Conference on the Silica Sand Resources of Minnesota and Wisconsin

October 1-3, 2012
Earle Brown Heritage Center, Brooklyn Park, MN

Program and Abstracts

Organized by

Society for Mining, Metallurgy & Exploration
Conference on the Silica Sand Resources of Minnesota and Wisconsin

October 1-3, 2012
Earle Brown Heritage Center, Brooklyn Park, MN

PROGRAM AND ABSTRACTS

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Society of Mining, Metallurgy, and Exploration, Twin Cities Subsection - www.smetwincities.org

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Cover Photos: Upper left – Mine wall at Fairmount Minerals’ operation at Menomonie, WI, photo by John Listenberger; Upper right and lower left – facilities at Preferred Sands operation in Blair, WI, photos by Kent Syverson; Lower right – Quartz sand grains from the Jordan SS, photo by Kent Syverson.
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About the Conference

Mining of high-purity silica sand rock formations has been conducted in the upper Mississippi River Valley for over a century. However, the boom in domestic oil and gas exploration over the past decade, largely spurred by increased use of hydraulic fracturing techniques, has driven a new mineral rush in Minnesota and Wisconsin for deposits of what the industry calls "Northern White Sand". By virtue of its nearly pure quartz composition, friability, and coarse grain size, this resource is considered an ideal "frac sand" for use as a proppant in oil and gas exploration and extraction. Currently, silica sand’s use by the oil and gas industry is its second largest market by volume in the US after glassmaking (2012, Industrial Minerals Mag.).

In the face of this rush to expand current operations and develop new mines, there is an urgent need among the public, media, government regulatory agencies, and energy and mineral resource industries for credible information about this industry. This conference seeks to answer many of the questions various stakeholders have raised about the development of this resource.

- Why are these silica sand deposits located in the upper Midwest?
- How is silica sand used in oil and gas exploration and what are its other uses?
- What makes an ideal silica sand deposit?
- How are these deposits mined and the sand processed?
- What environmental safeguards are employed during mining and processing to preserve water and air quality?
- How is the material handled and transported?
- How are sand mines reclaimed?
- What regulations apply to silica sand mines and what permits are needed to develop a mine and processing plant?
- What is the local and regional economic impact of silica sand mines?

The conference has been jointly organized by the University of Minnesota Duluth’s Precambrian Research Center (PRC) and the Twin Cities subsection of the Society of Mining, Metallurgy, and Exploration (SME) and is being held in conjunction with the Midwest Groundwater Association Meeting at the Earle Brown Heritage Center in Brooklyn Park, MN.

Clearly, the expansion of silica sand mining and permits to mine has become a very sensitive issue in southeastern Minnesota and western Wisconsin in recent years. It is not the intent of this conference to engage in a policy debate about the merits or demerits of silica sand mining. That is an issue for local jurisdictions to decide. Rather, the intent of this conference is to provide factual and unbiased information regarding mining, processing, transportation, environmental protections, and regulations of silica sand resources of Minnesota and Wisconsin. We have worked very hard to keep this conference from having a pro/anti mining or pro/anti oil & natural gas agenda. We hope the information provided during the technical talks and the field trip serves to educate the various stakeholders about this important resource.

Conference Co-chairs

Jim Miller     Louis Rudnicki
Conference Schedule

Monday, October 1 - Welcoming Banquet
Earle Brown Heritage Center, Brooklyn Park, MN
5:00-8:00 Registration Open
5:30-6:30 Reception/Cash Bar/Band
6:30-8:00 Banquet
8:00-9:00 Keynote Talk - Dr. Stephen Brand
ConocoPhillips, VP of Technology and Development, retired
Talk Title – Unconventional Resources - Technological Drivers behind the Domestic Boom in Oil and Gas Exploration

Tuesday, October 2 - Technical Session on Silica Sand Resources
Earle Brown Heritage Center, Brooklyn Park, MN
7:00-10:15 Conference Registration Open
8:00-8:15 Introduction (Jim Miller-UMD/PRC, Louis Rudnicki-SME)
8:15-9:00 Geological Occurrences and Origins of Silica Sand Formations in the Upper Mississippi River Valley
Presenters – Tony Runkel (Chief Geologist, Minnesota Geological Survey) and Kent Syverson (Professor, University of Wisconsin-Eau Claire)
9:00-9:20 Uses of Silica Sand, Part I - Silica Sand as a Proppant in HydroFrac Drilling for Oil & Gas
Presenter – Pankaj Taneja (VP of Minerals, Schlumberger, Well Services Division)
9:25-9:45 Uses of Silica Sand, Part II - The Importance of Silica Sand for Metal-casting, Water Filtration, Glass Production, Sports & Recreation Uses, and Building Products
Presenter – Maureen Lynn (VP of Marketing and Sales, Fairmount Minerals)
9:45-10:15 Morning Break
10:15-10:45 Site Evaluations for Silica Sand Mines
Presenter – Darrell Reed (Geologist, SEH Consultants)
10:45-11:15 Silica Sand Mining Techniques
Presenter – John Litsenberger (Consultant for Goodhue Co; formerly with Wisconsin Industrial Sand/Fairmount Minerals)
11:15-11:45 Wet Frac Sand Processing
Presenter – Christopher Kelley (Sales Manager – Aggregate Processing, McLanahan Corporation)
12:00-1:00 Lunch
**Technical Session on Silica Sand Resources** (cont.)

1:00-1:30  Silica Sand Processing - Water Quantity and Quality  
*Presenter - Scott McCurdy* (Hydrogeologist, Cedar Corp-Environmental Group)

1:30-2:00  Air Quality Controls related to Silica Sand Mining, Processing, and Transportation  
*Presenter – Jeff Hedman* (Engineer, Air Quality Permits Section, MN Pollution Control Agency)

2:00-2:30  Transportation Options and Issues  
*Presenter - Brennan Thomas* (CEO, Pro Sands)

2:30-3:00  Reclamation of Silica Sand Operations  
*Presenters - Paul Eger* (Environmental Engineer, Global Minerals Engineering) and Karl Everett (Consulting Mining Engineer/Geologist)

3:00-3:30  Afternoon Break

3:30-4:00  Nonmetallic Mining Regulatory Framework in Wisconsin  
*Presenter – Bruce Brown* (Senior Geologist, Wisconsin Geological and Natural History Survey, retired)

4:00-4:40  Permitting and Regulation of Silica Sand Mining Operations in Minnesota  
*Presenters – Wendy Turri* (Wastewater Program Manger, MN Pollution Control Agency) and Lisa Hanni (Land Use Management Director, Goodhue County, MN)

4:40-5:10  Economic Analysis of Silica Sand Operations  
*Presenter - Mark Krumenacher* (Senior Vice President, GZA GeoEnvironmental)

5:15-6:00  Cocktail Reception (open to all registrants)

6:00-7:30  Buffet Dinner  
*Talk Title: Political and Regulatory Climate for Silica Sand Mines: A Legal Perspective*

7:30-9:00  Q&A on Silica Sand Mining (presenters will be available for a final question and answer session; open to all technical session registrants).

**Wednesday, October 3 – Field Trip on Silica Sand Resources of Western Wisconsin**

7:30 AM -8:00 PM  Depart Earle Brown Heritage Center

*See Silica Sand Conference Guidebook for schedule details.*
CONFERENCE SPONSORS

Platinum Sponsor ($1500)

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Earle Brown Heritage Center
Room Functions

Main Entrance
Field Trips
Depart Here

Registration
Conference Room

Exhibitor Booths
Welcoming Banquet (10/1)
Exhibitor Booths
Breaks & Lunch

Exhibitor Tables
Tues (10/2)
Reception
Garden City Ballroom
& Banquet

Lower Level
TACK A
TACK B
Banquet Keynote Speaker - Stephen Brand, PhD

Talk Title: Unconventional Resources - Technological Drivers behind the Domestic Boom in Oil and Gas Exploration

Dr. Stephen Brand recently retired from Conoco Phillips where he was the Senior Vice President of Technology. Dr. Brand received his Bachelor of Arts degree in Geology from the University of Minnesota Duluth in 1971, then went on to earn his MS and Ph.D. degrees at Purdue University. After receiving his Ph.D., Dr. Brand chose to pursue a career in the energy industry. Joining ConocoPhillips as an exploration geologist in 1976, Dr. Brand has gone on to hold numerous senior-level positions, which have involved research and development, exploration, business development, operations, and strategic planning in terms of petroleum, natural gas, and alternative energy resources.

Dr. Brand was the supervisor of development geology from 1982 to 1989 before being named manager of exploration and production for North American business development. In 1992 Dr. Brand became President of ConocoPhillips’ Canadian Division where he managed exploration and production operations, which included the production of a major natural gas field in the BC foothills. In 1995 he took on the responsibility of exploration and production manager for international business development; and then, in 1998, became the President of ConocoPhillips’ Australia Division. In a five year period he built the division from a two-person organization to a major gas producer with 356 personnel.

In 2005, Dr. Brand became the Vice President of ConocoPhillips for exploration and business development. Then, in 2007, he assumed the position of Senior Vice President, Technology. In this position Dr. Brand developed a global research and development organization with 600 total personnel, of which about 250 are Ph.D. researchers. As Senior Vice President he directed ConocoPhillips’ research and development of new technologies and applications that enabled the company to access and develop non-traditional hydrocarbon reservoirs such as shale oil, gas hydrates, stranded gas, and arctic resources. He also oversaw research in a biofuels program that has a significant focus on algae. Finally, he established a team of researchers to develop innovative technology solutions for existing assets and provide diversification in broader energy businesses, clean technology, and renewable/alternative energy.

In 2010, Dr. Brand was inducted into the University of Minnesota Duluth’s Academy of Science and Engineering. The academy gives public recognition to distinguished alumni and special friends of the Swenson College of Science and Engineering, who have brought distinction to themselves through their participation, commitment, and leadership in their chosen profession.

In 2011, Dr. Brand retired from Conoco Phillips, but continues to be involved in consulting about unconventional resources, the focus of his banquet talk.
Expansion of Silica Sand Mining in the Central Midcontinent Region: What Does the “Boom” look like; Why Here; and What are the Concerns?

Anthony C. Runkel, Minnesota Geological Survey, 2642 University Avenue West, St Paul, MN, 55114

Paleozoic age bedrock layers of quartzose sandstone in the central midcontinent of North America have been mined since the 1800’s to supply “silica sand” for use in a number of industrial applications. They are well known to both sedimentologists and industry as some of the most mineralogically pure sandstone on Earth, composed of greater than 95 percent quartz. The recent rapid expansion of silica sand mining in the central midcontinent is driven by demand for proppant used in the process of hydrofracking for oil and natural gas. Several attributes make the sandstone in the central midcontinent, especially parts of Minnesota, Wisconsin, Illinois and Iowa, particularly desirable. Not only are they composed mostly of high-strength and relatively inert quartz, the grains are especially well-rounded, well-sorted, relatively coarse-grained, and are poorly cemented. Furthermore, extraction and transport is relatively easy because the sandstone layers are at or near the land surface across aerially large footprints, and road and rail networks are well-developed.

Geologic conditions in the central midcontinent 500 to 450 million years ago were especially conducive to the deposition of quartz-rich sand layers. Less stable minerals were to a large extent leached out of a chemically weathered cratonic interior landmass that supplied mostly quartz sand to a shoreline that often was positioned in what is today southern Minnesota and Wisconsin. Abrasion during transport by wind was an important mechanism in producing the round and spherical shape of the sand grains. This extremely mature sand was ultimately deposited as geographically widespread sheets because the region had a very low gradient, and therefore the sandy shoreline migrated great distances in response to relatively small changes in sea level. Last, these layers were likely never well cemented, and were later subjected to a combination of erosional and depositional events that left them close to the land surface across large areas today.

Together, Minnesota and Wisconsin have expanded from what was likely fewer than 15 silica sand mining operations ten years ago, to about 100 active or “in development” mines according to recent estimates, the vast majority of them in Wisconsin. Nearly all mines are open excavations, but a few underground mines are also currently active. The regional industry may soon have the capacity to provide nearly 50 million tons of processed silica sand each year according to some estimates.

Concerns have been expressed about the expansion of silica sand mining. The most common are related to increased truck traffic, landscape aesthetics, surface and groundwater quality and quantity related to washing procedures and mine dewatering, and airborne silica dust. Many of these issues are addressed by state and local regulations developed originally for other mining activities such as aggregate extraction. However, several counties and townships have established temporary moratoriums on permitting of new mines, to provide time to develop strategies to address these concerns and manage the rapid expansion of the industry.

Tony Runkel is Chief Geologist of the Minnesota Geological Survey, and adjunct professor in the Department of Earth Sciences; both are units of the University of Minnesota. His research emphasis targets the sedimentologic, stratigraphic, and fracture attributes of Paleozoic bedrock in southeastern Minnesota (including the Twin Cities Metropolitan region), which includes the quartz-rich sandstone layers that are the focus of this meeting. Tony grew up in southeastern Minnesota, and holds a B.A. in Geology from the University of Minnesota, an M.S. from the University of Montana, and a PhD. from the University of Texas at Austin.
Expansion of Silica Sand Mining in the Central Midcontinent

Topics:
- What is “silica sand”?
- Why the mining “boom”?
- Why here?
- What’s the “boom” look like?
- Mining practices
- Concerns

Bedrock “silica sand”

Quartz: Silicon and Oxygen (SiO₂)
One of the most common minerals at the Earth’s surface

Typical “glacial” sand on top of bedrock

Greater than 95 percent grains of the mineral quartz; rounded grains

Quartz abundant, but other minerals also admixed
Many angular grains

Silica sand has been mined in the midcontinent over 100 years

Some Purposes:
- Tunneling for storage
- Storm sewer system
- Glass making
- Foundry sand
- Abrasives
- Cattle bedding
- General fill
- Underground buildings

Hydrofracking
Why here? "Best" accessible frac sand deposits
CAMBRIAN AND ORDOVICIAN SANDSTONE

Layers with v. high % quartz
Monocrystalline
High sphericity
V. well rounded
Relatively coarse-grained!
Poorly cemented
Near land surface
Bulk transportation system

Modified from Bruce Brown, Wisconsin Geological and Natural History Survey

Why here? The Geologic Story
Lower Paleozoic Rocks, southeastern Minnesota
~500-350 Ma
Mostly marine
Thin, widespread layers

Why here? The Geologic Story
Cambrian Laurentia
Silica-rich sandstone

Lower Paleozoic Rocks, southeastern Minnesota
~500-350 Ma
Mostly marine
Thin, widespread layers
Why here? The Geologic Story

MINERALOGY/GRAIN SIZE, LOWER PALEOZOIC SILICICLASTIC STRATA

- Cambrian Laurentia
  - Fine-to-coarse-grained
  - >95% quartz
  - Accessory minerals (mostly heavies)
  - K-feldspar "trace" plag

- Cambrian Sandstone
  - Very fine and finer quartz
  - Up to 40% feldspar
  - Glauconite
  - Accessory minerals (m. heavies, muscovite)

Why here? The Geologic Story

Chemical weathering

- Saprolite
  - Cambrian Sandstone
  - 1850 Ma Tonalite

Chemical weathering

- Oak Ridge National Laboratory
- "Goldich weathering series"

Why here? The Geologic Story

Textural Maturity—origin?

- Fluvial abrasion?
- Swash/shoreface abrasion?
- Multigenerational reworking?

- Eolian abrasion
Why here? The Geologic Story
Deposition in sheets

Why here? The Geologic Story
Preservation and minimal burial

Increased hydrofracking + relative scarcity of "best" sand has led to:

The result
Removal of overburden
Excavation (backhoe, ripping, blasting)
Dewatering (some sites)
(transport to processing facility)
Crushing
Washing/separating sizes
Drying
Transport to rail (barge)

OPPOSITION TO EXPANSION OF SILICA SAND MINING
Concerns:
- Noise
  - Truck transport (traffic, road degradation, noise, safety, dust)
- Dust (silicosis?)
- Surface and groundwater water impacts
  - Aquifer drawdown (pit dewatering)
  - Groundwater contamination (polyacrylamide)
- Landscape alterations...reclamation plans
- Opposition to end use (hydrofracking) of sand

Most are currently regulated to varying degrees by MPCA, MDNR, and via County level ordinances.

A key question...how does it differ from aggregate mining that has been practiced and regulated for decades?

Critical to all of the above, is...magnitude of the expansion... Where is this going?

e.g. 200 acres mining/year for region acceptable?

Moratoriums
Quarzite Formations
Silica sand mines (locations agree)
"Pro-permit" (formally or de facto)
Quarzite formations
Silica sand mines (locations agree)}
The sand-mining industry has been booming in the State of Wisconsin. As of July 2012, 87 sand facilities were operating or under construction, and another 20 facilities were in the proposal stage. This talk will address factors influencing the growth of the silica sand industry in Wisconsin, describe the important sand-producing units, and discuss sand-exploration districts and trends in Wisconsin.

Most new frac sand facilities are in the western part of Wisconsin where upper Cambrian sandstone units are present at the surface. Major sandstone units include the Mt. Simon, Wonewoc, and Jordan formations. Because the glacier did not cover this area during the last glaciation, glacial overburden is not thick and the sand units are more accessible. In addition, rail lines are present to move the sand to market. The Cambrian sandstone units are briefly described below from oldest unit to youngest unit.

The Mt. Simon Formation marks the base of the Paleozoic sedimentary sequence in Wisconsin. The Mt. Simon is on average medium to coarse grained (even conglomeratic at the base) and is quite feldspathic in places. The Mt. Simon is a good source of 20/40-mesh sand and has been exploited in Clark and Wood counties.

The Wonewoc Formation is exposed over a large region and has been the target of much exploration and development. The Wonewoc Formation contains fine- to coarse-grained sand, is a good producer of 20/50-mesh sand, and is finer-grained than the Mt. Simon Formation. Preferred Sands reports 7K 20/40-mesh sand and 9K 30/50-mesh sand values from its mine in Blair, WI. Companies such as Hi-Crush, Great Northern Sand, Superior Silica Sand, U.S. Silica, and Fairmount Minerals have all opened Wonewoc mines across western Wisconsin. “Cranberry sand” taken out of bogs near Tomah is essentially Wonewoc Formation that was eroded and redeposited in glacial Lake Wisconsin.

The Jordan Formation is the youngest Cambrian sandstone in the region. The upper part of the Jordan Formation, the Van Oser Member, is an excellent producer of 20/40-mesh quartzose sand. Typically the Jordan sand disaggregates easily, but in some cases extreme silica and calcite cementation causes the rock to break across the grains. The Jordan Formation is overlain by the bluff-forming Oneota Dolomite. This dolomite is commonly more than 100 ft thick above the Jordan, so Fairmount Minerals has operated underground mines at Maiden Rock and Bay City (Pierce County) to avoid the overburden issue. Jordan Formation is exposed at the surface in Barron County to the north, and this continues to be an exploration target.

The expanding frac sand industry has increased railroad traffic in western Wisconsin. Some rail lines are being upgraded (or reopened) to carry heavy loads of sand. For example, Canadian National Railway Company is spending $35 million to reopen an east-west rail line between Barron and Ladysmith, WI. Railroad improvements will be critical for supporting the expanding sand industry in Wisconsin.
Dr. Kent M. Syverson has been employed in the Dept. of Geology at UW-Eau Claire for twenty years. He is a professor and the department chair. Kent is a glacial geologist by training, and he received his B.S. in Geology (minor in Chemistry) at UM-Duluth in 1986. He completed his Ph.D. in Geology at UW-Madison in 1992 with a minor distributed between Civil & Environmental Engineering and Geography. He has mapped the glacial geology of Chippewa County, WI, for the Wisconsin Geological and Natural History Survey (WGNHS). Kent served as the lead technical editor for the updated Pleistocene lithostratigraphy volume recently published by the WGNHS. Kent is a Licensed Professional Geologist in the State of Wisconsin.

Kent has been a frac sand consultant in the State of Wisconsin for more than three years. As part of Syverson GeoConsulting LLC, Kent has conducted frac sand prospecting projects and frac sand education sessions for sand companies, realtors/land brokers, and private citizens. He is co-directing a petrologic study of cement mineralogy within the Mt. Simon, Wonewoc, and Jordan Formations of western Wisconsin. Kent is well acquainted with frac sand mining developments in western Wisconsin and has served as a media expert for many newspaper articles and Wisconsin Public Radio programs, as well as for Upstream, the international oil and gas journal.
Geological Occurrences of Silica Sand Formations
Part II: Overview of sand mining in Wisconsin

Dr. Kent M. Syverson
Dept. of Geology
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Digging up jobs, and controversy

From Eau Claire Leader-Telegram, page 1A, December 25, 2011

New $70 million EOG processing plant in Chippewa Falls

$1 billion? investments in western WI

From Wisconsin Center for Investigative Journalism
Goals of talk

- Explain factors influencing the growth of the silica sand industry in Wisconsin.
- Describe major frac sand units in the State of Wisconsin and the districts where they are mined.
- Discuss current trends in sand mining and exploration in Wisconsin.
Much of western WI not glaciated recently – little glacial overburden in southwestern and west-central Wisconsin.
Mt. Simon Fm.

- Very coarse grained at base (conglomeratic)
- Feldspathic in places

All histograms from Tony Runkel

All photomicrographs from J. Brian Mahoney, Amy Rasmussen, and Rebecca Moore

Clark and Wood counties

Yellow = Mt. Simon Fm.

Marshfield
Wonewoc Fm.
- Good producer 30/50
- 7K crush strength reported on 20/40 and 9K on 30/50 (Preferred Sands, Blair mine)

60 to 80-ft thick mining target
Preferred Sands mine, Blair

Trempealeau/Jackson counties
Red = Wonewoc Fm.

Brown (1988)
Jordan Fm.
- Upper Jordan Fm. (Van Oser Mbr.) is excellent 20/40 producer
- Overlain by dolomite
• Typically poorly cemented.
• Buffalo Cty outcrop (above): 42% 20/40 and 70% 30/50.

• Jordan Fm. may have zones of extreme cementation that prevent disaggregation.
• Cement can be silica or calcite.

• Oneota Dolomite (seen in bluff) is commonly more than 100 ft thick above Jordan Fm.
• This overburden is major obstacle for surficial mining of the Jordan Fm.
Mississippi River corridor (Pierce/Pepin counties) Jordan Fm. targets. Fairmount Minerals is big producer.

Light blue = Oneota Dolomite
Yellow = Jordan Fm.

Brown (1988)

- Dolomite commonly quarried down to Jordan Fm.
- Potential exploration target for a surficial Jordan Fm. mine.

Fairmount Minerals' Maiden Rock mine, upper Jordan Fm.
Mine 25-35 ft thick horizon
Photo from MN Public Radio
Bright yellow = Jordan Fm.

Great Northern Sand mine

St. Peter Fm.
- Not major target for frac sand in Wisconsin (low 20/50, high 40/70)
St. Peter Fm.
- Extremely mature, pure quartz sandstone
- Badger Mining Corp. mines St. Peter Fm. as foundry sand in eastern Wisconsin (Fond du Lac County).

Non-traditional sand sources – cranberry sand

Above: cranberry bogs northeast of Tomah, WI

Sand deposited in glacial Lake Wisconsin – today Central Sand Plains, quite swampy
Sand from cranberry bogs is largely disaggregated and redeposited Wonewoc Fm.

Monroe and Jackson counties, central Wisconsin

Why is Wisconsin experiencing a frac sand boom?

- Medium- to coarse-grained, strong sand at or near the surface.
- Good road and rail transportation networks.
- As of July 2012, 87 sand facilities are operating or under construction, and another 20 facilities are in the proposal stage. (From Wisconsin Center for Investigative Journalism.)
Silica Sand as a Proppant in Hydro-Fracturing for Oil and Gas

Pankaj Taneja, Vice President of Minerals, Schlumberger-Well Services Division, Sugar Land, TX

Hydraulic Fracturing goal is to improve well productivity by creating a flow path from the formation to the wellbore. Hydraulic Fracturing is one of the key elements in Well Completion part of the O&G well life cycle. Optimizing the Fracture Conductivity and selecting the lowest cost proppant for the treatment is instrumental in achieving the technical and economic requirements. The attached presentation focuses on the Fracture Design and Proppant selection process utilized by Service Company and Operators to technically and economically optimize the hydraulic fracturing treatment.

In hydraulic fracturing treatments, proppant added to the fracturing fluid are utilized to keep the fracture open and to create a highly conductive flow path for the hydrocarbons to the wellbore. Proppant and polymer are both critical to the success of fracturing treatments. To be successful, appropriate type and concentration of proppant must be used. In addition, the fracturing fluid properties must be designed for proppant transport and cleanup. More and more, oil & gas companies are producing from tighter, low permeability reservoir which naturally cannot provide a pathway for the oil and gas to flow into the wellbore. Hydraulic fracturing provides the highway that is needed to make the Oil and Gas reach faster to the wellbore from the reservoir.

When a hydraulic fracture is created, the in-situ stresses must be overcome to open and propagate the fracture. Once the hydraulic pressure in the fracture is reduced, these same stresses tend to close the fracture. If the proppant is not strong enough to withstand the Closure Stress of the fracture, it will be crushed and the permeability of the propped fracture will be drastically reduced. There are various classes of Proppant that can be used depending on the Crush Value of the Proppant and the Closure Stress that the Proppant is required to withstand after the completion of the Hydraulic Fracture treatment. Please find below the list of commonly used proppant and the approximate Crush Value Ranges:

- Naturally Occurring Sand (up to 6000 psi Stress)
  - Brown: Brady, Hickory, Texas Brown Sand
  - White: Ottawa, Jordan, St. Peters
- Light-Weight Ceramic (up to 8000 psi Stress)
  - Clays based (alumina < 55 wt.%)
- Intermediate-Strength Proppant (up to 10000 psi Stress)
  - Sintered low grade bauxite (alumina of 65 – 75 wt.%) with addition of clays
- High-Strength Proppant (up to 15000 psi Stress)
  - Sintered high grade bauxite (alumina of more than 85 wt.%)
- Resin coated proppant:
  - Pre-cured RCP and RCS
  - Curable RCP and RCS

The fracture design is based on maximizing the incremental production from the well. For designing the fracture treatment the formation properties like reservoir, geophysical and geomechanical properties needs to be well understood. These formation properties are acquired by the use of drilling data, wireline logs and conducting “Mini-Fracs” on wells.

One of the key design parameters that are used to design the fracture treatment is $C_{fr}$. $C_{fr}$ is known as dimensionless fracture conductivity and is the ratio between the flow capacity of the hydraulic fracture and the flow capacity of the reservoir. The equation of this parameter is illustrated below:

$$C_{fr} = \frac{\text{fracture deliverability}}{\text{reservoir deliverability}} = \frac{k_f \times w_f}{k_r \times x_f}$$
Since Pratt in 1961 many studies have shown that for a High Permeability formation the design $Cfd$ should be >2 and for a Low Permeability formation the design $Cfd$ should be >10. The typical value used for designing fracturing treatments is a $Cfd$ of 15 – 30.

It can be demonstrated with the use of the above design parameters that at a given stress the permeability of the formation can influence the proppant selection process. This is illustrated below with the following examples.

**Tight Reservoir (0.1mD)** @8000 psi stress, the required proppant pack permeability and conductivity technically requires the need for Resin Coated Sand or ISP Ceramic Proppant. The operator typically decides between the 2 options based on economic considerations and availability.

**Shale Reservoir (0.001mD)** @8000 psi stress, the required proppant pack permeability and conductivity technically requires the need for Sand. The Operator can decide on a technically superior proppant such as Resin or ISP based on the additional safety factor that they might want to include in the design and economic/availability considerations.

There are a range of options within the above proppant group that the market has to offer. The service companies and operators do extensive amount of laboratory testing in order to pick the “best fit” proppant from the various options. The lab testing of proppant is governed by the various procedures laid out by API and ISO such as ISO 13503-5, API RP19C etc. The ideal characteristics of the proppant can be described below:

- Crush resistant (high strength)
- Slightly deformable
- Compatible with fluid systems
- Low specific gravity
- No flowback
- No embedment
- Chemically resistant
- Readily available
- Cost effective

Finally Hydraulic Fracturing as a technology is continuously evolving. Schlumberger has been in the fore front of technology development with the introduction of HiWAY. HiWAY* is a new hydraulic fracturing technique that creates a network of open channels through the proppant pack, improving fracture conductivity by orders of magnitude. Research and Development efforts also continue in the field of Proppant Detection, Surface Active Chemistry and Engineered Geometry to develop a new generation of proppant for Oil and Gas.

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**Pankaj Taneja** is currently working as Vice President - Minerals for Schlumberger’s Well Services Division based out of Sugar Land, Texas. He has over 16 years’ experience in Oilfield Services and has worked in various capacities in Middle East, Asia and North America. He has extensive experience with Pressure Pumping Operations with services such as Fracturing, Cementing, Coiled Tubing and Offshore Stimulation Vessel. Pankaj by education is a Bachelor of Technology (Marine) and is a member of Society of Petroleum Engineers.
Hydraulic Fracturing – “Fracking”

In hydraulic fracturing treatments, proppant which is added to the fracturing fluids are used to keep the fracture open and to create a highly conductive flow of hydrocarbon to the wellbore. Proppants and polymer are critical to the success of fracturing treatments.

Fracture opens during injection
Proppant suspended in fluid
Filter cake on fracture faces
Polymer trapped in proppant pack
Conductive fracture propped open

Fracture closes after injection

Agenda

Introduction to Hydraulic Fracturing
Fracture Conductivity and Residence
Types of Proppants and Selection Criteria
Proppant Testing
New Technology
Summary
Football Stadium Analogy

Drilling & completing workflow

Find the reservoir → Drill the well → Complete the well → Produce the well → Abandon the well

Reservoir information:
- Stress profile
- Permeability

Lateral placement:
- Fracture height

Evaluation:
- Production
- Microseismic
- Tracers

Fracture fluid selection:
- Temperature
- Shear tolerance
- Pressure tolerance
- pH

Proppant selection:
- Optimise

Staging design:
- # stages
- Clusters
- Perforations

Fracture design:

On site diagnostics:
- Mini fall off
- Injection tests

Execution:
- Pump as designed

Volume determination:
- Required lengths
- Fluid leakoff

Injection rate

Fracture geometry:
- CFD

Production forecast

Economics

Proppant selection workflow

Effective stress
- Closure stress
- Pwf

Reservoir permeability

Fracture half length

Dimensionless fracture conductivity

Extreme considerations:
- Non darcy effects
- Multi phase flow

Placement
- Mesh size
Resin Coated Proppants

- Effectively transforms a brittle proppant into a flexible proppant
- Stress and point-to-point loading distributed over a larger surface area
- Encapsulates crushed grains and reduces fines migration
- Reduce damage from cyclic loading due to cushioning effect

Pre-Cured Resin Coated Proppant
- Cured during manufacturing process
- Enhance performance at high stress

Curable Resin Coated Proppant
- Cure and bind proppant particles during shut in
- Major application - to prevent proppant flowback

Treatment Design Objective

Place an optimum fracture (NPV)
- Maximize incremental production.

Keys to successful fracture stimulation (Δ prod):
- Knowledge of formation permeability
- Adequate propped fracture length (Xf)
- Adequate fracture conductivity
- Fracture containment
Fracturing Design Objectives

How Much Conductivity Is Needed?

Since Pratt in 1961 many studies have shown:

- High perm Clf > 2
- Low perm Clf > 10
  - Typically 15 – 30

Proppant selection example

**Tight Reservoir – 0.1mD**

\[ C_{fr} = \frac{k \times d}{k_w} \]

\[ 15 = \frac{k \times 0.1}{0.0001 \times 250} \]

\[ k \times 0.1 = (15 \times 0.0001 \times 250) = 4 \text{ md-ft} \]

\[ k = 4 \text{ md-ft} \]

\[ d = 45,000 \text{ md} \]

**Shale Reservoir – 0.001mD**

\[ C_{fr} = \frac{k \times d}{k_w} \]

\[ 15 = \frac{k \times 0.001}{0.0001 \times 250} \]

\[ k \times 0.001 = (15 \times 0.0001 \times 250) = 0.96 \text{ md-ft} \]

\[ k = 4 \text{ md-ft} \]

\[ d = 0.96 \text{ md} \]

\[ d = 12 \text{ ft} \]
Proppant selection example

8,000 psi effective stress

Tight Reservoir – 0.1mD
- Require 45 darcy
- RCS = 40 darcy
- ISP = 200 darcy

Shale Reservoir – 0.001mD
- Require 1 darcy
- Sand = 12 darcy

Economics – tight reservoir example

<table>
<thead>
<tr>
<th>Proppant Type</th>
<th>$/Darcy</th>
<th>Job Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>$0.007</td>
<td>$120,000</td>
</tr>
<tr>
<td>Premium Sand</td>
<td>$0.006</td>
<td>$150,000</td>
</tr>
<tr>
<td>Resin Coated Sand</td>
<td>$0.004</td>
<td>$225,000</td>
</tr>
<tr>
<td>Ceramic</td>
<td>$0.002</td>
<td></td>
</tr>
</tbody>
</table>

Proppant Use Evolution – Shale Gas Play

Dry Gas Play – A Typical Evolution of Usage

- Ceramics – Exploration (building reservoir models)
- Resins – Delineation (proving reserves)
- Sand – Development (optimizing cost)
Factors Affecting Proppant Pack Permeability

**Physical Properties of Proppant**
- Proppant Strength
- Grain Size and Distribution
- Roundness and Sphericity
- Fines and Impurities
- Density

**Other Factors**
- Fracture Width
- Closure Stress
- Proppant Concentration
- Embedment
- Proppant-Pack Porosity/Permeability
- Post-Closure Polymer Concentration - Fluid Damage

Ideal Proppant Characteristics
- Crush resistant (high strength)
- Slightly deformable
- Compatible with fluid systems
- Low specific gravity
- No flowback
- No embedment
- Chemically resistant
- Readily available
- Cost effective

Proppant Testing (Fracturing)

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-term durability</td>
<td>ISO 13503-5</td>
<td>Applies closure test across a bed of 9 x 19 in, 300 psi stress, ensuring a steady state condition. Fracture width, differential pressure, pressure drop, and flow rate are measured at each stress level. Proppant pack permeability and conductivity are evaluated.</td>
</tr>
<tr>
<td>Sieve distribution</td>
<td>ISO 13503-2 / API RP19C, Section 6</td>
<td>&gt;90% of the material retained between large and small mesh, both inclusive.</td>
</tr>
<tr>
<td>Sphericity and Roundness</td>
<td>ISO 13503-2 / API RP19C, Section 7</td>
<td>&gt;0.6 (sand)</td>
</tr>
<tr>
<td>Crush Resistance</td>
<td>ISO 13503-2, Section 11</td>
<td>Combination of proppant type and stress. e.g., &lt;6% for 70/140 sand @ 5000 psi, &lt;8% for 40/70 sand @ 5000 psi. K-value: The highest stress level in which proppant generates no more than 10% crushed material, rounded down to nearest 1000 psi.</td>
</tr>
<tr>
<td>Turbidity</td>
<td>ISO 13503-5</td>
<td>Strength of highest stress level in which proppant generates no more than 10% crushed material. Provision is made to ensure 100 psi pressure drop over 24 hours.</td>
</tr>
</tbody>
</table>

HiWAY: A Paradigm Shift in Hydraulic Fracturing

- 1947 First hydraulic fracturing job
- 1950 Fracturing using gelled oil
- 1950 Water-based, non-crosslinked fluids
- 1955 Bonded crosslinked fluids
- 1973 Crosslinked derivatized gels (HPG, CMHPG, etc.)
- 1977 High-strength ceramic proppants
- 1980 Foam fracturing
- 1984 Encapsulated breakers
- 1986 Fiber-based fracturing control
- 1987 Low polymer loadings
- 1997 Microspheres (VES)
- 2003 Micro-waterless fluid to monitor frac jobs
- 2005 Refined well, multistage fractures
- 2005 Fiber-based proppant transport
- 2010 HiWAY® Flow-Channel Fracturing
- 2011 HiWAY® Flow-Channel Modeling

HiWAY*: A Paradigm Shift in Hydraulic Fracturing

- 20030 1947 First hydraulic fracturing job
- 20035 1950 Fracturing using gelled oil
- 20050 1950 Water-based, non-crosslinked fluids
- 20080 1955 Bonded crosslinked fluids
- 20105 1973 Crosslinked derivatized gels (HPG, CMHPG, etc.)
- 20130 1977 High-strength ceramic proppants
- 20155 1980 Foam fracturing
- 20180 1984 Encapsulated breakers
- 20205 1986 Fiber-based fracturing control
- 20230 1987 Low polymer loadings
- 20255 1997 Microspheres (VES)
- 20280 2003 Micro-waterless fluid to monitor frac jobs
- 20305 2005 Refined well, multistage fractures
- 20325 2005 Fiber-based proppant transport
- 20350 2010 HiWAY® Flow-Channel Fracturing
- 20375 2011 HiWAY® Flow-Channel Modeling
Future direction and considerations

Channel fracturing
1. Heterogeneous Proppant Placement
2. HiWAY: "Heterogeneous Proppant Placement"

Proppant detection
1. Tagged proppant to determine fracture geometry
2. Surface chemistry: Conducting, semi-conducting, non-conducting, chemical coatings may be used

Surface active chemistry
1. Scale inhibitor impregnated proppant

Engineered Geometry
ROAD SHAPED CERAMIC PROPPANT
1. Unconventional rod shape
2. Substantial conductivity improvement
3. Creation of a consolidated pack
4. Enhanced ability of the pack to clean up
The Importance of Silica Sand for Metal-casting, Water Filtration, Glass Production, Sports & Recreation Uses, and Building Products

Maureen 'Mo' Lynn, VP Sales & Marketing, Fairmount Minerals

As the most abundant mineral in the earth’s crust, silica sand is widely used for many different Industrial and Recreation markets. The high purity SiO₂ content and low iron levels, makes silica sand the ideal component used to make clear and durable glass and glassware. The high refractoriness and purity of silica sand helps the Foundry Industry make high performance metal castings. Municipal Water Filtration and Wastewater Treatment rely on sand filtration for water purification as well as commercial and residential swimming pools. Our roads, bridges, concrete foundations and sidewalks all contain silica sand for added strength and durability. Solar power would not be achieved without premium silica sand. Our detergents, toothpaste, and many other household items, are perfected with the addition of processed silica sand. In essence, our everyday lives heavily rely on silica sand and the beneficial properties.

Mo Lynn, an Industrial Engineer Graduate from Penn State University, has been with Fairmount Minerals for 16 years. Mo started as a Technical Sales Representative living in Chicago for a year and then moved to Indianapolis as a Regional Sales Manager for 5 years covering Fairmount’s Industrial and Recreation markets. After moving to Harrisburg, PA, she had responsibilities from sales and marketing to General Manager of Fairmount’s specialty division, Mineral Visions. In January 2011, Mo assumed her current position as VP of Sales and Marketing and relocated to the Cleveland area with her husband and 3 kids.
Overview

- Video on applications
- Definition of Silica Sand
- Various Industrial & Recreation uses
  - Glass
  - Metal Castings
  - Building & Construction
  - Water Filtration
  - Sports & Recreation
- Conclusion
Definitions of Silica

- A white or colorless crystalline compound, SiO₂, occurring abundantly as quartz, sand, flint, agate, and many other minerals and used to manufacture a wide variety of materials, especially glass and concrete. (American Heritage Dictionary)

- Other names:
  - Quartz
  - Silicon Dioxide
  - SiO₂
  - Silicic Oxide

- The MOST abundant compound in the Earth's Crust (43%).

(Source: Exploring Chemical Elements and their Compounds; David L. Heiserman, 1992)

Industrial & Recreation Markets

- Glass, 42%
- Foundry, 20%
- Building Products, 10%
- Chemical Applications, 4%
- Turf & Landscape, 4%
- Other, 14%
- Gravel, 6%

Approximately 22 Million Tons

Glass Industry
Glass

- Silica is a common fundamental constituent of glass and is in the amorphous form (non-crystalline).
- The history of glassmaking can be traced back to 3500 BC in Mesopotamia.
- The first glassmaking "manual" dates back to ca. 650 BC.
- During the Roman Empire, high purity silica sand was sourced to make clear glass and the art of glass blowing was mastered.

Roman Glass (circa 300 AD)

Glass Facts...

- The US Glass Industry employs more than 143,000 people.
- Ships more than $28 Billion of glass products annually in the US.
- 100% Recyclable.
- 20 Millions tons produced annually.
- 82% of glass industry employees are production workers with wages averaging about 9% above the manufacturing average.
- Top US Glass Manufacturers
  - Cardinal Glass, O-I, Pilkington, PPG, Owens Corning, Libbey, Anchor Hocking.
  - [http://glassislife.com/caseforglass/sustainability](http://glassislife.com/caseforglass/sustainability)

Important uses of Glass

- Many different glass containers
- Windows in homes, schools, and office buildings.
- Cameras, microscopes, watches and telescopes.
- Windshields
- Solar Panels
- Eyeglasses
- Light bulbs
- LCD TV Screens.
- Scientific glass tubes
- Fiberglass insulation
- Cell phones screens.
- Optical fibers carry data all over the world at the speed of light over the Internet, the worldwide network of computers.
Basic Metal Casting Process...

- Mix sand with clay or chemical binder.
- Place a pattern in sand to create a mold.
- Incorporate the pattern and sand in a gating system.
- Remove the pattern.
- Fill the mold cavity with molten metal.
- Allow the metal to cool.
- Break away the sand mold and remove the casting.
Foundry / Metal Casting Industry

- Metal Casting dates back to around 3500 BC in China.
- The first casting produced in the U.S. was the Saugus Pot, cast in 1642 near Lynn, MA.
- The Liberty Bell was cast in sand.
- The metalcasting industry represents 200,000 jobs in the U.S. today.
- More than 12.6 million tons of castings in the U.S. were valued at more than $31.5 billion.
- The U.S. is the world’s second-largest producer of castings (China is first), followed by Japan, Russia, Germany and India.

Metal Casting Industry Facts...

- Over 70% of all metal castings are produced via a sand casting process.
- More than 90 percent of all manufactured goods in the United States contain cast metal components.
- Products include:
  - Engine blocks
  - Transmission housings
  - Farm & construction equipment
  - Fire hydrants
  - Medical parts
  - Military parts
  - Aerospace components
  - Pipes & valves for plumbing fixtures and boilers.

Building Products & Construction Industry
Construction Industry & Building Products

- As the most abundant mineral, silica sand has been and continues to be a very important component of many different building products and applications.
- The high purity and cleanliness of the sand add strength and durability while keeping the cost of the products low.

Uses in Building Products.

- Cement, mortars and grouts.
- Roofing for Shingles or flat roofs.
- Road construction
- Bridge Decking
- Patio Pavers
- Stucco
- Bricks
- Fiberglass Insulation
- Industrial Flooring
- Paints & Adhesives
- Pool Plaster

Water Filtration
**Water Filtration**

**History**
- In **1804**, the first actual municipal sand filtration water treatment plant was built in Scotland.
- The sand filtration method saw further progress when rapid sand filtration was developed in the U.S. in the 1880s.
- The **1905** completion of the McMillan Reservoir was a Washington public health milestone which used sand filtration rather than chemicals for water purification. This led to the elimination of typhoid epidemics and the reduction of many other communicable diseases in the city.

**Uses of Silica Sand for Water Filtration**
- Most US Municipal Water facilities use sand for processes and purifying water.
- Sand is the most common Pool Filter Media used in the US.
- Sand is also widely used in Waste Water treatment for Municipalities as well as industrial applications.

**Turf & Landscape**
Turf & Landscape

- Golf
  - Topdressing sands that aerate the soil
  - Premium clean Bunker sands

- Synthetic Turf
  - Sand infills the synthetic grasses holding the blades up and providing ballast.

Other “Turf & Landscape” applications

- Play Sand
  - Washed, dried, clean silica sand
  - Colored Play Sand

- Equestrian
  - Sand for horse arenas provides firm yet soft footing to prevent injuries.
  - Horse tracks also rely on sand to assist in the drainage and firmness.

Conclusion....

- As the most abundant and cost effective mineral on this earth, mankind has generated many different critical uses for silica sand.
- As you drive your vehicle home, remember that your engine block, break rotors, drive shaft, exhaust manifold and many other components were cast in sand...
- As you are driving looking through your glass windshield, also remember that the roads and bridges were constructed with sand....
- When you get home, remember that all of the glass and glassware were all made with sand....
• As you enjoy your warm comfortable home, remember that the fiberglass installation was manufactured with sand as well as the shingles that protect your house....
• As you turn on your faucet, remember that the fixtures were cast in sand....
• As the clean water flows, remember that sand filtration helped purify it....
• As you use your smartphone, remember that the screen was made possible because of high purity silica sand....

• For thousands of years, silica sand has been a critical component to our civilization.
• Over the years, innovation and science have found new and effective uses to help better our lives and this continues even to today.
• After hearing this presentation, can you imagine your life without....

SILICA SAND?
Site Evaluation for Silica Sand Mines

Darrell Reed, Geologist, SEH Consultants, Chippewa Falls, WI

Thorough technical studies of Wisconsin and Minnesota properties are essential for assessing the economics of potential frac sand mine sites. Paper studies conducted prior to performing field investigations provide geologists background information for development of outcrop evaluation and soil boring programs. Effective soil boring programs depend on anticipated subsurface conditions with application of the most effective and economic drilling technologies. Methods for assessing outcrop and soil boring data will be discussed, with several innovative techniques described. Analyses and interpretation of sieve data through the use of several spreadsheet applications will be discussed. Sand resource assessments should be developed with client expectation input, contact elevation and sieve cutoff criteria applied.

______________________________________________________

Darrell Reed has worked as a geologist / project manager with Short Elliott Hendrickson in their Chippewa Falls, Wisconsin office for the past nineteen years. He is a Licensed Professional Geologist in the State of Wisconsin and a Certified Professional Geologist. Darrell grew up in New Auburn, Wisconsin and graduated with an Earth Science degree from the University of Wisconsin - River Falls in 1978. In 1980 he completed his Masters degree in Geology from Eastern Washington University.

Prior to joining SEH, Darrell worked as an exploration and production geologist with EXXON in their Gulf Coast and Alaska divisions. Currently he’s the lead geologist in SEH’s sand mining market area and has worked on sand exploration projects, resource assessments, reclamation plans and high capacity well permits throughout western Wisconsin.
Site Evaluation for Silica Sand Mines

Darrell Reed

Outline of Presentation

• Paper Studies / Groundwater Investigations
• Outcrop / near surface investigations
• Soil Boring Programs
• Sieve Analyses / ISO 13503 / API RP 19C
• Resource Assessments

Western Wisconsin Stratigraphic Chart
Formations of Interest

- St. Peter Formation – finer grained
- Jordan Formation – medium grained, overburden removal (Prairie du Chien)
- Wonewoc Formation – medium grained, overburden removal (Tunnel City)
- Mt. Simon Formation – medium - coarse grained with shale interbeds, groundwater

Site Evaluations – Key Points

- Development of paper studies prior to field mobilization
- Match the drilling method to the type of drilling environment
- Importance of survey control to assess formation and sand sample intervals
- Be able to communicate with Client in the field through the use of sample trays and cross sections
- Understand the Client expectations of the resource assessment

Outline of Presentation

- Paper Studies
- Outcrop / near surface investigations
- Soil Boring Programs
- Groundwater Investigations
- Sieve Analyses & ISO 13503 / API RP 19C
- Resource Assessments
Paper Studies

- Review topographic and aerial maps
- Understand property boundaries
- Geology Maps / Groundwater Maps
- Area Studies by WDNR / MGS / WGNHS
- University faculty / State Geologists / Drillers / property owners

Additional Sources of Information

- Field Trip Guidebooks – Wisc. and Minn.
- NRCS Web Soil Survey (WSS)
- Well Constructors Reports / Geologic Logs / WiscLith / Published Outcrop Studies
- USGS Publications and Groundwater Data
- Professional Journals / MS and PhD thesis

Western Wisconsin Bedrock Geology Maps
(from WGNHS, B. Brown, 1988)
Groundwater Maps - Chippewa County, Wis.
(from WGNHS, I. Lippelt, 1988)

Outline of Presentation

• Paper Studies
• Outcrop / near surface investigations
• Soil Boring Programs
• Groundwater Investigations
• Sieve Analyses & ISO 13503 / API RP 19C
• Resource Assessments

Outcrop Studies

• Advantages – Low cost, profile view of sand formations
• Logging road cuts, backhoe test pits
• Can be excellent information with survey data (Trimble R-8 GPS)
• Sample bedrock, not eroded sand
• Rock samples allow for identification of sedimentary structures
• Disadvantages – Limited vertical sampling
• “Badger / Gopher hole” prospecting (loose sands)
Outline of Presentation

- Paper Studies / Groundwater Investigation
- Outcrop / near surface investigations
- Soil Boring Programs
- Sieve Analyses & ISO 13503 / API RP 19C
- Resource Assessments
Soil Boring Programs (SEH)

- Drilling method used based on subsurface conditions (bedrock, loose sands, groundwater)
- Sample at 5-foot intervals (SEH)
- Survey during drilling program (SEH)
- Establish formation elevation contacts
- Limit drilling of bedrock overburden (reduce drilling costs)
- Assess groundwater depth in boreholes

Drilling Methods

- Air Rotary – Less cost, good quality samples, limited by groundwater and depth
- Dual Wall Reverse Circulation – Higher cost, high quality samples. Use for sampling in groundwater
- Hollow stem auger – Less cost, limited sample volume, good in unconsolidated int.
- Rotosonic – Higher cost, core study and analyses, can get limited recovery in favorable sand intervals, use for sampling in groundwater

Drilling - Air Rotary
Sample Handling - Photomicrographs

Outline of Presentation

- Paper Studies / Groundwater Investigation
- Outcrop / near surface investigations
- Soil Boring Programs
- Sieve Analysis and Frac Sand Properties
- Resource Assessments

Sieve Analyses

- Most important data in site evaluations
- Sieve analyses at 5-foot sample intervals (SEH)
- Elevations of sample intervals valuable in data analysis
- Use EXCEL spreadsheets for presentation of sieve results (tables and cross sections)
- Development of structural cross sections across property using sieve data to identify more coarse grained intervals
Sampling Methods - Sieves

Sieve Analyses Interpretation

- Correlation of ground elevation data to sieve intervals
- Frac sand focus on No. 16 mesh to No. 70 mesh
- Cumulative 70% retained on No. 70 mesh used as a common cutoff (SEH)
- Little silt and clay in most frac sand deposits
- Assess waste factors (typically 20 – 30%)
- Need to sieve finer sand samples to establish thickness of pay

Sieve Results Detail
Cross Section of Sieve Results

Frac Sand Properties

• ISO 13503-2 / API RP 19C – essential data for operators.
• Composite sample development from 5-foot sand sample intervals
• Split samples / equal weights
• Instructions for lab / follow chain-of-custody procedures (SEH)
• Communications with lab and Client

Outline of Presentation

• Paper Studies / Groundwater Investigation
• Outcrop / near surface investigations
• Soil Boring Programs
• Sieve Analyses and Frac Sand Properties
• Resource Assessments
Resource Assessments

- Understand what your Client needs (what fractions are important, cutoff applications)
- Overburden thickness an economic limitation?
- Mining all material between bottom and top elevation of pay zone
- Regulations apply for buffer zone or is pay sand developed in the water table
- Apply waste factors to resource assessment
- Use of GIS/Excel spreadsheets in resource assessment calculations

Resource Assessment Map

Factors to Consider in Site Evaluations

- Water issues (wetlands, perched water, springs, streams)
- Glacial remnants (valley down cutting and fill). No topographic evidence.
- Depositional environments (sand grain size variation across site)
- Setbacks / Utilities / Mine Planning / Regulations
- Proper boring abandonment and documentation
- Communications with Client
Future Challenges

- Geologic studies - mine and petrographic studies
- Groundwater studies - need for data collection, groundwater monitoring well networks
- Block modeling / mine planning development
- Chasing the coarser grain......
- Chasing the fine?......future gas markets

Thank You

Darrell Reed
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Silica Sand Mining Techniques

John Litsenberger, Consultant, Goodhue County, MN; formerly with Wisconsin Industrial Sand/Fairmount Minerals

The mining of silica sand is not a new phenomenon. Silica sands have been mined for hundreds of years to manufacture glass and to glaze pottery. Over the past 200 years, these sands have been sought after by the foundry industry, sand blasters, railroads (for traction sand), for use in water filtration, as construction aggregates, and for golf course construction. However, it has been only within the past decade or two and through the development of new drilling processes in oil and gas wells that we have seen an explosion in the demand for well rounded, high quality silica sand to be used as proppants in the quest for more efficient means of extracting hydrocarbons from the earth. The upper, mid continent region of the United States contain large reserves of high quality silica sands in the St. Peter, Jordan, Ironton/Galesville, and Wonewoc Sandstones. Of these four distinct formations, the Jordan Sandstone, the Wonewoc Sandstone, and the St. Peter are the primary targets. Although sand is mined and recovered in numerous areas of the country, it is the high purity and well rounded attributes of these sandstones that have created a mining rush for this region. We’ll throw in the Ironton/Galesville as a bonus. A recent count of silica sand mining operations, nation wide, yields roughly 180 identifiable mines and plants. And, within the upper mid-central region of Wisconsin, Michigan, Minnesota, Illinois and Iowa we have 63 active mines and/or plants, one third of such facilities nationwide. Fortunately for the companies seeking to mine silica sand, the Jordan and the Wonewoc Sandstones provide abundant reserves close to or at the surface in southeastern Minnesota and throughout western and west central Wisconsin. In northern Illinois and in Iowa the St. Peter Sandstone is the targeted formation. Michigan recovers its silica sands from the shoreline dunes of eastern Lake Michigan. With this abundance of at surface reserves, surface mining techniques account for the vast majority of mining operations. Currently, out of nearly 200 mining properties nationwide, only three are true underground operations; a fourth is on the drawing boards for western Wisconsin.

The two primary techniques for recovering silica sand are through the use of surface mining methods or underground mining methods. This paper will delve into both mining methods and discuss their application in the recovery of silica sand within the upper mid continent region of the United States. Integral to this discussion are those methods of mining currently in practice as well as some of the issues and concerns that have developed with the public over the mining operations. This paper will also look at other mining methods that are either used on a limited basis or that have the potential for use in mining these sands. Mining the sands is only one of the challenges facing the miner, however. The local populace has voiced multiple concerns involving health, environmental, nuisance, and safety issues about the mining operations. These too, must be dealt with by the miner and how the miner responds to these concerns will have a far reaching affect on how the industry as a whole is perceived by the public. This paper will also address these issues with some suggestions for the miner.

________________________________________________________
John Litsenberger began his mining career working with American Metals Climax and the Climax Mine near Leadville, Colorado in 1970. For the next twenty five years he continued to work in underground metal mines throughout the United States with a brief, one year, stint in Turkey. Following the closure of the White Pine Mine in Michigan in late 1995, John made the move to industrial minerals. Over the next twelve years, he worked in underground limestone in Missouri and aggregates in Pennsylvania. In 2008, John joined Wisconsin Industrial Sand and was instrumental in the startup operations of two local mining and processing operations. With retirement in 2010, he began his association with the Goodhue County committee studying silica sand mining and processing and its possible affects on the public. As one of only two miners on the committee, John’s role was largely one of educator. This study was wrapped up in July, culminating in major changes to the county’s mining regulations that will not only provide protection to the citizens of Goodhue County and to the soon to arrive producers of silica sand but provide an effective medium for direct contact between citizens and the mining companies for a better communication, cooperation and success of all.
SILICA SAND MINING TECHNIQUES

REAPING THE SANDS OF TIME

PRODUCT END USES

- Glass Manufacturing
- Foundry molds
- Abrasives
- Construction aggregate
- Water filtration
- Golf Course Construction
- Hydrofracking

SILICA SAND MINING OPERATIONS

- USGS-178 Silica sand mining operations in US and another Silica sand mining operations in Canada.
- Wisconsin-36
- Minnesota-7
- Illinois-8
- Iowa-3
- Michigan-9
WISCONSIN SAND DEPOSITS AND SAND MINES

ST. PETER SANDSTONE

DISTRIBUTION OF SILICA SANDS
MINING METHODS
Two Primary Methods

• Open Pit Mining
• Underground Mining

SURFACE MINING

• Quarrying
• Sand (and gravel)
• Sub-Water Table (dredging or de-watering)
• Contour Mining

LIFE CYCLE OF A SURFACE MINE

• Mine Development
• Production Mining
• Reclamation
OPEN PIT MINING
QUARRYING

- Drill and Blast
- Digging with Excavator
- Bulldozer excavation

SINGLE BENCH MINE

OPEN PIT MINING
Sand (and gravel)

- Sand Dune removal
- River Deposits
DUNE MINING

OPEN PIT MINING
Sub-Water Table

- Formation De-Watering

- Dredging

TYPICAL SAND DREDGE
OPEN PIT MINING
Contour Mining

- Use quarrying techniques
- Narrow strip following contour of slope
- Limited use
- Often used for erosion control

CONTOUR MINING
General Concept
Remove overburden and caprock

DUST SUPPRESSION
DUST SUPPRESSION
Haul Roads

DUST COLLECTION

UNDERGROUND MINING
• Room and Pillar
• Cut and Fill
• Sub-level caving
UNDERGROUND MINING
Room and Pillar

- The most common of underground mining methods
- Access typically via adit into highwall
- Productivity less than open pit methods

ROOM AND PILLAR
Inline Pillars

ROOM AND PILLAR
Staggered Pillars

Headings-East/West       Crosscuts-North/South
MINE HEADING
Vertical View

- Cathedral Roof

UNDERGROUND MINING
Cut and Fill
Sub-Level Caving

- Potential mining methods but currently not used

DRILLING IN A SAND MINE
Christopher Kelley, Sales Manager, Aggregate and Industrial Sands Division at McLanahan Corporation, Hollidaysburg, Pennsylvania

NO ABSTRACT

Christopher Kelley graduated in 1978 from the New York State Ranger School (Wanakena, NY) with an associates degree in Forest Technology and received his BS degree in 1980 from Syracuse University (Syracuse, NY) in Resource Management- Forestry. He received a MA in Finance in 1984 from Western Connecticut University (Danbury, CT). Worked as a framing carpenter and home builder until 1991 and then from 1991 to 2008 worked for Derrick Corporation (Fine Screening Technologies) reaching the position of VP for Sales and Marketing. Presently, Chris is director of Aggregate and Industrial Sands Division at McLanahan Corporation in Hollidaysburg, Pennsylvania.
Wet Frac Sand Processing
Meeting the Demands of a Growing Market

October 2nd, 2012 Minnesota

CHRISTOPHER KELLEY | Sales Manager

Objectives of Wet Frac Sand Processing
- Liberate Individual Silica Particles
- Remove Non Silica Contaminants
- Liberate and Remove Clay Impurities
- Remove Non Frac Sand Size Fractions
  (Depends of Processors Requirements)
- Break Up Clusters

Basically Take Raw Sand and Prepare it for Feed To Dryer and Dry Screening Plant
Frac Sand

Mining Methods:

– Dredging
– Harvest w/ Earthmoving Equipment (Liberated Sands)
– Blasting and Harvest w/ Earthmoving Equipment (Not Liberated Sands)

Primary Crushing and Tertiary Impactors for materials over 6 to 8” size

– Use of Jaw Crusher followed by Either Horizontal Shaft Impactors (HSI) or Vertical Shaft Impactors (VSI)
– It is important to only liberate and not crush the individual silica particles during liberation
– Can be operated in closed circuit with Primary screen with circulating load returning to tertiary impactors
Preparing Lead

Non Liberated Sands Over 6-8” (Primary Jaw)

Non Liberated Sands Over 6-8” (Tertiary Impactor)

Preparation of Non Liberated Sands (less than 6-8”)

Single Stage Crushing for materials typically 6 to 8” size or less

- Use Either Horizontal Shaft Impactors (HSI)
- or Vertical Shaft Impactors (VSI)
- It is important to only liberate and not crush the individual silica particles during liberation
A square or round hydraulic chamber that makes separations via an upward streaming column of water (teeter water) that separates particles based on their hindered settling rate differential. Separation efficiencies are same as high efficiency wet screening machines (90%) however footprint is smaller and capital costs are lower. To change cut point (separation) simply calculate water quantity required and change teeter water flow rate. Pump that supplies Teeter water is designated for that duty only.

- Feed enters the top of the unit via a central feed well.
- Water is injected through a series of pipes to cause an upward rising current.
- A zone of suspended or “teetered” solids is established.
- Fines flow over a weir at the top of the unit.
- The slurry density of the teetered bed is monitored by a pressure transmitter.
- A PID controller maintains the teetered bed density by adjusting the underflow valve, which releases coarse material.
Dewatering Screen Installation typical discharge of Frac Sand: 8 mesh (2.36mm) by 70 mesh (212 micron) is between 10 & 15% moisture.

Typical discharge of Frac Sand: 3 mesh (2.36mm) by 70 mesh (212 micron) is between 4 & 5% moisture.
• Used to liberate clays from silica particles
• Rotating shaft with paddles causes particle on particle scouring
• Feed should be about 68 to 78% solids
  – Too dilute and the particles glide past one another
  – Too dense and the pulp won’t flow through system

**Motor Gearbox Shell Baffles Outlet**

**Attrition Cells Paddle Arrangement**

• Paddles pump up or down
• Alternating arrangement
• Four paddles per blade arrangement
• Five (5) sets of blade arrangements
• 60 HP motor
• No Belts or Sheaves
• All surfaces rubber lined
• After recovering the Frac sand material producers are typically left with the minus 70 mesh (212µ) or minus 50 mesh (300µ) material along with the majority of process water
• The solids are basically fine sands, silts and clays
• It is desirable to minimize the amount of solids reporting to settling ponds in order to minimize pond size and cleaning costs.
• Producers should find marketable uses for these discarded solids such as:
  – Foundry sands
  – Flowable fills
  – Industrial Fillers
  – Landfill cover
  – Soil Augmentation
• Remote locations of plants makes finding economically feasible uses for byproducts difficult
• Reduce Settling Pond Size
• Reduce Energy Requirements for Pumping of Tailing to Settling Ponds
• Allow Immediate Reuse of Water in Process
• Allow for Use of Other Technologies to totally Eliminate Settling Ponds
SETTLING POND ELIMINATION

Environmentally responsible while also allowing easy reclamation of the process site after reserves are depleted

Reasons for Settling Pond Elimination

– Government restrictions on ponds
– No space available for ponds
– Immediate reuse of water in process
– Ponds would be on sand reserves
– Eliminate costs of maintaining ponds
– Potential for monetary value via recovery of clays in a consistent form (very rare)

OPTIONS (Settling Pond Elimination)

• Centrifuges
• Belt Filter Press
• Recessed Plate & Frame Press
• Others being developed
DECANTER CENTRIFUGE (Crosssection view)

Advantages
• Compact
• Able to adjust discharge moisture
• Quick set up time
• Very mobile
• Easy to clean

Disadvantages
• Requires full time skilled attendant
• High capital cost
• Requires polymer addition
• Requires mechanics who can maintain and fix equipment with extremely tight tolerances
• When things go wrong repairs can be extremely expensive
Advantages

• Inexpensive

Disadvantages

• Requires full time skilled attendant
• Requires a large quantity of polymer (cationic) addition
• Inconsistent product discharge
• Hard to adjust discharge moisture
• Extremely messy
• Ask someone who has had one in their facility
### Advantages

- No attendant required
- No additional polymer required
- Can adjust cake dryness (cycle length)
- Clean site around press
- Few moving parts easy to maintain
- Easy to clean

### Disadvantages

- Large not mobile
- Higher capital cost
Frac Sand Stockpile Ready for Dryer and Final Sizing
Silica Sand Processing – Water Quantity and Quality

Scott E. McCurdy, PG, Director, Cedar Corporation-Environmental Group, Menomonie, WI

Water use in the region is heavily dependent on groundwater. Thousands of water supply wells serve many residential, agricultural, municipal and industrial needs. The Cambrian sandstone and overlying Ordovician limestone and Pleistocene sand and gravel aquifers provide 10’s of millions of fresh water per day.

Nonmetallic mining processors use water to wash the fines and size the product. Processors use some 4500 to 6000 gallons per minute moving and washing the raw material. Local aquifers are not sufficient to provide this demand and water reuse is a necessary element in the design and operation of the facilities. Typical operations used unlined sedimentation ponds to for water clarification and source water for processing. Although this method works, more sophisticated techniques are being employed to reduce the amount of water being used improving corporate environmental consciousness and the bottom line.

Water quality concerns stem from the use of chemicals on site and there remains a need to provide monitoring to establish baseline water quality prior to the startup of processing as well as ongoing monitoring to ensure chemical usage has not contaminated local aquifers.

Scott McCurdy received a B.Sc. in Geology, Physics & Mathematics from Dalhousie University, Nova Scotia, Canada in 1973 and a Master of Science in Environmental & Public Health from University of Wisconsin-Eau Claire in 1992. Since 1973 he has combined experience in geophysical exploration, geology, and environmental consulting, the last 23 years focused on soil, groundwater, and air pollution issues. He is a Project Manager and Hydrogeologist and Director of the Environmental Group at Cedar Corporation. He has been a registered professional since 1975 and is currently a Registered Professional Geologist (1995) in Wisconsin, and a Certified Professional Geologist by the Association of Professional Geologists (1991). Scott currently consults with several towns and villages in western Wisconsin providing insight and direction to regulate and monitor industrial sand mining in these communities.
Conference on the Silica Sand Resources of Minnesota and Wisconsin

Silica Sand Processing
Water Quantity and Quality

Scott E. McCurdy, PG
Cedar Corporation

Industrial Sand Processing

- Industrial sand processing heavily dependent on clean water
  - Mechanical methods move raw sand to initial screens
  - Mechanical screens remove the larger fractions
  - Wet plants use 4,000 to 6,500 gpm to move sand slurries and wash fines from the target fractions
  - Used process water discharged to sedimentation ponds for treatment and, when available, recycling.

Industrial Sand Processing

- Unlined sedimentation ponds leak minimizing water recycling efforts
- Flocculants and coagulants are used to decrease water reuse turn around time
- Water recycling opportunities limited as water turbidity increases with reuse. Makeup water is introduced to improve water quality
Problems related to Water

- Moving water is inefficient and expensive.
  - Typically 2 or 3 wells each with 100 Hp pumps are needed
  - 300 Hp pumps are needed to recirculate water from sediment ponds to processing areas are common.
- Groundwater wells typically provide production rates of 400 to 800 gpd or more but less than the 4,500 to 6,000 gpm required for processing.
- Requires ponds or tanks as interim water sources.
- Chemical use has the potential to contaminate off site waters

Water Source

In the frac sand belt of western Wisconsin and eastern Minnesota; municipal, industrial, agricultural, and private users rely heavily on ground water. The Pleistocene, Ordovician, and Cambrian aquifers cover thousands of square miles in this region providing 10's of millions of gallons of water per day for everyone’s use. This is a plentiful and shallow source of high quality fresh water.

Well Density

- Municipal, agricultural and industrial wells operate from 500 to 2,000 gpm in these aquifers, and 1,000's of wells are present.
- In one Wisconsin county with a population of 35,000, there are currently 5,100 registered wells. Of this population, about 20,000 are served with a handful of municipal wells.
Well Density

- Some local residents are concerned about the influx of the number of high capacity water users the sand processors bring to the area.
- Their fear is that the industrial sand mining industry will sufficiently deplete the aquifers, putting all users at risk.

“Whiskey is for drinking. Water is for fighting.”
- Samuel Clemens

Water Use

- The Cambrian aquifers have been pump tested by several municipalities. One such pump test completed in eastern Eau Claire County, WI in the last 10 years where the aquifer is only 100 feet thick.
- The operator pumped the well continuously for 29 days at 300 gallons per minute. They achieved a drawdown of 48 feet in less than a day and held it for the remainder of the test. The well produced 12.5 million gallons of water over the test and upon cessation of pumping the well recovered 45 feet in under 90 minutes.
- Similar results have been observed at other communities with thicker aquifers where 2,000 gpm pump tests have been completed and not had a significant effect on the local water table.

Water Use

- Water studies in Cambrian Aquifer areas show that local Industrial Sand Processing projected water use should not deplete the aquifers, but there is still considerable public concern over potential local interference with other water users.
- Water use at some Industrial Sand Process Plants is under review by the operators in an effort to improve water efficiency, public perception, meet corporate environmental conservation goals, and lower long term operational costs.
Water Recycle Efforts

- Water use reduction is achieved through
  - Lining of sedimentation ponds
  - Replacement of sedimentation ponds with thickener tanks
  - Recovery of storm water & dust control water
  - Recovery of process water from stockpiles
  - Recovery of sediment water by use of belt and/or filter presses on sediment slurry
- All equal reduced energy, chemical, and make up water usage.

Water Recycle Efforts
stormwater / sedimentation pond

Water Recycle Efforts

- Lining of sedimentation ponds
  - Unlined ponds were allowed to seal using the clay fines in the process water. Method is effective but initial water loss is high
  - Lining the ponds increases the ability to reuse water but the turbidity increases to a point where the pond is no longer effective even with chemical treatment; thus additional ponds are required
- Replacement of sedimentation ponds with thickener tanks
  - Clarifier or thickener tanks are in use to improve water clarity efforts by concentrating chemical use and provide controlled sludge removal
  - Recycle water is directed to clarifier tanks for treatment
  - Treated water is directed to storage tanks for use in process
Water Recycle Efforts
Clarifier or thickener tank discharge

Water Recycle Efforts

- Make up water is directed to clean water storage tanks.
- Storm water is collected at some facilities for reuse in process or dust control.
- Stockpiles typically are 17 to 20% moisture and must “dry” to approximately 5% before drying and final sizing.
- Drain tiles under the stockpiles can recover water which is used for processing.

Water Recycle Efforts
Make up water tank
Water Recycle Efforts

- Dust control is heavily dependent on water use. Typical single water cannon will use 250 to 300 gpm.
- Experience is showing the wet stockpiles can be misted with alternate sprayers and mechanically managed to help mitigate dust issues and reduce water cannon usage.
- Plate and filter belt presses are proposed to recover water from the process sludge minimizing water haul back to the reclamation area or disposal site. Recovered water can be used for processing.

Water Recycle Efforts
Misting sprayers

Water Use Reduction

- Implementation of water recycling efforts at 3 Fairmount facilities in WI realized 32 % to 75 % reduction in gallons of water used per ton of produced sand.
- Water use varies dependent on the operation but typical usage after implementation of water recycling controls is 81 to 418 gpm down from 127 to 910 gpm (35% to 54% reduction).
### Flocculants and Coagulants

- Chemicals used to improve gravity settling of fines in sediment ponds and tanks.
- Chemicals can be polyacrylamides and acrylamides among others.
- Acrylamide is a toxin and can enter the environment from sediment ponds and sediment sludge to returned mined areas for reclamation.

### Acrylamide

- Mobile in the environment but degrades when exposed to aerobic environments and UV radiation.
- Potential ground water contaminant. EPA acceptable drinking water limit is 50 parts per trillion.
- Insufficient information on degradation when buried.
Polyacrylamide (PAM)

- Less mobile than acrylamide in the environment as it adsorbs to silt and clay grains
- Evidence of degradation to acrylamide when non-adsorbed PAM in environment.
- Insufficient information on degradation when buried.

Effective Tools to Minimize Contamination

- Monitoring groundwater at facility boundaries
- Use of sediment sludge in a manner that takes advantage of the chemical degradation properties to enhance chemical destruction.
- Use of thickener tanks to control chemical use and exposure pathways.
- Use of NSF 60 approved chemicals

Questions

Thank You
Air Quality Controls related to Sand Mining, Processing, and Transportation

Jeff Hedman, Engineer, Air Quality Permits Section, Minnesota Pollution Control Agency, St. Paul

Sand mining and processing operations are known sources of particulate matter emissions. Air pollutants such as particulate matter have been regulated in various forms for over 40 years. Particulate matter is regulated because of well documented effects on human health and welfare; specifically, this pollutant affects the respiratory and cardiovascular systems and can lead to mortality. This pollutant is sub-classified by its size and is referred to as Total Suspended Particulate (TSP), Particulate Matter with an aerodynamic diameter of less than 10 microns (PM10), and Particulate Matter with an aerodynamic diameter of less than 2.5 microns (PM2.5). Deposition of particulate matter has been shown to negatively affect visibility, ecology, and man-made infrastructure. For these reasons, the USEPA has set standards designed to protect human health and welfare. Silica sand is regulated as particulate matter.

Analysis of particulate matter size distribution has identified several distinct groupings, or modes. These modes are tied to two distinct formation processes: accumulation of fine particulates, and break-up of large solids. Combustion processes produce finer particles than mechanical wear processes. Because the majority of processes at sand mining and processing operation involves mechanical abrasion, it is believed that these sites produce particulate matter with larger aerodynamic diameters.

Various control strategies have been developed to mitigate particulate matter emissions. Control strategy selection is informed by the nature of the process of interest; certain control strategies are more effective for smaller particles, while many control strategies are effective for larger particles. Control strategy is also dependant upon a ducted or enclosed process. Processes without ducting, such as a sand pile, must be approached differently than those processes with ducted emissions.

Monitoring methodologies have been developed to ensure that ambient air standards are being met. Ambient monitoring is generally used to monitor air over entire populations, as opposed to single facilities. The Minnesota Pollution Control Agency monitors for TSP, PM10, and PM2.5. Monitored data indicates that Minnesota has met all National Ambient Air Quality Standards for particulate matter.

Jeff Hedman has worked for the Industrial Division of the Minnesota Pollution Control Agency for four years. Jeff primarily works in the Air Quality Permits Section, which requires intra-agency coordination with the Compliance, Enforcement, Ambient Monitoring, Computer Modeling, Risk Assessment, and Leadership teams; and extra-agency coordination with EPA, consultants, facilities, and other state agencies.
Air Quality Controls related to Sand Mining, Processing, and Transportation
Conference on the Silica Sand Resources of Minnesota and Wisconsin

Jeff Hedman
Engineer
Air Quality Permits
October 2, 2012

Presentation Overview

- Characteristics of Particulates
- Emission Sources
- Control of Particulates
- Air Quality Monitoring

Why Care About Particulates?

Health!
- Cardiovascular Effects
- Respiratory Effects

Welfare!
- Visibility
- Ecology
- Infrastructure Damage

Particulate Size

Ambient Air Quality Standards

Primary Standards (Protect Human Health):

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<th>TSP</th>
<th>PM_{10}</th>
<th>PM_{2.5}</th>
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<td>Annual 24-hour</td>
<td>Annual 24-hour</td>
</tr>
<tr>
<td></td>
<td>n/a</td>
<td>n/a</td>
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<td></td>
<td>150 ug/m³</td>
<td>35 ug/m³</td>
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Secondary Standards (Protect Welfare):

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<th>TSP</th>
<th>PM_{10}</th>
<th>PM_{2.5}</th>
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<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Minnesota</td>
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Presentation Overview

- Characteristics of Particulates
- **Emission Sources**
- Control of Particulates
- Air Quality Monitoring
Particulate Generation

Table 3-1. Characteristics of ambient fine (ultrafine plus accumulation mode) and coarse particles.

<table>
<thead>
<tr>
<th>Fine</th>
<th>Accumulation</th>
</tr>
</thead>
</table>
Presentation Overview

- Characteristics of Particulates
- Emission Sources
- Control of Particulates
- Air Quality Monitoring

Cyclone

- Performance
  - TSP: 80 – 99.9%
  - PM$_{10}$: 10 – 95%
  - PM$_{2.5}$: 0 – 70%
- Limitations
  - Tradeoff: efficiency or throughput

Baghouse

- Performance
  - TSP: 90 – 99.9%
  - PM$_{10}$: 85 – 99.9%
  - PM$_{2.5}$: 80 – 99.9%
- Limitations
  - Moisture Content
  - Temperature
  - Bag replacement

Image: Air Pollutant and Control Techniques – Particulate Matter
http://www.epa.gov/apct/bces/module6/matter/control/control.htm
Electrostatic Precipitator

- **Performance**
  - TSP: 99 – 99.9%
  - PM$_{10}$: 97– 99.5%
  - PM$_{2.5}$: 96 – 99%

- **Limitations**
  - Cost
  - Footprint
  - Intolerant to Load Variation
  - Resistivity of silica

Wet Scrubber

- **Performance**
  - TSP: 70 – 99.5%
  - PM$_{10}$: 70 – 99%
  - PM$_{2.5}$: 25 – 97%

- **Limitations**
  - Wastewater is created
  - High Pressure Drops

Selection of Control Equipment
Fugitive Dust Mitigation
- Apply Water
- Commercial Dust Suppressants
- Enclosure
  - Process
  - Transportation
- Pave Surfaces
- Construct Berms
- Minimize Drop Height
- Wheel Wash Station
- Vehicle Trackout Control Device

Presentation Overview
- Characteristics of Particulates
- Emission Sources
- Control of Particulates
- Air Quality Monitoring

How do you monitor?

Monitoring Plan
- Objective
- Site Selection
- Network Scale
- Sampler, Analytical Method
- QA/QC Procedures
- Sampling Frequency, Duration
- Reporting Requirement
Monitoring Results: 24-hour PM$_{2.5}$

![Graph showing PM$_{2.5}$ monitoring results for different locations.](image)

Monitoring Results: 24-hour PM$_{10}$

![Graph showing PM$_{10}$ monitoring results for different locations.](image)

Presentation Overview

- Characteristics of Particulates
- Emission Sources
- Control of Particulates
- Air Quality Monitoring
Presentation Overview

- Characteristics of Particulates
- Emission Sources
- Control of Particulates
- Air Quality Monitoring
- Silica?

Silica Sand Basics

Relative Sizes

- PM2.5
- PM10
- Human Hair
- US Sieve Size 20
- US Sieve Size 40
- US Sieve Size 140
- US Sieve Size 20, largest frac sand size
- US Sieve Size 40, desirable frac sand size

Tony Runkel, Minnesota Geological Survey
Characteristics of Particulates: Silica

- **OSHA**
  - Jurisdiction: Workplace
  - Numerous Studies on Workplace Exposure
  - Known Health Effects at PM$_4$ Size Range

- **EPA**
  - Jurisdiction: “Ambient Air”
  - Silica generally regulated as Particulate Matter
  - Clean Air Act Section 112: Silica Not Classified as a Hazardous Air Pollutant
  - Little Data on Environmental Exposure

Emission Source: Silica

- Blast → Excavate → Crush
- Sort → Dry → Wash
- Store → Transport to End Use

Control of Particulates: Silica

Air Pollutant and Control Techniques – Particulate Matter
http://www.epa.gov/appti/bces/module6/matter/control/control.htm
Air Quality Monitoring: Silica

<table>
<thead>
<tr>
<th>Problems</th>
<th>Possible Solutions?</th>
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<tr>
<td>• No Ambient Air Standard for PM\textsubscript{4}</td>
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<tr>
<td>• No Federal Reference Method for Monitoring PM\textsubscript{4}</td>
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<tr>
<td>• Silica Analytical Method?</td>
<td>MDH Literature Review: use 3 \textmu g/m\textsuperscript{3} as PM\textsubscript{4}</td>
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<tr>
<td></td>
<td>Modify PM\textsubscript{2.5} environmental monitor</td>
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<tr>
<td></td>
<td>Use NIOSH 7500 or 7602 for silica analysis</td>
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</tbody>
</table>

Data Gaps

- Silica Emissions vs. Process Type and Rate
- Silica Environmental Exposure Data
- Standardized Monitoring Method for PM\textsubscript{4}
- Short-term vs. Long-Term Health Effects?
Transportation Options and Issues

Brennan Thomas, CEO, Pro Sands, Dallas, TX

NO ABSTRACT

Mr. Thomas is co-founder and CEO of Pro Sands - a frac sand supply and logistics company. His past experience includes engineering positions at several major Universities as well as business ventures in optical technology, restaurants, and internet advertising. He holds a master's degree in engineering and an MBA from the University of Arizona and currently resides in Dallas, TX. Pro Sands has most recently, entered the silica sand processing business and operates dry plant / storage facilities in Texas and Louisiana.

NO PPT NOTES
Reclamation of Silica Sand Operations

Paul Eger, Environmental Engineer, Global Minerals Engineering, Hibbing, MN.

Mineland reclamation is a critical part of mining and successful reclamation begins before the mine starts. The basis of successful reclamation is to have a good plan and to follow it. Reclamation or closure plans are now a standard requirement for all mining operations.

Reclamation has been defined as the process of returning land that was temporarily used for mining into land that is safe and useful for some other purpose. The reclaimed site can be used for a variety of activities, including agriculture, wildlife, forestry, recreation, residential or industrial development. The desired use is generally defined by an agreement between the mine operator and the community.

Sand, gravel and industrial minerals (including silica sand) are regulated by local units of government, generally the counties. At silica sand operations, reclamation generally occurs during mining. This is defined as concurrent or progressive reclamation and means that only a small portion of the overall mining area is open and active at any time. After the first area has been mined, the exhausted pit is backfilled with material from the new mining area. The soil profile is maintained and the amount of soil handling is minimized. Reclamation success criteria are established and can include percent cover, productivity and sustainability. Examples of successful reclamation will be discussed.

For over 30 years, Paul Eger has worked with environmental issues related to mining both in the public and private sector. For most of his career, Paul was a principal engineer for the Minnesota Department of Natural Resources, Division of Lands and Minerals. He was a pioneer in the use of wetlands to remove trace metals from mine drainage. His work focused on the development of successful passive treatment systems, methods to prevent and mitigate mine drainage challenges and reclamation approaches that led to successful site closures. He has also been a leader in the development of cost-effective and environmentally safe reclamation using waste products, such as biosolids, municipal solid waste compost, and dredge material from Lake Superior. He was part of the team that developed Minnesota’s reclamation rules for both ferrous and non-ferrous mining and served as an expert witness on water quality issues and at reclamation rules hearings. Paul also was a key member of the DNR’s hazardous waste team, where he was responsible for site investigations and the cleanup of abandoned dump sites. Paul was the co-team leader of the Interstate Technology and Regulatory Council’s Mining Waste team, which recently produced a web based guidance tool to help select treatment technologies for mining sites. He has authored of over 90 technical papers and reports that focus on mined land reclamation and passive mine water treatment.
Reclamation of Silica Sand Operations

Paul Eger
Global Minerals Engineering
Hibbing, MN

What is Reclamation?

• The process of returning land that was temporarily used for mining into land that is safe and useful for some other purpose.

When Does Reclamation Begin?

• At the end of mining
• 5 years before the mine closes
• When the company goes bankrupt
• Before the mine opens
• All of the above
The Basis of Good Reclamation

- Have a good plan
- Stick to it!

Mineland Reclamation Requirements
General Categories

- Siting
  - Avoidance
  - Setbacks
- Final Shape
  - Requirements on height and slope
- End Use
  - Stable land forms
  - Establish vegetation
    - Prevent erosion
    - Provide habitat
- Financial Assurance

Sand, gravel, industrial mineral reclamation

- Local Units of Government
  - Typically counties
- General siting requirements
- Key is planning
- Save the topsoil
- Reclamation and reuse very successful
Reclamation plan

- Maps
  - Initial
  - Mining Plan
  - Final
    - Fill
    - Topsoil
- Designated end use
  - Planting
  - Measures of success
  - Completion dates
- Financial Assurance
A Guide to Developing Reclamation Plans for Nonmetallic Mining Sites in Wisconsin
February 2002

Reclamation plans (Wisconsin)
Required by local or county ordinance
Comply with standards in:
Nonmetallic Mining Reclamation Rule,
Chapter NR 135, Wisconsin Administrative Code.

123
Nelson Mine, Grey Cloud Island

- Topsoil low quality
- Southern exposure
- Several failed reclamation attempts

Cooperative Project

- Used organic amendments
  - Municipal solid waste compost
  - Nviro soil
  - Native prairie species

South Washington County Garden Tour
July 1999
Reclamation- Industrial sands

- Mining over 30 years
- Generally small areas open
  - Unimin expansion
  - ~ 1200 acres mined over 30 years
  - ~ 40 acres per year
- Reclaim as mine
  - Concurrent reclamation
  - Backfill
- Final land use
  - Mutually agreed

Unimin – Ottawa Facility

Randall Mine Reclamation
Innovative Reclamation Ideas

Karl Everett, P.E., P.G. Consulting Mining Engineer / Geologist

Mining Companies have to meet certain regulatory and permitting requirements associated with the reclamation of mined lands. This basic obligation is needed to release bonds associated with the return of the land to those minimum standards. These days it is critical from a political perspective to be good neighbors and to interact harmoniously with the community. Sustainability is a new concept that includes our responsibility for the long-term maintenance of our resources. Mining companies must consider this responsibility in the reclamation and mining of resources and their effect on the environmental, economic, and social dimensions, and encompass the concept of stewardship and the responsible management of resource use and the interaction with the community. This presentation offers innovative reclamation ideas and techniques for mining companies to consider for the final reclamation of mining properties. There are numerous examples in which mining companies and communities have gone the extra mile to complete reclamation projects that are stellar examples of how reclamation of mined land can interact with the community. This presentation provides some examples where mining companies have worked with the community to create remarkable reclamation projects.

The reclamation process must begin with detailed planning of the resource and develop a mining and reclamation and development plan for the project. As Steven Covey said, “begin with the end in mind.” This presentation offers ideas and examples of successful reclamation projects. Some of these are published in the National Stone, Sand and Gravel Association reclamation guidebook “Shaping Landscapes for Tomorrow” that I worked on with Anthony M. Bauer of Bauer-Ford Reclamation Design. This presentation provides numerous success stories of creative reclamation alternatives of mined land. These include not only wildlife areas, prairies and agricultural areas, but wetland banks, parks and arboretums, hiking and bike trails, beaches and golf courses, residential development and office parks.

Karl Everett has over 30 years experience working for the mining industry and as a consultant for mining and industrial clients. His areas of expertise include managing mining, environmental, and engineering projects for metal and non-metal, surface and underground mining operations. Karl is a licensed P.E. and a geologist, and has completed resource evaluations for several Wisconsin industrial sand properties, and has completed mine planning and completed EAW and EIS environmental assessments for several Minnesota industrial sand properties.

Karl attended the University of Minnesota, Duluth and received a B.S. degree in Geology; and a M.S, degree in Mining Engineering from the University of Idaho. He worked thirteen years for Oglebay Norton Co. in various mining and environmental roles, including Senior Environmental Manager covering environmental affairs for all their U.S. facilities, including their silica sand operations located in Texas, California, Colorado and Ohio; Mining Engineer for their Minnesota taconite operations; and most recently as Senior EHS Manager he directed environmental health and safety programs for their eastern and southern limestone operations.
Innovative Reclamation Ideas

Karl Everett, P.E., P.G.
Mining Engineer / Geologist

UMD Conference on Silica Sand Resources of MN and WI
October 1, 2012

Reclamation Options

Why? – Environmental Issues
- Bonding and Permitting Requirements
- Community
- Sustainability
Begin with the end in mind

Reclamation
- Agricultural
- Wildlife

Site Beautification
Success Stories--Reclamation
- Parks & Recreation Areas
- Swimming Beaches
- Golf Courses & Driving Ranges
- Skiing & Sledding Hills
- Bike Riding Trails
- Wildlife & Wetlands

Ski Hills & Recreational Use
Iron Mining Industry Reclamation
- Biking Trails
- Ski Hills
- Fishing and Recreation
- Theme Parks

Mesabi Iron Range
Mining in your neighbors’ backyard
Ski Hill, Park, Tennis Courts and Baseball Complex

Recreational Uses – Bike Paths

Wildlife and Wetlands
Wetland Creation / Restoration
One of the best opportunities for wetland creation

Badger Mining Co. Snake Creek Walking Trail Project
Badger Mining Corporation had a unique opportunity to expand the Snake Creek Wetland Trail, a 2.5-mile public “wetland trail” extending between Swamp Road and St. Marie Road in central Green Lake County, Wisconsin.

“Unimin's objective is to work in harmony with our natural surroundings.”

- **Land Restoration**
  - “Unimin designs and funds a reclamation strategy as part of every mine development plan and implements that strategy throughout the mineral extraction process.”
Wildlife and Wetlands
Operations reclaimed as wildlife habitat
1) Lake Renwick Heron Rookery
2) Max McGraw wildlife preserve--Meyer Materials Co., Elgin, IL

Golf Courses
Prairie Isle golf course, Prairie Grove, IL
Sand & gravel operation converted into golf course

Shooting Ranges
Prairie Sand & Gravel, Beloit WI
Driving Ranges
James Bunnel & Sons,
Cleaves, OH

1) Driving range
2) Miniature golf
3) Batting cages
4) Go-cart track

Endangered Species
Morton - Arboretum, Lisle, IL

• Joy Morton, Morton Salt Co. - grandfather founded Arbor Day
• 1000 acre outdoor “tree museum”
• Sand & gravel pit reclaimed with endangered species
• Walking paths
• Prairie restoration
• Dolomitic prairie

Morton Arboretum,
Lisle, IL
Sand & Gravel Pit Reclamation
• Historic Photo

Sand & Gravel Pit Reclamation
• Today

Quarry Park, Racine WI
Swimming Beach & Facility
Fishing Pier

Soccer Field

Quarry Reclamation
Centennial Park - Naperville, IL

Three reclaimed quarries in downtown:
1) the Riverwalk
2) swimming beach
3) paddle boats
4) baseball diamond
5) playground
6) skating & hockey rink
7) sledding hill
8) outdoor concerts, carnivals, & festivals
9) river and quarry front housing
Paddleboat Park

Plan Ahead
The Nonmetallic Mining Regulatory Framework in Wisconsin

Bruce A. Brown, Senior Geologist (retired), Wisconsin Geological and Natural History Survey, Madison, WI

Wisconsin law requires reclamation of nonmetallic mining sites, but does not specifically regulate mining activities. Nonmetallic mines are subject to the same regulations as other industrial operations regarding storm water, solid waste, wastewater, and groundwater and surface water use and impact. Nonmetallic mining operations are required to obtain permits regulating these and other activities that potentially impact the environment or are covered by state or federal regulation such as endangered species.

Reclamation is administered at the county or local level with DNR oversight. A reclamation plan must be approved, subject to public input, and financial assurance in place before mining begins. The counties, through their Land conservation and zoning departments manage the reclamation program. The counties and towns set operating conditions not covered by DNR regulations through the zoning process or the use of local police powers in the absence of zoning.

The state level regulations are generally straightforward, but obtaining the necessary permits is only half the battle. The ultimate success of a project depends on working with county and local units of government to obtain zoning changes and define operating conditions.

Bruce Brown recently retired as Senior Geologist with the Wisconsin Geological and Natural History Survey. He has a B.Sc. degree in geology from the University of Illinois, M.Sc. from the University of Oregon, and a Ph.D. from the University of Manitoba. He is a licensed Professional Geologist in the states of Wisconsin and Minnesota. During 34 years at the Wisconsin Survey he worked on a wide range of projects relating to the geology and the mineral and water resources of Wisconsin. He is a co-author of the Bedrock Geologic Map of Wisconsin, and has authored numerous maps and articles on Wisconsin geology. His recent professional interests include application of geology to engineering and environmental problems, the development of digital geologic maps and data for land-use planning and resource management, and nonmetallic and metallic mineral resources. He served as a member of the Wisconsin DNR Technical Advisory committee that wrote the nonmetallic reclamation rules (N.R.135) and on the Nonmetallic Mining Advisory Committee.
THE NONMETALLIC MINING REGULATORY FRAMEWORK IN WISCONSIN

Bruce A. Brown

SENIOR GEOLOGIST, EMERITUS
Wisconsin Geological and Natural History Survey

OCTOBER 2, 2012

GENERAL REGULATORY FRAMEWORK

• STATE AND FEDERAL - Administered by state agencies in cooperation with federal agencies.
• COUNTY - Includes reclamation, zoning and land use, shoreland and floodplain zoning, road use, etc.
• TOWN AND LOCAL - Operating conditions, road use, etc. may be regulated at the town level through zoning of police powers.

WISCONSIN DNR REGULATIONS

• Air permits
• Stormwater permits
• High capacity well permits
• Wetland and waterway permits
• Endangered and threatened species
• Archeological review
AIR QUALITY PERMITS

- Applicant required to quantify all air emission sources at the proposed facility.
- DNR reviews application and determines if ambient air quality standards will be met.
- Air permit will contain operational and testing requirements to assure compliance with permit.
- Ambient particulate monitoring will be required unless a waiver is granted.
- A fugitive dust plan is required by the permit.

WPDES GENERAL NONMETALLIC MINING STORMWATER PERMIT

- Permit regulates discharge of stormwater and process wastewater to groundwater or surface water.
- Wastewater includes process wash water, non contact cooling water, vehicle wash water, and water from mine dewatering.

HIGH CAPACITY WELL PERMIT DEWATERING PERMIT

- A permit is required for a high-capacity well or for dewatering if total groundwater withdrawal exceeds 70 gallons per minute.
- DNR review includes analysis of the potential impact to springs, trout streams, outstanding and exceptional resource waters, and public water supply wells.
- DNR has begun to consider potential impact to nearby private wells.
### WETLAND REGULATIONS

- Ponds within 500 feet of or connected to navigable waters.
- Grading and excavation within 300 feet of navigable water.
- Dredging from lakes or streams.
- Permit applicants must demonstrate that any proposed impacts cannot be avoided or further reduced, and that the overall project will not have significant adverse impacts on wetland function and value, including secondary impacts.

### ENDANGERED AND THREATENED SPECIES AND ARCHEOLOGICAL RESOURCES

- The DNR shares joint responsibility with U.S. Fish and Wildlife Service through a formal cooperative agreement to administer the Endangered and Threatened Species Act of 1973.
- The DNR also cooperates with the Wisconsin Archaeological Survey to protect archaeological sites.
- All mine and processing sites including areas disturbed for supporting infrastructure must undergo an analysis to determine if the project will impact threatened or endangered species or archaeological sites.
- The applicant must take steps to avoid or minimize impact on these resources.

### COUNTY AND LOCAL REGULATIONS

- Environmental rules administered with DNR oversight.
- Shoreland zoning and floodplain regulations.
- Mine reclamation usually by county land conservation or zoning dept.
- Local and Town jurisdiction depends on whether town is zoned.
NR 135 NONMETALLIC MINE RECLAMATION

- Reclamation required by state law is generally administered by county or local authority with DNR oversight.
- All nonmetallic mines must have a reclamation plan that meets the minimum standards of NR 135, and is approved by the county or local regulatory authority.
- The holder of the reclamation permit must provide financial assurance adequate to carry out the reclamation plan in the event of a default by the permit holder. The bond or other assurance cannot be used for any other purpose.

 SOURCES OF INFORMATION

- DNR website – dnr.wi.gov, many useful links.
- DNR regional service centers - real people you can talk to.
- County websites, land conservation and zoning programs.
- Wisconsin Counties Association - wicounties.org .

DNR WEBSITE
DNR LINKS

DNR NONMETALLIC MINING

Nonmetallic mining overview
Nonmetallic mining is the extraction of silica sand, rock, or similar materials from natural deposits. The main commercial categories of nonmetallic mines are quarrying and pits. Nonmetallic mining is a widespread activity in Wisconsin. The variety of products that are extracted from Wisconsin's nonmetallic mines includes:

- Building materials
- Sand for construction
- Crushed stone for roads and buildings
- Gypsum for cement manufacture
- Obsidian for jewelry
- Sphalerite for copper production
- Trona for industrial applications
- Torus for manufacturing

Nonmetallic mining does not involve substantial amounts of metals; instead, it involves extraction of minerals and/or rock materials.
CONCLUSIONS

• Wisconsin has few statewide rules specific to nonmetallic mining, but many other rules apply to various aspects of mining.
• DNR issues most environmental permits but delegates reclamation to the County and local level with DNR oversight.
• Counties and/or Town governments control zoning and define many of the conditions of operating a mine in their jurisdictions.

FINAL THOUGHTS

• You can successfully navigate through the DNR permitting process, but that alone won’t guarantee that you can open a mine.
• In Wisconsin, “all politics is local” and you will eventually have to ask for zoning changes or a conditional use permit at the County or Town level.
• How you handle public relations can make or break a project.

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Minnesota Regulations and Permitting for Silica Sand Mining

Wendy Turri, Wastewater Program Manager, Minnesota Pollution Control Agency, Rochester, MN

This presentation discusses the environmental regulations for silica sand mining required by the Minnesota Pollution Control Agency (MPCA). The presentation covers Air regulations and permits, Water regulations and permits, Environmental review, and Enforcement.

Air emissions are possible from all steps in the silicate sand mining process except the washing process. To assure that emissions are controlled, one of three types of air quality permits is required: a registration permit, a general permit, or an individual permit. The registration permits are simple permits. The requirements are defined in rule and the permittee must follow them. The permittee is limited to a maximum of 50 tons per year of particulate matter to qualify for these permits. The general permit is issued once every five years. Facilities that meet the requirements in the permit are covered after they apply. Most sand processing sites hold this type of permit. Emissions from these facilities must be less than 90 tons permit year of particulate matter. Individual permits are for the bigger facilities and/or those that have a sand dryer. This permit requires a 30 day public notice permit for comments. All of the permitted facilities are required to track and submit information.

Water discharges are primarily from the dewatering, stormwater, and washing steps in the mining process. The pollutants of concern are suspended solids, turbidity, pH, chemical additives, and heat. National Pollutant Discharge Elimination System (NPDES) wastewaters permits are used to control the discharge of pollutants to surface and ground waters. One of two types of permits is required at all silica sand mining facilities; a general permit, which the majority of the facilities are covered under or an individual permit. The general permit is issued once every five years and facilities apply for coverage under the permit. An individual permit must be public noticed for comments and is specific to an individual facility. An individual permit is required if the facility is discharging water from their washing process to surface water.

Environmental Assessment review is done by the local unit of government. The MPCA reviews their documents and submits comments. There are two types of environmental review; an Environmental Assessment Worksheet (EAW) and an Environmental Impact Statement (EIS). The EAW is required for facilities that are greater than 40 acres. The EAW is a worksheet that looks comprehensively at all the areas where the facility could have an environmental impact. The function of the EAW is to decide if an EIS is needed. The EIS is required for facilities that are greater than 160 acres. This is a very detailed study which goes through a public scoping process to decide what needs to be studied. The EIS has various opportunities for public input and generally takes a year plus to complete.

To assure compliance at all the different processes of the silica sand mining industry where the MPCA has regulations and/or permits enforcement tools are used. The goal is always environmental compliance. Compliance determinations are made as the result of a compliance, inspections, or review of permit data that has been submitted. Enforcement responses take into account the extent of the non-compliance. There are approximately 20 different enforcement tools that are used starting from informal warnings to negotiated settlements.
Penalties can be up to $10,000 per day per violations and include orders requiring the discharge or emission to be ceased.

Wendy Turri is currently Statewide Wastewater Program Manager, as well as Rochester Regional Office Manager, for the Minnesota Pollution Control Agency. She has a BS degree in chemistry, has worked five years for the City of Rochester at their Water Reclamation Plant in the lab and as the pre-treatment coordinator, and has worked the last 25 years at the Minnesota Pollution Control Agency in various positions, primarily in the area of wastewater.
Environmental Regulations for Silica Sand Mining

Wendy Turri
Manager
Municipal Wastewater

Frac Sand Basics

Relative Sizes

US Sieve Size 20, largest frac sand size
US Sieve Size 40, desirable frac sand size
PM2.5
PM10
Human Hair
US Sieve Size 20
US Sieve Size 140
Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement

Process Flow

1. Blast
2. Excavate
3. Crush
4. Sort
5. Dry
6. Wash
7. Store
8. Transport to End Use

Permit Types

- **Registration Permit** – Rules have been written and Frac sand facility applies for coverage.
  - No dryer and < 50 tons/year of particulate.

- **General Permit** – Permit has been adopted and Frac sand facility applies for coverage.
  - No dryers and < 90 tons/year of particulate matter.
  - Most of the Frac sand facilities will fall under this one

- **Individual Permit** – Site specific, must have if using a dryer.
  - Requires 30 day public notice permit
Permit Reporting Requirement
(These apply to all permit types)

- Annual
  - Compliance Certification
  - Annual Emission Inventory
- Semi-annual
  - Deviation Reporting
- Monthly
  - Emission Calculations
- "Daily"
  - Control Equipment Parameter Checks
  - Fuel Usage Logs
  - Throughput Data

Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement

Process Flow

1. Blast
2. Excavate
3. Crush
4. Sort
5. Dry
6. Wash
7. Store
8. Transport to End Use
9. End Use
Common Pollutants from Non-Metallic Mining Facilities

- Suspended solids
- Turbidity
- pH
- Chemical additives (as approved by MPCA)
- Heat

Water Quality Permits

- NPDES Permits — Regulating Pollutant Discharges to Surface Waters
  - Technology Based Effluent Limits (TBELs)
    - Level playing field
  - Water Quality Based Effluent Limits (WQBELs)
    - Protect designated uses
  - Limits for Frac Sand facilities
    - Solids, pH, flow, oil and grease, additives

Wastewater NPDES/SDS Permits: General vs. Individual

- General: Majority
  - Permit has already passed through public notice – no additional notice required
  - Covers multiple sites under common ownership and similar environmental impacts
  - Only allows stormwater and dewatering discharges to surface water

- Individual
  - Requires 30-day public notice
  - Requires comprehensive analysis of activities and potential environmental impacts
MPCA Chemical/ Additive Review Process

- Permittees shall receive written approval from the MPCA before using or increasing usage of chemical additive.
- Chemical additive will undergo a MPCA review to determine impact to surface waters.
- MPCA is comparing the concentration of chemicals in the addition to State and Federal drinking water criteria to determine impact on groundwater.

Polyacrylamide

- Used by facilities that clean or process sand as a flocculent to remove unwanted minerals and fines from sand or used to enhance the settling of solids in a clarifier or pond.
- Acrylamide is water soluble, non-volatile, and biodegradable.
- The estimated half-life of acrylamide is between 21 and 36 hours.
- We continue to evaluate the risks associated with polyacrylamide.

Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement
Environmental Review

- Environmental Assessment Worksheet (EAW)
  - Greater than **40 acres**; average depth at least **10 ft**
  - Lower for forested or naturally vegetated land in shoreland areas

- Environmental Impact Statement (EIS)
  - Greater than **160 acres**; average depth at least **10 ft**
  - Also lower in shoreland areas

- The Local Unit of Government is the regulating authority

Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
  - **Enforcement**

Compliance Determination

- Complaints – follow up on all complaints
- Annual, quarterly, monthly reports
- Inspections
Air Enforcement Considerations

- Permit level
  - Registration permits or Title V Air Permits
  - Proper permit level is critical to limits, control technologies, operational controls, fugitive and dust controls, measures, and reports required.
- Knowing and obtaining the proper permit is the responsibility of the regulated party
- These types of violations could result in significant penalties for economic advantages gained over competitors and delays in production while getting the proper permits and approvals.

Air Compliance Concerns

- Look at air measures for compliance such as:
  - Operational limits
  - Surrogate measures of proper control technology like baghouse pressure readings
  - General particulate matter, dust, control and proper wetting measures of roads and piles
  - Submittals and such things as Semi-Annual Reports or deviation reports on any malfunctioning or downtime of equipment.

Water Compliance Concerns

- Proper permit coverage
- Run off and stormwater controls
- Avoiding discharge of cleaning water or other treatment water
- Meeting limits accepted in a permit or in a rule
- Being aware that with limits or not, discharges are not to cause pollution or nuisance conditions to waters of the state, e.g. turbidity, high strength discharges.
Enforcement Actions

- Enforcement response takes into account extent/severity of non-compliance, including:
  - Environmental harm
  - Economic benefit of non-compliance
  - First time vs. repeat offense
  - Speed with which the offense is corrected

- Approximately 20 different enforcement tools:
  - Monetary penalties
  - Stipulation Agreement
  - Supplemental Environmental Project

Enforcement Process

- Generally less serious violations result in warnings first with corrective actions and a documented return to compliance
- Serious or repeat violations or economic advantages may result in penalties
- Penalties can be up to $10,000 per day per violation and include orders requiring the discharge or emission to be ceased.
- Corrective actions will be required and can be costly.
Local Land Use Regulations in Minnesota

Lisa Hanni, Land Use Management Director and County Recorder, Goodhue County, MN

In Minnesota, with few exceptions, land use permitting is performed at the local level. There can be many steps, multiple tracks, and depending on your view of an issue either too much - or not enough - public participation.

This presentation will review the basics of land use regulation in Minnesota and give an example of the public process of silica sand regulation in Goodhue County.

Lisa Hanni has a Master’s Degree in Public Administration and has worked in the Land Surveying and GIS disciplines since 1985. She is a licensed Land Surveyor in the State of Minnesota and currently chairs the State licensing board of Architects, Engineers, Land Surveyors, Landscape Architects, Geologists, and Interior Designers. She is active in writing and reviewing State and National surveying exams and legislative policies.

She has worked for private surveying firms in Maryland, Illinois, and Minnesota, and has been in county government since 1992. In 1998 Ms. Hanni became the Goodhue County Surveyor, and in 2002 was appointed the Land Use Management Director for the County. As Director, she oversees the building, zoning, planning, and environmental health offices and is involved in the writing and enforcing of ordinances. Ms. Hanni is also the Goodhue County Recorder and the Dodge County Surveyor.
Comprehensive planning is the process that a community uses to determine its goals and aspirations in terms of future development. Geographically, Comprehensive planning typically covers the extents of the whole community and are developed for the long-term purposes.

Comprehensive Plan:
A Comprehensive Plan is the document that is produced by the community that is meant to articulate the goals and values that the community envisions for future land use. It typically outlines housing, transportation, preservation of certain features or characteristics, and land uses. It is the basis of the community’s official controls (zoning).

Statutory Authority
In Minnesota:
- Counties receive their authority to plan, develop, and zone by MS 394
- Cities receive their authority to plan, develop, and zone by MS 462
- Townships receive their authority to plan, develop, and zone by MS 366

Potential to have dual zoning tracks: County and Township

MS 394.33:
“...no town shall enact or enforce official controls inconsistent with or less restrictive than the standards prescribed in the official controls adopted by the board...” (referring to the County Board)
Zoning Ordinances

Zoning ordinances are the details of the Comprehensive Plan. They define a number of details such as:

- Permitted uses
- Building heights, sizes, and setbacks
- Minimum lot sizes
- Business hours of operation
- Use setbacks and screening

Part of a Zoning Ordinance is the establishment of Districts that separate one set of land uses from another.
Goodhue County’s Zoning Ordinance:

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   1.1 Scope of the Zoning Ordinance, Inc.
   1.2 Purpose of the Ordinance
   1.3 Goodhue County Soil Conservation District
   1.4 Declaration of Local Authority
   1.5 Restrictions on Use of Land
   1.6 Location and Zoning
   1.7 Limitations on Use of Land
   1.8 Development Standards
   1.9 Performance Standards
   2. Performance Standards
   3. Zoning Districts
   4. Subdivision of Land
   5. Subdivision of Land
   6. Subdivision of Land
   7. Subdivision of Land
   8. Subdivision of Land

Goodhue County’s Zoning Districts:

Permitted Uses:

These are uses that are deemed permitted and are typically approved administratively.

SECTION 2. PERMITTED USES

Subd. 1. Single family dwellings.

Subd. 2. A second farm dwelling.

Subd. 3. Any agriculture operation including tree farms.

Subd. 4. Direct marketing of produce in a Farm Market/On-Farm Market/Roadside Stand in a retail structure not to exceed 2400 square feet in area.

Subd. 5. Any mining, quarrying, excavating, or filling of land subject to the standards of Article 14 of this Ordinance.

Subd. 6. Plant nurseries and sales.

Subd. 7. Home occupations as regulated in Article 11 of this Ordinance.

Subd. 8. Wind Energy Conversion Systems in accordance with Article 18 of this Ordinance.

Subd. 9. Farm Wineries including Tasting Rooms in buildings up to 10,000 square feet subject to approval of a zoning permit by the Zoning Administrator (see Article 11, Section 28).
SECTION 3. CONDITIONAL USES AND INTERIM USES

In the A-2, Agriculture District, the following uses may be allowed subject to obtaining a conditional use permit in accordance with the provisions of Article 4 of this Ordinance.

Subd. 1. A mobile home as a temporary second dwelling when there is a need to provide health care services to residents of one of the dwellings.

Subd. 2. Any aircraft landing field and associated facilities.

Subd. 3. Any commercial outdoor recreation facilities including, but not limited to, golf courses, driving ranges, tennis courts, swimming pools, and park facilities.

Subd. 4. Any community building, church, cemetery or memorial garden.

Subd. 5. Any commercial radio and television towers and transmitters.

Subd. 6. Any public, private or nursery school.

Subd. 7. Any public stable.

Subd. 8. Any raising of fur bearing animals or commercial kennel.

Subd. 9. Commercial and industrial uses primarily intended to serve the agricultural community.

Subd. 10. Any boarding and rooming houses or bed & breakfast inn.

Subd. 11. Campground and RV site.

Subd. 12. Park manager's residence limited to one single family unit per any licensed campground or RV site regulated, consisting of thirty (30) or more campsites.

Subd. 13. Any veterinary clinics.


Subd. 15. Any migratory labor camp.

Subd. 16. Any park or recreational area operated by a governmental agency.

Subd. 17. Hunting club or shooting preserve.

Subd. 18. Temporary or seasonal off-site roadside produce stands. No more than two (2) signs totaling fifty (50) square feet of sign area advertising the stand shall be permitted. In addition, the structure shall be limited to not exceed 2,000 square feet.

Subd. 19. Educational Farm Retreat.

Subd. 20. Retreat Centers.

Subd. 21. Wind Energy Conversion Systems as per Article 18 of this Ordinance.

Subd. 22. Non-Agricultural uses/activities associated with an agri-tourism (as defined in Article 10).

Subd. 23. Direct marketing of produce in a Farm Market/On-Farm Market/Roadside Stand in a retail structure that exceeds 2,400 square feet (see Article 11, Section 29).

Subd. 24. Farm Wineries including Tasting Rooms in buildings exceeding 10,000 square feet subject to approval of a zoning permit by the Zoning Administrator (see Article 11, Section 28).

Permitted / Conditionally Permitted

Mining Permitted in: (*Mining Article 14 requires all regulated mining facilities to obtain a CUP)

A1 Agricultural Protection District
A2 Agricultural District
Any mining, quarrying, excavating, or filling of land subject to the standards of Article 14 of this Ordinance.

Mining Conditionally Permitted in:

A3 Urban Fringe District
Any mining, excavating or filling of land subject to any of the above (listed in A3) conditional uses when located on the same property.

Public Hearings

Public Hearings are required for:
• Ordinance adoption, amendments (Including Interim Ordinances)
• Conditional Use Permits
• Interim Use Permits
• Variances
• Subdivision proposals

Public Hearings must be:
• Noticed 10 days prior to the meeting in the Official Newspaper
• Written notice to property owners within 500 feet, ¼ mile, or ½ mile depending on the request
• Written notice to affected Town Board and City Council within 2 miles of request
Hanni

60 Day Rule

MS 15.99 Time Deadline For Agency Action

Subd. 2. Deadline for response.
(a) Except as otherwise provided in this section, section 462.358, subdivision 3b, or 473.175, or chapter 505, and notwithstanding any other law to the contrary, an agency must approve or deny within 60 days a written request relating to zoning applications, watershed district review, soil and water conservation district review, or expansion of the metropolitan urban service area for a permit, license, or other governmental approval of an action. Failure of an agency to deny a request within 60 days is approval of the request. If an agency denies the request, it must state in writing the reasons for the denial at the time that it denies the request.

Subd. 3. Application; extensions.
(a) The time limit in subdivision 2 begins upon the agency's receipt of a written request containing all information required by law or by a previously adopted rule, ordinance, or policy of the agency, including the applicable application fee. If an agency receives a written request that does not contain all required information, the 60-day limit starts over only if the agency sends written notice within 15 business days of receipt of the request telling the requester what information is missing.

- Complete application – including application fees
- 15 days to review application for completeness

PAC 2013

10 day Newspaper notice
Planning Commission Public Hearing Recommendation to County Board
County Board meeting (Public Hearing) Decision
Moratoriums:

MS 394.34 INTERIM ZONING.

If a county is conducting or in good faith intends to conduct studies within a reasonable time, or has held or is holding a hearing for the purpose of considering a comprehensive plan or official controls or an amendment, extension, or addition to either, or in the event new territory for which no zoning may have been adopted, may be annexed to a municipality, the board in order to protect the public health, safety, and general welfare may adopt as an emergency measure a temporary interim zoning map or temporary interim zoning ordinance; the purpose of which shall be to classify and regulate uses and related matters as constitutes the emergency. Such interim resolution shall be limited to one year from the date it becomes effective and to one year to renewal thereafter.

Goodhue County Mining Study Committee

Purchase of Property:
2 parcels totaling 155 acres purchased at a price of $15,944 - $17,851/acre
1 parcel adjacent to rail and river
Noted on the CRV that possible use for sand mining

Citizen Request for Moratorium:
Request for a one year moratorium on the issuance of any Conditional Use Permit for a new silica/frac sand mining operation within rural Goodhue County

Planning Advisory Commission (PAC):
Held public hearing on June 20, 2011
Voted to deny moratorium request due to the fact the County has a good Mineral Extraction ordinance in place

Goodhue County Mining Study Committee

County Board meeting:
Held public hearing September 6, 2011
Voted to approve moratorium request

Moratorium to Study:
• Air quality
• Water quality & quantity
• Economic & social impacts
• Transportation impacts
• Possible modifications to zoning & comprehensive plan as it pertains to dust control and setbacks
**Goodhue County Mining Study Committee**

**County Board meeting:**
Appointed Mining Study Committee (MSC) October 4, 2011

- 9 members
  - 5 public members (by Commissioner District)
  - 2 mining experts
  - 2 PAC members

**Goodhue County Mining Study Committee**

**Mining Study Committee (MSC):**  Met monthly

- Discussed charge, basic planning and zoning process
- Went to Menominee for mining site visit
- Distribute studies and reports
- Prepared and posted Request for Proposal for professional services
- Invited experts: Tony Runkel, Jeff Green and Scot Johnson, Wendi Turri, Jeff Hedman, County Assessors

*The public attended every meeting except the site visit*

**Goodhue County Mining Study Committee**

**Mining Study Committee (MSC):**

Professional Services:

1. Document existing mines; compare/contrast existing operations with a silica sand operation; describe chemicals used in processing

2. Outline federal and state regulations and compare them to Goodhue County’s ordinance; propose best practices for blasting, noise, material processing and washing; outline typical transportation needs

3. Describe land reclamation plans, reclamation costs, financial assurances for open pit, underground, and contour mining operations
Report Highlights:

- Written discussion of the issues brought up by the moratorium request
- Written discussion of other items brought up through the study:
  - MTEP
  - Noise concerns
  - BP, DA, Traffic Studies
  - Zoning designation
  - CUP vs. IUP
  - Township Approvals
- Provides a brief background on the MSC review
- Outlines suggested ordinance changes

Main Ordinance Changes:

- Added additional definitions
- Added option for intensive use permits
- Added more information on the application process:
  - Map A: Existing conditions—Geology, Hydrology
  - Map B: Proposed operations—operative protection, location of fuel storage and retention ponds
  - Map C: Reclamation plans—pped, erosion control, and stabilization
- IF a site proposes mining as a de facto operation, it must be submitted
- IF a site mines below the water table, dewater the site, and drains in the mining or ponding, or is within 600' of any springs, it must have a water monitoring plan and monitor the water continually
- A facility has to have screening measures to mitigate visual impacts from existing historic, cultural, and architectural features such as trails, landscapes, and dwellings.
- The County may increase setbacks based on residential location, social or economic concerns, type of mining, or to mitigate public nuisance
- The facility must provide a Road Impact Study, Road Agreement, and/or Development Agreement
- The facility must provide a Noise Impacts Study and a Mining Technical Evaluation Panel review
Goodhue County Mining Study Committee

Report Highlights:

- Existing assessment:
  - 12 of the existing mines have Jordan Sandstone beneath the mine floor
  - 30% report using water for washing and dust suppression
  - 40% blast
  - Truck traffic ranges from 3-150/day

- Existing regulation:
  - Federal
  - State
  - Local

- Environmental Impacts

- Reclamation Issues

End of Story???

July 16 & 30, 2012 PAC Public Hearing and Meetings

- Approve all ordinance proposals (with minor additions)
- Extend moratorium for another year

August 16, 2012 County Board Public Hearing

- Approve all PAC ordinance proposals + change setbacks to dwellings from 300 feet to 1000 feet
- Extend moratorium for another year
- Add another member to the MSC (environmentalist)
- Study 18 more items

WHEREAS, The County Board recognizes a need for additional study in the following areas:
1. Relationship between economic and recreational value
2. Explore statewide study with the legislature
3. Existing mines not grandfathered
4. Pros/Cons of banning silica sand mining
5. Hours of operation
6. Setbacks to dwellings and sensitive features
7. Quantity limits on mining
8. High, medium and low impact mining classification
9. Meeting with Township Officials
10. How to evaluate silica sand differently, based on intensity and size, and create a definition and specific rules for it
11. Disenfranchisement of the landowners who currently own this resource
12. Land reclamation
13. Defining best practices
14. Emergency fund
15. Comprehensive Plan and silica sand
16. More definition for the reclamation funds (how to estimate, provide a three year projected amount)
17. Explore production tax or other revenue-capture financial options
18. Evaluate if there are areas that would be inappropriate for mining

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Economic Analysis of Industrial Sand Operations
Economic Benefits and Costs to State and Local Communities

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An economic analysis of industrial sand operations in Minnesota and Wisconsin included a review of economic benefits and cost to state and local communities based on available resources and interviews. The economic benefits of industrial sand mining and processing operations are quantifiable, can be calculated and verified, and are widely documented by state and local agencies. The economic benefits stem from jobs at the mining operations and at numerous affected job sectors including: professional geologists, engineers, scientists, finance, legal and real estate; food, beverage and accommodations; construction trades; transportation; other manufacturing; etc. Jobs result in taxes, salaries, and benefits that echo through the economy as Direct, Induced and Indirect Impacts; and ripple further through employment multipliers. Economic costs to state and local communities are generally not quantifiable, are not studied and reported, or are not a serious consequence of industrial sand mining and processing operations in Minnesota and Wisconsin. The majority of economic costs that affect local communities are caused by local mining opposition groups, not by the mining operations. The majority of references to costs associated with industrial sand mining and processing operations are not economic, but are intangible, not directly measurable, and unverifiable. The cost to the environment, public health and safety, traffic, quality of life, tourism and real estate are often cited and asserted as fact, but without substantiating data and supporting technical justification. The available literature shows that the economic benefits to industrial sand operations are real and positive and greatly outweigh any actual or perceived cost to state or local communities.

Mark Krumenacher is a Principal and Senior Vice President of GZA GeoEnvironmental, Inc. and is based in Waukesha, Wisconsin. Mark has served as Principal, Project Manager and Project Hydrogeologist during the past 25 years with GZA on environmental, geologic, hydrogeologic and engineering projects throughout North America. He is a Professional Geologist with licensure nationally and in several states and is a Certified Hazardous Materials Manager. He has managed and conducted geologic, hydrogeologic and, engineering studies, remedial investigations, environmental assessments, pre-acquisition environmental due diligence and hazardous waste management at various properties including surface and underground mines, large industrial, commercial and urban redevelopment projects, Federal Superfund sites and state-lead environmental projects. He has provided testimony in support of aggregate and industrial mineral mining before municipal, Township and County units of government as well as NGOs, local environmental groups and Community Advisory Council to help address concerns of residents.
Mark is actively involved with the several mining associations; including the National Industrial Sand Association, Industrial Minerals Association-North America, National Stone Sand and Gravel Association, Illinois Association of Aggregate Producers, and Society for Mining Metallurgy and Exploration.
Economic Analysis of Silica Sand Resources

Economic Benefits and Costs to State and Local Communities

Mark J. Krumenacher, PG, CPG
Principal/Senior Vice President
GZA GeoEnvironmental, Inc.

Introduction

Focus
- Economic Benefit
- Economic Cost vs. Non Economic Cost
- To State and Local Communities

Not:
- Value of Sand
- Long Term Forecast of Industrial Sand Mining
- Benefits or Costs of End Use
Economic Analysis of Silica Sand Resources

• Research – Studies, Reports, Papers, Internet
  - National and Regional
  - State Agencies - MN and WI
  - County and Local Studies and Interviews
  - Websites

Economic Analysis of Silica Sand Resources

• Research
  - National / Regional
    - W.E. Upjohn Institute for Employment Research
    - Workforce Connections, Inc.
    - Center for Spatial Economics
    - Economic Modeling Specialists
    - Federal Reserve Bank of Minnesota
    - Mississippi River Parkway Commission
    - Wisconsin Center for Investigative Journalism

Economic Analysis of Silica Sand Resources

• Research
  - Minnesota
    - Environmental Quality Board (EQB)
    - Department of Natural Resources (MDNR)
    - Geological Survey (MGS)
    - Pollution Control Agency (MPCA)
    - Department of Health (MDH)
    - Department of Transportation (MDOT)
Economic Analysis of Silica Sand Resources

- Research
  - Wisconsin
    - Natural Resources Board (NRB)
    - Department of Natural Resources (WDNR)
    - Geological and Natural History Survey (WGNHS)
    - Department of Health Services (WDHS)
    - Department of Transportation (WDOT)
    - Department of Workforce Development (DWD)
  - University of Wisconsin Extension (UWEX)
- University of Wisconsin – Madison, Stevens Point

County Studies and Interviews
- Buffalo
- Chippewa
- Goodhue
- La Crosse
- Monroe
- Pierce
- Trempealeau
- Winona

Websites
- Save the Bluffs
- Save the Hills
- Hale No to Frac
- Maiden Rock CC
- Everything Red Wing
- The Price of Sand
- Environment Minn.
- Monroe County …
- Concerned Dovre …
- Great River Road …
- Hay River Frac …
- Tunnel City …
- Frac Sand – Winona …
- Countless Newspaper Articles and Letters

Economic Analysis of Silica Sand Resources
Economic Analysis of Silica Sand Resources

- Overview
  - Economic Benefits
    - Calculated - Quantifiable
  - Economic Costs
    - Estimated - Somewhat Quantifiable
  - Non Economic Costs
    - Quantifiable - Not in Dollars
    - Assumed - Not Quantifiable

Economic Analysis of Silica Sand Resources

- Economic Benefits
  - Widely Studied
    - State and Local
  - Can be Calculated
  - Can be Verified
  - Based on Fact

Economic Analysis of Silica Sand Resources

- Economic Benefits
  - Jobs
  - Confusion???
Economic Analysis of Silica Sand Resources

- Economic Benefits
  - Jobs – Mining
    - Mining Operations
    - Processing Operations
    - Transportation
  - Jobs – Non Mining
    - Construction – Plants, Roads, Railroads
    - Transportation – Truck, Rail
    - Finance, Insurance, IT, Real Estate, Legal
    - Professional – Geologists, Engineers, Scientists
    - Education, Health Care, Arts
    - Accommodations, Food, Beverage
    - Retail – Convenience, Gas, Hardware, Clothing

- Salary and Spending of Mine Employees
  - Direct Impact
  - Induced Impact
  - Employment Multiplier
  - Indirect Impact
Economic Analysis of Silica Sand Resources

- Economic Benefits
  - Taxes
  - Income
  - Property
  - Sales
  - Lodging
  - Fuel

- Economic Benefits - Other
  - Wealth Effect
  - Land Sales
  - Leases
  - Royalties
  - Mine Company Philanthropy

- Railroad Revitalization - MN & WI
  - Burlington Northern - $100MM
  - Progressive Rail - $30 - $50MM
  - Canadian National - $35MM
  - Canadian Pacific - $300MM

- Enhances Other Industries
Economic Analysis of Silica Sand Resources

- **Economic Benefits**
  - “Boom or Bust”
    - Applies to Some Operations
  - “Flickering Effect”
    - Applies to All Industries

- **Economic Costs**
  - $Spent by State and Local Communities
    - No Data in Research
    - Not Well Documented
    - May be Negligible
    - Typically Falls Under Role of Government

- **State Level**
  - State Reviews – Permitting
  - Special Studies
  - Transportation Infrastructure – Applicable??

No Quantifiable Cost to MN or WI Residents
Economic Analysis of Silica Sand Resources

- Economic Costs
  - Local Level
    - Permitting Process
    - Moratoriums
    - Bans – Lost Opportunities for Economic Benefits
    - Lawsuits
      - Citizen Groups Against Government
      - Mining Companies Against Government

- Non Economic Costs
  - Divisiveness
    - Agitated by Few
    - Driven by ????
    - Dominated by Misinformation
    - Feeds Off Fear Mongering
    - Absolutely Not Necessary

- Cited in Press and Activist Websites
- Not Cited by Regulators & Scientific Community
- Assumptions and Allegations Asserted as Facts
- Not Supported by Facts or Technical Justification
Economic Analysis of Silica Sand Resources

- Non Economic Costs
  - Real Estate Values
    - Most Studies Cited in Background
    - Not Applicable to MN and WI Sand Industry
    - Did Not Apply to Mines
    - None Found That Document Decreased Values

Economic Analysis of Silica Sand Resources

- Non Economic Costs
  - Real Estate Values
    - Pierce County Study, WI Certified Appraisers (Jan 15, 2011)
    - Winona County Planning Department (Nov 10, 2011)

Economic Analysis of Silica Sand Resources

- Non Economic Costs
  - Property Values
    - Goodhue County Mining Study Committee (July 2012)
    - Federal Reserve Bank of Minnesota (July 2012)
      - As a rule, mining activity raises residential property values by increasing average household income; people can afford more expensive housing.
Economic Analysis of Silica Sand Resources

- Conclusions
  - The Economic Benefits are Verifiable and Quantifiable
  - The Economic Costs – Almost Always Caused by Anti-Mining Groups
  - The Non Economic Costs are Assumed and Not Substantiate by Facts or Technical Data
Tuesday Night Banquet Speaker – Anders Helquist

Talk Title: Political and Regulatory Climate for Silica Sand Mines - A Legal Perspective

Anders Helquist is lawyer for Weld, Riley, Prenn & Ricci, S.C. in Eau Claire, Wisconsin and is a member of the firm’s Frac Sand, Mining and Minerals, Administrative, and Government Relations sections.

Anders serves as local counsel to entities such as EOG Resources, Smart Sand, Inc., and Hi-Crush Proppants. He provides guidance to those and other industrial frac sand entities seeking to establish nonmetallic mines in Wisconsin. Anders utilizes his experience in regulatory matters and government affairs to represent the frac sand industry in permitting, moratorium mitigation, and contract matters. He works cooperatively with the Wisconsin DNR to obtain all necessary air permits and wetland or other waterway permits, with local governments to obtain conditional use permits, rezonings, reclamation plans and other approvals, and with applicable federal agencies (e.g., MSHA and the U.S. Army Corps of Engineers).

His experience also includes negotiating, drafting, and obtaining developer’s and road haul agreements on behalf of frac sand entities. Additionally, Anders provides counsel to local governmental units. He combines his knowledge of municipal law and experience in labor and employment law to provide those governmental entities with comprehensive legal advice. Anders is also the attorney for the Village of Somerset and other municipalities throughout western Wisconsin.

He is a graduate of Taylor University in Upland, Indiana (B.A., magna cum laude) and the Drake University School of Law (J.D., high honors, Order of the Coif), where he was an Articles Editor for the Drake Law Review. Prior to joining the firm, Anders spent a law school semester in Drake’s Judicial Honors Program, serving as an intern for the Honorable Federal Magistrate Judge Ross A. Walters in the Southern District of Iowa.