Aggregate Resource Evaluation of a School-Trust Parcel Southeast of Big Fork in Itasca County, MN

Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director

Project 334-13
June 2001

Aggregate Resource Evaluation of a School-Trust Parcel Southeast of Big Fork in Itasca County, MN

Glenn D. Melchert
June 2001

Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director
500 Lafayette Road
St. Paul, MN 55155-4045

Project 334-13

Table of Contents

Acknowledgments

This report is the culmination of cooperative efforts by numerous individuals. Special recognition goes to Paul Dubuque who showed initiative in soliciting advice so that he could wisely manage the aggregate resource at this site. Paul Dubuque and Craig Anderson (DNR Forestry) showed the site. Tim Wotzka of the Itasca County survey crew provided information on the property corners for the east line. Richard Aho and Tom Negaard (survey crew) and Lowell Pommerening (DNR Engineering) surveyed the drill holes. Several individuals from DNR Division of Lands and Minerals (LAM) played key roles in the field work and sample processing. They include Mike Ellett (Giddings probe operator and cat work), Ricco Riihiluoma (cat work, drilling operator, and sample processing), and Doug Rosnau (backhoe work). Tom Anderson (LAM) did a fine job of coordinating last-minute equipment needs in a timely basis. Dan Steinbrink willingly answered my many questions about the Techbase computer program. Pete Clevenstine and Jon Ellingson provided assistance with mine planning and graphics.

Executive Summary

This report summarizes the results of an aggregate evaluation of approximately 23 acres of state school trust fund land. The site is managed by DNR Forestry (Effie Area office) and is located in the SE quarter, NE quarter, section 36, T. 60 N., R. 25W (Unorganized Township), Itasca County, Minnesota. It is accessed from County Road 341.

DNR Forestry has had requests recently from aggregate producers desiring to lease this property for aggregate production needed for public road projects. Forestry personnel wanted to know the extent, quantity, and quality of the gravel before granting a lease. DNR Forestry requested an aggregate evaluation from DNR Lands and Minerals so that Forestry would have the information they need to manage the land in the best way possible.

Field work began on October 9, 2000 with one day of reconnaissance drilling with the Giddings Probe. Then four days of drilling with the MnDOT rig were completed. Drilling was difficult because numerous cobbles and boulders in the upper part of the gravel severely inhibited drilling. A backhoe was used one day to assist in the evaluation. Eleven holes were completed that were at least 9 feet deep. Results from the evaluation are summarized below.

- the entire site appears to contain gravel
- overburden consists of slightly silty sand and ranges in thickness from 0 to 5.5 feet
- except for the south western half of the deposit, all of the gravel occurs above the water table. The water table is deeper than 50 feet at the top of the hill and less than 10 feet at the base of the hill nearer the lakes and swamps. Five drill holes encountered the water table at an elevation ranging from 1380 to1384 feet.
- allowing for setbacks, the area that can be potentially mined covers 12.6 acres
- within the 12.6 acres is a gravel resource of around 600,000 cubic yards
- if the gravel is mined so that the pit walls do not exceed 3:1 slopes, then the mineable gravel is about 475,000 yards
- the entire gravel deposit averages about 29 feet thick (range 24 to 33 feet thick)
- the top 12 feet (average) of gravel is very rocky relative to the gravel immediately below

Gravel A

- about 250,000 cubic yards (in place) mineable
- quality is excellent. This material meets MnDOT's criteria for deleterious particles in bituminous and concrete–deleterious particles are absent or in trace amounts
- average gravel content is 56% (range 71 to 37%)
- average thickness is 12 feet (range 8 to 22 feet)
- the bottom of this layer grades into gravel B

Gravel B

- about 225,000 yards (in place) mineable

- the quality appears very good. This material likely meets MnDOT's criteria for deleterious particles in bituminous and concrete–shale was present in trace amounts only
- average gravel content is 30% (range 56 to 5%)
- average thickness is 17 feet (range 9 to 23 feet)
- below this gravel is clean sand except for scattered occurrences of gravelly sand

Recommendations

It is agreed that both gravel layers shall be mined as a single unit. This should minimize waste of the resource and maximize revenue. Mining as a single unit eliminates the potential for high-grading of the better-quality gravel and allows for staged reclamation as parts of the pit are depleted.

Introduction

The site evaluated is state school trust fund land managed by the Minnesota Department of Natural Resources Division of Forestry (DNR Forestry) in Region 2. DNR Forestry (Effie Area) was approached by contractors desiring to lease the property for gravel. DNR Forestry was concerned whether there was sufficient aggregate for the needs of the contractor as well as providing material for DNR's future needs. DNR Forestry requested that DNR Division of Lands and Minerals conduct an aggregate resource evaluation of the property.

The specific area evaluated covers about 23 acres in the SE quarter, NE quarter, Section 36, T. 60N., R. 25W, in northern Itasca County, MN (Figure 1). A forest road leads from the site less than one-half mile to County Road 341 (gravel). The county road leads about one-half mile to County Road 7 (paved, Figure 2). The nearest municipality is Big Fork about 15 miles away.

__Purpose__ – The site was evaluated to determine the extent, quantity, and quality of the gravel. With this information, strategies to optimize use of the resource in the interest of the school trust are proposed and to outline a mine plan. The anticipated use of this gravel is for future public road projects and DNR Forestry's needs.

__Dates of field work__ – October 9-12, 23, 2000. Follow up GPS work was done on December 18, 2000.

Geologic Setting

The part of the state where the evaluation site occurs has undergone a rather complex and poorly understood glacial history. This is an area where sediments of glaciers from the northwest (Koochiching sublobe of the Des Moines Lobe) and glaciers from the north or northeast (Rainy Lobe) overlap. Glacial sediments from the Des Moines lobe contain a substantial proportion of limestone. Sediments derived from the Rainy lobe contain no limestone unless the ice incorporated pre-existing deposits of the Des Moines lobe that were in its path. No limestone was found in the gravel at this site which indicates this gravel is derived from a Rainy Lobe glacier.

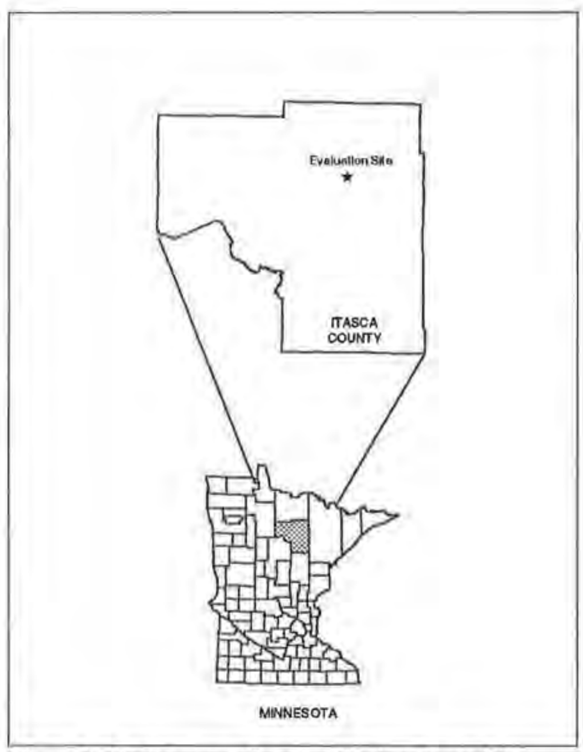


Figure 1. Index map showing the location of the evaluation site.

The distribution of the gravel and topography of the land indicate this is an ice-contact feature. As the ice melted, flowing water transported the gravel that filled in a crack or low spot in the

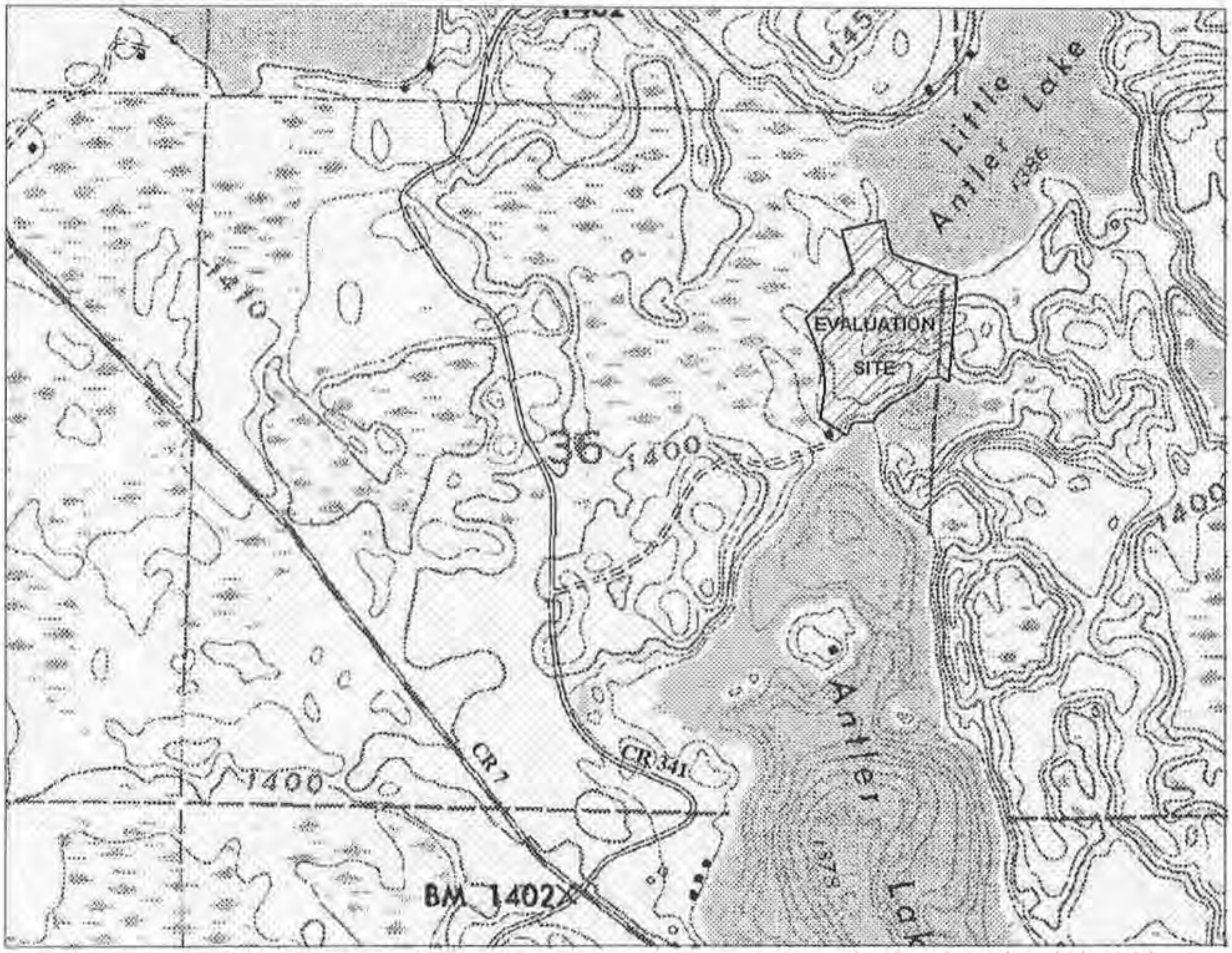


Figure 2. A portion of the Anderson Lake Quadrangle showing access to the evaluation site. The width of this map represents about 1.5 miles.

glacier. After the ice completely melted, a hill of gravel remained.

Methods

Map interpretation – Air photos (NAPP 3045-26 to 27 flown 5/17/91), U. S. Geological Survey (USGS) Quadrangle maps (Anderson Lake, MN), and digital orthophotos (DOQ's) were analyzed for geological interpretations and the identification of features and landforms in the study site. This site is in the St. Louis Moraines subsection of the Ecological Classification System (ECS).

Auger drilling – Auger drilling was the method used to determine the distribution, extent (edge), quality, and geology of the gravel deposit. First, eleven holes were drilled using the pickup-mounted Giddings Soil probe (Figure 3). Auger sizes used ranged from 6 inch to 2 inch. This machine is relatively mobile and able to go places a larger rig cannot. The primary purpose of the first 11 holes was to determine where gravel is present and where it is absent. Normally the

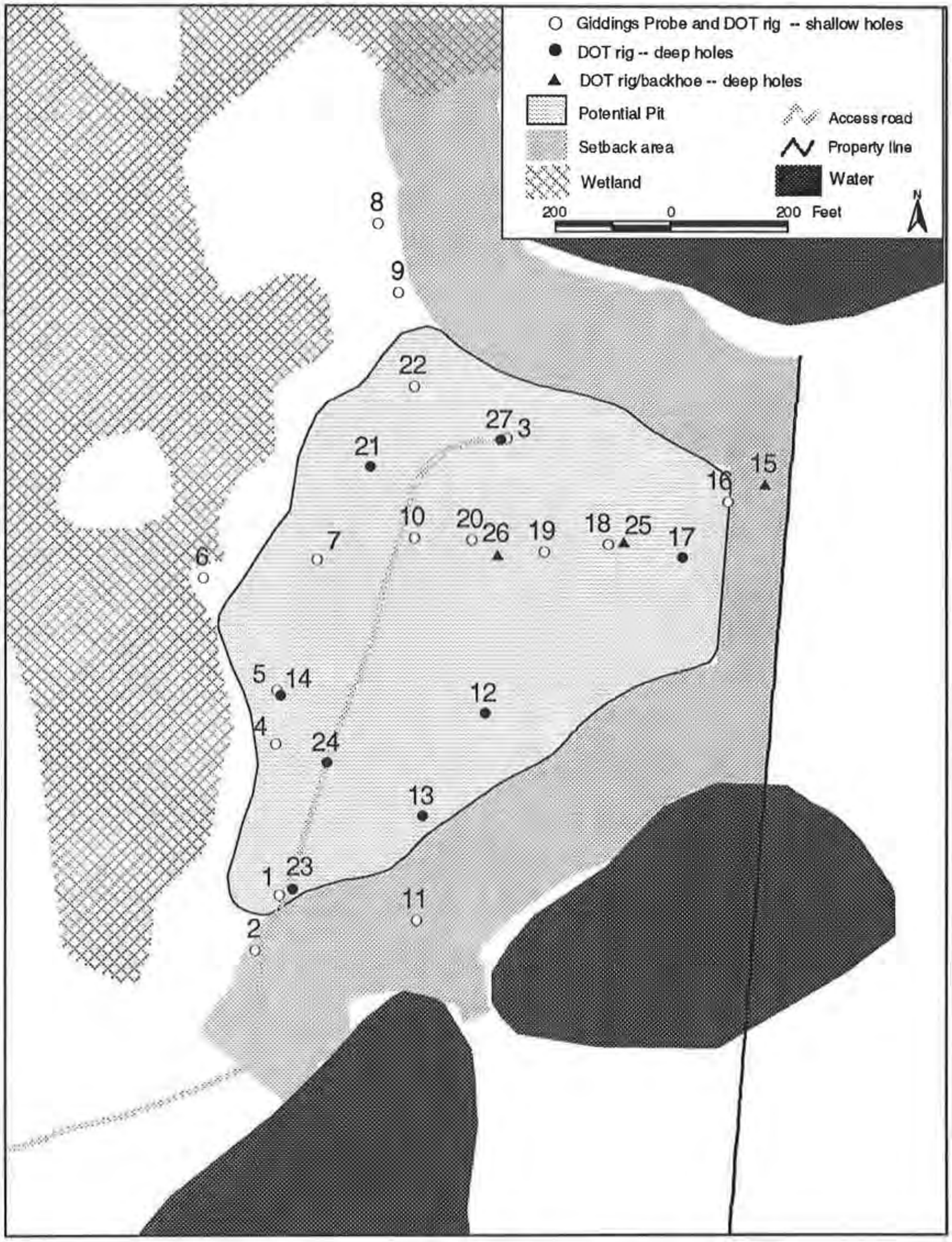


Figure 3. Distribution of drill holes in relation to setback areas and the potential pit. Holes 1 - 11 were drilled with the Giddings Probe. The remaining holes were drilled with the MnDOT rig. The triangles represent MnDOT holes that started with a backhoe hole. The open circles designate holes less than 9 feet deep. Filled circles and triangles represent holes deeper than 9 feet.

Giddings probe has little difficulty drilling 8 to 10 feet. At this site, however, numerous boulders in the upper part of the gravel made drilling very difficult and most of the holes did not reach five feet. Most of these holes, however, were able to penetrate one or two feet into the gravel confirming its presence across the site.

Sixteen holes were drilled with a large Minnesota Department of Transportation (MnDOT) drill truck (Figure 3). This is the same rig MnDOT uses to evaluate their aggregate deposits. This rig uses an auger ten inches in diameter which obtains a representative sample of coarse material in the 1 ½ inch to 3 inch range. Geologic logs were described based on material retrieved with the auger. During drilling the auger typically was retrieved after drilling in 10 foot increments. Samples were then collected off the auger for gradation analyses and quality testing.

Drilling proved difficult for the MnDOT rig too, especially in the northern two-thirds of the site. Boulders that were 1 to 2 feet in diameter, at a depth of 3 to 5 feet, were so plentiful that even after 16 attempts at numerous locations across this area, not a single drill hole reached deeper than 9 feet. Since we had so little information about the character of the gravel (thickness and quality) over a substantial portion of the study area, a new approach was tried.

A backhoe with a telescoping bucket (Ford 555B) was used to dig a trench with a nearly vertical face about 12 feet deep (Figure 4 and 5). Then the MnDOT rig was backed to the end of the trench and drilling commenced at that point. A system of scaffolding (ladders and planks) with sheets of plywood was placed across the trench to create a working platform for personnel to safely drill and sample (Figure 6). Four holes using this method were completed in one long day. Only an occasional boulder was encountered in the 12 to 20 foot range. A couple of times the gravel shook off the auger as it was retrieved from the hole and no sample was collected. This occurred in two of the holes when the auger, as it was being retrieved, scraped and jarred against large cobbles or boulders on the side of the hole. It was possible to retrieve samples from deeper in the hole because the rocks in the upper part of the hole were eventually pushed aside with the additional drilling. The holes drilled using this technique were #15, 25, 26, and 27.

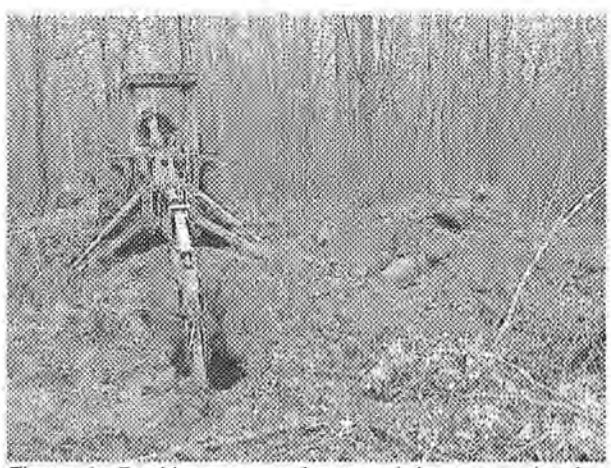


Figure 4. Backhoe excavating trench in preparation for drilling.

Figure 5. Spoil pile from backhoe excavation. Note the numerous relatively large boulders present. Length of shovel handle is 3.25 feet.


Figure 6. Drilling over a trench dug with the backhoe. Plywood covers the trench.

Gradations and quality analysis -- Gravel samples from 11 holes (27 samples total) were sieved for gradation analysis at DNR Lands and Minerals office in Hibbing. The samples were then combined into two composite samples, each representing a different gravel layer and sent to MnDOT's Materials Testing Laboratory in St. Paul and tested for lithology, overall gradations, and deleterious materials such as shale, total spall and iron oxide content. Gradation results were compared to class 5 guidelines. Deleterious materials were compared to bituminous specifications.

GIS -- Personnel from DNR's Engineering Unit located the holes by Real-Time Kinematic GPS (Global Positioning System) methods using a local grid which gave a horizontal and vertical accuracies with errors of less than an inch and less than a foot, respectively. The local grid was adjusted to real coordinates by knowing the coordinates of two of the points. The GPS units used were by Sokkia. Two units were used, one remained stationary and transmitted correction information continuously via radio to the second unit. The second unit (rover) logged the drill holes. The various maps were made in ArcView, Techbase, and Surfer.

Computer modeling – Geologic data collected during drilling and gradation data were entered into a database and modeled with software developed by TECHBASE International. Topography, overburden, gravel layers, and water table were modeled using kriging algorithms to generate gravel volumes above and below the water table, overburden volumes, quality, and ultimate pit topography.

Results

Drilling -- Drilling showed that the gravel covers the entire area. Less than 6 inches of topsoil and up to 5.5 feet of slightly silty fine to medium sand overburden covers the gravel. The vast majority of the deposit has overburden ranging from zero to three feet. The thicker overburden primarily occurs along the southwest margin of the deposit in holes 4, 5, 14, and 23 (Plate 3). Some pebbles and boulders occur in the overburden.

The cross sections in Plate 2 show how the gravel occurs in two layers of variable thickness with one directly lying over the other. The upper layer (gravel A) ranges in thickness from at least 8 to 22 feet (average 12 feet) and contains numerous cobbles and boulders. Note that the minimum thickness of 8 feet is conservative. Boulders prevented us from drilling through the upper gravel in places. The largest boulders observed at the surface and from the backhoe excavations were 2.5 feet in diameter (Figure 5).

The lower layer (gravel B) is sandier and contains less rock and silt than gravel A. Furthermore, nearly all of the rock in gravel B is less than 1 ½ inch in diameter. Gravel B ranges from 9 to 23 feet in thickness (average 17 feet). Gravel B is inconsistent laterally in terms of gravel content. In holes 13 and 26, for example, the gravel content is relatively low in the 14 to 22% range. In another example, hole 24 has sand at 15 to 20 feet, but if the sand is blended with the gravel below, a desirable product can be attained. No large cobbles or boulders were encountered within gravel B.

When both gravel layers are combined, they form a layer of gravel of relatively uniform thickness and quality (Plate 3).

A clean "beach" sand usually occurs abruptly below gravel B. In holes 24, 25, and 27, however, sand with a low quantity of fine gravel occurs instead of the clean sand. In these three holes, this material, called gravel C, ranges in thickness from 13 to 15 feet (average 13.7 feet). These were the only holes where this gravel occurred and a pattern to its distribution was not determined.

The water table is deeper than 50 feet at the top of the hill and less than 10 feet at the base of the hill nearer the lakes and swamps. In the five drill holes where the water table was encountered, it occurred at an elevation ranging from 1380 to1384 feet.

In two holes the water table was encountered at a depth of around 30 feet. In these holes, the four or five feet of sediments straddling the water table were stained a very distinctive deep reddish black color. The sediments below the water table were gray.

Quantity – The area outlined as potentially mineable covers 12.6 acres (Figure 3, Plate 1, 2). There are about 600,000 yards of in-place gravel within the pit margin, assuming vertical pit walls. It is not possible to mine all of that however. If mining occurs so that the pit slopes do not exceed 3:1 (3 horizontal to 1 vertical), then there are about 250,000 and 225,000 yards of gravels A and B, respectively for a total of 475,000 yards (Table 1).

No volumes were calculated for gravel C because of the large potential error in calculating such a volume. The error would be high because the gravel only occurred in isolated holes.

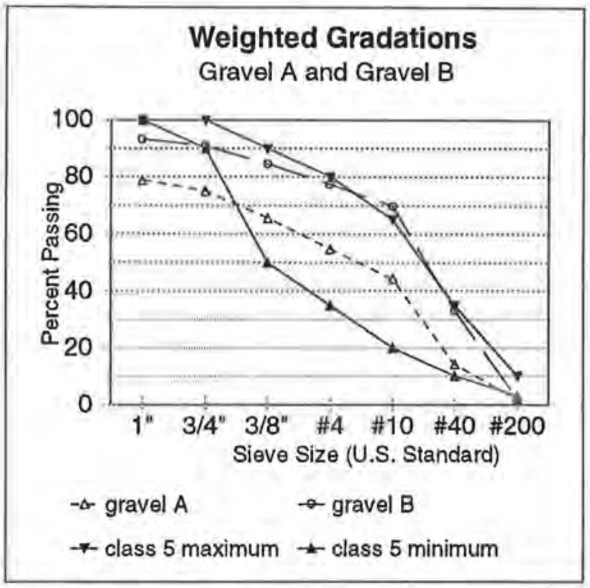
Table 1. Modeled estimates of the quantity of gravel (in-place) at the site. The volume error is an estimate of potential error associated with the volume. It is based on the uncertainty of the data used for the calculations to derive the volumes for each unit. Volume is a 3-dimensional shape. A source of volume error is that some variation occurs along the edges of the deposit and between drill holes. We have good estimates of the top, bottom, and edges of the deposit, especially for gravel A.

Gravel Unit	Area (ft^2)	Acres	Feet of gravel	Volume (cu yds)		
				Total Resource	With sloping requirements	Error (+/-)
A	549,000	12.6	12	260,000	250,000	20
B	549,000	12.6	17	350,000	225,000	35
A & B combined	549,000	12.6	29	600,000	475,000	30

Gradations and quality analysis – The gradation data presented in the first graph in Figure 7 shows that the two gravel units are quite different. Gravel A clearly falls well within the range for class 5 aggregate. Gravel B, however, does not quite meet class 5 gradations because it falls slightly outside the range for the #10 mesh size. The second graph in Figure 7 shows that if the two gravel units are mined together as a single unit, they would meet class 5 gradations. Note that the gradation curve may change a bit after crushing because the material larger than 3/4 inch will be incorporated into the smaller sizes and also particles larger than 4 inches are not included in these gradations. Note: These are only general guidelines that are useful for planning. Specific testing should be done for each pile of class 5 made.

Table 2 shows the data used to construct the graphs. This table shows that the gravel units miss meeting the #200 mesh gradation by 1.3%. The sieving method used by the DNR underestimates this value because we dry sieve. MnDOT washes the sample prior to sieving for a more accurate measurement of the fine particles. The results from MnDOT show the composite sample for gravel A has 6.1% passing the 200 mesh (Appendix E). This value falls within the gradations for class 5. The data for the composite of gravel B from MnDOT is 2.2%.

This gravel appears to be of high quality such that it may be acceptable for all possible uses. No shale or carbonates were observed during drilling. Table 3 shows that gravel A meets specifications for aggregate in bituminous and concrete in regards to deleterious content. The primary deleterious materials in bituminous and concrete mixes are shale, iron oxides, and soft particles. Other tests are usually required before acceptance for use in bituminous or concrete, but they are more appropriately done after the material is crushed.



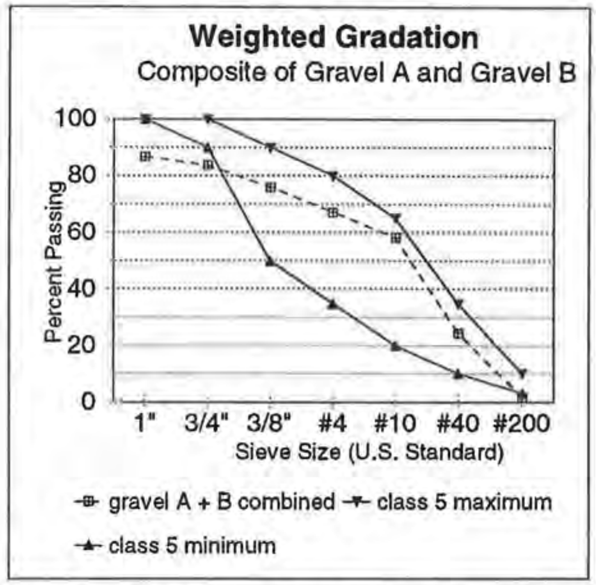


Figure 7. These graphics compare the size gradations for each gravel to MnDOT's numbers for class 5 aggregate. Values that plot between the upper and lower limits are acceptable. These graphs are intended to provide a point of reference to a familiar gravel product (class 5). A project may require material meeting different gradations. Percent passing refers to the proportion of the sample that passes through a particular sieve size. Particles larger than 3/4 inch would be crushed.

Table 2. Weighted average gradations for gravels A, B, and the gravels combined. This is the traditional method of presenting gradation results. The sieve sizes get progressively smaller moving to the right in the table. The cutoff we use for gravel is material larger than the #10 sieve. For gravel A, then, 44% of the sample passed through the #10 sieve. This means that this gravel has an average of 56% gravel (100 - 44 = 56).

Unit	Percent of material passing through respective sieves (coarse fraction)												Percent of material passing through respective sieves (fine fraction)							
	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	½"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
	100 mm	75 mm	63 mm	50 mm	37.5 mm	31.5 mm	25 mm	19 mm	16 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	2.0 mm	1.18 mm	0.60 mm	0.425 mm	0.30 mm	0.15 mm	0.075 mm
gravel A	100	99	97	88	84	82	79	75	73	70	66	55	47	44	34	20	14	10	4	1.7
gravel B	100	99	98	97	96	95	93	91	89	88	85	77	72	70	61	45	33	21	6	1.8
combined gravels	100	99	98	93	91	89	87	84	82	79	76	67	61	58	49	34	25	16	5	1.7
class 5 upper limit							100	100			90	80		65			35			10
class 5 lower limit							100	90			50	35		20			10			3

Table 3. Test results for deleterious materials in the gravel (see Appendix E). These values are for a composite sample of all the samples collected (see Appendix C). Rows in the first column identified with a +1/2", + 4, or -4 refer to only the portion of the sample retained on a ½" sieve, a #4 sieve, and passing through a #4 sieve, respectively.

	Composite average (%)		[1]Bituminous specifications (maximum %)			Concrete specifications (maximum %)
	Gravel A	Gravel B	Type 31	Type 41, 47	Type 61	
+1/2" shale	0	NA				0.4
+4 shale	0	NA				0.7
-4 shale	trace	trace		5.0		
+4 iron oxide	0	NA				0.3
total spall	0	NA	5.0		1.0	
total +4 spall	0	NA		2.5		1.5

[1] Depending on the type of bituminous mixture desired, some of these specifications may not apply.
NA = not analyzed
trace = 0.0045 - 0.044

Discussion

This site contains a substantial volume of aggregate. Gravel A is very valuable because it contains lots of rock and has only a trace of deleterious materials. This material could be used for class 5, bituminous or concrete mixes. High quality gravel like this should be used for concrete or bituminous. Gravel A has about 56% gravel (larger than #10 mesh) and 21% of this is larger than 1 inch. Furthermore, no rock larger than 3 inches was included in the gradations. Cobbles and boulders larger than about 4 inches may represent up to 10 – 15% of gravel A (by volume), based on a qualitative estimate. This suggests it may be possible, depending on the product desired, to screen off a substantial quantity of the oversized material. This oversized material could then be crushed separately to make a premium product, or blended with other aggregate. The largest cobbles and boulders seem to occur in the northern two-thirds of the site.

Gravel B does not meet class 5 gradations. If class 5 is desired from this layer, it will be necessary to blend it with gravel A, or at least with some of the rock from gravel A and possibly silt from the overburden. Crushing will create a small amount of silt (passing 200 mesh).

Gravel B may make a good concrete aggregate because a low silt content is required.

Gravel C would make a good granular fill. Projects that involve rebuilding paved roads in Itasca County often require large quantities of free-draining granular (sand or coarser) material.

Even though the thickness of gravels A and B fluctuates quite a bit, when combined into a single mining lift, the total thickness ranges from 24 to 33 feet with an average thickness of 27 feet.

Mine planning – Mining of this gravel body requires some planning. Zoning ordinances require setbacks from property lines and bodies of water of 100 feet and 200 feet, respectively (Appendix F). Within these setbacks, no disturbance to the land or vegetation can occur. Furthermore, operators need to be mindful of wetlands just west of the deposit. Nevertheless, there are still around 475,000 cubic yards of gravel that may be easily mined from this site, assuming 3:1 slopes, and possibly more if backfill techniques are used for final sloping.

The land manager is now aware that both layers of gravel should be mined at the same time--to ensure optimal use of the entire resource and minimize waste. If at first only gravel A is mined, the chance that gravel B would be mined at a later date is minimized substantially. This is because of the relatively low and variable gravel content in gravel B. In addition, when both layers are mined concurrently, portions of the pit would become depleted of gravel (both gravel A and B are mined out) and those portions could be permanently reclaimed.

It is likely that an operator that comes into this pit will not need all of the resource to complete their project. The land manager has the option of deciding which portion of the pit should be mined first. When the pit is first opened, it will be necessary to pile the overburden in areas that will be mined in the future (due to no-disturbance buffers from the lakes). This also helps to ensure that the overburden will be re-spread for reclamation upon completion of a phase of mining or prior to a new phase of mining.

The total quantity of in-place overburden is about 27,000 yards. This volume would increase some, due to swell, as it is piled. This material must be reserved in piles and re-spread as topsoil for reclamation as portions of the pit are depleted.

In the five drill holes where the water table was encountered, it occurred at an elevation ranging from 1380 to1384 feet. The gravel is completely above the water table at the top of the hill. The gravel plunges below the water table in the southwest one third of the site. In this area a wetland of about 3 to 4 acres in size could be created if the gravel below the water table is mined.

The best approach when mining below the water table may be with a large excavator. With a 3:1 slope projected below the water table, the deepest gravel occurs at an elevation of about 1364 feet. This is about 20 feet below the water table. Therefore, an excavator that can excavate to a depth of 15-20 feet will be able to mine nearly all of the mineable gravel that occurs below water.

Runoff, erosion, and siltation outside the pit is minimized or eliminated by maintaining a small natural berm to a height of several feet above the water table along the west side of the pit. Berms will already be in place to the south, east, and north because of setback requirements and the lay of the land. Then any water erosion, turbid water, and sedimentation will be confined to inside the pit.

Glossary

boulder– a stone (usually rounded) larger than 256 mm (9 inches) in diameter.

cobble– a stone larger than 64 mm (2.5 inches) and smaller than a boulder.

deleterious material– any material that detracts from the quality of a sand or gravel product, and if deleterious materials are present in sufficient quantities the gravel product may be unsuitable for particular uses. Common deleterious materials are shale, iron oxides, unsound chert, clay balls, and other soft particles.

feature– a physical phenomenon that exists on the earth's surface, such as a lake, valley, or hill.

GIS– stands for **g**eographic **i**nformation **s**ystem. It is a computer system for the input, editing, storage, maintenance, analysis, and output of spatial information. Each type or category of data is commonly thought of as a separate layer of information.

GPS– stands for **g**lobal **p**ositioning **s**ystem. It is a satellite-based system which, in conjunction with a receiver, determines locations on the earth's surface.

granule– particles of rock between 2 mm (0.08 inch) and 4 mm (0.16 inch) in diameter.

gravel– an accumulation of granular material, usually deposited by running water, that contains sufficient pebbles and larger stones to be marketable as gravel. When listed as a percentage of gravel, it is a measurement or estimate of the amount of the material, by weight, that is larger than 2 mm (commonly described as plus #10 mesh or retained on the #10 mesh).

ice-contact feature– layered deposits or accumulations of material deposited in contact with melting glacier ice. Examples are kames and eskers.

kriging algorithm– A regular grid of cells is overlain the scattered drill data. Values for each cell are estimated by fitting a mathematical surface to the scattered data.

overburden– material of any nature that overlies a deposit of useful material.

pebble– stones ranging in size from 4mm (0.16 inch) to 64 mm (2.5 inch) in diameter.

Appendices A - F

Appendix A. Detailed descriptions of each drill hole.

Appendix B. Samples composited for quality testing.

Appendix C. Complete gradation data.

Appendix D. Location and other information about each drill hole and other control points.

Appendix E. Test results from MnDOT laboratory.

Appendix F. A review of zoning ordinances pertaining to gravel extraction in Itasca County.

Appendix A. Detailed descriptions of each drill hole. Holes 1 through 12 were drilled with the Giddings probe. The remaining holes were drilled with the MnDOT rig. The upper 12 feet of material in holes 15, 25, 26, and 27 was excavated with a backhoe prior to drilling, due to excessive boulders. The layer column refers to the category the material was placed into for modeling purposes. In cases where two layers are listed, they are separated by a slash, and the second listing was used in modeling. For example, the designation 'ob/grvl A' means the material normally is overburden, but since it was sampled with the gravel below, with positive results, it can be blended with the gravel during mining--so it was modeled as gravel. Abbreviations used in the "color" column: lt = light, dk = dark, gry = gray, blk = black, brn = brown, yel = yellow, org = orange. Other abbreviations used throughout: grvl = gravel, sd = sand, slty = silty, vf = very fine, f = fine, m = medium, c = coarse.

Drill Hole	From (ft)	To (ft)	Color	Sediment	Layer	% gravel (field estimate)	Dominant gravel size (in)	max gravel size(in)	Comments
1	0	3.5	lt brown	sli slty m sand	ob	3			occasional granules and pebbles
1	3.5	5	lt brown	slty sd with grvl	grvl A	20+		2	v. rocky at 3.5-5 ft, refusal at 4 ft, skidded 4 ft, refusal at 5 ft on rock.
2	0	0.5	gry black	slty sd	soil/ob	1			
2	0.5	2.5	lt brown	m sd	ob	1			pebbles at 1.5 ft.
2	2.5	3.5	gry brown	slty m sd	ob	3		0.25	moist, granules.
2	3.5	6.5	gry brown	v slty sand	ob	4		0.25	grind on rock at 5.5 - 6.5 ft-refusal, a few granules are cream-colored-most are dk gray.
3	0	3	yel org brn	f sand	ob	1	0.125	0.5	fairly clean.
3	3	4.5	brown	gravel	grvl A	25	0.5	2	grinding rock at 3-4 ft, skidded 2 ft, refusal at 4.5 ft; well graded sand, mafics dominant.
4	0	3.5	lt gray	m sd	ob	2	0.125	0.25	rare pea; water table at 2 ft; boulders on surface.
4	3.5	5	gray	sandy silt	ob	3		0.25	orange mottles.
4	5	5.5	gray brown	muddy sand	ob	3		0.25	grind rock at 5 - 5.5 ft, refusal at 5.5 ft.
5	0	1.5	lt org brn	sand	ob	1		0.125	
5	1.5	4.5	lt brown	sand	ob	4		0.5	few pebbles in lower part.
5	4.5	7.5	lt brown	sand with grvl	grvl A	?			grind rock from 4.5 - 7.5 ft - refusal; well graded sand.
6	0	2	lt org brn	f sand	ob	3		1	powdery sand; few pebbles at 1.5-2 ft.
6	2	3.5	lt brn	gravel	grvl A	30		3	grinding rocks from 2 - 3.5 ft - refusal.

Drill Hole	From (ft)	To (ft)	Color	Sediment	Layer	% gravel (field estimate)	Dominant gravel size (in)	max gravel size(in)	Comments
7	0	3.5	brn	gravel	grvl A	40		4	2 ft boulder nearby; top 0.5 ft is sandy; lots of 1 - 4" pebbles, refusal at 3.5 ft; mafics mostly, no limestone.
8	0	3	brn	slty grvl	grvl A	35	0.75	2	good gradation; refusal on rock at 3 ft.
9	0	1	lt brn	m sd with grvl	ob	15	0.25	0.5	
9	1	2	lt brn	slty grvl	grvl A	25	0.25	0.5	refusal on rock at 1.5 ft, skid 5 ft, refusal at 2 ft.
10	0	3	lt brn	slty f sd with grvl	grvl A	20	0.125	0.75	refusal on rock at 3 ft.
11	0	2	lt brn	slty grvl	grvl A	35	0.375	4	
11	2	6	gray brn	muddy grvl	grvl A	45	0.5	4	quite silty, well graded, water at 3 ft.
12	0	4.5	brn	slty sd and grvl	grvl A	25		3	medium sand matrix, topsoil is 2-4" thick
12	4.5	22	brn	c grvl	grvl A	45	0.75	6	well graded, mostly mafic cobbles, 1 ft of 4-6" cobbles at 5 ft, ground and pulled up cobbles from 5-22 ft, stopped at 22 ft due to numerous cobbles in hole.
13	0	3	lt org brn	slty f sd	ob	2			occasional pebble
13	3	11	brn	c grvl	grvl A	35	0.75	6	well graded, cobbles from 3-6 ft
13	11	27	lt brn	sand with grvl	grvl B	20	0.125	2	minimal grinding from 11-20 ft, less grvl in lower 7 ft, clean.
13	27	30	lt brn	m sd	sand	3	0.125	0.5	clean
13	30	34	dk org red	sand	sand	5	0.125	0.5	iron-stained (dk reddish orange to black)
13	34	35	green gry	sand	sand	5	0.125	0.5	rare grvl, water at 33.5 ft.
14	0	4	lt org brn	m sd	ob	1			rare granules and pebbles
14	4	5	gry brn	slty sd	ob	5			some clods.
14	5	16	brn	slty grvl	grvl A	35		4	well graded, becomes muddy from 8-16 ft; grind rocks at 5.5-14 ft; water at 10 ft.
14	16	35	gray	c sd with grvl	grvl B	25	0.25	3	grvl ranges from 10 to 35%;mostly pea grvl and and, rare cobbles; clean.
15	0	4	yel brn	slty f sd with grvl	grvl A	30	0.75	4	gravel in f-m sd matrix; topsoil is 1-4" thick.

Drill Hole	From (ft)	To (ft)	Color	Sediment	Layer	% gravel (field estimate)	Dominant gravel size (in)	max gravel size(in)	Comments
15	4	9	brn	grvl	grvl A	45			cobbles are gabbro, basalt, or granite; 4 attempts here with refusal at 7, 6, 9, and 4 ft.
15.1	0	2.5	lt gry brn	slty sd	ob	1			backhoe hole upper 12ft.
15.1	2.5	12	dk brn	c grvl	grvl A	60	1.5	24	lots of boulders--none larger than about 2 ft.
15.1	12	18	brn	grvl	grvl A	45		5	well graded
15.1	18	29	lt brn	sd with grvl	grvl B	25	0.375	1	cleaner than above, well graded sand.
15.1	29	40	white brn	sand	sand	5		0.25	v. clean, sorted, but varied layers.
15.1	40	50	white brn	sand	sand	4		0.25	one c. sd/pea grvl layer about 1 ft thick at 40 ft.
16	0	4	brn	v slty sand	ob	10			clods.
16	4	7	brn	slty c grvl	grvl A	45			grind on rocks at 4-7 ft, refusal at 7 ft.
17	0	4	lt brn	f sd with grvl	grvl A	30	0.25		
17	4	9	brn	slty grvl	grvl A	40	0.375	5	rocky, refusal at 9 ft, 3 attempts.
18	0	1	org brn	f sd	ob	10		1	2.5 ft diameter boulder at surface.
18	1	3	brn	sd and grvl	grvl A	25	0.375	2	refusal on rock at 3 ft.
19	0	3	brn	slty sd with grvl	grvl A	20	0.25	2	2-3 ft boulders barely project above the surface.
19	3	5	brn	slty grvl	grvl A	40	0.5	5	grind rocks at 3-5 ft, refusal on rock at 5 ft.
20	0	3	lt brn	slty f sd with grvl	grvl A	20	0.75	1	9" by 12" rock at 1 ft depth; numerous 2-3 ft bldrs at or just below the topsoil.
20	3	4	brn	slty c grvl	grvl A		1.5	9	refusal on rock at 4 ft.
21	0	1.5	lt org brn	m sd	ob/ grvl A	2			
21	1.5	6	brn	slty grvl	grvl A	35	0.75	5	good binder.
21	6	9	dk brn	c sd and grvl	grvl A	35	0.25	2	some dark staining; refusal on rock at 9 ft.
22	0	3	lt brn	slty f-m sd	grvl A	15	0.75	3	occasional boulders (12 x 16 x 12") on surface.
22	3	5	brn	slty sd and grvl	grvl A	30			rocks at 3-5 ft, 3 attempts--refusal on rock at 5, 3 and 4 ft.
23	0	1	lt org brn	f-m sd	ob	2			
23	1	4	gry brn	silt	ob	10			forms soft clods.

Drill Hole	From (ft)	To (ft)	Color	Sediment	Layer	% gravel (field estimate)	Dominant gravel size (in)	max gravel size(in)	Comments
23	4	12	dk brn	c sd and grvl	grvl A	35	0.75	6	well graded, occasional cobbles throughout.
23	12	15	dk red brn	c sd and grvl	grvl A	35			iron-stained; refusal on rock at 15.5 ft.
24	0	5	brn	grvl	grvl A	40	0.75	3	drilling in road cut; well graded--upper several ft are removed; occasional cobbles.
24	5	10	lt brn	c sd and grvl	grvl A	35	0.375	3	clean, variable layers.
24	10	15	lt brn	sd with grvl	grvl B	25			easy drilling.
24	15	17	yel white	f sd	sand/ grvl B	0			clean, easy drilling
24	17	20	lt brn	sand	sand/ grvl B	10	0.25	0.5	clean, easy drilling, possible rock at 25 ft.
24	20	28	brn	f grvl	grvl B	40	0.375	0.75	pea grvl, missed upper contact.
24	28	33	dk red brn	f grvl	grvl B	40	0.75	2	iron-stained, water at 31 ft.
24	33	40	gray	grvl	grvl C	35	0.25	1	clean, well graded sand and gravel, finer grvl with depth; full recovery.
24	40	50	gray	sd with grvl	grvl C	25			clean, full recovery.
25	0	3	lt brn	slty sd	ob/ grvl A	5			backhoe hole upper 13ft.
25	3	13	brn	c grvl	grvl A	60			layer of 1-2 ft bldrs from 3-5 ft--difficult to hoe; cobbles as large as 9" throughout.
25	13	21	brn	grvl	grvl B	40			rocks throughout;, v poor recovery.
25	21	30	lt brn	sd with grvl	grvl B	25	0.375	1	clean, well graded sand.
25	30	43	brn	sd with grvl	grvl C	25	0.25	1	clean, graded sand, tite drlg below 35 ft.
25	43	50	brn white	m sd	sand	0			clean, well sorted.
26	0	3	lt brn	slty sd	ob	15			grvl inc. with depth; backhoe to 12 ft; some bldrs at surface.
26	3	12	dk brn	c grvl	grvl A	60			lots of 9" cobbles, few 1-2 ft bldrs.
26	12	20	dk brn	grvl	grvl A	50	1.5		c. sd matrix, graded, missed lower contact.
26	20	36	lt brn	sd with grvl	grvl B	22	0.25	0.5	clean sd with f. grvl
26	36	50	brn white	m sd	sand	1			clean, quartz sand; tite drlg below 38 ft.
27	0	3	lt org brn	slty sd	ob				no rocks on surface.
27	3	11	dk brn	c grvl	grvl A	45		24	biggest bldrs are about 2x2x1.5 ft; backhoe to 12 ft

Drill Hole	From (ft)	To (ft)	Color	Sediment	Layer	% gravel (field estimate)	Dominant gravel size (in)	max gravel size(in)	Comments
27	11	20	brn	c sd and grvl	grvl B	35			larger cobble or bldr at 14-17 ft, moist at 15-20 ft, cleaner at 15-20 ft.
27	20	33	brn	c sd with grvl	grvl B				crunching at 28 ft; v poor recovery--most of grvl shook off flights.
27	33	48	lt brn	c sd with grvl	grvl C	25	0.125		dry, lots of granules; tite drlg below 35 ft.
27	48	50	white	m sd	sand	0			clean quartz sand.

Appendix B. Samples composited for quality testing. Samples identified as composite A were combined to make a single composite for the upper gravel A layer. Samples identified as composite B were combined to make a single composite for the gravel B layer. Samples not labeled A or B were not collected from either of those layers and therefore not composited.

Sample #	Composite sample #	Hole ID	From	To	Feet of material
33413.12001	gravel A	12	0.0	22.0	22.0
33413.13002	gravel A	13	3.0	11.0	8.0
33413.14004	gravel A	14	5.0	16.0	11.0
33413.15015	gravel A	15	12.0	18.0	6.0
33413.15019	gravel A	15	2.5	12.0	9.5
33413.17007	gravel A	17	0.0	9.0	9.0
33413.21009	gravel A	21	0.0	9.0	9.0
33413.23010	gravel A	23	4.0	15.0	11.0
33413.24011	gravel A	24	0.0	10.0	10.0
33413.25020	gravel A	25	0.0	13.0	13.0
33413.26024	gravel A	26	3.0	12.0	9.0
33413.26025	gravel A	26	12.0	20.0	8.0
33413.27027	gravel A	27	3.0	11.0	8.0
33413.13003	gravel B	13	11.0	27.0	16.0
33413.14005	gravel B	14	16.0	35.0	19.0
33413.15016	gravel B	15	18.0	29.0	11.0
33413.24012	gravel B	24	10.0	20.0	10.0
33413.24013	gravel B	24	20.0	33.0	13.0
33413.25021	gravel B	25	21.0	30.0	9.0
33413.26026	gravel B	26	20.0	36.0	16.0
33413.27028	gravel B	27	11.0	20.0	9.0
33413.15017		15	29.0	40.0	11.0
33413.15018		15	40.0	50.0	10.0
33413.24014		24	33.0	50.0	17.0
33413.25022		25	30.0	43.0	13.0
33413.25023		25	0.5	3.0	2.5
33413.27030		27	33.0	48.0	15.0

Appendix C. Complete gradation data. This table includes gradations by weight for every sample sieved. The first 5 numbers of the sample # indicate the project number. The first two numbers after the decimal indicate the drill hole, and the three remaining numbers are unique numbers for each sample. Sieve sizes are U.S. Standard.

Sample #	Hole ID	from	To	Feet of material	Percent of material passing respective sieves (coarse fraction)												Percent of material passing respective sieves (fine fraction)							
					4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
33413.12001	12	0.0	22.0	22.0	100	100	100	86	80	76	72	67	64	62	58	48	42	40	31	18	12	8	3	1.4
33413.13002	13	3.0	11.0	8.0	100	100	89	85	82	78	74	69	66	63	59	49	43	40	29	16	11	7	3	1.2
33413.13003	13	11.0	27.0	16.0	100	100	100	100	99	98	98	97	96	95	93	88	81	78	66	46	32	20	5	1.7
33413.14004	14	5.0	16.0	11.0	100	100	100	85	82	81	77	72	69	63	57	42	37	34	24	15	11	8	4	1.7
33413.14005	14	16.0	35.0	19.0	100	94	94	92	88	87	84	82	80	79	76	70	64	62	55	39	29	18	5	1.4
33413.15015	15	12.0	18.0	6.0	100	100	93	91	87	86	83	78	76	72	66	52	40	37	28	17	12	8	3	1.0
33413.15016	15	18.0	29.0	11.0	100	100	100	100	100	98	98	95	94	93	91	84	76	74	61	39	28	16	3	1.0
33413.15017	15	29.0	40.0	11.0	100	100	100	100	100	100	100	100	100	100	99	98	97	97	95	88	78	60	23	5.6
33413.15018	15	40.0	50.0	10.0	100	100	100	100	100	100	100	100	100	99	99	98	97	96	93	82	69	50	9	2.0
33413.15019	15	2.5	12.0	9.5	100	91	86	79	77	74	72	68	66	63	58	45	33	29	17	7	5	4	2	1.3
33413.17007	17	0.0	9.0	9.0	100	100	94	92	90	88	86	84	82	78	74	60	50	47	37	28	23	19	9	4.3
33413.21009	21	0.0	9.0	9.0	100	100	100	95	92	92	89	86	85	83	80	69	58	55	42	31	25	20	8	3.8
33413.23010	23	4.0	15.0	11.0	100	100	100	89	84	82	79	75	73	70	66	56	50	47	34	18	11	6	2	0.8
33413.24011	24	0.0	10.0	10.0	100	100	100	93	89	86	83	81	79	76	73	65	59	57	50	36	25	16	4	1.3
33413.24012	24	10.0	20.0	10.0	100	100	100	100	100	99	99	99	99	99	98	96	95	95	90	78	63	44	12	3.6
33413.24013	24	20.0	33.0	13.0	100	100	100	97	96	95	92	86	82	77	69	53	46	44	38	28	21	13	4	1.3
33413.24014	24	33.0	50.0	17.0	100	100	100	100	100	100	99	98	97	96	93	86	78	76	57	29	18	10	3	1.1
33413.25020	25	0.0	13.0	13.0	100	100	100	90	88	86	85	83	82	80	78	72	65	63	51	23	11	5	2	0.7
33413.25021	25	21.0	30.0	9.0	100	100	100	100	96	95	91	88	87	85	82	74	68	66	57	43	34	24	6	1.5
33413.25022	25	30.0	43.0	13.0	100	100	100	100	100	100	99	97	97	96	95	91	87	85	76	54	38	25	7	1.8
33413.25023	25	0.5	3.0	2.5	100	100	100	100	100	100	98	97	96	95	93	88	83	82	77	67	58	46	15	7.0
33413.26024	26	3.0	12.0	9.0	100	100	95	86	81	79	75	69	66	63	60	50	44	41	31	19	13	9	4	1.7
33413.26025	26	12.0	20.0	8.0	100	100	100	91	87	84	79	73	69	66	61	47	38	35	25	13	8	5	2	0.7
33413.26026	26	20.0	36.0	16.0	100	100	100	100	100	100	100	100	99	97	95	91	88	86	78	60	45	30	8	2.6
33413.27027	27	3.0	11.0	8.0	100	100	96	90	86	83	81	79	76	74	70	56	48	45	33	22	18	14	7	3.6
33413.27028	27	11.0	20.0	9.0	100	100	90	90	90	88	84	79	77	74	71	62	52	50	40	23	14	7	2	1.0
33413.27030	27	33.0	48.0	15.0	100	100	100	100	100	100	99	98	97	96	95	89	86	84	75	52	36	22	4	1.1

Appendix D. Location and other information about each drill hole and other control sites. Elevations are in NAVD 1988.

Hole ID	State Plane_y coordinate (NAD 27)	State Plane_x coordinate (NAD 27)	UTM_ y coordinate (NAD 83)	UTM_x coordinate (NAD 83)	Ground Elevation (ft)	Ground Elevation (m)	depth to water table (ft)	water elevation (ft)	depth drilled (ft)
1	416077.5	1913205.3	5276192.86	466041.53	1396.4	425.63			5
2	415985.1	1913163.6	5276164.71	466028.79	1388.1	423.10			6.5
3	416862.9	1913594.2	5276432.01	466160.33	1442.0	439.52			4.5
4	416336.2	1913197.6	5276271.68	466039.28	1385.7	422.37	2	1383.7	5.5
5	416429.0	1913199.8	5276299.96	466039.98	1393.8	424.83			7.5
6	416622.8	1913073.4	5276359.06	466001.55	1398.9	426.40			3.5
7	416653.2	1913269.7	5276368.23	466061.38	1394.0	424.90			3.5
8	417231.9	1913373.2	5276544.53	466093.15	1406.0	428.54			3
9	417112.8	1913408.1	5276508.23	466103.71	1399.8	426.66			2
10	416691.9	1913435.0	5276379.97	466111.75	1427.3	435.03			3
11	416035.0	1913440.1	5276179.82	466113.05	1383.3	421.64	3	1380.3	6
12	416387.2	1913557.6	5276287.07	466149.01	1404.1	427.96			22
13	416212.8	1913451.1	5276233.99	466116.48	1414.5	431.13	33.5	1381.0	35
14	416418.0	1913207.5	5276296.61	466042.34	1393.3	424.68	10	1383.3	35
15	416783.1	1914037.9	5276407.54	466295.50	1434.2	437.14			50
16	416752.4	1913974.7	5276398.19	466276.23	1430.8	436.11			7
17	416655.0	1913898.1	5276368.54	466252.85	1438.3	438.39			9
18	416678.9	1913770.1	5276375.88	466213.87	1434.0	437.20			3
19	416667.4	1913658.9	5276372.43	466179.98	1442.6	439.71			5
20	416687.0	1913534.5	5276378.44	466142.06	1435.8	437.64			4
21	416813.7	1913360.9	5276417.12	466089.22	1417.6	432.07			9
22	416953.1	1913436.5	5276459.55	466112.32	1418.2	432.27			5
23	416087.3	1913229.0	5276195.83	466048.75	1398.1	426.14			15
24	416303.2	1913287.2	5276261.60	466066.55	1411.0	430.06	31	1380.0	50
25	416681.8	1913794.7	5276376.76	466221.36	1437.0	437.99			50
26	416661.8	1913578.7	5276370.74	466155.52	1440.3	439.00			50
27	416858.6	1913584.9	5276430.71	466157.48	1441.9	439.51			50
400	416689.0	1913408.3	5276379.11	466103.62	1426.3	434.73			NAp
401	416469.2	1913342.5	5276312.14	466083.47	1420.9	433.08			NAp
402	415895.0	1913508.7	5276137.13	466133.90	1376.7	419.63			NAp
403	417002.9	1914096.8	5276474.42	466313.53	1388.9	423.34			NAp
404	417019.3	1914093.8	5276479.49	466312.62	1386.9	422.72			NAp

Notes: Hole ID #400 and 401 are pins set along access road.
Hole ID #402 and 404 are elevations of the ice on Antler Lake and Little Antler Lake, respectively.
Hole ID #403 is the north property corner.
Nap = not applicable

Appendix E. Test results from MnDOT laboratory in Maplewood, MN.

State of Minnesota Department of Transportation
Aggregates Test Report

JAN 08 2001

Sample ID CO-PS00-0095	**IAS Name:**	**Sample ID**	**IAS Name:**
Field ID: Composite #31	**Project No:** OTH DNR	**Field ID:**	**Project No:**
Date Sampled: 10/15/00	**Proj Eng:**	**Date Sampled**	**Proj Eng:**
Date Received: 12/15/00	**County Number:**	**Date Received**	**County Number:**
Usage:	**County Name:**	**Usage:**	**County Name:**
Submitter: Glenn Melchert	**City Number**	**Submitter:**	**City Number**
Grad Spec:	**City Name:**	**Grad Spec:**	**City Name**
Spec. Class:	**Bridge #:**	**Spec. Class:**	**Bridge #:**
Quality Spec:	**Sampled From:** GRAVEL A	**Quality Spec:**	**Sampled From:**
T.H. Number	**Pit #:**	**T.H. Number**	**Pit #:**
	Pit Name:		**Pit Name:**
	Comment:		**Comment:**

% Passing Sieve:	Lab Test	Field Test	Spec. Limits Low	Spec. Limits High	Lab Test	Field Test	Spec. Limits Low	Spec. Limits High
37.5mm (1 1/2")	100							
31.5mm (1 1/4")	89							
25.0mm (1")	87							
19.0mm (3/4")	84							
16.0mm (5/8")	81							
12.5mm (1/2")	78							
9.5mm (3/8")	74							
4.75mm (#4)	66							
2.36mm (#8)	55							
2.00mm (#10)	52							
1.18mm (#16)	43							
600um (#30)	30							
425um (#40)	23							
300um (#50)	17							
150um (#100)	10							
75um (#200)	6.1							
% Shale In Sand	***0.0							
% Other Rock	100.0							

JAN - 9 2001

cc: G. Melchert (DNR)
Agg. Office

Approved By: [signature]

Charge:
1 - 1012
1 - 1013
1 - 1014
1 - 1029

* Value does not meet Spec
** Value out of Field-Lab Tolerance
*** Trace (0.0045 - 0.044) Detected
% Shale In Sand N.C. = Trace

☐ Meets Requirements
☐ Does Not Meet Requirement
☑ For Info Only

100 % rock (above) means:

0% shale (+1/2, +4)
0% iron oxide
0% unsound chert
0% ochre

Page 1 of 1 1/6/01 10:00:04 AM

State of Minnesota Department of Transportation
Aggregates Test Report

JAN 08 2001

Sample ID CO-PS00-0096	IAS Name:	Sample ID	IAS Name:
Field ID: Composite #32	Project No: OTH DNR	Field ID:	Project No:
Date Sampled: 10/15/00	Proj Eng:	Date Sampled	Proj Eng:
Date Received: 12/15/00	County Number:	Date Received	County Number:
Usage:	County Name:	Usage:	County Name:
Submitter: Glenn Melchert	City Number	Submitter:	City Number
Grad Spec:	City Name:	Grad Spec:	City Name
Spec. Class:	Bridge #:	Spec. Class:	Bridge #:
Quality Spec:	Sampled From: GRAVEL B	Quality Spec:	Sampled From:
T.H. Number	Pit #:	T.H. Number	Pit #:
	Pit Name:		Pit Name:
	Comment:		Comment:

% Passing Sieve:	Lab Test	Field Test	Spec. Limits Low	Spec. Limits High	Lab Test	Field Test	Spec. Limits Low	Spec. Limits High
37.5mm (1 1/2")	100							
31.5mm (1 1/4")	97							
25.0mm (1")	94							
19.0mm (3/4")	92							
16.0mm (5/8")	90							
12.5mm (1/2")	88							
9.5mm (3/8")	87							
4.75mm (#4)	80							
2.36mm (#8)	71							
2.00mm (#10)	69							
1.18mm (#16)	59							
600um (#30)	42							
425um (#40)	30							
300um (#50)	18							
150um (#100)	6							
75um (#200)	2.2							
% Shale in Sand	***0.0							

cc: G. Melchert (DNR)
Agg. Office

Approved By: [signature]

Charge: 1 - 1012
1 - 1013
1 - 1029

Remarks: Not enough material for a lithological count.

* Value does not meet Spec
** Value out of Field-Lab Tolerance
*** Trace (0.0045 - 0.044) Detected
% Shale in Sand N.C. = Trace

☐ Meets Requirements
☐ Does Not Meet Requirement
☑ For Info Only

Appendix F. A review of zoning ordinances pertaining to gravel extraction in Itasca County (from the county zoning office in Grand Rapids).

Informational Handout 1 Extractive Uses

INFORMATIONAL HANDOUT PERTAINING TO EXTRACTIVE USE/S

EFFECTIVE DATE: 9/15/98

EXTRACTIVE USE:

(including gravel pits over 1 acre and excluding temporary borrow areas) the use of land for surface or subsurface removal of sand, gravel, rock, industrial minerals, other nonmetallic minerals, and peat not regulated under Mn Statutes Section 93.44 to 93.51.

LAND USE CLASSIFICATION LIST:

Land uses marked (X) in classification list shall mean land use is permitted.
Land uses marked (0) in classification list shall mean land use is permitted only by Conditional Land Use Permit.
Land uses marked (R) in classification list shall mean land use is restricted.

1. Residential; 2. Seasonal Residential; 3. Farm Residential; 4. Recreational Commercial; 5. Lt. Industrial Commercial; 6. Heavy Industrial; 7. Public; 8. Open; 9. Waterfront Public; 10. Rural Residential; 11. Special Protection Overlying District .

	1	2	3	4	5	6	7	8	9	10	11
										**	
EXTRACTIVE USE:	0	0	X	O	X	X	X	X	R	X	R

size extractive use within the Big Fork River and Mississippi River Scenic Class Corridor/s (and not in a restricted zone) shall require the processing of a c/u permit. Any size extractive use within the Mississippi River Wild Class is Restricted. ****In a FR Zone, a Conditional Use shall be necessary if there is an existing dwelling/residence within 1000' of the extractive use and related activities.**

[SECTION/S 5.81-5.92]: EXTRACTIVE USES (OVER 1 ACRE):

This Section is for the purpose of:
1) Providing for the economic availability and removal of sand, gravel, rock, soil and other materials vital to the continued growth of Itasca County.
2) Establishing regulations, safeguards and controls in the unincorporated areas of the County regarding noise, dust, traffic, drainage, groundwater quality and other factors which will minimize the environmental and aesthetic impacts on mined or adjacent property.
3) Reducing the potential for pollution caused by wind, soil erosion and sedimentation.
4) Establishing locations, orderly approval process and operating conditions under which extractive use operations will be allowed in the unincorporated areas of the County and to establish conditions which ensure the restoration of mined areas consistent with the existing and planned land use patterns.

An extractive use which is located outside the Bigfork River and the Mississippi River Scenic Class Corridor/s, shall be authorized by permit, FEE: $200.00, on a form provided by the Zoning Officer, in accordance with the land use classification list, provided it is exempt from the Environmental Quality Board Review Program, the appropriate fee/s have been received and ALL of the following standards are fully complied with.

The property owner shall be responsible for obtaining any other applicable permit, required for an extractive use, relating to fuel and hazardous materials management, air quality management, solid waste management, water quality management, water withdrawals, riprap and discharge outlets, discharge of dredged or fill materials within waters and wetland, from the local, State or Federal Agency/Department.

Setbacks: All related activities, equipment, processing facilities, material storage, including clearing, excavating, stockpiling or other filling related to the pit operation shall be located at least:

A. 250' from any established residence other than the owner/operator of said extractive use
B. 200' from an incorporated municipality and ordinary high water mark;
C. 100' from property line/s
D. 50' from the right-of-way from any public road

Related activities include, but are not limited to the following:
- -Stockpiling of bituminous, sand, gravel and rock
- -washing of rock
- -crushing
- -bituminous, asphalt, hot mix processing equipment
- -parking facilities,
- -haul roads
- -settling basins
- -buildings

Screening: To minimize problems of dust and to shield extractive use operations from public view:

A. the existing vegetation shall remain as screening between the extractive use site/related activities and the surrounding residences and public roads.
B. a screening barrier or berm may be required between the extractive use site and the adjacent properties. The need, size, kind, type and location shall be determined by the Zoning Official or authorized designee.

Haul Roads and Entrances/Exits Standards:

A. Entrance/exit haul roads shall be constructed to avoid creating a traffic safety hazard and to minimize the view into the extractive use site, utilizing road curves, topography and existing vegetation.
B. During the hours of operation, 'trucks hauling' signs shall be placed along the public roadways leading to the extractive use site entrances at a distance of not less than 500' from the entrances. Signs shall be removed or covered during non-operating hours.

C. Access(es) shall be controlled by the property owner.
D. Dust control to be implemented as necessary, from the processing site to the nearest paved road, on operations that would have over 10 one way road hauling trips or 5 round-trips per day.
E. Size and Type of Sign shall be approved by the applicable road authority.

Hours of Operation:

A. Overall extractive use operation shall be from 6:00 a.m. -7:00 p.m. Monday through Saturday.
B. Emergency situations shall be approved by the Itasca County Highway Engineer or authorized designee.
C. There shall be no mechanical equipment operation started before 6:00 a.m.

Other Standards:

A. all fluids/oils shall be handled and stored in accordance with the Minnesota Pollution Control Agency's regulations.
B. all noxious weeds designated by the Commissioner of Agriculture and Itasca County shall be controlled by the property owner. Plants designated as noxious weeds include: Field bindweed, Hemp, Purple Loosestrife, Poison Ivy, Lefy Spurge, Perennial Sowthistle, Bull Thistle, Canada Thistle, Musk Thistle, Plumeless Thistle, Orange Hawkweek, Oxeye Daisy, Tall Buttercup and Tansy.
C. submittal of such other information as may be necessary to determine the nature of the extractive use/related activities and reclamation.
D. it shall be the property owner's responsibility to notify the Zoning Office, prior to transferring the property, during the duration of the extractive use permit.
E. it shall be the property owner's responsibility to assure that the property taxes are current and up to date. Delinquent taxes shall make the extractive use permit null and void.

Financial Assurance:

A. Insurance: On County controlled lands, the Lessee (Operator) agrees to purchase liability insurance naming the Lessor (County) as an insured, or additional named insured, in an amount at least equal to the maximum liability limits set forth in Minnesota Statute 466.04, Subd. 1, currently $300,000 per person and $750,000 per occurrence, and agrees to provide a Certificate of Insurance or other document, to the Itasca County Auditor/Treasurer, demonstrating that such insurance has been procured to the Lessor (County).
B. Bond - Security for Reclamation: On lands not controlled by the County, the property owner agrees to post a bond, cash deposits or other security, payable to Itasca County and filed with the Itasca County Auditor/Treasurer, and in such form as the County may require. It shall be the responsibility of the property owner to

provide a Registered Engineer's written estimate of the total cost to reclaim the property that will be stripped of overburden. The sum of the security shall equal one and one-half times (1.5) of that written estimate. Bonds shall be for a minimum of one year and shall include a provision for notification to the County at least sixty (60) days prior to cancellation or non-renewal.

Reclamation Standards:

A. Slopes: No site shall exceed 3 feet horizontal to 1 foot vertical incline. This angle of repose shall extend vertically 6 feet below the lowest seasonal groundwater level. This angle of repose may be modified to a flatter, but not steeper angle, if it is shown that the material to be excavated or to be used in reclamation of the site will be unstable at 3:1 ratio.

B. Topsoil storage and reapplication: All topsoil on an extractive use site shall be saved for future application, unless it can be demonstrated that it is not all needed for reclamation.

   Topsoil shall be reapplied to the slopes as uniformly as possible. Sites which lack adequate topsoil shall have the topsoil applied preferentially to the sloped areas.

Seeding/revegetation/stabilization:

A. Seeding mixture shall be in accordance with the recommendations of the Itasca County Soil and Water Conservation District.
B. Alternative seeding mixtures shall be considered by the Zoning Department on a case by case basis. Evidence must be provided showing that the proposed mix will be sufficient to deter erosion on the site.
C. Planting of woody vegetation may be accepted in combination with other stabilization techniques.
D. Sodding maybe required for drainageways, ditch checks, highly erodible areas of a site as shown on the reclamation plan or as required by the Zoning Department.
E. Riprap maybe required for drainageways, ditch outlet, culvert ends or bridge openings as shown on the reclamation plan or as required by the Zoning Department.
F. All seeding/revegetation and stabilization on inactive portions of the pit shall be implemented upon completion. The final revegetation/restoration being completed within one year of cessation of the operation.
G. The areas which are reclaimed for purposes of a Minnesota Department of Natural Resources Wildlife Management area and/or wetland mitigation shall be allowed exceptions to enhance wildlife habitat.