Capital Quarries Company, Inc
Value Mapping Project

Eric Strope - Capital Quarries

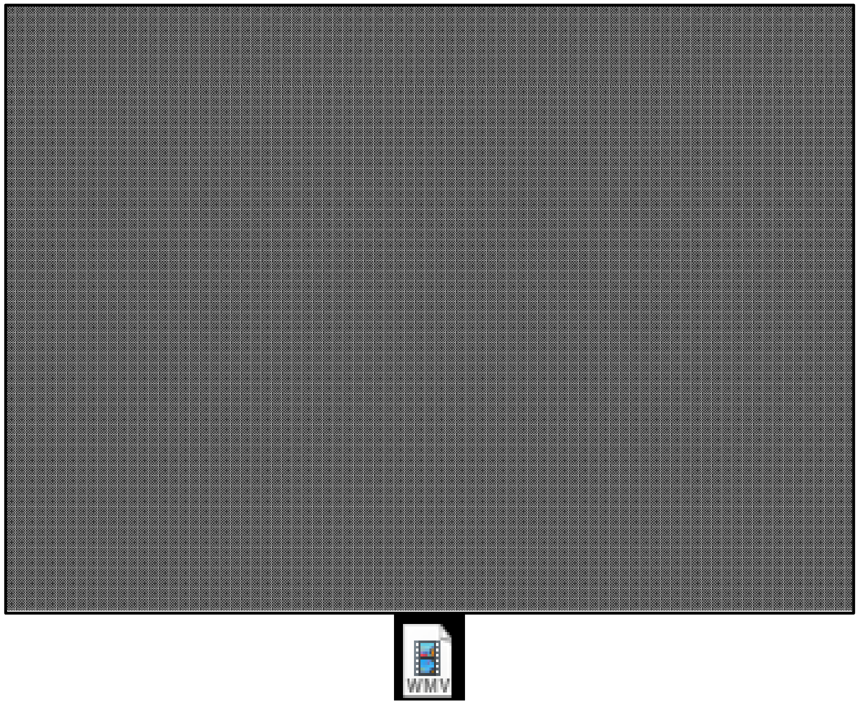
Larry Mirabelli – Dyno Nobel   Bill Hissem - Sandvik

QUARRY ACADEMY

Improving Processes. Instilling Expertise.

Focus of Project

- Reduction of total costs to convert insitu rock reserves to saleable product.
- Validate that extra dollars spent in drilling and blasting can lower total production cost.



02 - Sandvik Mtng 1-26-08 Clip2 - Expectations - 1-27.wmv

Capital Quarries Company, Inc
Value Mapping Project

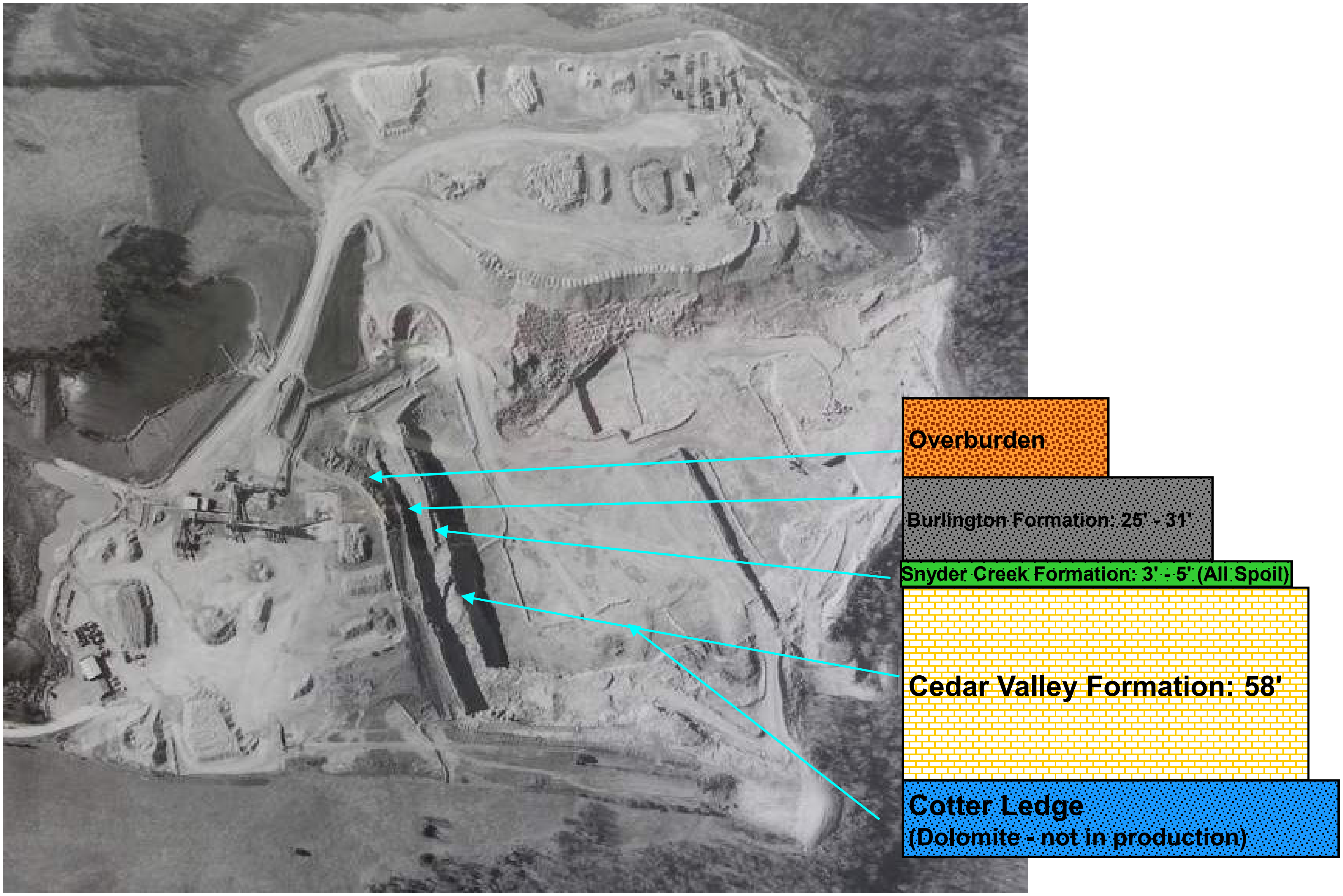
- **Sept 2006 to April 2007**
- **Capital Quarries Company Inc.**
  - ✓ **Holt Summit MO.**
    - 500,000 saleable tons/yr
    - 700,000 ton/yr blasted.

Missouri Quarry Productivity Improvement - Casework

- Baselining
- Identification and implementation of metrics
- “Lean Thinking” Analysis
- Use of blasting fragmentation and process equipment models.
- Field validation of process improvement solutions

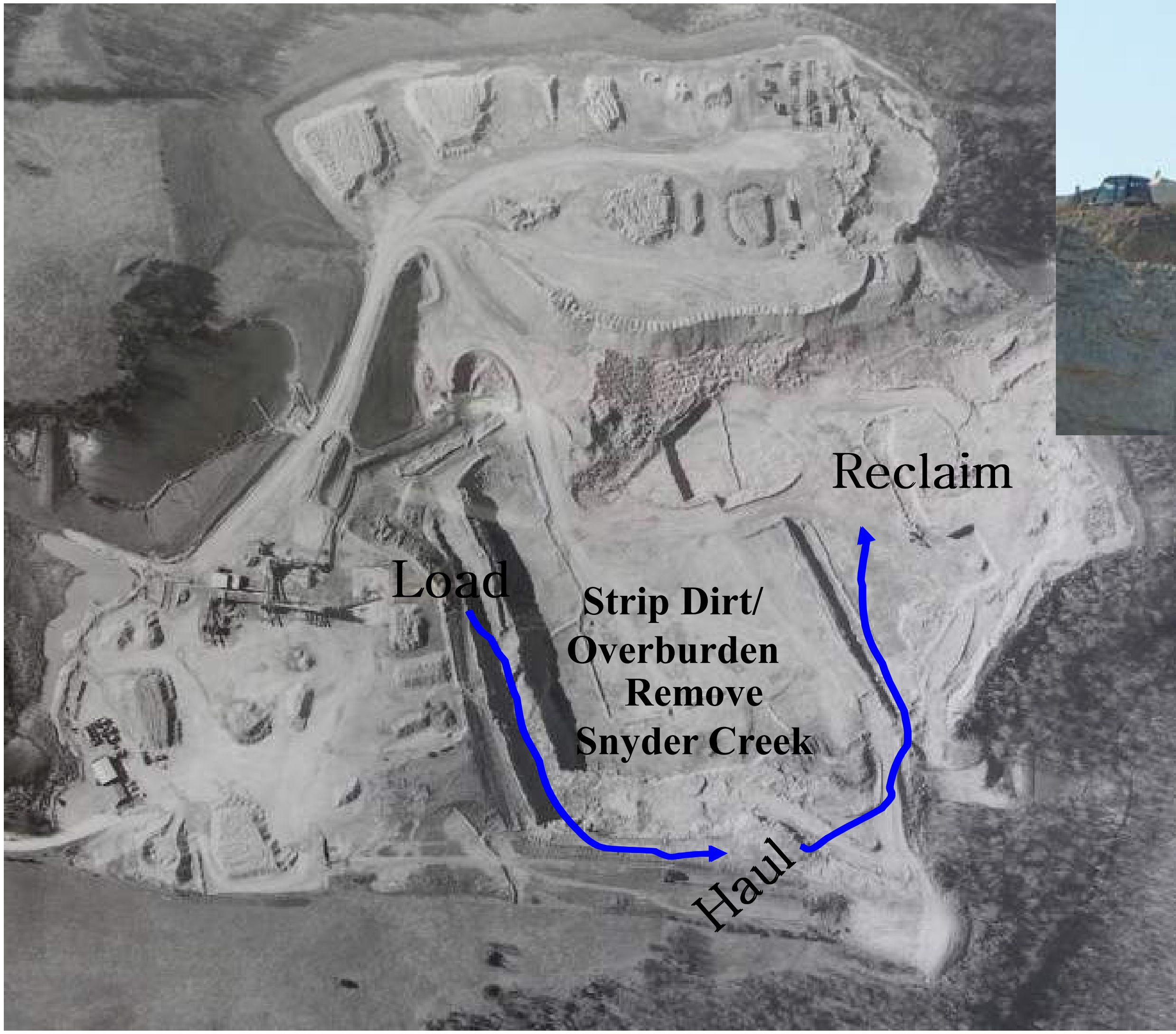
QUARRY ACADEMY

The Quarry



Overburden
Burlington Formation: 25' - 31'
Snyder Creek Formation: 3' - 5' (All Spoil)
Cedar Valley Formation: 58'
Cotter Ledge
(Dolomite - not in production)

The Quarry Process



Waste
Streams

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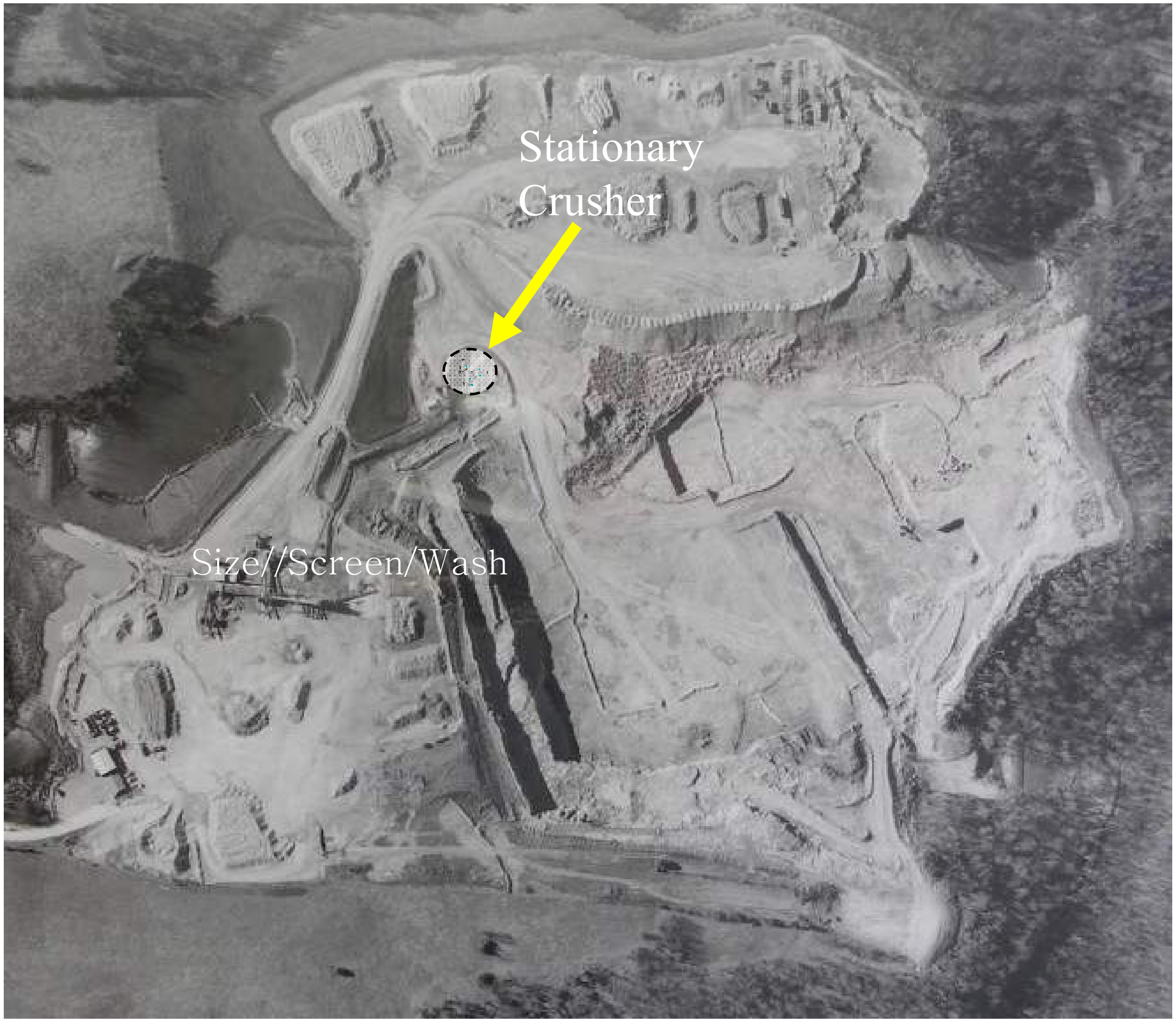
The Quarry Process

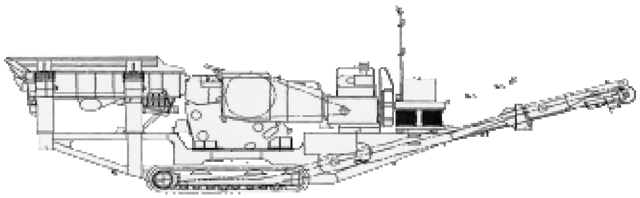


Crush and Screen prior to project.

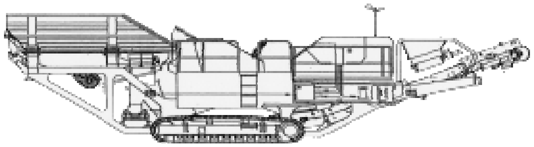
The Quarry Process

QUARRY
ACADEMY

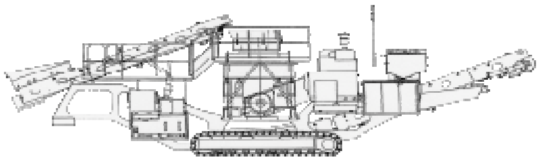
Diesel Powered Mobile Crushing Plant



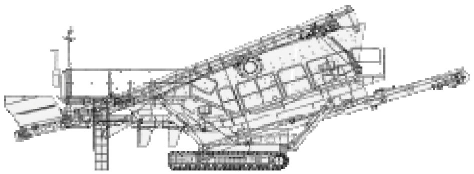
Primary - 44 x 34 Jaw



Secondary – Horizontal Impact Crusher



Tertiary - Cone Crusher



Three (3) Triple Deck Screen Units

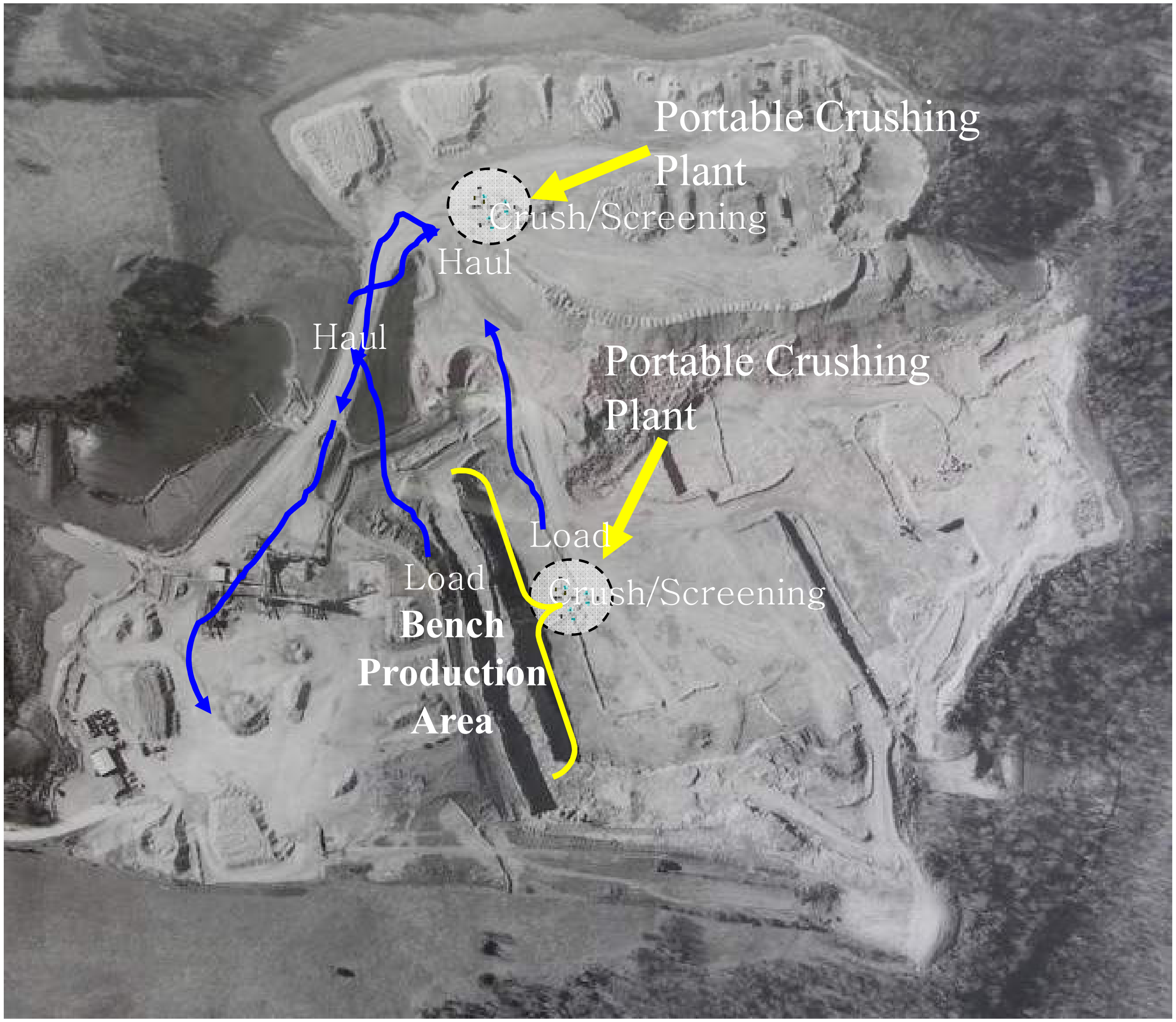
QUARRY ACADEMY

Quarry Process

- **Products**
  - ✓ **2 inch x 4 inch stone**
  - ✓ **1 inch x 2 inch stone**
  - ✓ **9/16 inch x 1 inch road base**
  - ✓ **3/8 inch x 1 inch concrete rock**
  - ✓ **5/16 inch x 3/8 inch stone**
- **Waste**
  - ✓ **>0 inch to 5/16 inch fines**

QUARRY ACADEMY

The Quarry Process



Drilling

- Top hammer mid-range class track drill
  - ✓ 1 ¾ inch diameter T45 rod
  - ✓ 4 inch bits
- Burlington Formation
  - ✓ 10 ft x 14 ft x 33 ft
  - ✓ 4 to 5 rows
- Cedar Valley Formation
  - ✓ 10 ft x 14 ft x 60 ft
  - ✓ 2 to 3 rows
- Subdrill 2 ft

QUARRY ACADEMY

Blasting

- Dyno Nobel Titan® 1000 SD
  - ✓ Bulk repumpable blasting agent emulsion
- Trojan ® 35 & 45 Cast Boosters
- Nonel ® Initiation System
  - ✓ 25 ms between holes
  - ✓ 67 ms between rows
- Stem 7 ft
- Powder Factor
  - ✓ Burlington 0.95 lb/cu yd
  - ✓ Cedar Valley 1.14 lb/cu yd
- Approx. 20,000 ton blasts

QUARRY ACADEMY

Baselining

- Period July 10 to August 15, 2006
- Evaluated each process step
  - ✓ Standard operating procedure
  - ✓ Costs
- Historical records back to May 1, 2006
- Benches surveyed; drill holes surveyed; blasting & operator logs reviewed; muck pile fragmentation analyzed; primary crusher throughput, finished products and waste tonnages were monitored.

Identification and Implementation of Metrics

- 3D Bench survey; drill holes survey blast load sheets; seismograph reports; drill cycle time; in-pit muck pile photo fragmentation analysis; loader cycle time & bucket weight monitoring; oversize count; hydraulic hammer time (in-pit and at primary); crusher feed rate; daily operator logs; haul truck counts.
- Non standard highlighted above in blue.

QUARRY ACADEMY

“Lean Thinking” Analysis

- **Examined productivity, operational effectiveness, operational efficiency; waste and profitability.**
- **Identified best practices that could be adapted or extended to enhance operational effectiveness.**
- **“Ways to work smarter not harder!”**

  (Eric Strope - President CQCI)

QUARRY ACADEMY

Improvement Areas

- Quarrying benches separately
- Drilling precision and accuracy
- Explosive Energy Distribution throughout rock mass
- Excavation & crushing of muckpile. (tight muck, oversize, reduced throughput)
- Fines/Waste
- Process water (wash plant, settlement ponds etc.)

QUARRY ACADEMY

Modeling

- Fragmentation and process equipment simulators were used to select alternatives with best chance of creating positive change.

✓ **Fragmentation**

- Kuz-Ram & Modified Kuz-Ram

✓ **Process Equipment**

- Metso Bruno®
- Sandvik Plant Designer®

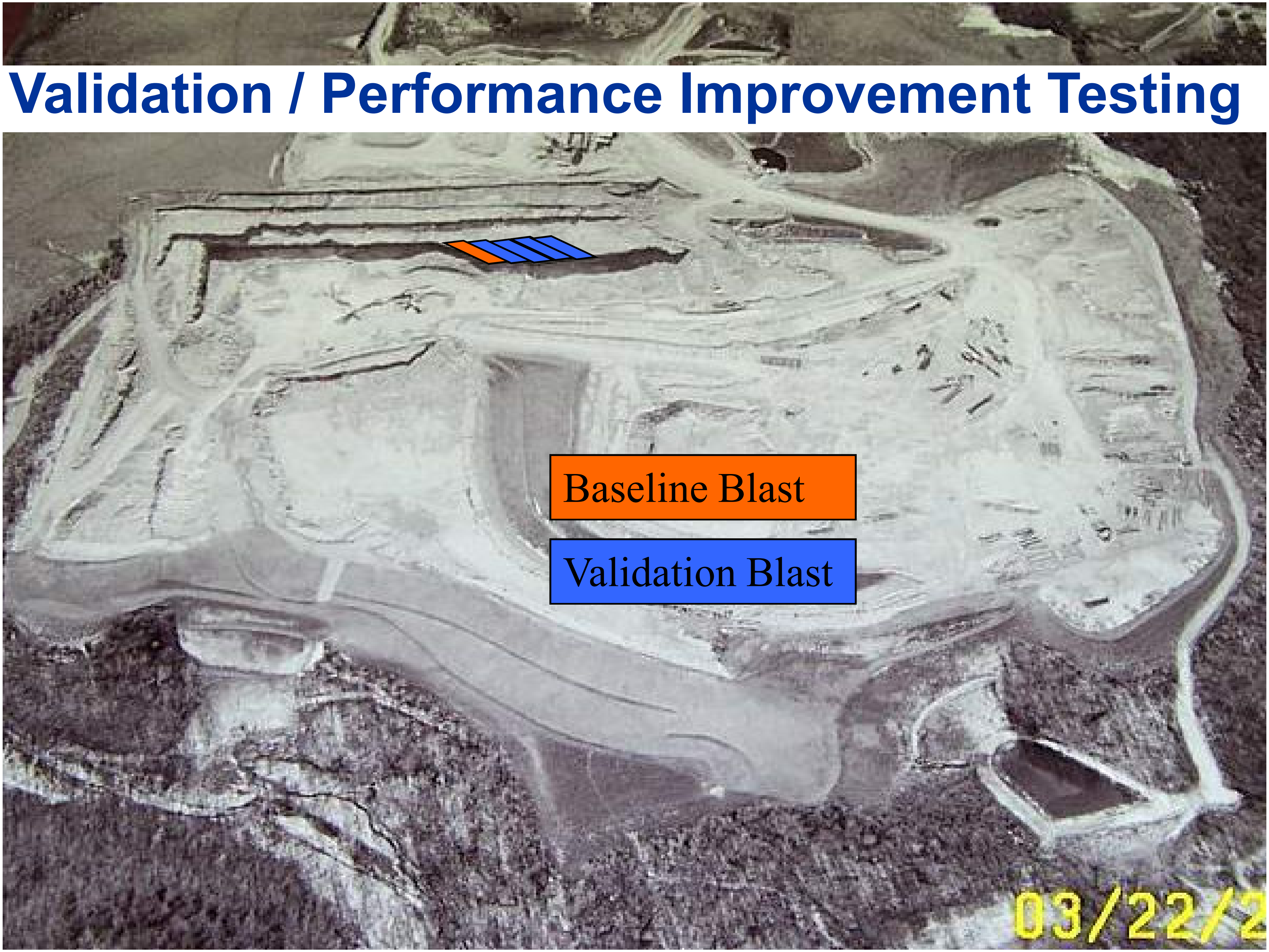
QUARRY ACADEMY

Field Validation of Process Improvements

- Cedar Valley Bench Only.
- Blast sizes - 15,000 to 20,000 tons
- Four (4) Validation Blasts
- One (1) additional Baseline Blast
- All blasts were 3 rows.
- Blast Design
  - ✓ 12 ft x 10 ft x 60 ft (Row 1)
  - ✓ 10 ft x 12 ft x 60 ft (Row 2 & 3)

QUARRY ACADEMY

Validation / Performance Improvement Testing



Drilling & Blasting

- **Drilling**
  - ✓ **No change to equipment**
- **Blasting**
  - ✓ **Grade of repumpable blasting agent emulsion and type/size cast boosters remained unchanged.**
  - ✓ **Electronic Detonators replaced Nonel.**
    - remove any variability of individual blast hole firing times;
    - assure absolute control of blast hole sequencing; and
    - to allow non-conventional timing choices to be implemented.
  - ✓ **Amount of stemming 7 ft.**
  - ✓ **Powder Factor increased to 1.33 lb/cu yd.**

QUARRY ACADEMY

Drilling & Blasting

- **Blasthole Timing**
  - ✓ **All validation blasts were consistent with 10 ms between holes in row 1.**
  - ✓ **Blast 1**
    - 17 ms between holes (row 2 and 3)
    - 67 ms between rows
  - ✓ **Blast 2**
    - 16 ms between holes (row 2 and 3)
    - 75 ms and 82 ms between rows

QUARRY ACADEMY

Drilling & Blasting

- **Blasthole Timing**
  - ✓ **All validation blasts consistent with 10 ms between holes in row 1.**
  - ✓ **Blast 3**
    - 12 ms between holes (row 2 and 3)
    - 118 ms between rows
  - ✓ **Blast 4**
    - 17 ms between holes (row 2 and 3)
    - 118 ms between rows

Validation Blast # 3

Blast 3 - Face View 03 21 2006.wmv

QUARRY ACADEMY

Discussion

- **Capital Quarries was ideal candidate for testing.**
  - ✓ **Not new to continuous improvement process**
  - ✓ **Utilized "Lean Thinking" principles.**
  - ✓ **Empoyees change oriented.**
  - ✓ **Key Factor**
    - Use of portable and mobile in-pit crushing/screening plant.
    - Operational setup compressed entire rock crushing and sizing process and cost model to 1,500 ft radius.

"Blast to 1 inch Minus" Process Model"

QUARRY ACADEMY

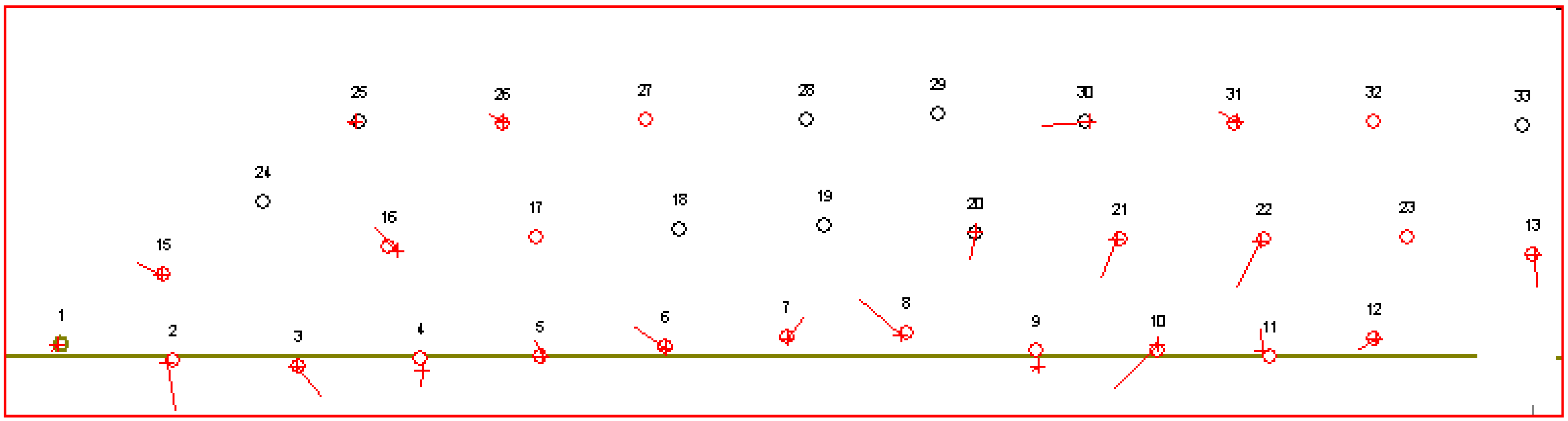
Discussion

- Changes to blast design were made to reduce top size to less than 37 inches or 85% of size of feed box for the 44" x 34" jaw crusher.
  - ✓ Factory targeted capacity of 340 – 470 tons per hr @ 6 inch closed side setting;
  - ✓ Eliminate hard toe;
  - ✓ Facilitate digging for front end loader;
  - ✓ Eliminate sorting of oversize

QUARRY ACADEMY

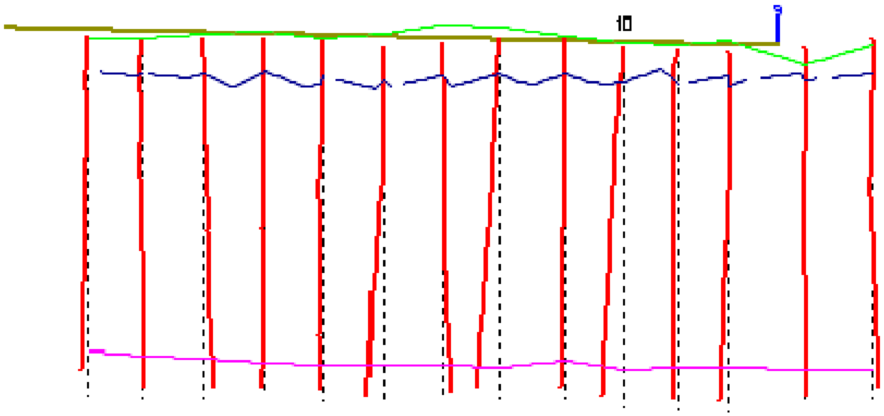
Discussion

- **Blast Layout and Drilling**
  - ✓ **Baseline**
    - Planned vs "As Built"   2.5 - 10.5% variance B & S
  - ✓ **Validation**
    - Planned vs "As Built"   2 - 7% variance B & S



Discussion

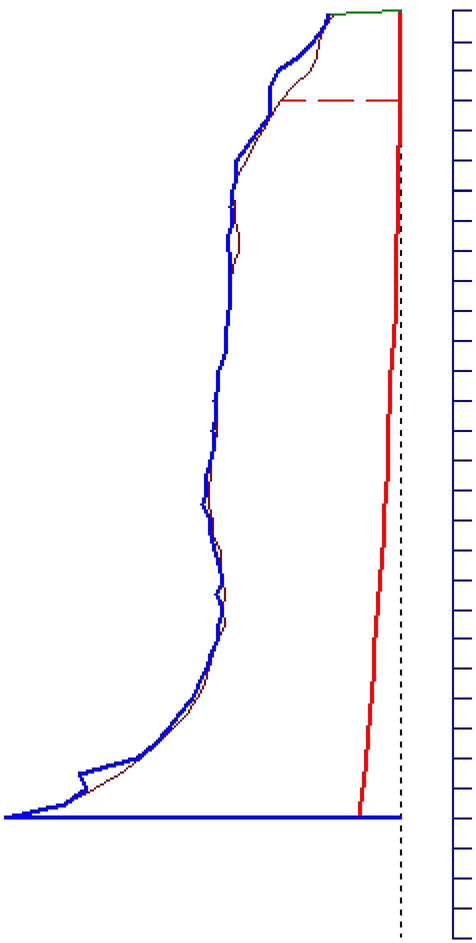
- Drill hole deviation
  - ✓ At best 50% of holes within 1.5 ft deviation. (17% worst, 39% Average)
- 18% - Accumulated variance for average face row burdens.

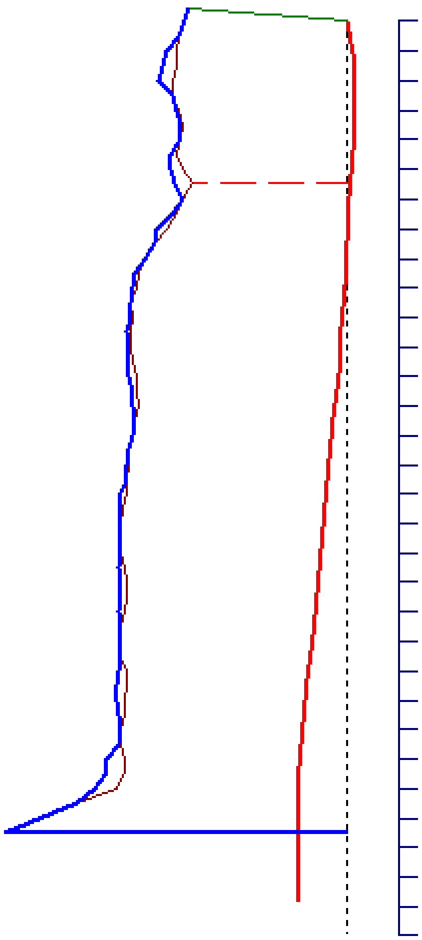


QUARRY ACADEMY

Discussion

- Blast 1 had excellent fragmentation and crusher throughput but required a blast design layout change.
- Front row burdens were light and required custom loading.
  - ✓ Average min. burden 8.5 ft
  - ✓ Average burden 10.5 ft
- Additional 2 ft was added to burden layout for front row.
  - ✓ Average min. burden 10.8 ft
  - ✓ Average burden 13.5 ft.

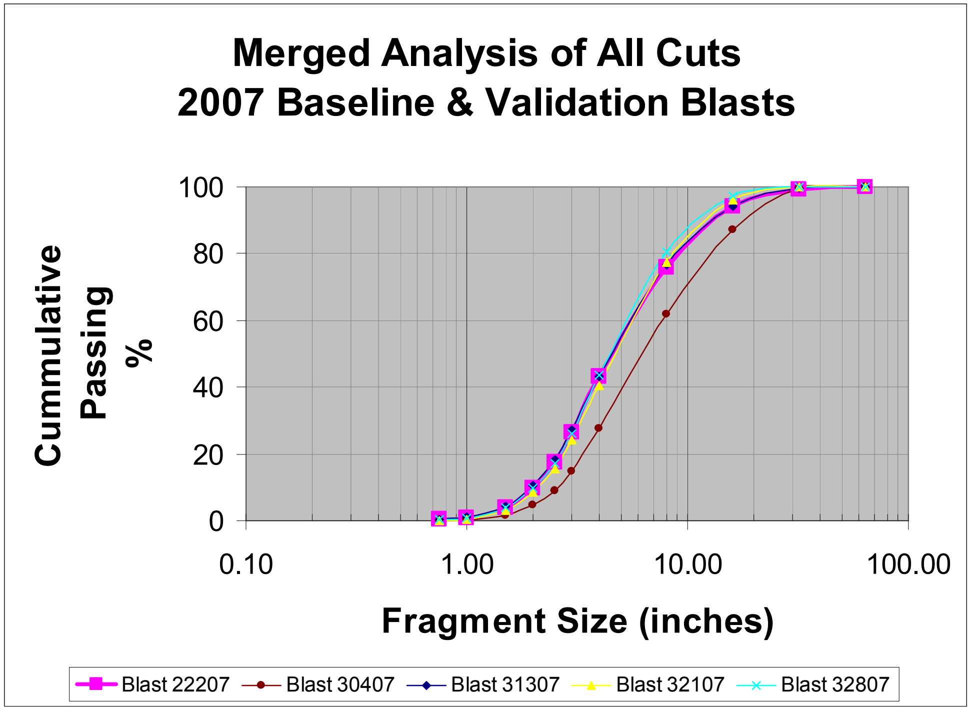




QUARRY ACADEMY

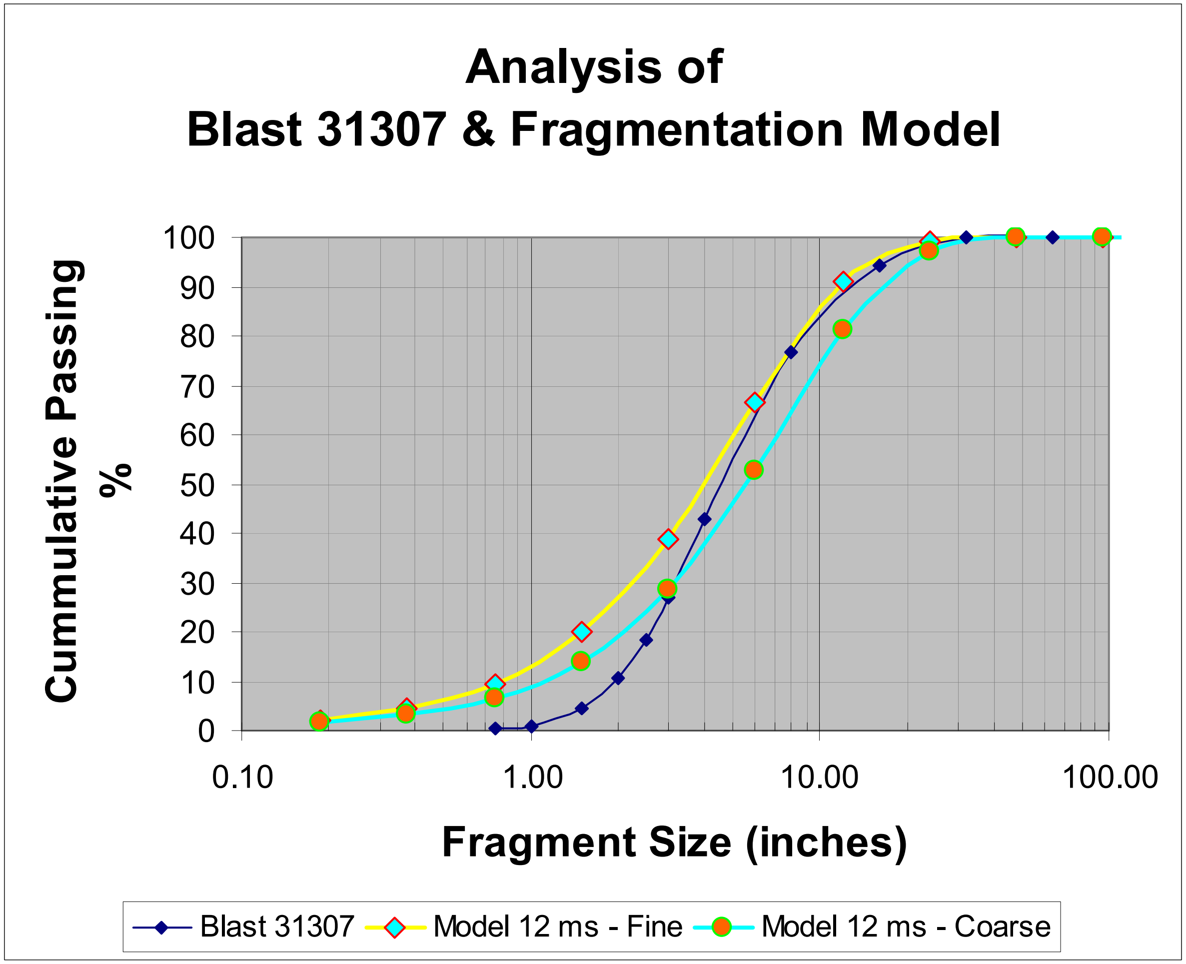
Discussion

- Fragmentation in all validation blasts resulted in meeting the 100% passing 37 inch criteria.
  - ✓ Eliminated oversize segregation in the pit.
  - ✓ Reduced use of the jaw mounted hammer to minimal.
  - ✓ No dramatic differences were observed in fragmentation gradation of validation blasts.



QUARRY ACADEMY

Discussion

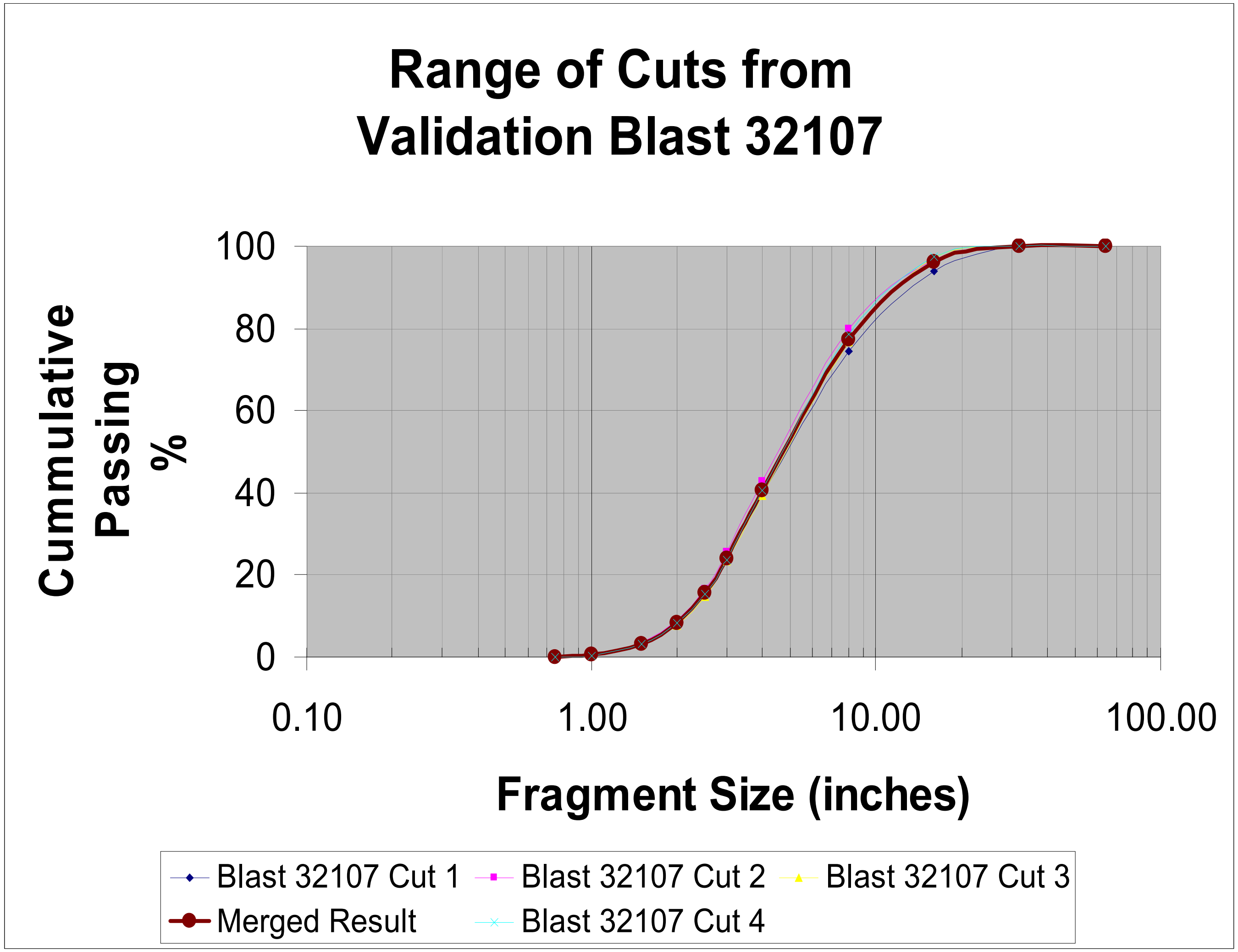


- Improvements simulated by the fragmentation model for 12 ms inter-hole time were not obvious.

QUARRY ACADEMY

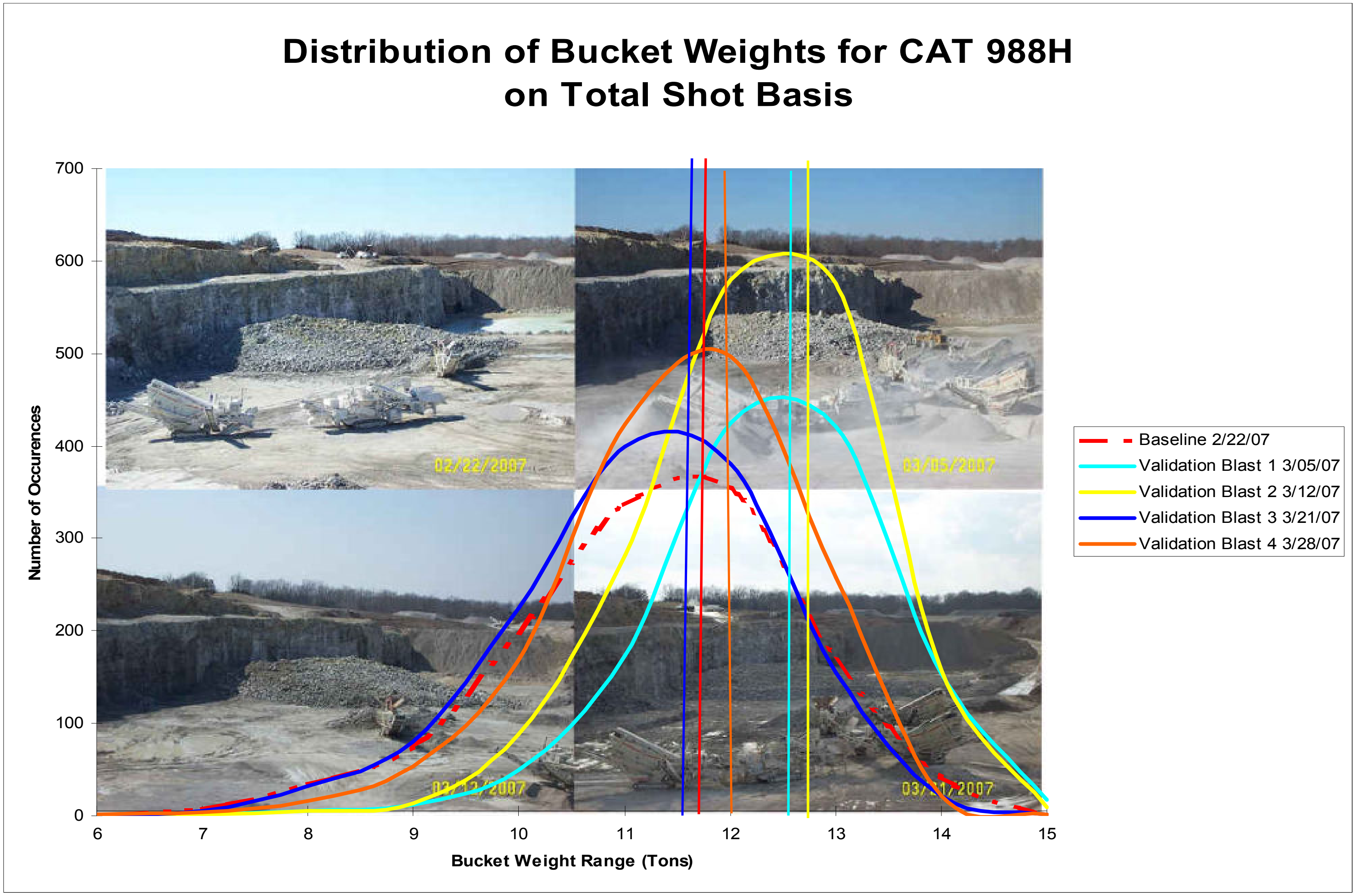
Discussion

- **12 ms between hole times did display most consistent gradation.**



QUARRY ACADEMY

Discussion



QUARRY ACADEMY

Discussion

	CAT 988H					
	# Cycles per Shift	Avg Cycle Time min:secs	Avg Bucket Weight tons	% Buckets over 12 ton	Crusher Feed Rate (overall) tons/hr	Daily In-Pit Crushing Tons/shift
Baseline	1,234	2:04	11.97	51.85%	366.24	14,267
Validation Blast #1	1,263	1:30	12.84	80.36%	505.94	16,173
Validation Blast #2	1,671	1:41	12.62	73.17%	450.83	16,173
Validation Blast #3	1,301	1:36	11.62	41.62%	452.64	15,207
Average		1:35	12.36	65.05%	469.81	
Validation Blast #4	1,442	1:48	12.01	54.10%	363.70	17,314

- **Validation blasts 1 and 2**
  - ✓ **wheel loader cycle times were reduced by 15%;**
  - ✓ **bucket fill improved by 8 % and**
  - ✓ **the percentage of buckets weighing 12 tons or more improved by 63%.**

QUARRY ACADEMY

Discussion

	CAT 988H					
	# Cycles per Shift	Avg Cycle Time min:secs	Avg Bucket Weight tons	% Buckets over 12 ton	Crusher Feed Rate (overall) tons/hr	Daily In-Pit Crushing Tons/shift
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Average		1:35	12.36	65.05%	469.81	
Validation Blast #4	1,442	1:48	12.01	54.10%	363.70	17,314

- **For validation blast 3 (12ms)**
  - ✓ **loader cycle times were shortest;**
  - ✓ **there was no improvement over baseline in bucket fill;**
  - ✓ **there was a reduction of 11% in the percentage of buckets weighing 12 tons or more.**

QUARRY ACADEMY

Results

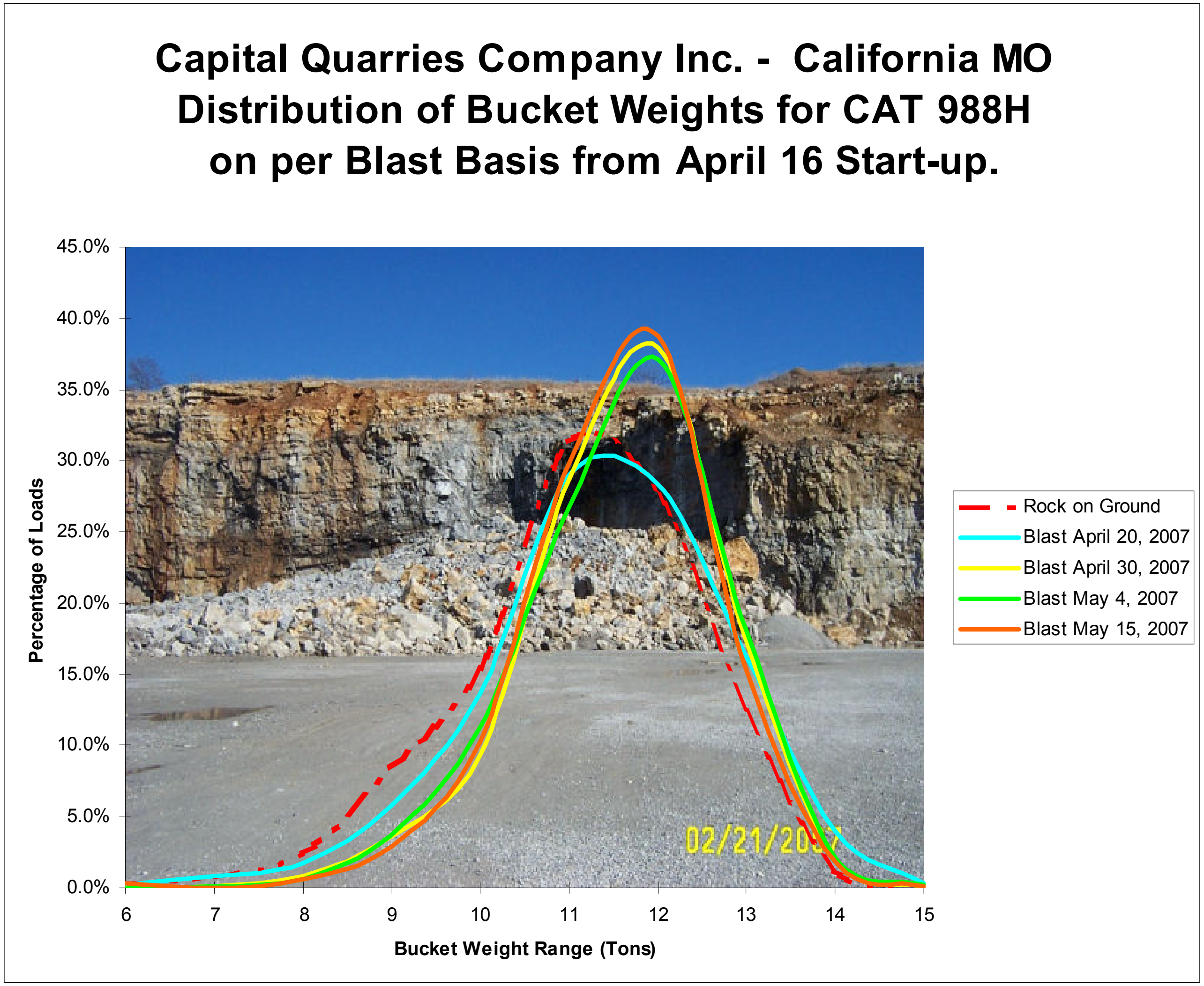
- Impressive cost savings and increases in plant tonnage throughput within the "Blast to 1 inch minus" process cost model were realized in spite of 28% increase in D&B costs!
  - ✓ 10 to 27% increase in crusher plant capacity over baseline of 373 tons per hour to an average of 475 tons/hr
  - ✓ 17% to 31 % reduction in net total cost per ton when scalping
  - ✓ 8.8% reduction in net total cost per ton without scalping

Transfer of Knowledge
Performance Testing

- **Diesel operated portable crushing plant, supporting equipment and the blast design were moved to the California, MO quarry.**
  - ✓ **Similar cost reductions were realized**
  - ✓ **Increased performance and productivity reduced actual operating days to produce a 100,000 ton order by 25% compared to budget.**

	CAT 988H								
Date	Operating Time hrs:min:sec	Daily Total To Jaw Tons	Average Cycle Time hrs:min:sec	Average Bucket Weight Tons	Buckets per shift #	Percent Buckets Over 12 ton	Down Time hrs:min:sec	Overall Crusher Feed Tons/hr	Adjusted Crusher Feed Tons/hr
Total	241:03:30	95,061.82			7,888		26:18:22		
Average			0:01:50	12.05		52.4%		394.35	442.66

Transfer of Knowledge
Performance Testing



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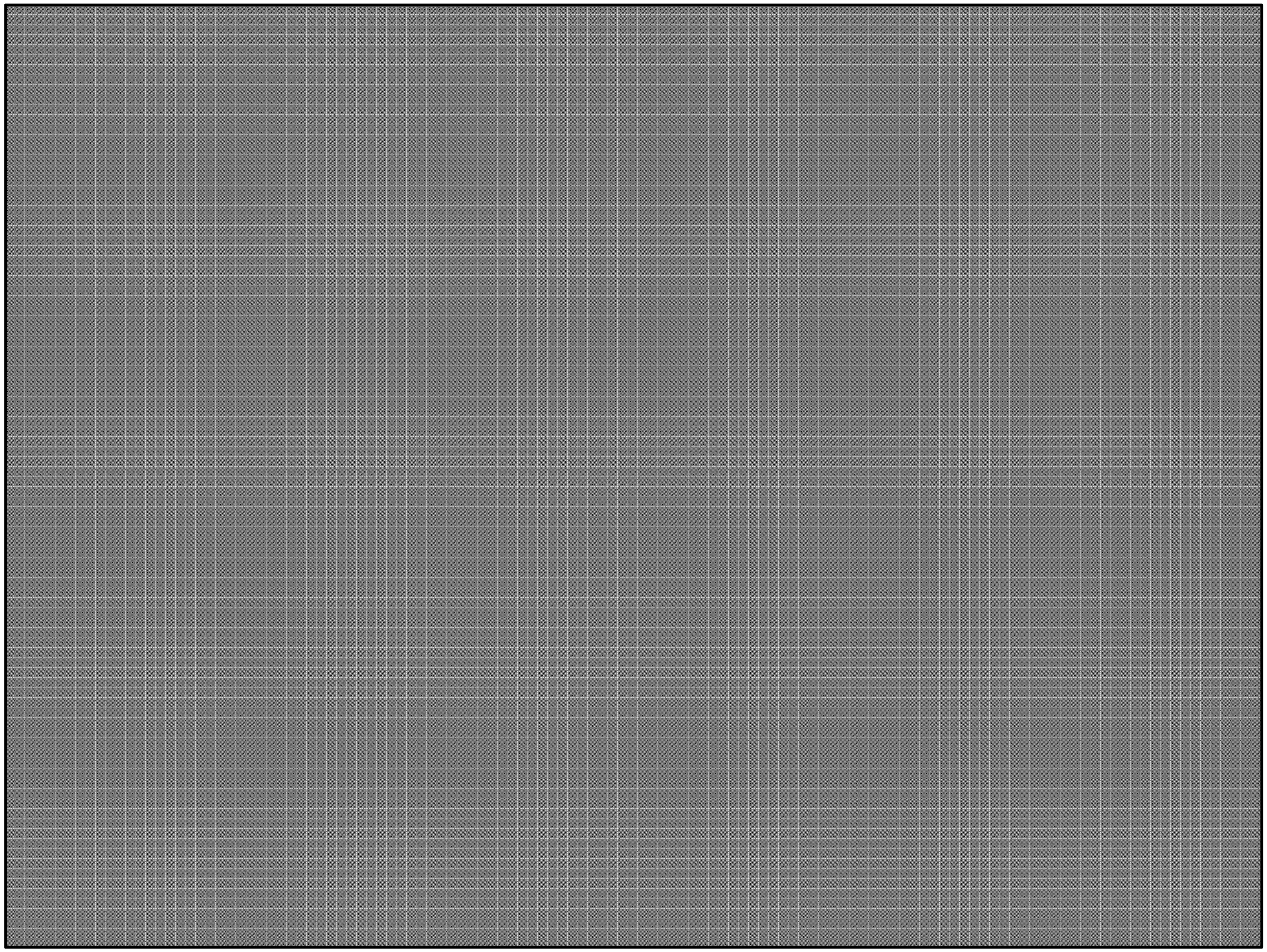
Eric Strope's Comment on Results



07 - Sandvik Mtng 1-26-08 Clip3 - Cant Go Back - 0-44.wmv

QUARRY ACADEMY

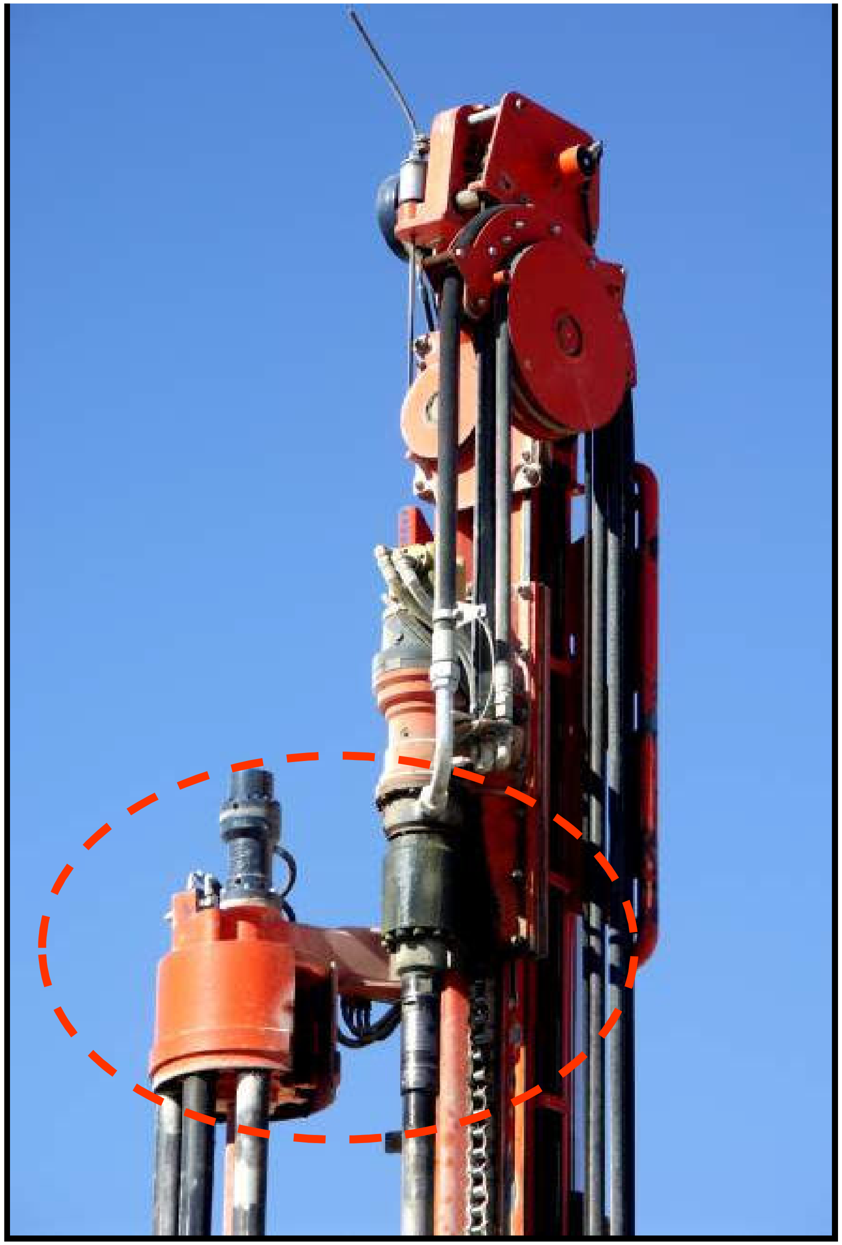
Value Mapping Project
Holts Summit Quarry

Project Execution

Phase 2

Blasthole Quality Control Program

QUARRY ACADEMY



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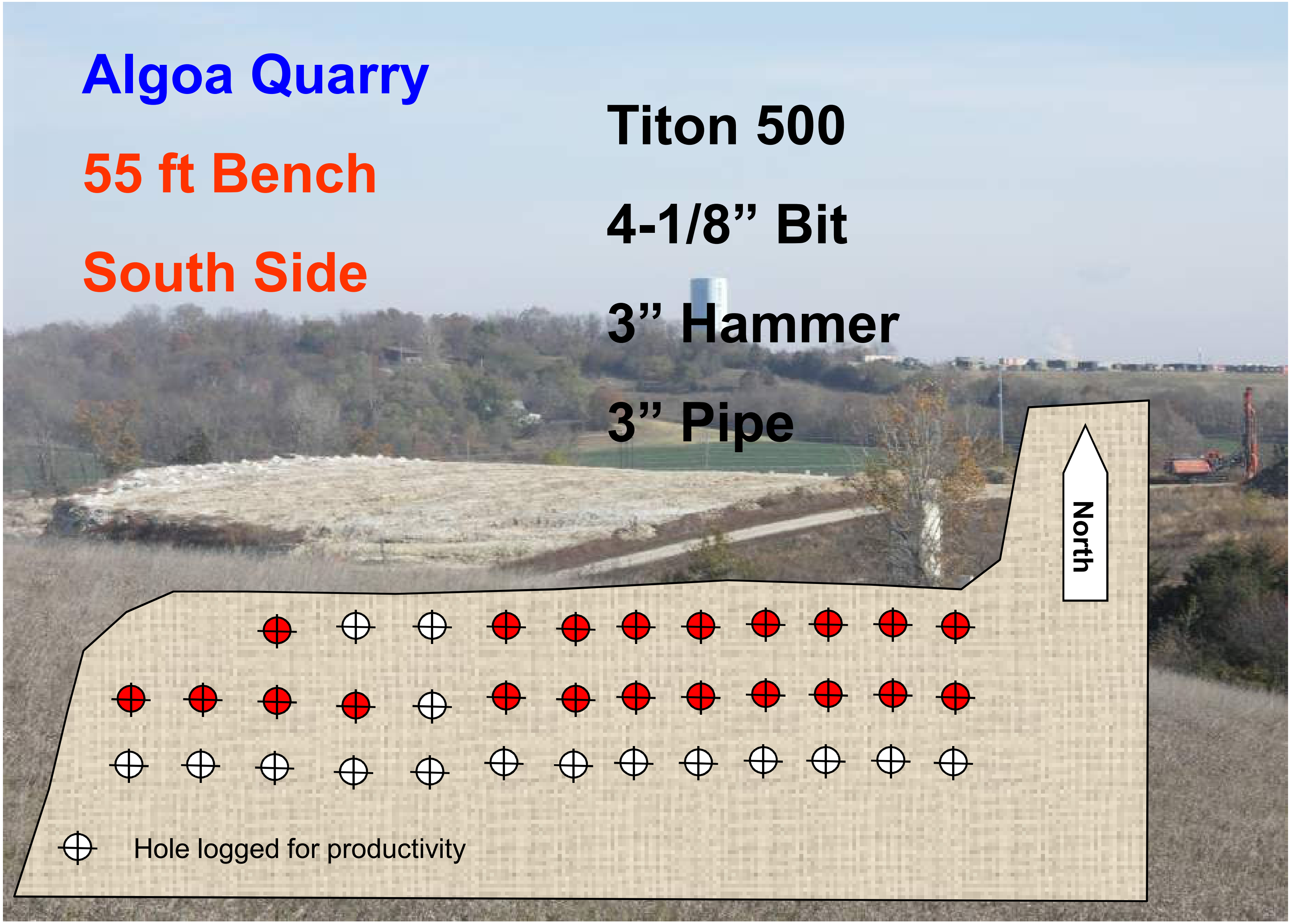

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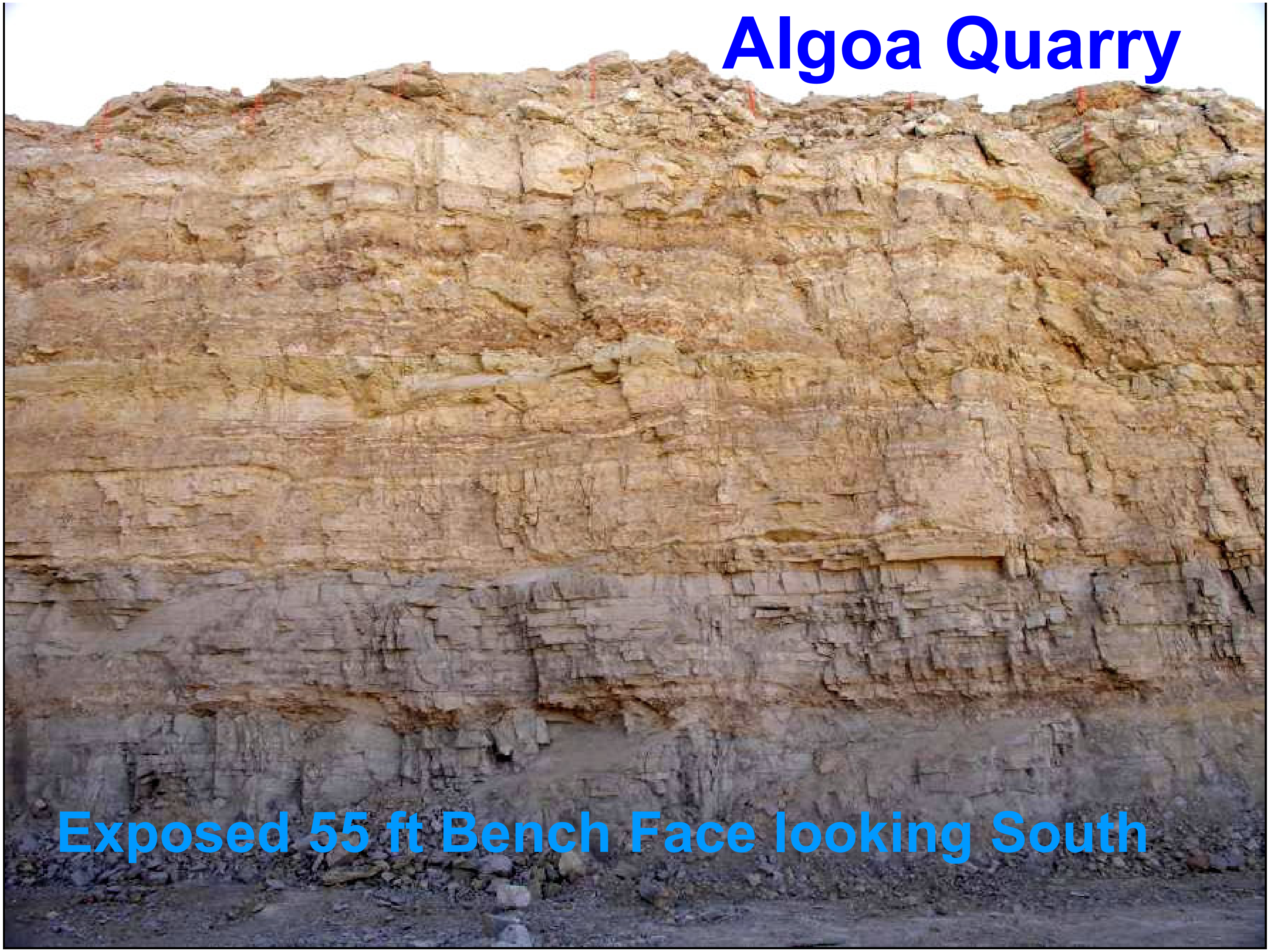
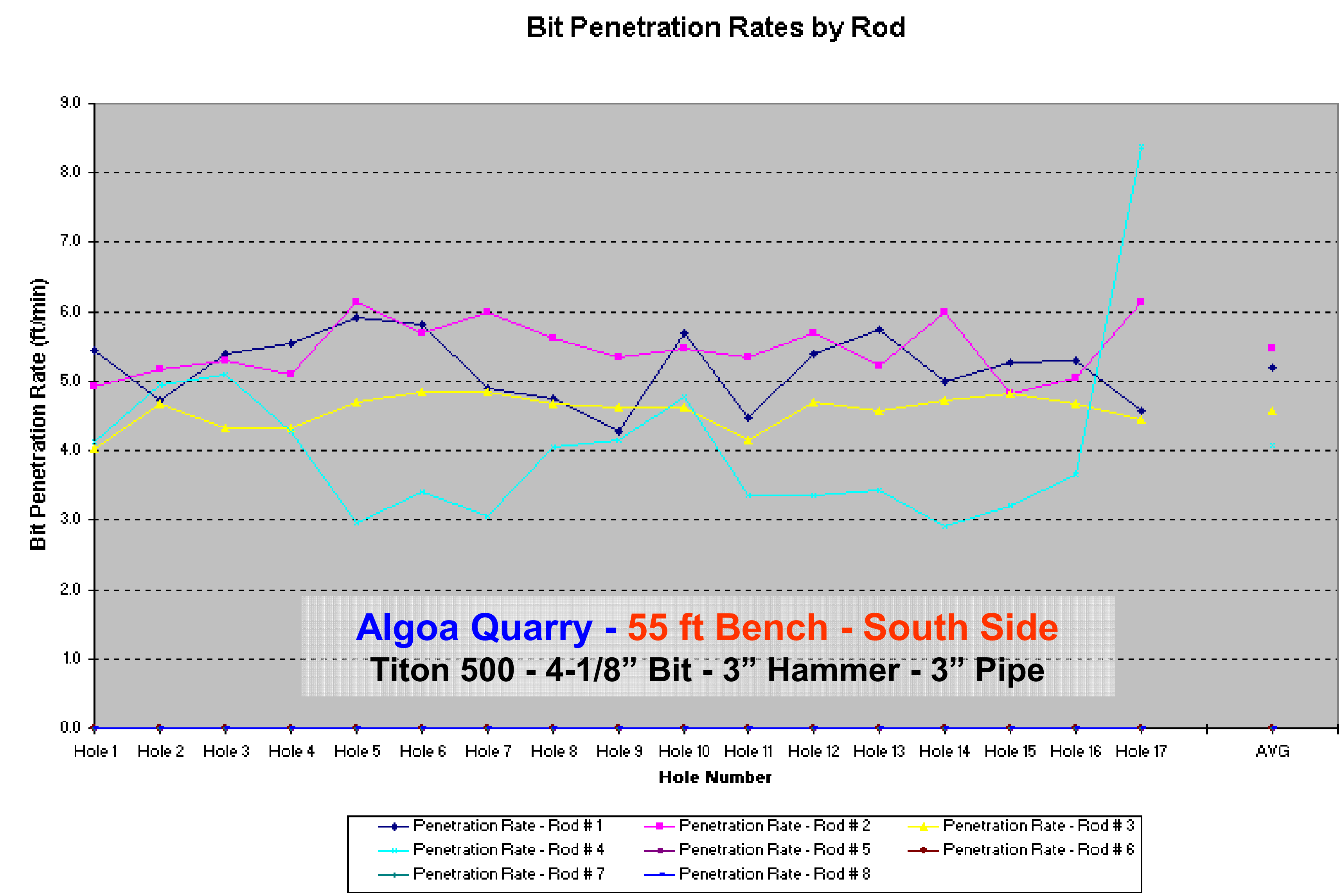

Algoa Quarry
Exposed 55 ft Bench Face looking South



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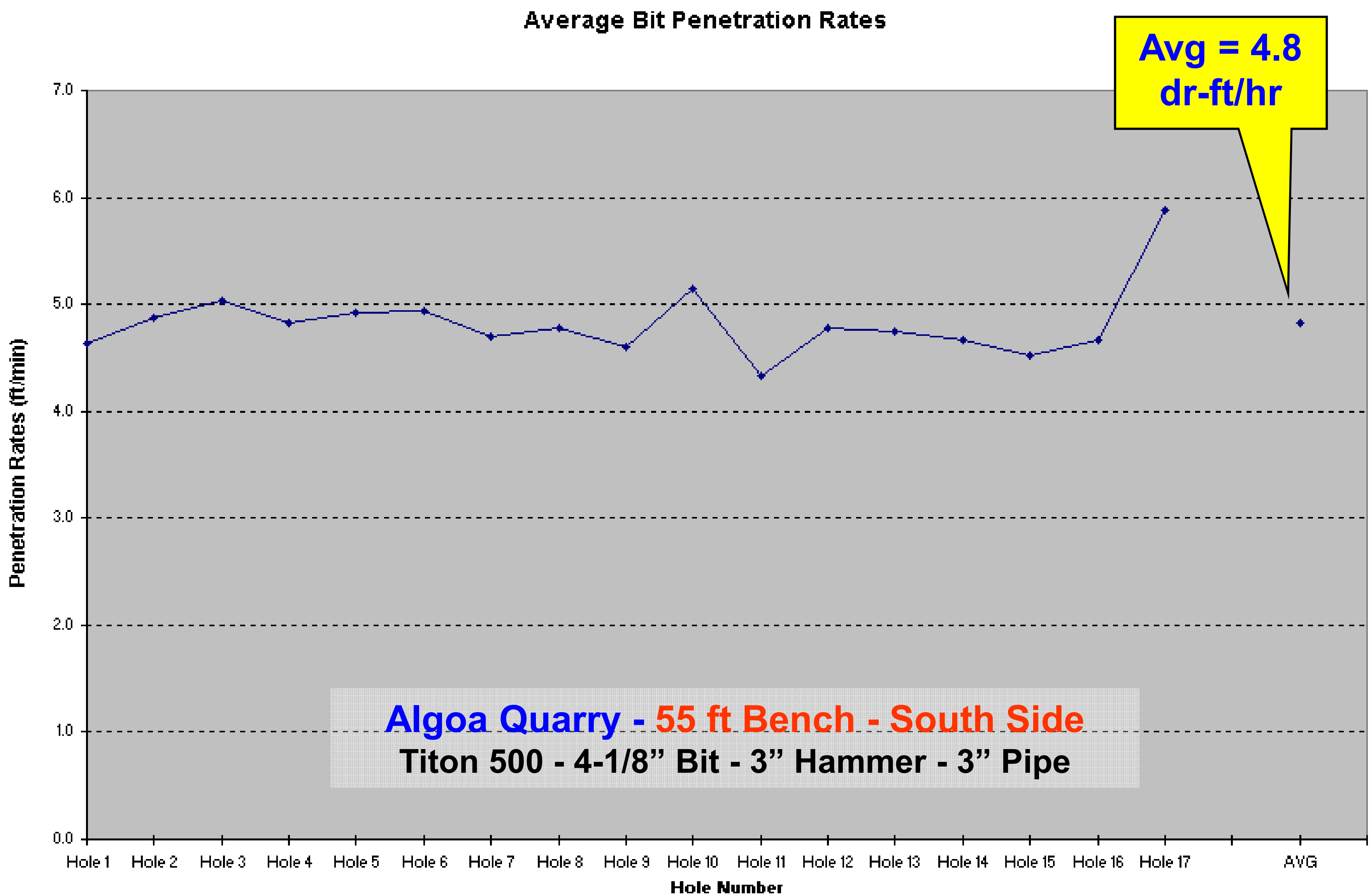

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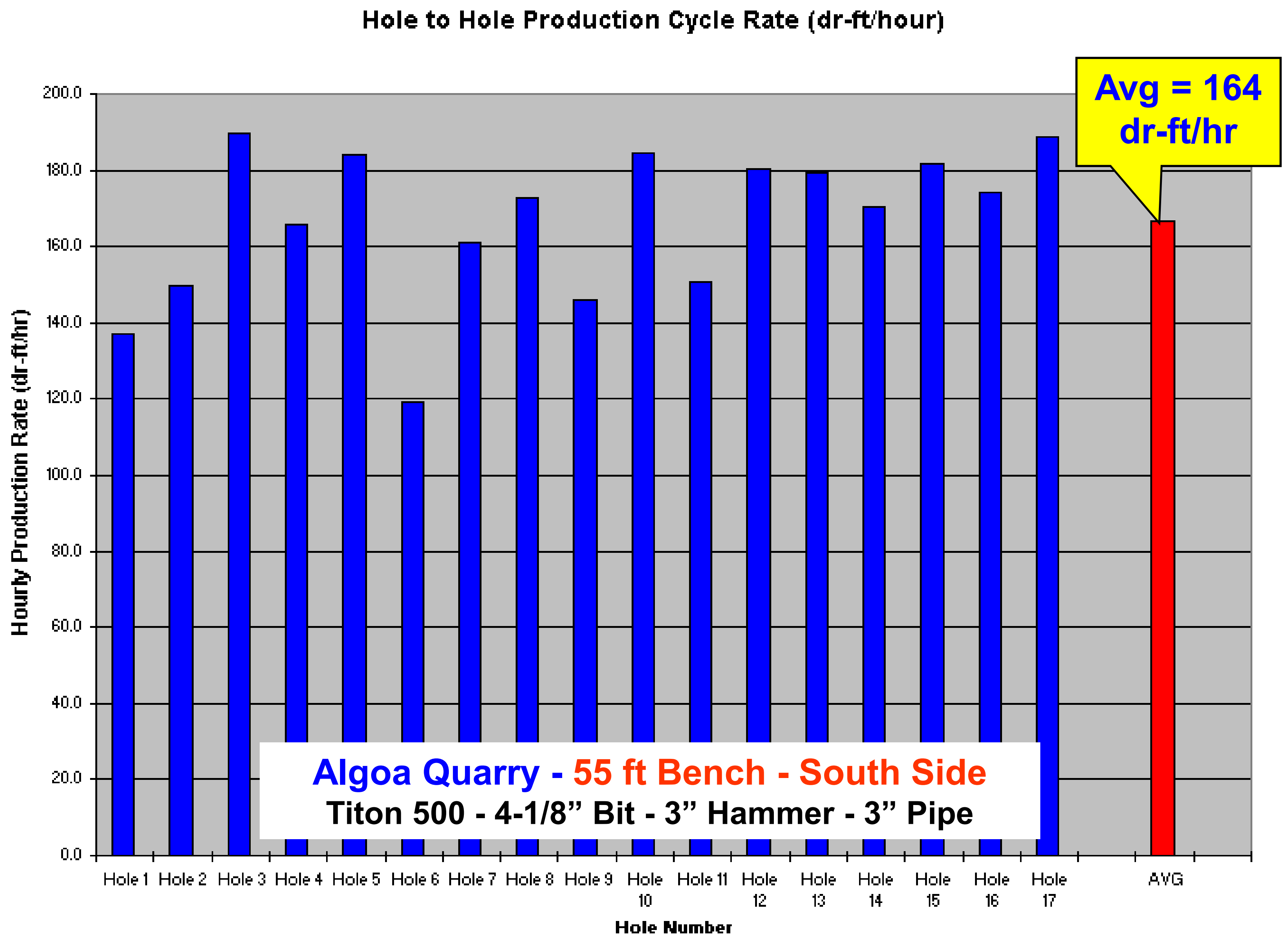
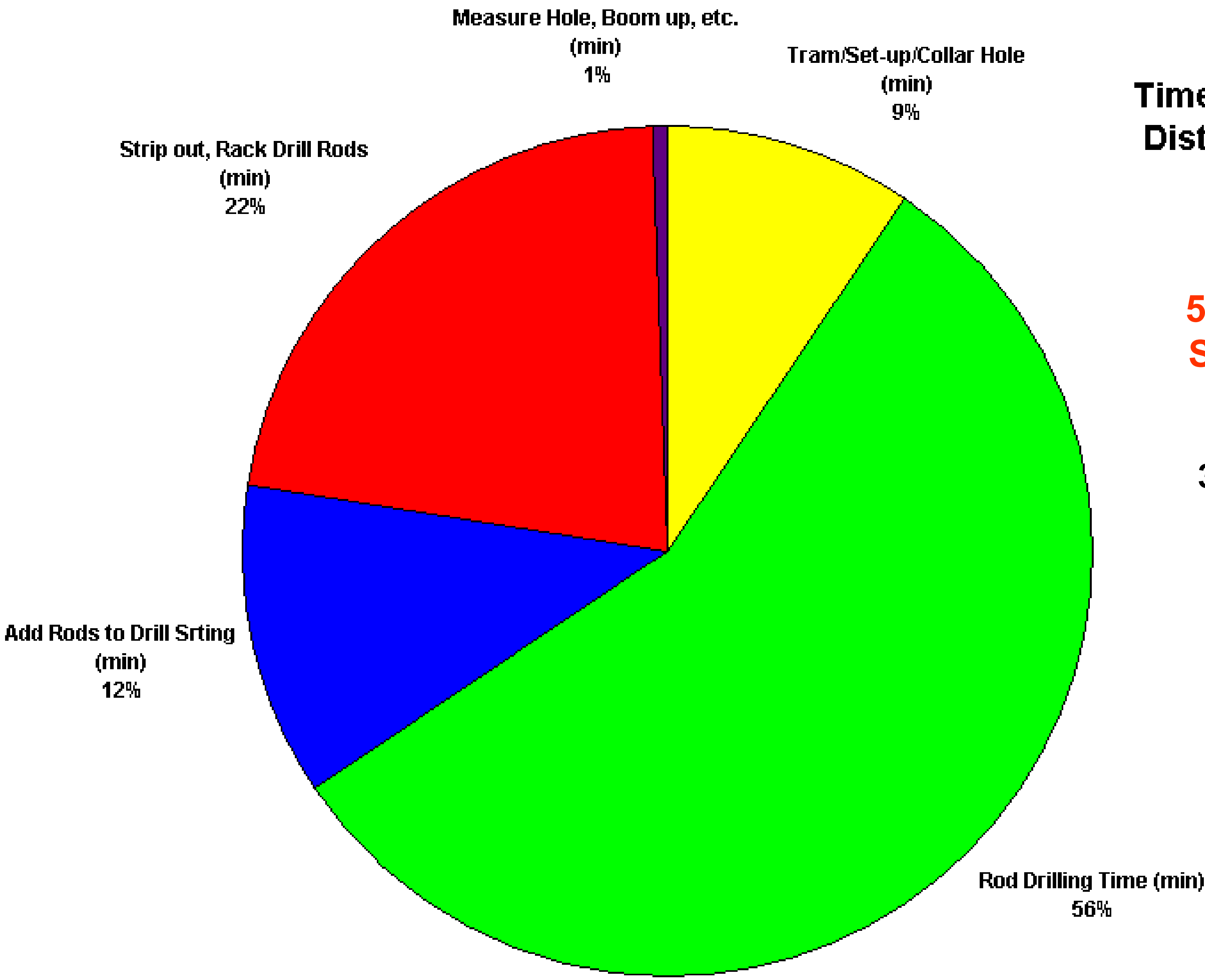


QUARRY ACADEMY

Time Activity Distribution

Algoa Quarry
55 ft Bench South Side
Titon 500
4-1/8" Bit
3" Hammer
3" Pipe



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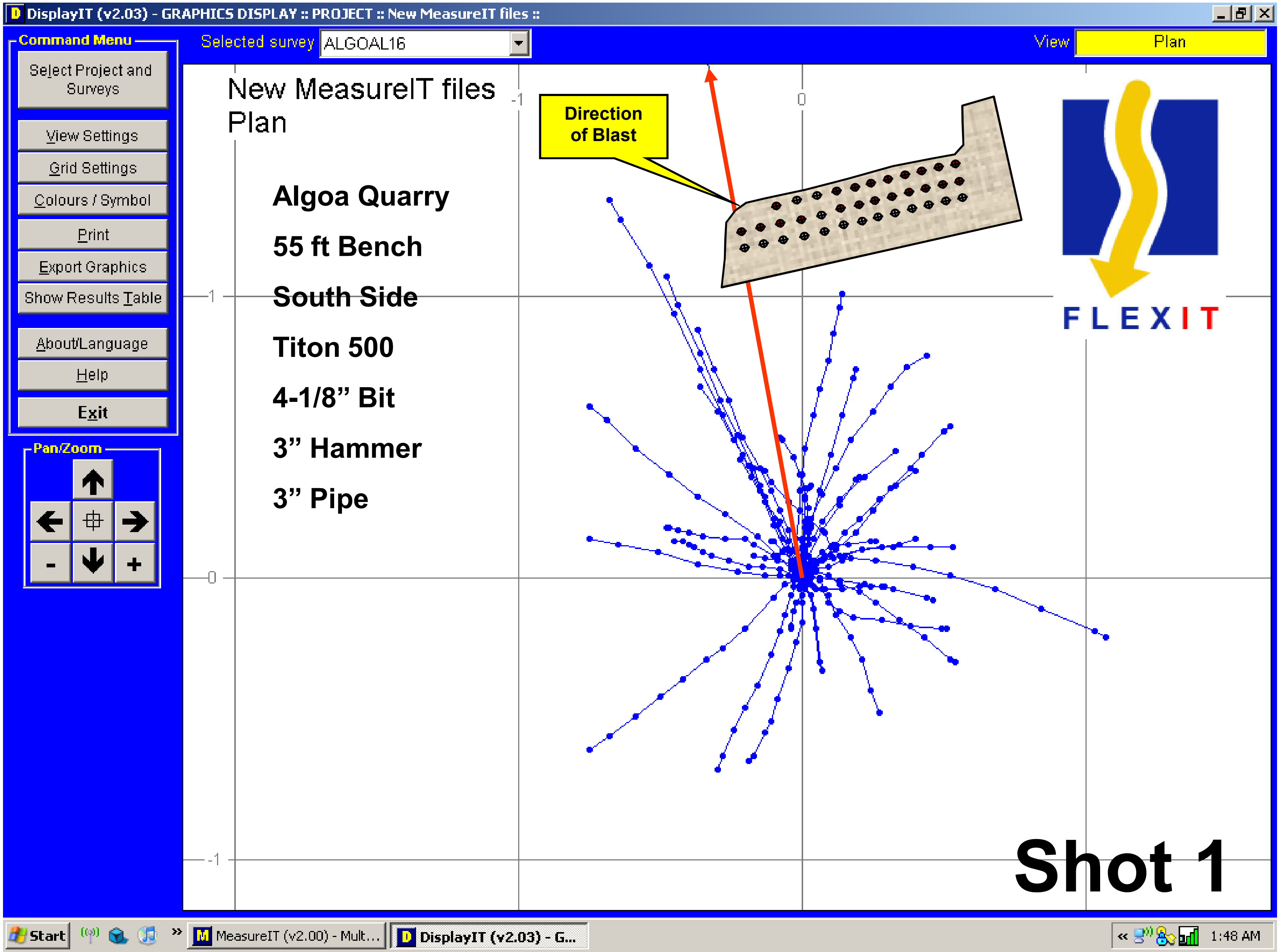

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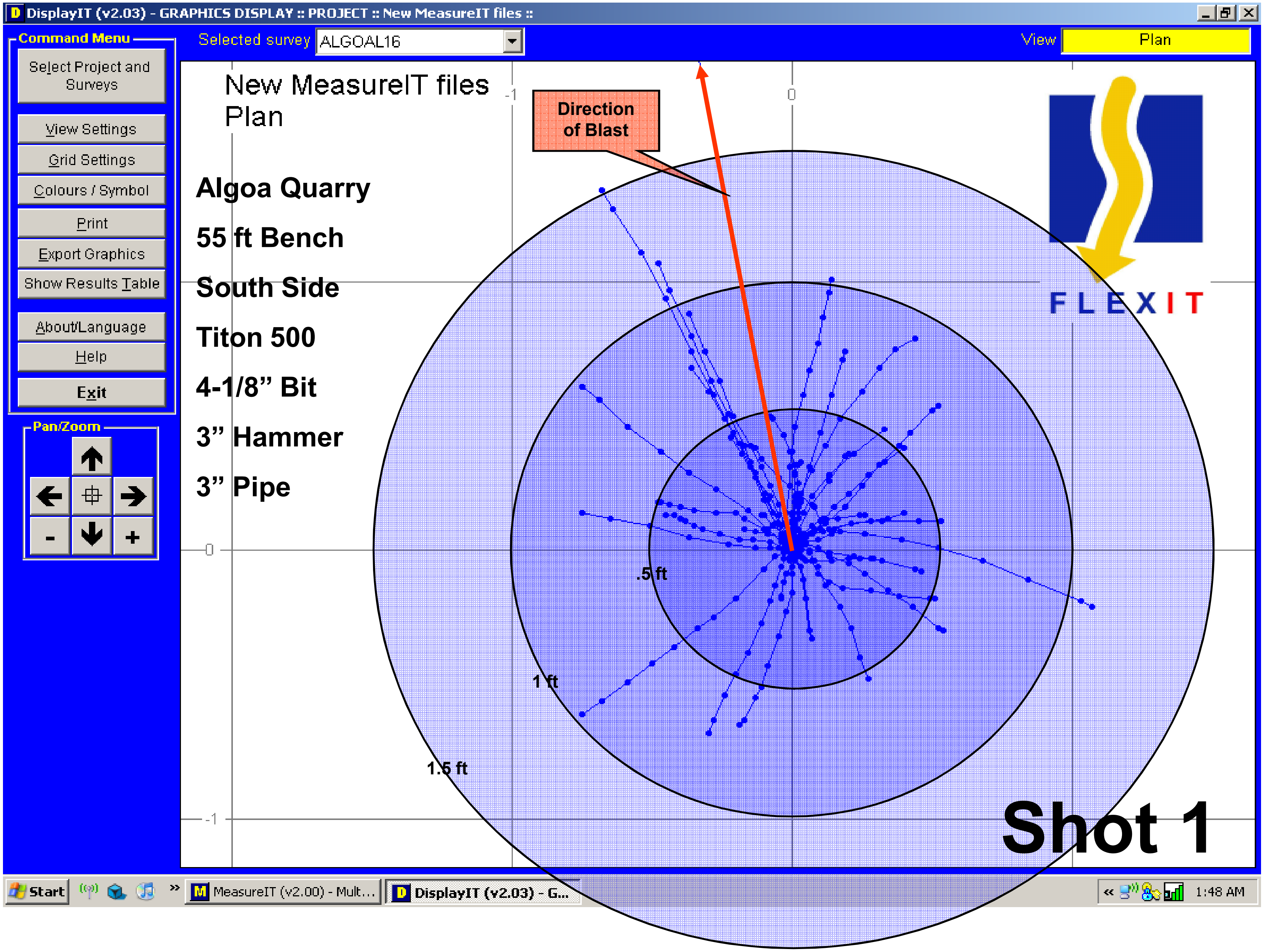
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View
Plan
New MeasureIT files
Plan
Algoa Quarry
55 ft Bench
South Side
Titon 500
4-1/8" Bit
3" Hammer
3" Pipe
Direction of Blast
FLEXIT
.5 ft
1 ft
1.5 ft
Shot 1
Start
MeasureIT (v2.00) - Mult...
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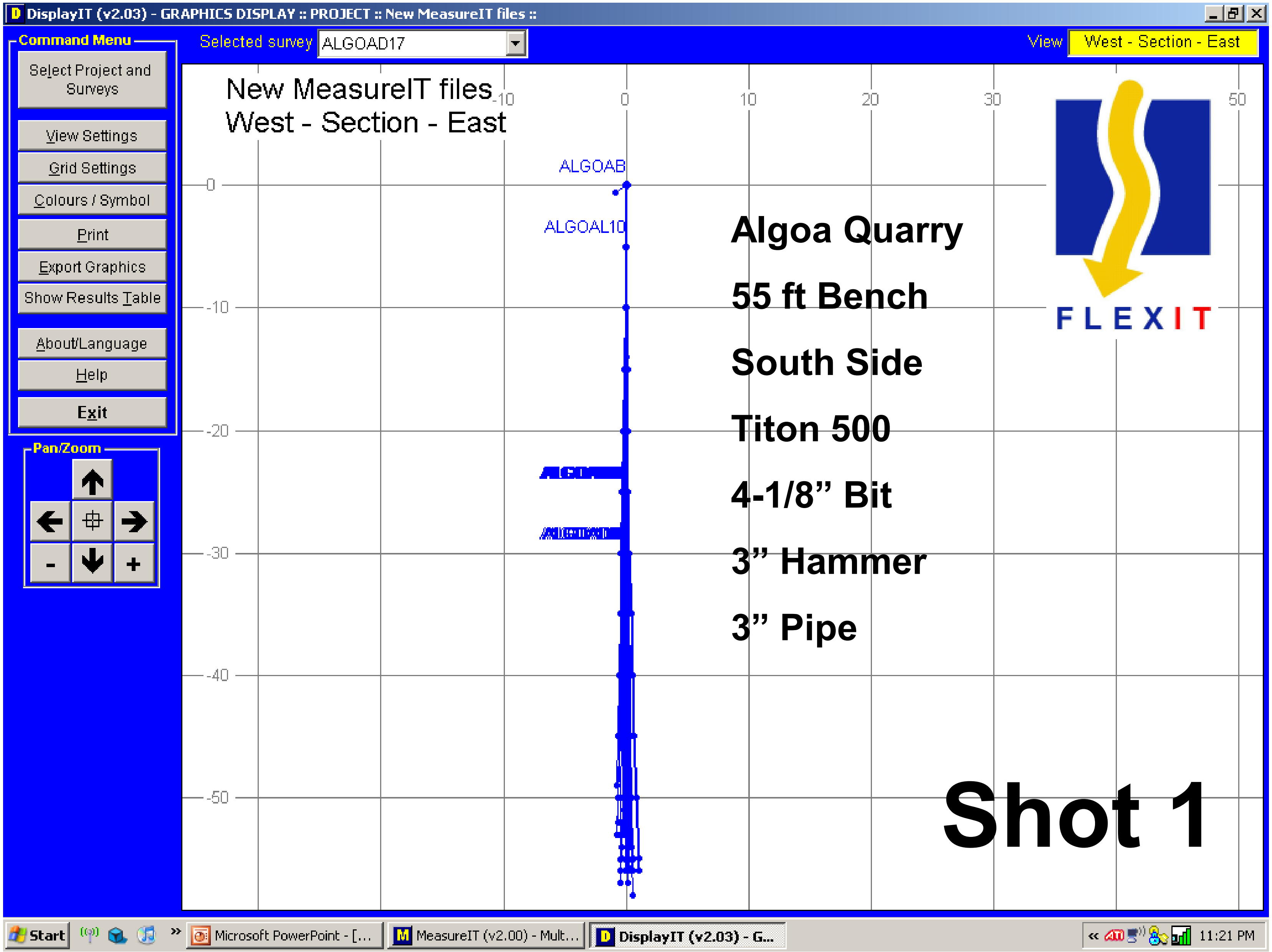

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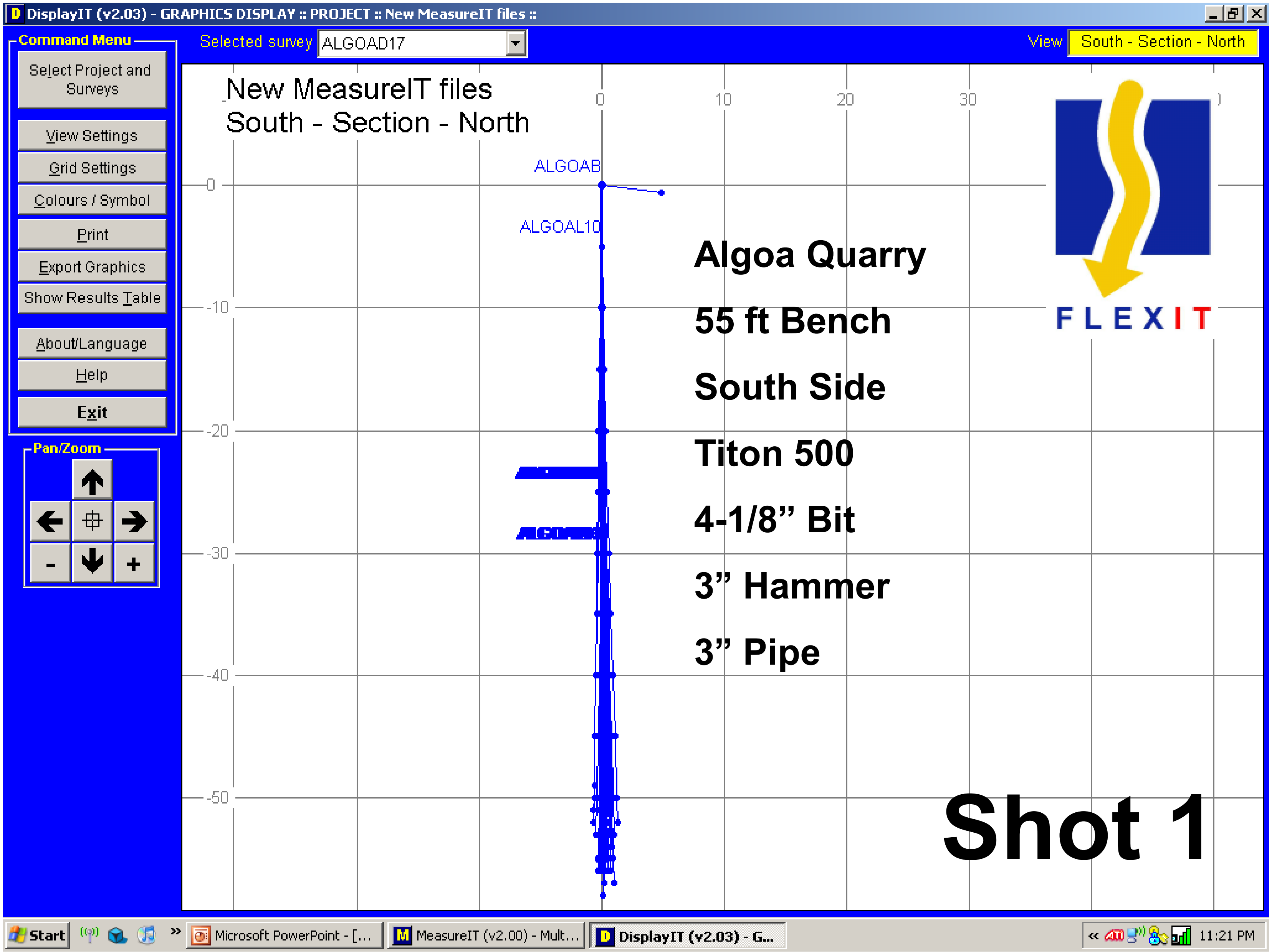
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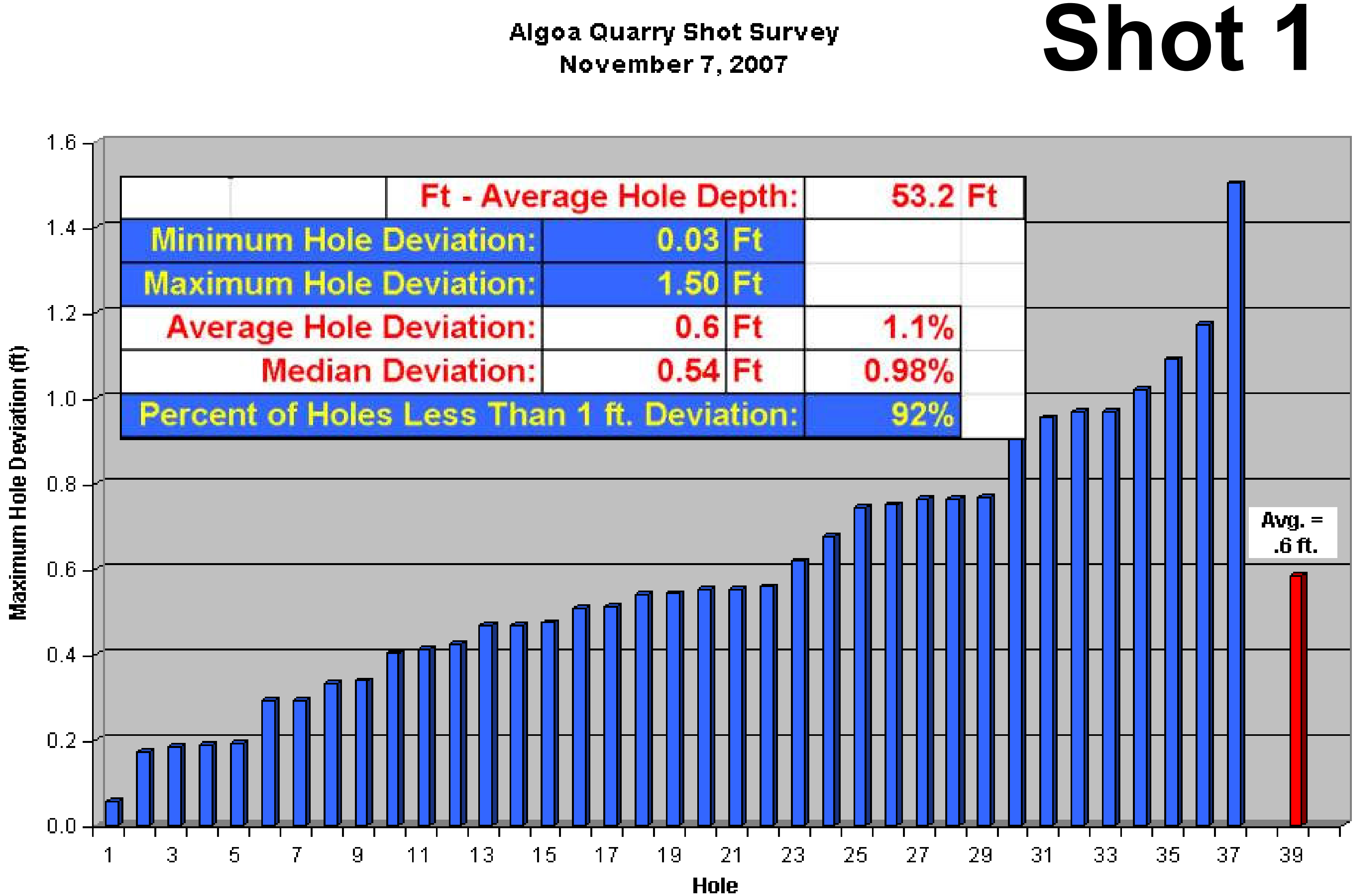
ALGOAB
ALGOAL10
Algoa Quarry
55 ft Bench
South Side
Titon 500
4-1/8” Bit
3” Hammer
3” Pipe
FLEXIT
Shot 1
Start
Microsoft PowerPoint - [...
MeasureIT (v2.00) - Mult...
DisplayIT (v2.03) - G...
11:21 PM

Shot 1



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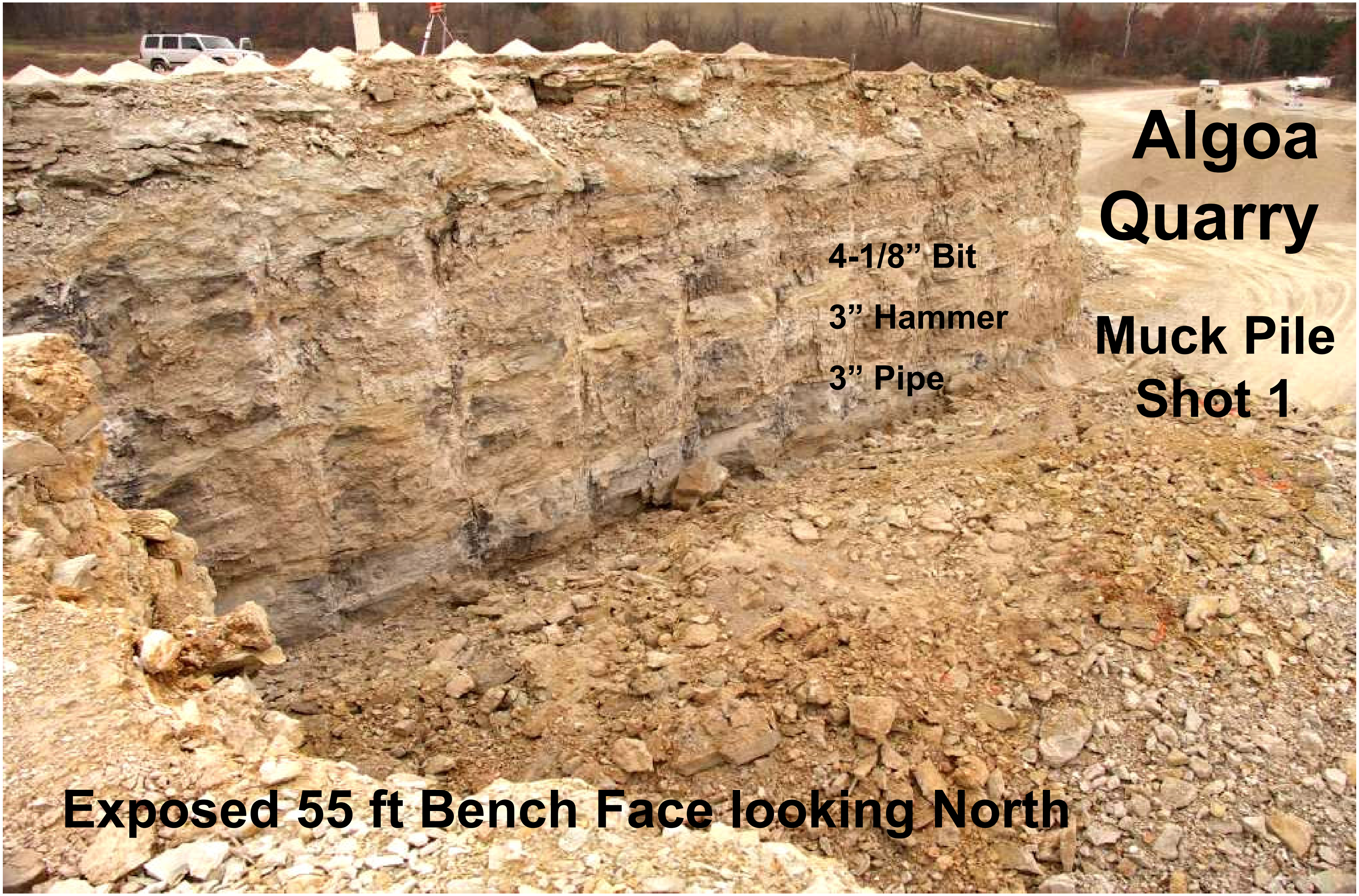
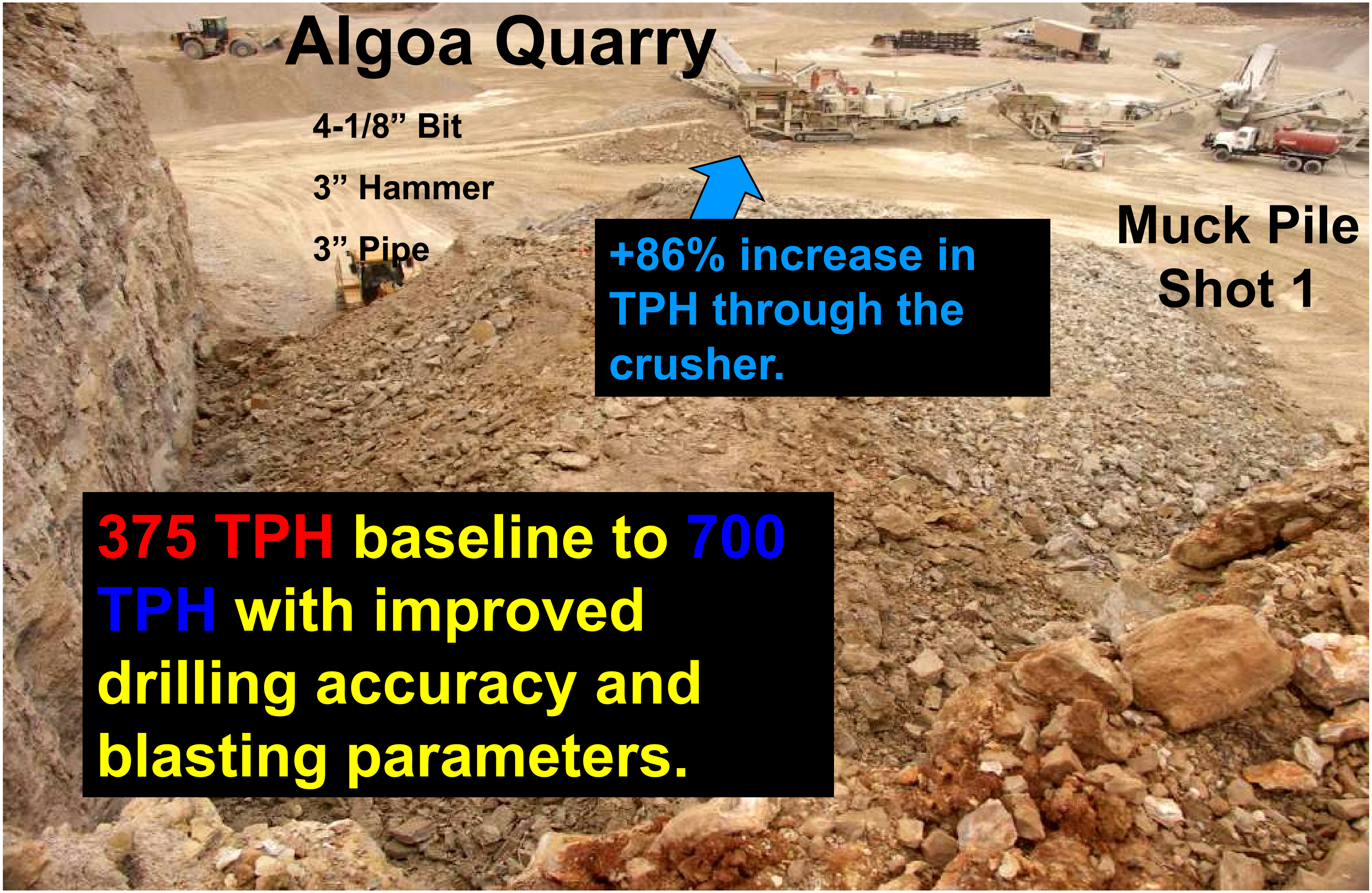


QUARRY ACADEMY

QUARRY ACADEMY


Algoa Quarry
4-1/8" Bit
3" Hammer
3" Pipe
+86% increase in TPH through the crusher.
Muck Pile Shot 1
375 TPH baseline to 700 TPH with improved drilling accuracy and blasting parameters.

Phase 2 Summary

- Average drill hole accuracy and precision improved, dropping to an average hole deviation of .6 feet to 1 foot off-center at depths below 40 feet.

- Nominal drilling cost remained neutral on a cost per dr-ft basis.

- Mean particle size dropped and muckpile shape and digability improved by a minimum 25% above phase 1 standards.

- Total crusher/screening plant productivity achieved close to double the ton/hour output of the original steady-state baseline.

QUARRY ACADEMY

Conclusions

- Drilling & Blasting can be a significant contributor to the aggregate producer's value chain. Maintaining control of the entire drill and blast process is imperative. Consistency and reproducibility are key drivers.

- The lessons learned in the casework were found to be transferable based on actual performance testing of the blast design at another of the Capital Quarries Company, Inc. operations.

QUARRY ACADEMY

Conclusions

- "Lean Thinking" helps "to see" all process improvements opportunities that can significantly effect finished product including drilling and blasting.

- Blasting and crushing models are useful tools to evaluate value-in-use solution hypotheses for crushed stone operations before on bench testing.

Conclusions

- Quantification of value cannot be done without consistent and valid metrics. “Real-time” or “Dashboard” metrics drive continuous improvement. Considering the variable batch nature of shot rock as it moves through the production process, internal accounting methods for costing require modification to accurately associate work activities and time dependent variables with the costs that each generate.

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No Turning Back!

www.quarryacademy.com

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SANDVIK