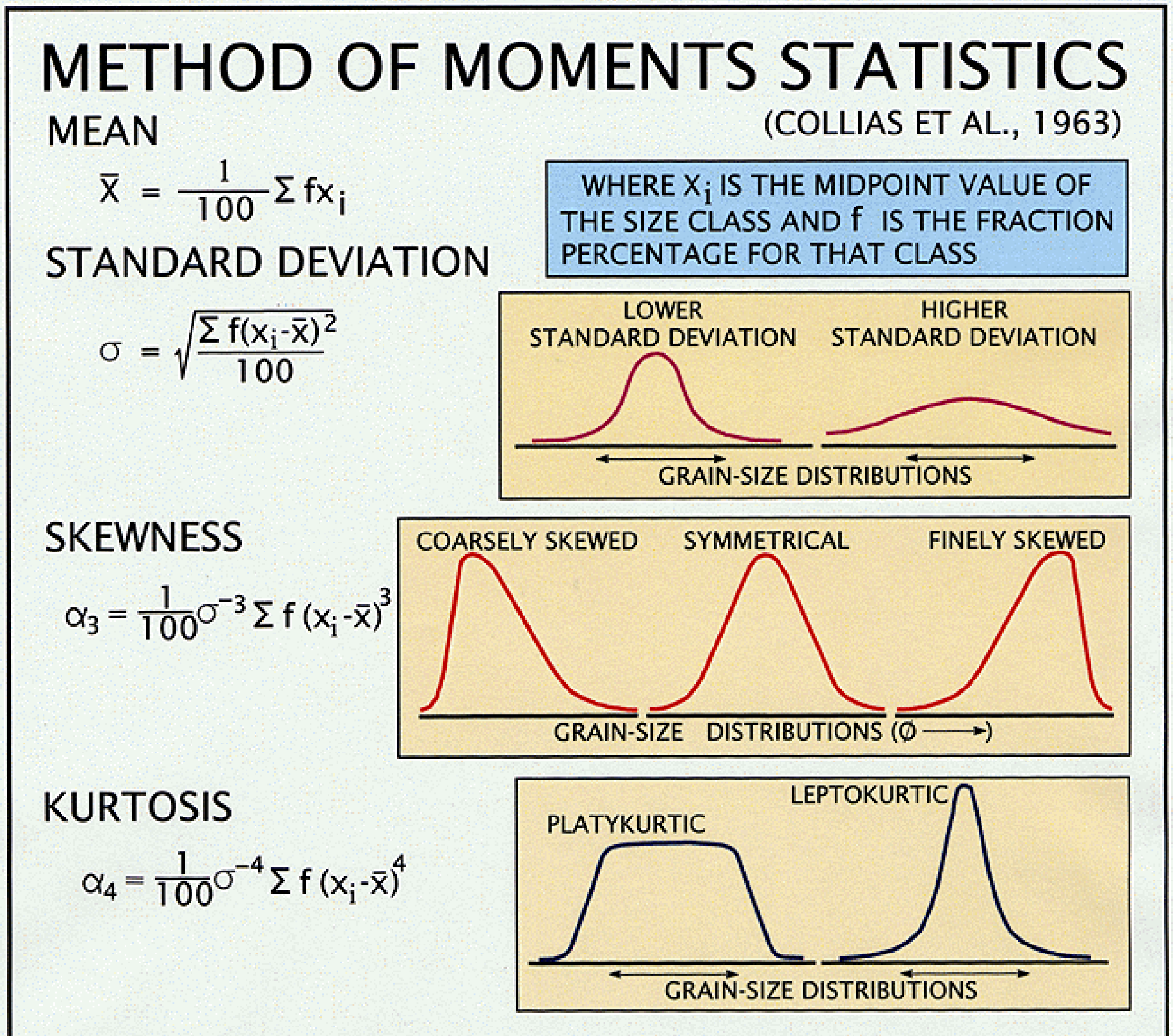
GRAPHIC KURTOSIS

$$K_G = \frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)}$$

K_G < 0.67, VERY PLATYKURTIC
0.67 TO 0.90, PLATYKURTIC
0.90 TO 1.11, MESOKURTIC
1.11 TO 1.50, LEPTOKURTIC
1.50 TO 3.0, VERY LEPTOKURTIC
> 3.0, EXTREMELY LEPTOKURTIC

Poppe, L.J., McMullen, K.Y., Williams, S.J., and Paskevich, V.F., eds. (2014.) USGS east-coast sediment analysis: Procedures, database, and GIS data, U.S. Geological Survey Open-File Report 2005-1001, available online at http://pubs.usgs.gov/of/2005/1001/

Method of Moments



Poppe, L.J., McMullen, K.Y., Williams, S.J., and Paskevich, V.F., eds. (2014.) USGS east-coast sediment analysis: Procedures, database, and GIS data, U.S. Geological Survey Open-File Report 2005-1001, available online at http://pubs.usgs.gov/of/2005/1001/

Estimates of Mean Particle Size

- Calculations performed using GRADISTAT v.8 (Kenneth Pye Assoc.)
  - Method of Moments statistics compares well with GSSTAT (USGS, Woods Hole Coastal and Marine Science Center)
  - Inclusive Graphics statistics verified by hand-calculations

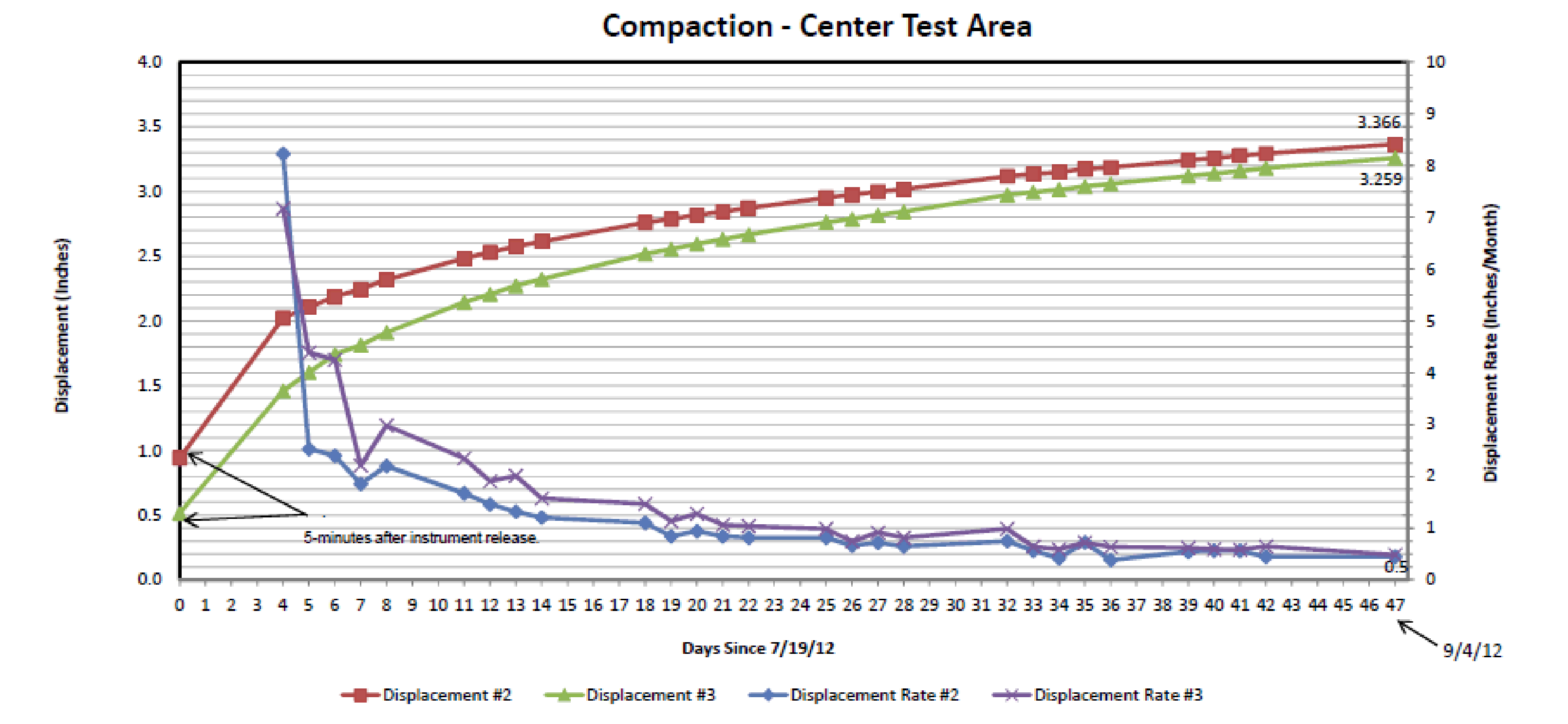
	Median (µm / ϕ)	Incl. Graph. Mean (µm / ϕ)	Meth. of Mom. Mean (µm / ϕ)
SA-1	4233.1 / -2.082	4641.4 / -2.215	4070.5 / -2.025
SA-2	8004.2 / -3.001	8410.3 / -3.072	7269.9 / -2.862
SA-3	2784.7 / -1.478	2335.3 / -1.224	2178.7 / -1.123
SA-4	4356.0 / -2.123	**5164.2 / -2.369**	4122.8 / -2.044

Recommended value
Poorly sorted, sandy very coarse gravel

Blott, S.L. and Pye, K. (2001.) GRADISTAT: A Grain Size Distribution and Statistics Package for the Analysis of Unconsolidated Sediments. Earth Surf. Process. Landforms 26: 1237–1248.

Conclusion

- Needed input parameters for mean grain size, moisture content, initial density, and geometry to use the "WIPP Crushed Salt Model" (Callahan, 1999) to model the WPC
- Parameters and model geometries were obtained from NWP's three panel closure construction demonstrations



WM2013 Presentation for Klein, T., Patterson, R., Camphouse, C., et al. (2013.) In-Situ Testing and Performance Assessment of a Redesigned WIPP Panel Closure. Paper 13192. WM2013 Conference, 24-28 Feb 2013, Phoenix, Arizona.

Sorry, no results yet.
Dinner is still in the oven.