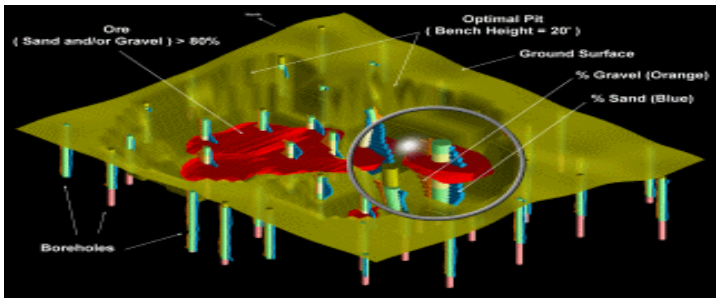
Sand & Gravel Case Study



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Creating a Borehole Database

A series of exploration boreholes were drilled. Samples were taken every five feet and sieved in order to determine the relative percentages of sand, gravel and clay (or other non-sand/gravel material). These samples were restricted to the interval below the base of the soil profile and the top of the bedrock. The borehole locations, stratigraphy (see Table 1), and sieve analyses (see Table 2) were then entered into a relational database.

Table 1: Information that was recorded for each borehole.	
Name	Unique borehole identifier (e.g. BH-01, BH-02, etc.)
Easting	UTM easting from GPS (in feet)
Northing	UTM northing from GPS (in feet)
Elevation	Elevation from GPS (in feet)
Soil Depth	Depth to base of soil (in feet).
Bedrock Depth	Depth to top of bedrock (in feet).
Total Depth	Total depth of borehole (in feet).

Table 2: Information that was recorded for each sample interval.	
Depth-1	Depth to top of sampled interval (feet).
Depth-2	Depth to base of sampled interval (feet).
Sand	% Sand (0 to 100)
Gravel	% Gravel (0 to 100)
Clay	% Clay or other non-sand/gravel material(0 - 100)

Displaying the Boreholes

Two and three-dimensional striplogs were constructed for each borehole.

The two-dimensional logs (Figure 1) include textual descriptions of the lithotypes as well as bargraphs depicting the relative percentages of sand, gravel, and clay. These logs are best suited for printed reports in which all of the borehole information is depicted within a single, albeit complex diagram.

The composite three dimensional logs (Figure 2) show the lithology as color-coded cylinders with bargraphs depicting the sand and gravel content. Although interesting, these logs quickly become confusing when plotting multiple logs in a three-dimensional diagram (Figure 4).

The three-dimensional percentage logs (Figure 3) show the relative concentration of a single constituent (e.g. % sand). These "spindle logs" are ideally suited when plotting a single constituent (Figures 5, 8 & 11)

Figure 1: 2-dimensional striplog

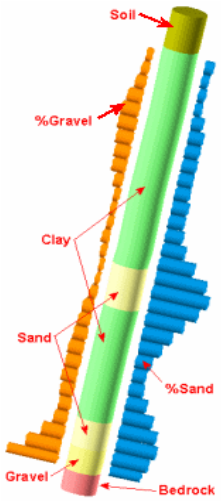


Figure 2: 3-dimensional composite striplog

Figure 3: 3-dimensional percentage log.

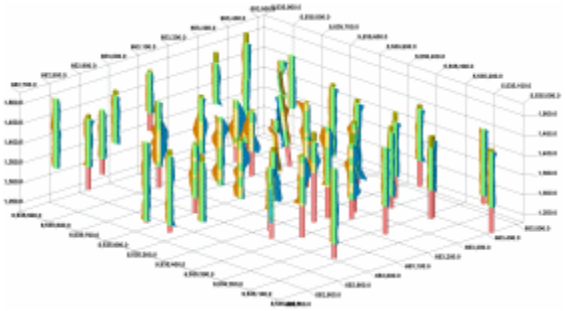


Figure 4: 3-Dimensional depiction of all boreholes

Generating the Initial Sand, Gravel & Clay Models

Solid “block” models for the sand, gravel, and clay data were created by using a modeling algorithm that estimates grade levels for a three dimensional matrix of imaginary blocks.

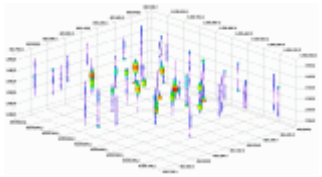


Figure 5: Sand Percentage Logs

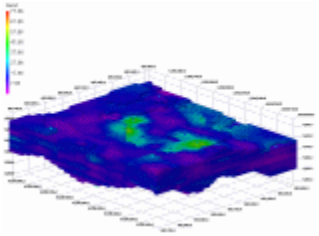


Figure 6: Sand Model

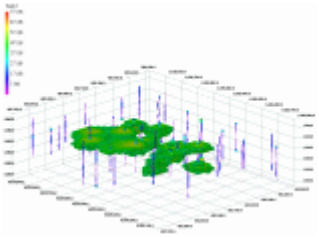


Figure 7: Sand > 40%

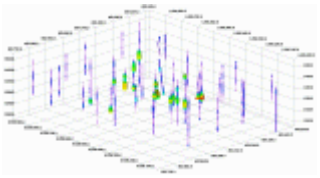


Figure 8: Gravel Percentage Logs

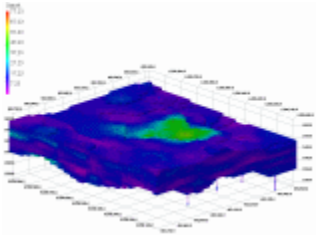


Figure 9: Gravel Model

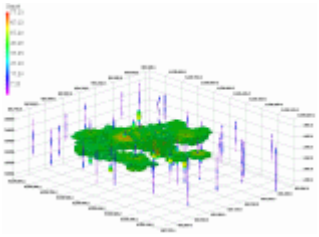


Figure 10: Gravel > 40%

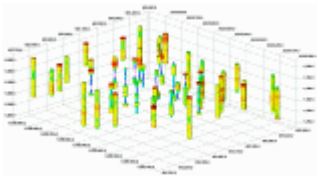


Figure 11: Clay Percentage Logs

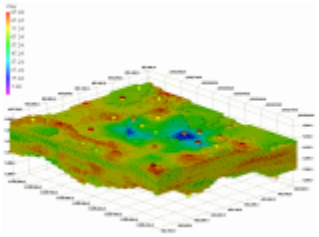


Figure 12: Clay Model

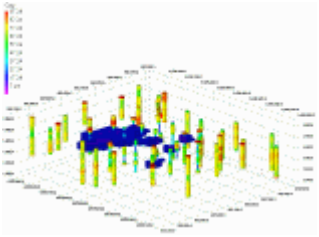


Figure 13: Clay < 20%

Computing Sand & Gravel Reserves

The sand and gravel models were combined by adding each of the block values (Figure 14). This combined model was then filtered to show only those regions where the sand and/or gravel are greater than 80 percent (Figure 15). Finally, a pit was generated (Figures 16, 17, & 18) by using a "floating cone" algorithm that removes material above the ore based on user-defined criteria (e.g. maximum slope, bench height, ore grade, etc.)

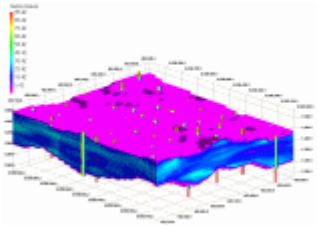


Figure 14: Sand + Gravel Model

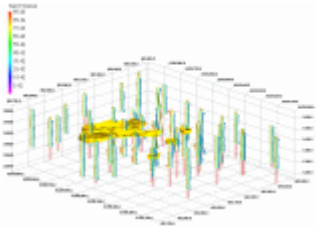


Figure 15: Sand+Gravel > 80%

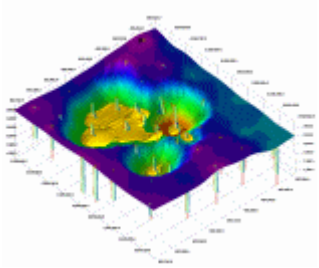


Figure 16: Optimum Pit Design. Max Slope = 45 deg. No Benches

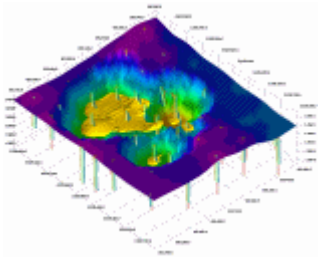


Figure 17: Optimum Pit Design Max Slope = 45 deg. Bench Height = 10 Feet

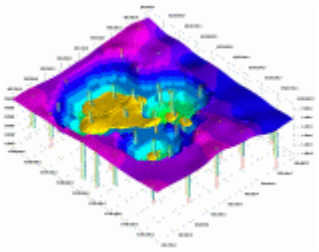
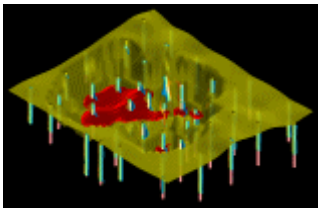


Figure 18: Optimum Pit Design Max Slope = 45 deg. Bench Height = 20 Feet



Appendix I

Classification Scheme		
Minimum Size (mm)	Maximum Size (mm)	Classification
20	200	Pebbles
2	20	Gravel
0.06	2	Sand
0.002	0.06	Silt
0	0.002	Clay