OPINIONS ON BLASTING

COUNTY MATERIALS CORPORATION

MARATHON CITY SITE

NE1/4, SECTION 1, T28N, R5E

MARATHON COUNTY, WI

DATE: JULY 22, 2003

SUBMITTED TO: JACK SONNENTAG AND KERRY LAABS
COUNTY MATERIALS CORPORATION
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SUBMITTED BY: JOHN R. TINKER, JR., Ph.D.
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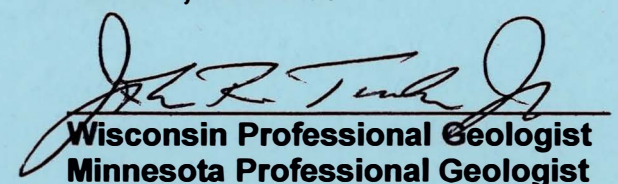

Wisconsin Professional Geologist
Minnesota Professional Geologist

INTRODUCTION

County Materials Corporation requests an opinion concerning the proposed non-metallic mining operation at its property in NE1/4, Section 1, T28N, R5E near Marathon City, Wisconsin. Specific concerns are 1) the impact of blasting on a contaminant plume on property adjacent to the quarry and 2) the impact of blasting on public wells serving Marathon City and on private water-supply wells in the area. To address these concerns the following answers to questions are presented.

1) What effect will blasting have on the rock beyond the area blasted?

2) What effect will blasting have on the direction of groundwater flow at the Weisenberger Tie & Lumber Company site?

3) What effect will blasting have on water levels in private water-supply wells in the vicinity of the quarry?

4) What effect will blasting have on the three public wells serving Marathon City?

5) Will blasting be felt by neighbors?

This report is one of two reports. The other report is entitled Capture Zones for Marathon City's Wells #1, #3, and #4 Marathon City, Wisconsin (JRT Hydro, Inc., July 22, 2003).

OPINIONS

Question 1: What effect will blasting have on the rock beyond the area blasted?

Answer 1: No effect from fracturing as supported by the following literature search.

BLASTING TASK FORCE (1997)

House Joint Resolution 133 of the State of Illinois established a Blasting Task Force to evaluate the effects of blast-induced ground vibrations on landfills and the need to limit ground vibrations from blasting at quarries to prevent damage to landfills. The final report (Blasting Task Force, 1997) of the task force is available upon request and has been presented to John Grump of the Wisconsin Department of Natural Resources. The Illinois Task Force relied heavily on the works of Dr. Calvin Konja of Precision Blasting Services stating "Dr. Konja is an

internationally recognized expert in the field of blasting and blast vibrations." Quotes of Dr. Konja in the final report are the following.

a. "The common unfounded fear of large vertical fractures forming below blastholes is impossible. In 368 years, no one has ever seen or reported large vertical fractures below blastholes. The fact is that for such fractures to occur, we would have to change the laws of physics."

b. "Another common unfounded fear is that fractures will move great distances horizontally away from blastholes. The reason blastholes are drilled on a tight grid and only a few feet from one another is because the explosive energy is insufficient to cause breakage at great distances from the blasthole.

In fact, blastholes normally cause breakage damage at a distance of 20 to 40 blasthole diameters away from the hole. For a 6-inch blasthole, breakage would be about 10 to 20 feet. Beyond this distance, there is no longer sufficient energy to cause rock breakage and the remaining energy produces vibration."

U.S. BUREAU OF MINES (Dr. Cathy Aimone-Martin, Aimone-Martin Associates, LLC, March 2003). See attached email to John Grump of the WI Department of Natural Resources.

Dr. Aimone-Martin states the following based on small scale experiments in which Dr. Aimone-Martin used a single hole, contained the explosives with matts, poured colored grout through the blasted region and cored around the blasthole, to later dissect the rock in slabs and analyze the fracture zone.
"The rule of thumb that has evolved from these experiments are that the cracks extend about 8-12 borehole radii away near the top of the hole (where is least confinement) and only 2-6 radii around the base (highest confinement)." For a 6-inch blasthole, breakage would be about 2 to 3 feet.

Dr. Aimone-Martin continues to state the following. "There is other logical reasoning for this limitation if you think about the way blasting patterns are designed, with spacings of blasthole that are on a rectangular or square layout. The patterns are such that fractures extend to a little over one half the distance between all holes. In that manner, the rock is completely fractured into particles that are easily moved. Never do fractures go outside this region except in the case of the back row, leaving a new highwall. Usually we see "backbreak" or tension cracks that extend -only at the surface- into the new highwall 10-20 feet. These are only surface cracks and are of limited extent, existing only locally (in a zone of about 20-30 feet) and never at depth. They are the result of inadequate timing and relief in the blasting pattern during detonation."

Dr. Aimone-Martin continues to state the following. "Therefore, the cracking (effectively, increase in porosity due to fractures and fragmentation) does not travel outside the blasting pattern region in a manner to affect the hydrology."

Further Dr. Aimone-Martin states: "There is absolutely no fracture in the downward manner ever in mine blasting. I need to warn you that there are many so called "experts" who speculate that fracture travels many hundreds of feet from a mine blast. That is never ever the case."

SUSAN SOLOYANIS, MITRETEK CORPORATION (See Attached Email to John Grump, WI Department of Natural Resources

Susan Soloyanis states "What we experienced in this blast-fracturing experiment was that the actual blast fracturing was contained within the designed geometry. No new fractures were created outside the blast fractured area." The personnel from the U.S. Geological Survey and Susan Soloyanis (Lane et al, undated) characterized the hydrogeology and the effects of blast facturing an in-situ recovery trench in a contaminated fractured-bedrock aquifer located on the Loring Air Force Base in Aroostook County, Maine. The blasting of the trench (no free face) was successful in creating fractures within the trench area thus increasing transmissivity and secondary porosity. Because the blasting was below the water-table, nearby groundwater monitoring wells USGS 1,3,4 and URS-3 expelled water for up to 15 seconds. Wells USGS 1, 3, and 4 were approximately 30-35 feet and well URS-3 was approximately 60-65 feet from the edge of the trench. The explusion of groundwater from wells at the Marathon site is not expected because blasting will be above the water table, directed toward a free face and not a trench, and is regulated by vibrations standards of COMM 7. What is expected at the Marathon site is that actual blast fracturing will be contained with the designed geometry as supported by Susan Soloyanis' statement.

Question 2: What effect will blasting have on the direction of groundwater flow at the Weisenberger Tie & Lumber Company site?

Answer: No effect from fracturing caused by blasting. The reasons for the answer are the following.

1. Blasting has occurred during the remediation effort at the Weisenberger site (Personnal Communication, County Materials). The contaminant plume at the Weisenberger site has moved down the hydraulic gradient at essentially right angles to the equipotential lines. See maps of groundwater elevation and contaminant plume as presented by Delta Environmental Consultants, Inc. and Robert E. Lee & Associates, Inc. available from the WI Department of Natural Resources.

The local groundwater flow directions as presented by Delta Environmental Consultants, Inc agree with the regional groundwater flow directions as interpreted from the Marathon and Edgar 7 1/2 minute topographic maps and from the groundwater modeling report by Kendy and Bradbury (1988) entitled Hydrogeology of the Wisconsin River Valley in Marathon County, Wisconsin. The natural distribution of total heads within the aquifer explains the direction of movement of the contaminant plume at the Weisenberger site.

2. See answers to question 1 above.

3. I have interpreted water-level data from groundwater observation wells at a Precambrian rock quarry in Marathon County where seven groundwater monitoring wells are within or at the margin of this hard-rock quarry. All seven, open- borehole wells terminate in Precambrian bedrock. Blasting has not affected the directions of groundwater flow at this site.

4. I have reviewed consultant reports and water-table maps for the Refuse Hideaway Landfill near the WK Construction Quarry in Dane County, WI. Numerous water-table observation wells and piezometers surround this landfill. Blasting in the dolomite quarry prior to, during, and after closure of the Refuse Hideaway landfill has not affected groundwater flow directions, the shape of the contaminant plume in the unconsolidated and sandstone aquifers, or the groundwater observation wells.

Question 3. What effect will blasting have on water levels in private water-supply wells in the vicinity of the quarry?

Answer 3: This is difficult to answer without knowing the exact location, depth, and well construction of each individual well and without field measurements of seismic waves and water levels at each well location. However, the following suggests that blasting will not cause problems for nearby private water-supply wells.

1. Neighbors adjacent to the quarry have not complained to County Materials Corporation about well problems (Personnal Communication, Jack Sonnentag).

2. The goal of blasting is to direct the seismic energy to dislodge rock from the quarry face and to minimize the seismic energy leaving the quarry site. See Answers to questions1 and 2 above.

3. The Illinois Task Force on Blasting (1997) concludes the following. "Thus the potential for changes to occur in aquifer permeability from blasting to the extent that natural ground-water gradients and flow patterns would be altered is highly

unlikely. Ground-water movement and ground-water monitoring programs designed to detect potential contaminants also should not be affected."

4. A comparative study of domestic water well integrity to coal mine blasting was completed by Stephens & Associates (2002) for the Office of Surface Mining, Reclamation and Enforcement in Pittsburgh, PA. To ascertain the induced effects of blasting and pumping vibrations from nearby coal mining sites on domestic well integrity, water quality/chemistry, and well yield, Stephens & Associates (2002) designed and implemented a quarterly monitoring program for domestic wells located near active mining operations in a tri-state (Virginia, West Virginia, and Kentucky) area. Stephens & Associates state " No adverse impacts to domestic water wells from surface coal mine blasting were measured during this study. This lack of impact is valid for peak surface ground motions that fall within 0.125 ips (the maximum ground motion recorded at the surface during the study)" . The highest reading recorded at the County quarry is 0.61 ips/ppv.

Stephens & Associates further state " Few changes that could be directly attributed to a blast event were observed in the water quality and well yield data collected. Water quality parameters did change slightly over time during measuring periods, but none of these changes seem to be related to blasting, but appeared instead to be the result of sensor drift and mixing of the water in the well due to pump cycling. Well yield and water level remained in a constant range throughout each individual monitoring season."

4. Blasting or "shooting" rock wells is used by well drillers to develop greater specific capacity for a well (Driscoll, 1988). Hundreds to thousands of pounds of explosives have been detonated in igneous rock to increase water production (Driscoll, 1988). According to Walton & Csallany (1962), well shooting practices in Illinois typically increased well bore diameter by a factor of two. This translates to an increase in the specific capacity (yield per foot of drawdown) of about 10 percent. The Illinois Blasting Task Force states "The literature referenced above suggests that the direct effects of blasting, even when the blast occurs within the aquifer itself, are localized. "Shooting" a well can change near-well permeability but as Konja suggested, such changes have not been experienced beyond 20 to 40 blasthole diameters."

Question 4. What effect will blasting have on the three public wells serving Marathon City?

Answer: None from fracturing, from vibrations, or from the airblast from blasting.

1. The distance between the quarry and the Marathon City's closest well (Well 3) is approximately 2500 feet. All three of Marathon City's wells are in the unconsolidated aquifer in the Big Rib River valley. This aquifer is permeable and has high primary porosity compared to the Precambrian bedrock. It is not a fractured geologic material.

See Fig 4 - GFlow Report

2. Answers to questions 1 and 2 above strongly suggest that fractures do not extend great distances from the blast site.

3. Blasting has occurred in the past at the County Material quarry next to the Wiesenberger site, and there is no known reported damage to Marathon City's well from vibrations and airblast from blasting.

Question 5. Will blasting be felt by neighbors?

Answer: Yes depending, in part, on the magnitude of the blast; the geologic material; and the distance from the blast. Vibrations from blasting are regulated by Wisconsin Adminstrative Code COMM 7 to prevent damage to structures. County Materials Corporation complies with applicable regulations on blasting (Personnal Communication, Kerry Laabs, County Materials Corporation).

Although damage to homes and changes to the groundwater flow system are not likely, vibrations from blasting may cause some complaints from nearby neighbors. Attempts to promote communication and education between County Materials, the blaster (Orica), and area residents should be promoted and supported (Siskind et al, 1980).

Assumptions To Answers

The answers presented above assume the following.

1. Blasting will be above the water table

2. The water table will not be lowered by dewatering the aquifer.

REFERENCES CITED

Aimone-Martin, Cathy, 2003, Email to John Grump, WI Department of Natural Resources, June 4.

Blasting Task Force, 1997, Final Report House Joint Resolution 133, submitted to Illinois Governor Jim Edgar, Department of Natural Resources Director Brent Manning, and the 90th General Assembly.

Department of Commerce Wisconsin Administrative Code 7, Explosive Materials.

Driscoll, F. G., 1986, Groundwater and Wells: Johnson Division, St. Paul, Minnesota 55112, 1088 p.

JRT, Hydro, Inc., 2003, Capture Zones for Marathon City's Wells #1, #3, and #4 Marathon City, WI: July 22.

Kendy, Eloise and Bradbury, Ken, 1988, Hydrogeology of the Wisconsin River Valley in Marathon County, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 64, 65 p.

Lane, J.W., Haeni, F. P., Soloyanis, S., Placzek, G., Williams, J.S., Johnson, C. D., Buursink, M.L., Joesten, P.K., and Knutson, K.D., undated, Geophysical Characterization of a Fractured-Bedrock Aquifer and Blast-Fractured Contaminant-Recovery Trench: U.S. Geological Survey, Office of Ground Water, Branch of Geophysics.

Stephens & Associates, 2002, Comparative Study of Domestic Water Well Integrity to Coal Mine Blasting Summary Report: Prepared for Office of Surface Mining Reclamation and Enforcement Pittsburgh, PA. June 28, 28 p.

Siskind, D.E., Stagg, M.S., Kopp, J.W. and Dowding, C.H., 1980, Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting.

Walton, W. C., and S. Csallany, 1962, Yields of Deep Sandstone Wells in Northern Illinois, Illinois State Water Survey Report 43, p 23-25.

Grump, John R

From: Cathy Aimone-Martin [caimone@nmt.edu]
Sent: Wednesday, June 04, 2003 11:17 AM
To: Grump, John R
Subject: Re: Secondary Porosity Due to Blasting

I am JUST NOW leaving for a 2.5 week field trip to mines and quarries in the west to do some blasting research. How timely!

I get your type of question very frequently. The damage zone around the base of even the column of explosives has been extensively researched by the US Bureau of Mines and many others for over 40 years. This has been done both for underground situations (with high confinement which causes high stresses to limits crack propagation radially from the blasthole) and surface blasting in benches (where two or three free faces exist, allowing for more movement and radial cracks that can propagate only a little farther).

I have done many such experiments on the smaller scale in which I have used a single hole, contained the explosives with matts, poured colored grout through the blasted region and cored around the blasthole, to later "dissect" the rock in slabs and analyze the fracture zone.

The rule of thumb that has evolved from these experiments are that the cracks extend about 8-12 borehole radii away near the top of the hole (where is least confinement) and only 2-6 radii around the base (highest confinement).

Therefore, if a mine is using a 10 in. diameter hole., one should not expect that cracks would extend farther than 120 in. or 10 ft. away.

There is other logical reasoning for this limitation if you think about the way blasting patterns are designed, with spacings of blasthole that are on a rectangular or square layout. The patterns are such that fractures extend to a little over one half the distance between all holes. In that manner, the rock is completely fractured into particles that are easily moved. Never do fractures go outside this region except in the case of the back row, leaving a new highwall. Usually we see "backbreak" or tension cracks that extend - only at the surface- into the new highwall 10-20 ft. These are only surface cracks and are of limited extent, existing only locally (in a zone of about 20-30 ft) and never at depth. They are the result of inadequate timing and relief in the blasting pattern during detonation.

Therefore, the cracking (effectively, increase in porosity due to fractures and fragmentation) does not travel outside the blasting pattern region in a manner to affect the hydrology.

Another issue I point out is that most mines do not blast within the water table. Water is well drained from a mine (big open pit) over time with natural drawdown or pumping. Water or even a little moisture is not good for explosives and will readily degrade the product so that it will have less energy.

There is absolutely no fracture in the downward manner ever in mine blasting; The work I do with Los Alamos National Lab in non-nuclear testing at the Nevada Test side when we simulate nuclear bomb with commercial explosives does cause a huge chamber with limited fracturing below the charge. But this is limited fracturing and only occurs when confinement is far beyond what mines would economically use!

So I have studied it all. And your questions are valid. I need to warn you that there as many so called "experts" who speculate that fracture travels many hundreds of ft. from a mine blast. That is never ever the case. These people do not do research and they are ignorant of the research literature. I have met many.

Good luck. I can be reached by cell phone for 3 weeks. 505-980-9949

Cathy

At 10:48 AM 6/4/03 -0500, you wrote:
>Hello Dr. Aimone-Martin. My name is John Grump and I am a hydrogeologist
>with the Wisconsin Department of Natural Resources. If you, or any of your
>collegues, could address the following question, I would appreciate the
>help. Question: Will the quarrying, by blasting, in a quartz diorite
>(granitic) formation enhance the secondary porosity of the rock for any
>appreciable distance? The reason for asking the question is that I have a
>contaminated groundwater plume (pentachlorophenol, dioxin, and furans) at
>a site and a materials company is planning to mine the bedrock at an
>adjacent site using blasting in boreholes. The potential problem is the
>location of three municipal wells down, and side gradient from the known
>contaminant plume. I am attempting to ascertain whether this blasting has
>any chance of creating secondary porosity in the bedrock that may possibly
>allow the contamination to flow to these wells.
>
>The blasting will take place within 250 feet of the known contamination.
>The distance to the municipal wells from the closest blast area is
>approximately 1,000 feet. The blasting is done in 3.5 inch boreholes to a
>depth of 20 to 40 feet which is at or near the water table. The blast holes
>are 8 feet apart in rows and there is a series of three rows, also 8 feet
>apart. The blasts are timed 0.1 second apart within the row and then go to
>the next row for the same time sequence. The blasting company, Orica, has
>stated that the blasting at similar quarries registers 0.61 ips/ppv
>vibration limit at the surface. Blasting at a quarry adjacent to the one
>being developed has caused vibrations in houses within 1,000 feet of the
>blasts. 100 to 200 pounds of Apex Gold explosive is used in each blast
>hole. Apex Gold is a sodium nitrate/fuel oil emulsion. The area in
>question is located in central Wisconsin approximately 10 miles west of
>Wausau.
>
>In the interest of brevity, I will end, knowing that you will probably need
>additional information in order to answer this question. Please feel free
>to contact me with any additional data you may need. I will do my best to
>provide that information. Thank you for your time. Any light that you may
>shine on this question will be appreciated.
>

Grump, John R

From: Soloyanis, Susan [ssoloyan@mitretek.org]
Sent: Monday, June 09, 2003 7:22 PM
To: Grump, John R
Cc: rmiller@kgs.ukans.edu
Subject: RE: Secondary Porosity Created Due to Blasting

Short answer - yes.
See Lane, J. W. Jr., Haeni, F. P., Soloyanis, Susan, Placzek, Gary, Williams, J. H., Johnson, C. D., Buursink, M. L., Joesten, P. K., and Knutson, K. D., Geophysical Characterization of a Fractured-Bedrock Aquifer and Blast-Fractured Contaminant-Recovery Trench: Symposium on the Application of Geophysics to Engineering and Environmental Problems, 1996. PDF available at http://water.usgs.gov/ogw/bgas/loring/index.html

What we experienced in this blast-fracturing experiment was that the actual blast fracturing was contained within the designed geometry. No new fractures were created outside the blast fractured area. What we did not expect was that water fountained from nearby wells (some really smart person had taken the caps off) 40 feet in the air for 18 seconds. I have some really neat video and can probably send you a clip when I am not on travel and have a fast internet connection. The result is that there was hydraulic pumping/cleaning in fractures outside the blast area - we think, in this case, that clays were flushed from fractures. I cannot estimate the radius of influence but I think that the effects of blast fracturing extend well beyond the area of "treatment". You would do well to be cautious. If vibrations are felt 1000' away, then I would guess that the aquifer is vibrating, too, at that distance and that there could be some enhancement of secondary porosity by hydraulic pumping at that distance.

Susan Soloyanis, Ph.D., P.G.
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-----Original Message-----
From: Grump, John R [mailto:John.Grump@dnr.state.wi.us]
Sent: Monday, June 09, 2003 2:11 PM
To: Soloyanis, Susan
Cc: Grump, John R
Subject: Secondary Porosity Created Due to Blasting

Hello Susan. I have been in contact with Rick Miller, with the Kansas Geologic Survey and he recommended contacting you. My name is John Grump
and I am a hydrogeologist with the Wisconsin Department of Natural Resources. If you, or any of your colleagues, could address the following
question, I would appreciate the help. Question: Will the quarrying, by blasting, in a quartz diorite (granitic) formation enhance the secondary porosity of the rock for any appreciable distance? The reason for asking
the question is that I have a contaminated groundwater plume (pentachlorophenol, dioxin, and furans) at a site and a materials company is
planning to mine the bedrock at an adjacent site using blasting in boreholes. The potential problem is the location of three municipal wells
down, and side gradient from the known contaminant plume. I am

attempting to ascertain whether this blasting has any chance of creating secondary porosity in the bedrock that may possibly allow the contamination to flow to these wells.

The blasting will take place within 250 feet of the known contamination. The distance to the municipal wells from the closest blast area is approximately 1,000 feet. The blasting is done in 3.5 inch boreholes to a depth of 20 to 40 feet which is at or near the water table. The blast holes are 8 feet apart in rows and there is a series of three rows, also 8 feet apart. The blasts are timed 0.1 second apart within the row and then go to the next row for the same time sequence. The blasting company, Orica, has stated that the blasting at similar quarries registers 0.61 ips/ppv vibration limit at the surface. Blasting at a quarry adjacent to the one being developed has caused vibrations in houses within 1,000 feet of the blasts. 100 to 200 pounds of Apex Gold explosive is used in each blast hole. Apex Gold is a sodium nitrate/fuel oil emulsion. The area in question is located in central Wisconsin approximately 10 miles west of Wausau.

In the interest of brevity, I will end, knowing that you will probably need additional information in order to answer this question. Please feel free to contact me with any additional data you may need. I will do my best to provide that information. Thank you for your time. Any light that you may shine on this question will be appreciated.

Bill's Copy

JRT HYDRO, INC
John R. Tinker, Jr., Ph.D.
W940 County Road WW
Eleva, WI 54738
715 287-4663

July 22, 2003

Bill Evans and John Grump
Wisconsin Department of Natural Resources
West Clairmont Street
Eau Claire, WI 54701

Dear Bill and John :

Enclosed are copies of my reports entitled Opinions on Blasting, County Materials Corporation Marathon City Site and Capture Zones for Marathon City's Wells #1, #3, and #4. Please call me if you have questions. Thank you.

Sincerely,

John R. Tinker, Jr., Ph.D.