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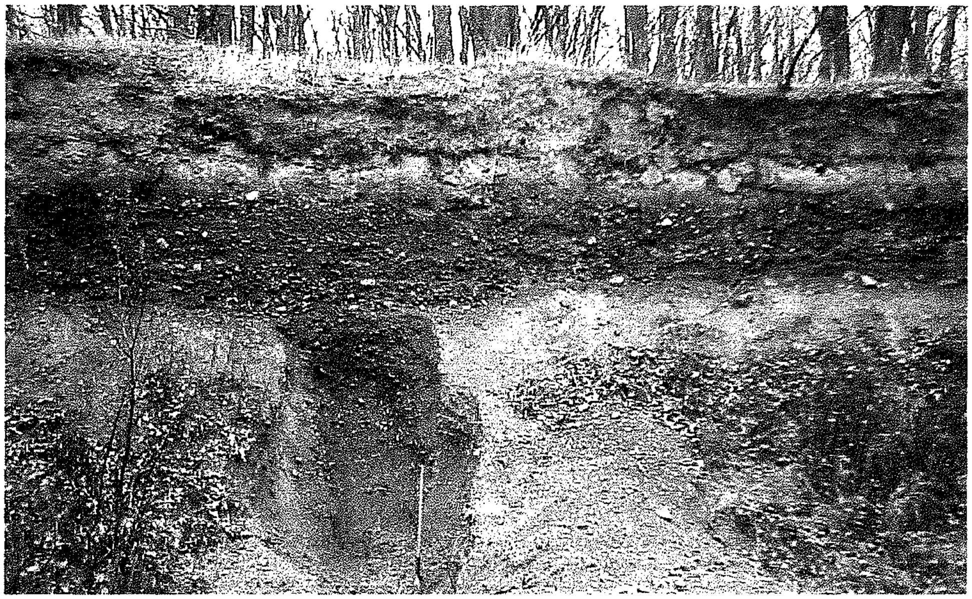
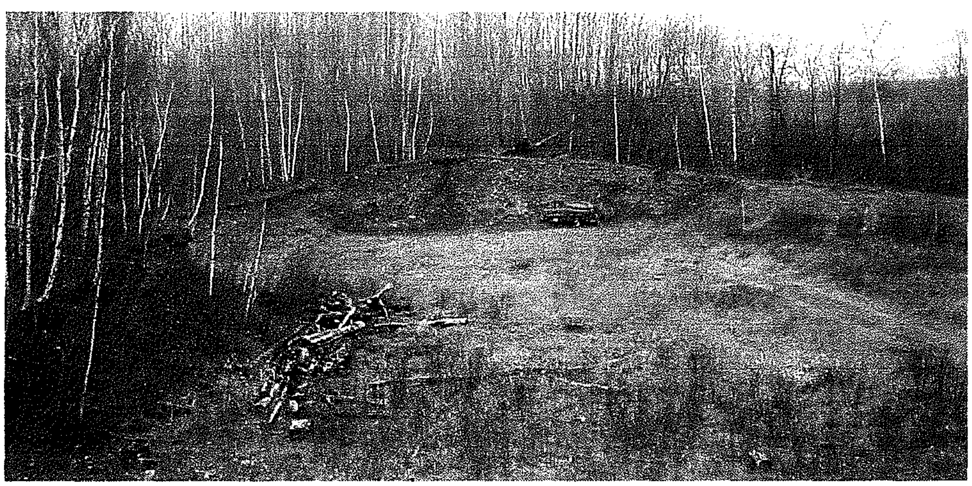
Aggregate Resource Evaluation of the Olson and Cranberry pits in the Mille Lacs Wildlife Management Area near Onamia, MN





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

Project 334-14
August 2001

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Acknowledgments

This report is the culmination of cooperative efforts by numerous individuals. This project came about because Dick Tuszynski, manager of the Mille Lacs Wildlife Management Area (WMA), was interested in long-term planning with respect to the finite gravel resources they were mining. He wanted to know the extent and quantity of the gravel remaining at their pits.

Dave Johnson and Richard Black, staff at the WMA, did a fine job of coordinating efforts and providing bulldozer and backhoe work, respectively. Ricco Riihiluoma, as usual, did a fine job as the drill rig operator and with processing the samples. Paul, the mechanic at the Minnesota Department of Transportation--Baxter office, with the coordination of Terry Beaudry, came through with flying colors as he repaired the drill rig with next-day service. In addition, Terry Beaudry and his cohorts are to be commended for flexible scheduling and keeping a well-maintained drill rig.

Executive Summary

This report summarizes the results of an aggregate evaluation conducted at two locations within the Mille Lacs Wildlife Management Area (WMA). DNR Wildlife requested that DNR Lands and Minerals evaluate the area surrounding two existing gravel pits to determine the quantity of gravel remaining at the sites, as well as it's extent. One site, called the Olson Pit, is in the northern portion of the WMA and located in Section 7, T. 41N., R. 25W, Lewis Township. The second site, called the Cranberry Pit, is in the western portion of the WMA and located in Section 34, T. 41N., R. 26W., Onamia Township.

Field work began on October 30, 2000 and was completed 3.5 days later after 17 holes were drilled with the Minnesota Department of Transportation (MnDOT) drill rig. With a 10-inch diameter solid stem auger, each hole was described to determine depth to gravel, bottom of the gravel, and depth to water table. Samples were collected to measure the size gradations of the gravel.

Results for each site are summarized below.

Olson Pit

- ❑ The entire area outlined in Figure 5 and Plate 1 covers 18.6 acres and contains gravel acceptable for class 5 use.
- ❑ The total gravel resource within the 18.6 acres is 850,000 cubic yards. Sloping requirements along the property line to the south reduce this amount to about 780,000 cubic yards. About 420,000 and 350,000 cubic yards occur above and below the water table, respectively. About 10,000 cubic yards remain in the bottom of the pit.
- ❑ Average gravel thickness is 28.7 feet (range 17 to 45 feet). An average of 15.4 feet occur above the water table.
- ❑ The water table occurs at 16 to 21 feet below ground surface.
- ❑ Material overlying the gravel (overburden) consists of about 4 inches of topsoil and 1.5 to 6 feet of silty very fine sand. Most of the area has about 3 feet of overburden.
- ❑ Gravel likely extends beyond the 18.6 acre outline. Wetlands and setbacks (property and road) affect some expansion beyond the outline.

Cranberry Pit

- ❑ The undisturbed ridge (esker) and the staging area outlined in Figure 7 and Plate 2 cover 3.6 and 0.9 acres, respectively, and contain gravel acceptable for class 5 use.
- ❑ The ridge and the staging area contain about 60,000 and 10,000 cubic yards of gravel, respectively. The existing pit is about depleted.
- ❑ All of the gravel is above the water table
- ❑ Less than 6 inches topsoil (overburden) overlies the gravel resource.

Introduction

Two gravel resources within the Mille Lacs Wildlife Management Area (WMA) were evaluated for their aggregate potential. This land is managed by the Minnesota Department of Natural Resources, Division of Wildlife (DNR Wildlife). DNR Wildlife wanted to know how much aggregate remained at these two sites. Knowledge of the extent, quantity and quality of the resource would aid in long-term planning in regards to their aggregate needs. DNR Wildlife requested that DNR Division of Lands and Minerals conduct an aggregate resource evaluation of the Olson Pit site and the Cranberry Pit site (Figure 1).

The area evaluated at the Olson pit covers about 21 acres in the SE quarter, SW quarter, Section 7, T. 41N., R. 25W, in Lewis Township, Mille Lacs County, MN (Figure 2). An unpaved township road (Olson Road) is adjacent to the site. Off the Olson Road, an unpaved WMA road (Flasch Trail) leads to County Road 22. The nearest municipality is Onamia, about 8 miles away.

The area evaluated at the Cranberry pit covers about 5.6 acres in the NE quarter, Section 34, T.

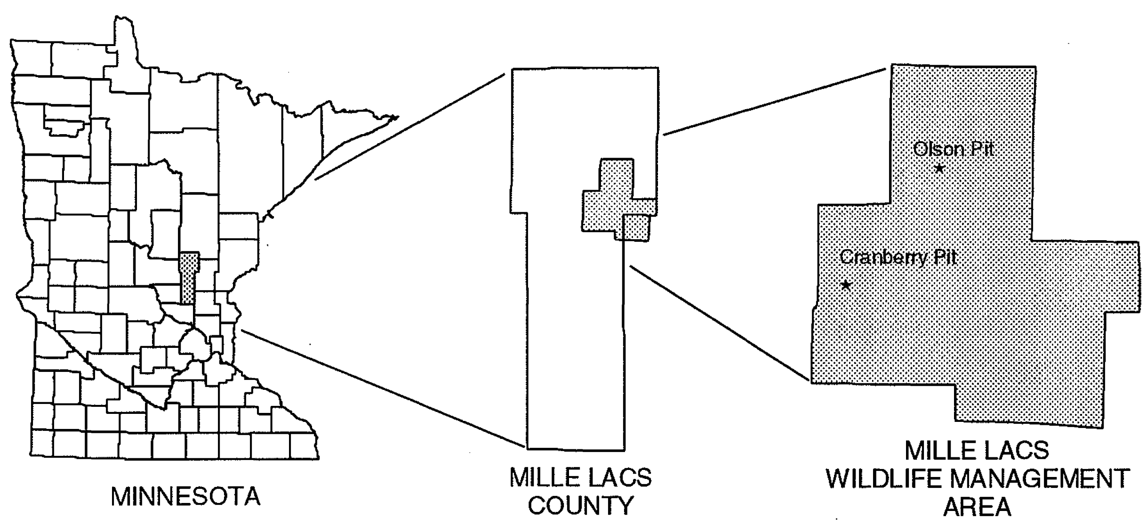


Figure 1. Index map showing locations of the gravel evaluations.

41N., R. 26W, in Onamia Township, Mille Lacs County, MN (Figure 2). A WMA road is
adjacent to the site and leads about 1.5 miles to unpaved County Road 19 (100th Avenue). Onamia is about 8 miles away.

Purpose – The two sites were evaluated to determine the extent, quantity, and quality of the gravel. The evaluation was not intended to provide a comprehensive delineation of the deposits, but rather more of a cursory evaluation. With this information, strategies to optimize use of the resource are proposed. The anticipated use of this gravel is for gravel road maintenance within the WMA.

Dates of field work – October 30 through November 2, 2000.

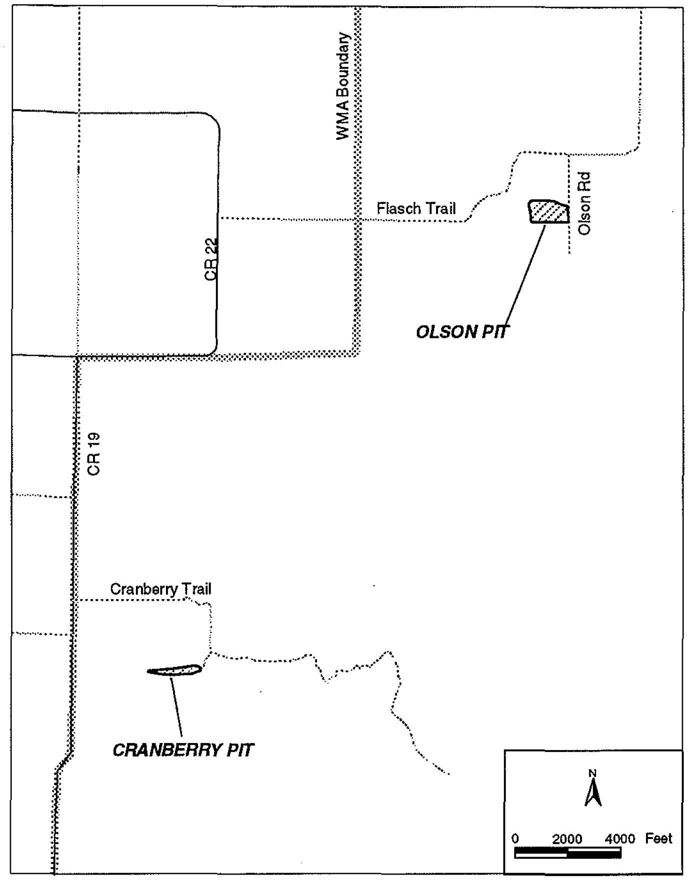


Figure 2. Index map showing access and roads to the Olson and Cranberry Pits.

Geologic Setting

East central Mille Lacs County has undergone a rather complex glacial history. This is an area where sediments of Wadena Lobe (also known as Rainy Lobe) glaciers that flowed from the north or northeast, and Superior Lobe glaciers that flowed from the northeast, overlap. The Superior Lobe was the last glacier to retreat from this area. Glacial sediments from the Superior Lobe are distinguished by the relatively high proportion of reddish-colored stones. Both gravel deposits evaluated were deposited by the Superior Lobe glacier.

The distribution of the gravel and topography of the land at the Olson pit indicate this is glacial outwash. The Superior Lobe glacier probably stopped retreating for a short time just a quarter mile east. This allowed streams that were flowing off of the ice to deposit outwash fans of sand and gravel over the area the Olson pit is located.

The distribution and character of the gravel at the Cranberry pit indicate this is an esker deposit. This is a small to moderate sized esker. The esker is about 21 feet high and 140 feet wide from toe to toe. The long narrow ridge that makes up this esker trends westward about 1200 feet and then turns to the southwest for another 800 feet before disappearing. The esker over the last 800 feet is very small. The esker is superimposed over what appears to be a drumlin that also trends westward.

Methods

<u>Map interpretation</u> – Air photos (NAPP 3134-102 to 103 and NAPP 3134-216 to 217 flown 4/21/91), U. S. Geological Survey (USGS) Quadrangle maps (Wahkon South and Milaca NE, MN), and digital orthophotos (DOQ's) were analyzed for geological interpretations and the identification of features and landforms in the study site.

<u>Auger drilling</u> -- Auger drilling was the method used to determine the distribution, extent (edge), quality, and geology of the gravel deposits. Ten holes were drilled with a Minnesota Department of Transportation (MnDOT) drill truck at the Olson pit and seven holes were drilled at the Cranberry pit. This is the same rig MnDOT uses to evaluate their aggregate deposits. This rig uses a ten-inch diameter auger. Geologic logs were described based on material retrieved with the auger. During drilling the auger typically was retrieved after drilling in 10 foot increments and described. Samples were then collected off the auger and bagged for gradation analyses. Hole #4 at the Olson Pit was described as a combination of logging the pit face (cleared with a backhoe) and drilling in the bottom of the pit. The pit wall (hole #18) was also described at the Cranberry Pit.

Drilling was difficult for the MnDOT rig at two sites at the Olson pit because of small boulders at

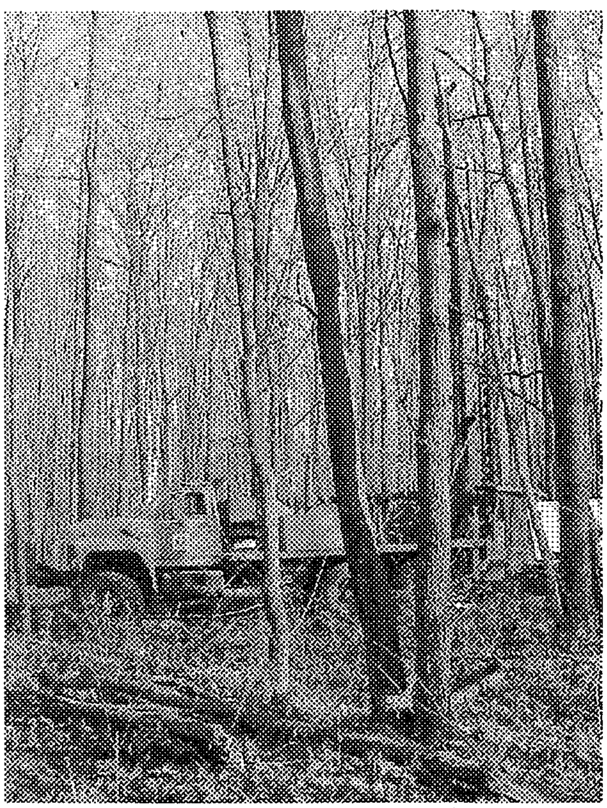


Figure 3. Drilling with the MnDOT rig at the Olson Pit.

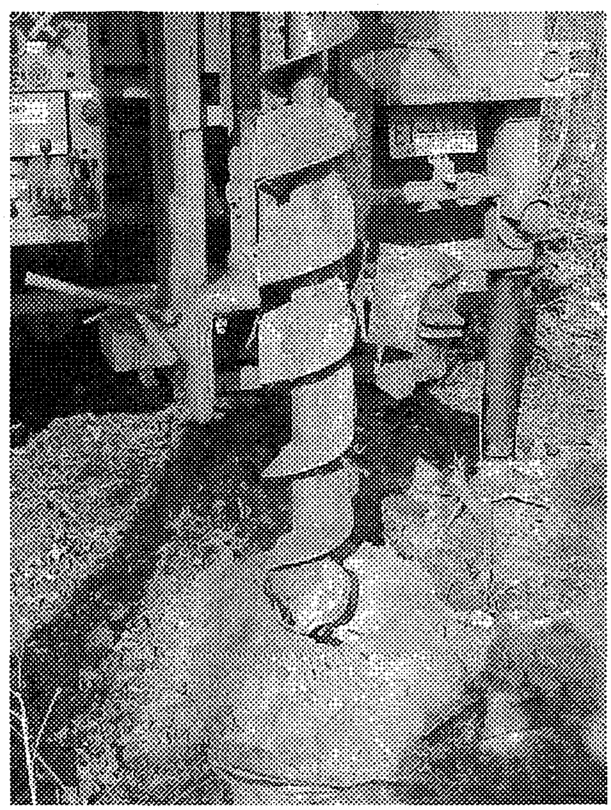


Figure 4. Material retrieved from the hole with the 10-inch diameter auger.

a depth of 4 to 6 feet. A backhoe was used to dig a trench with a nearly vertical face about 8 feet deep. 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. Holes #1 and #2 were drilled this way.

Gradations and quality analysis -- Gravel samples from 10 holes (27 samples) from the Olson pit and samples from 6 holes and one pit face (7 samples) from the Cranberry pit were sieved for gradation analysis at DNR Lands and Minerals office in Hibbing. Gradation results were compared to MnDOT's class 5 specifications.

GIS -- Drill holes and other features were located with a Garmin 12XL GPS (Global Positioning System) unit by averaging the readings for about a minute. Differential corrections were not applied because selective availability (intentional errors set by the government) was inactive. Accuracy of horizontal positions are estimated at about 20 meters or better. Elevations were not taken.

Maps were generated in ArcView programs.

Computer modeling – Geologic data collected during drilling and gradation data from the Olson pit were entered into a database and modeled with software developed by TECHBASE International. Overburden, gravel layers, and the water table were modeled using kriging algorithms to calculate gravel volumes above and below the water table.

Results – Olson Pit

Drilling -- Silty very fine sand to sandy silt, ranging from 1.5 to 6 feet in thickness, and averaging 3 feet thick, overlies the gravel everywhere. Black topsoil is 3 to 4 inches thick. The very fine sand and topsoil are referred to as overburden because they normally are stripped off the gravel prior to mining. In most holes the overburden is about three feet thick, but ranges from 1.5 to 6 feet. The thickest overburden occurs in holes #6 and #7 in the northern portion of the evaluated area. In most holes, the overburden is around 3 feet in thickness. Some boulders occur in the overburden and upper part of the gravel. Most boulders were less than 2 feet in diameter, but a few large ones occur at the ground surface. The largest boulder observed is 4 feet by 3.5 feet by 3 feet in size–it was on the ground surface.

Drilling showed that gravel blankets the entire area. The gravel ranges in thickness from 17 to 45.5 feet, averaging 28.7 feet. The top 5 to 10 feet of gravel is silty and somewhat muddy when wet. A cobble-rich layer with some small boulders occurs in the top two or three feet of the gravel. Cobbles also occur at various intervals of variable thickness to a depth as deep as 18 feet below the top of the gravel. Below the top 18 feet of gravel, cobbles and pebbles bigger than about 2 inches in diameter are rare or absent.

The water table was encountered at 16 to 21 feet below the ground surface. An average of 15.4 feet of gravel occurs above the water table and an average of 13.3 feet occur below the water table.

Quantity – The gravel extends in all directions from the existing pit. Pit development is constrained by the property line to the south, the road right of way to the east, and wet areas to the west and north. The potential pit extent drawn in Figure 5 and Plate 1 extends about 150 feet past the outermost drill holes, maintains a distance of 50 feet from the property line, covers about 18.6 acres, and is conservative. It is possible that gravel occurs beyond this line. The gravel was not projected to occur all the way to the road on the east, for example, because these areas were not drilled.

There are about 850,000 cubic yards of in-place gravel within the pit outline, assuming vertical pit walls. It is not possible to mine all of that, however, because of sloping requirements from the property line. If mining occurs so that the pit slopes on the south side of the pit do not exceed 6:1, the quantity is reduced by about 70,000 yards leaving about 780,000 cubic yards of mineable gravel (Table 1). Of this total, about 420,000 cubic yards occur above the water table and 350,000 cubic yards occur below the water table. Another 10,000 cubic yards remain at the bottom of the existing pit–some above and some below the water table.

Gradations and quality analysis – The gradation data presented in the first graph in Figure 6 compares the gravel above and below the water table. It shows that the gravel above water has more gravel than the portion below water. It is likely that both gravel portions would meet MnDOT's class 5 gradations after crushing. The second graph in Figure 6 shows that if the gravel above and below water are mined together as a single layer, class 5 gradations are met. Note that the gradation curve will change a bit after crushing because the material larger than 3/4 inch will be incorporated into the smaller sizes and particles larger than 4 inches are not included in these gradations. The addition of plus 4 inch material tends to lower the curve. Note: These are only general guidelines that are useful for planning. Specific testing, if necessary, should be done for each pile of class 5 made.

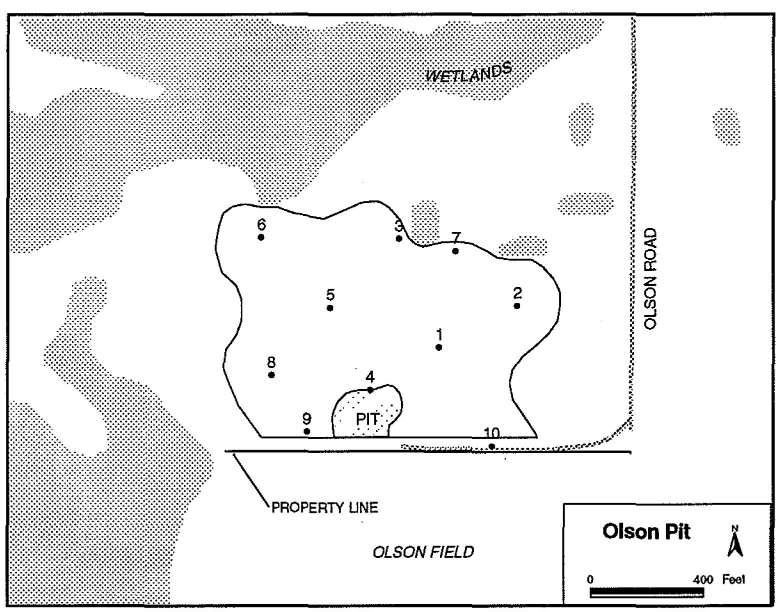
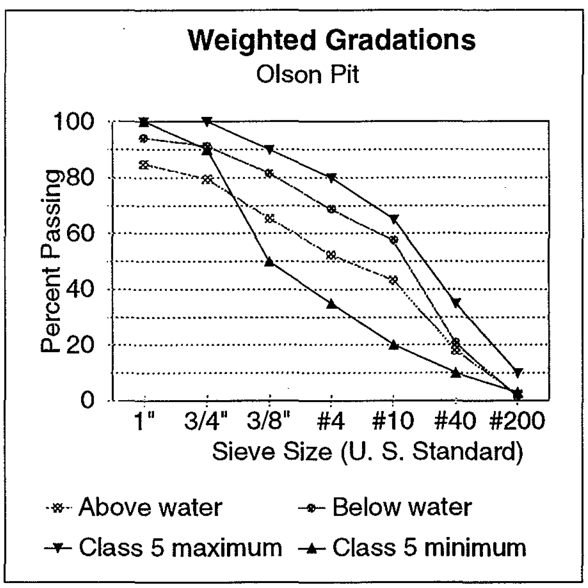


Figure 5. Drill holes, wetlands, and other features at the Olson pit. The black line circling the drill holes indicates the area used for volume calculations. Holes 1 and 2 were drilled after excavations with a backhoe. Hole 4 represents a combination of the pit wall and drilling in the bottom of the pit. Wetlands displayed are taken from the National Wetlands Inventory (NWI).

Table 1. Modeled estimates of the quantity of gravel (in-place) at the Olson site. The 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 for the top and bottom, but the edges are less certain.

Gravel Unit	Area (ft^2)	Acres	Feet of gravel	Volume (cubic yards)		
				Total Resource	With sloping requirements[2]	Error (+/-)
above water[1]	775,000	17.8	15.4	440,000	420,000	20/20
below water	775,000	17.8	13.3	380,000	350,000	25/25
existing pit[3]	36,500	0.8	23	30,000	10,000	20/25
combined	811,500	18.6	28.7	850,000	780,000	

[1]Calculations are based on mining stopping at the water table. If mining stopped 3 feet above the water table, for example, then the volume of gravel above water is about 90,000 yards less than presented in the table.
[2]This column shows the mineable volume if mining does not occur deeper than the 6:1 slope projected from the property line to the south.
[3]Calculations are based on the pit being 14 feet deep over its entirety.



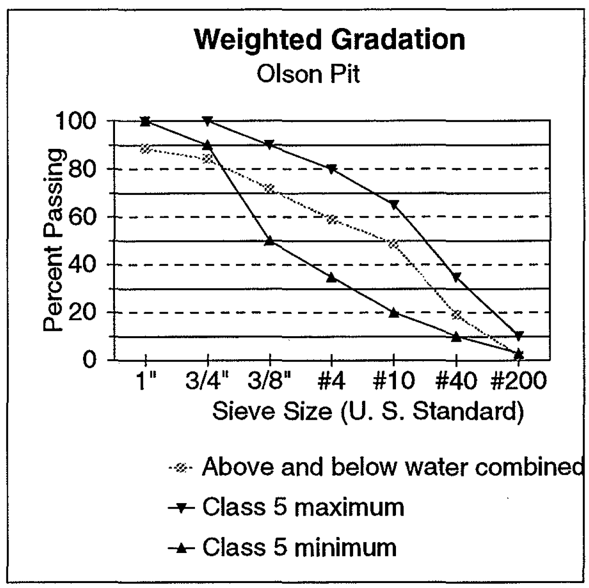


Figure 6. These graphs compare the size gradations of the gravel above and below the water table to MnDOT's gradation requirements for class 5 aggregate. These graphs are intended to provide a point of reference to a familiar gravel product (class 5). A project may require material meeting a different gradation. 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 shows the data used to construct the graphs. This table shows that the gravel units miss meeting the #200 mesh gradation by a small amount. The sieving method used by the DNR underestimates this value because we dry sieve, so some of the minus 200 mesh particles adhere to the larger particles and therefore do not get included in the minus 200 value. The table does indicate there is less silt in the gravel below the water table.

Lab tests for deleterious materials such as shale, soft particles, and iron oxides were not run on these gravels. Tests for deleterious materials are more important for bituminous or concrete uses. Gravels such as this derived from the Superior Lobe usually are of high quality such that this gravel may be acceptable for most uses. No shale or carbonates were observed during drilling.

Results – Cranberry Pit

Drilling -- Drilling showed that the gravel is confined to the undisturbed ridge and the staging area. The thickness of the gravel ranges from 19 to 22.5 feet in the ridge and ranges from 6 to 12 feet in the staging area. Less than 6 inches of topsoil cover the gravel in the ridge. Nothing covers the gravel in the staging area.

No large cobbles or boulders were encountered while drilling. The largest rocks encountered while drilling were about 8 inches in diameter. In most instances, the cobbles encountered while drilling were 3 to 6 inches in diameter.

The gravel body is somewhat layered. A predominant cobble layer that is around 3 feet thick occurs at a depth between 9 and 14 feet. At other depths, various sand, pea gravel, and occasional coarser gravel layers were detected while drilling.

The gravel occurs above the water table. Water, however, was encountered in two of the seven holes. In those two holes, the basal two feet of the gravel, which overlies till, was saturated, but

Table 2. Weighted average gradations for the Olson pit. This is the traditional method of presenting gradation results. The sieve sizes get progressively smaller moving to the right in the table. The values below the sieve sizes are the percent, by weight, of the total sample that falls through that sieve. The cutoff we use for gravel is material larger than the #10 sieve. For the gravel above water, then, 43% of the sample, by weight, passed through the #10 sieve. This means that this gravel has an average of 57% gravel (100 - 43 = 57). Values in parentheses represent the range in the samples.

	Percent of Material Passing Respective Sieve							Weight Percent Retained on Respective Sieve	
	1"	3/4"	3/8"	#4	#10	#40	#200	gravel +#10	crushable +3/4
Above water	85	80	65	52	43	18	2.1	57(45-73)	20(10-38)
Below water	94	91	82	69	57	21	1.3	43(35-58)	9(5-26)
Combined	88	84	72	59	49	19	1.8	51	16
Class 5 maximum	100	100	90	80	65	35	10.0	35	0
Class 5 minimum	100	90	50	35	20	10	3.0	80	10

the till below appeared unsaturated. The water appears to be localized in small pockets perched on the till.

Quantity – The area outlined as potentially mineable covers 4.5 acres (Figure 7, Plate 2). Of this, 0.9 acres represent the flat staging area east of the pit. Using simple calculations, it is estimated that 62,000 cubic yards exist within the undisturbed ridge and about 10,000 cubic yards remain in the staging area (Table 3). It is presumed that only minimal amounts of gravel remain in the pit area, so no estimates of that volume were made.

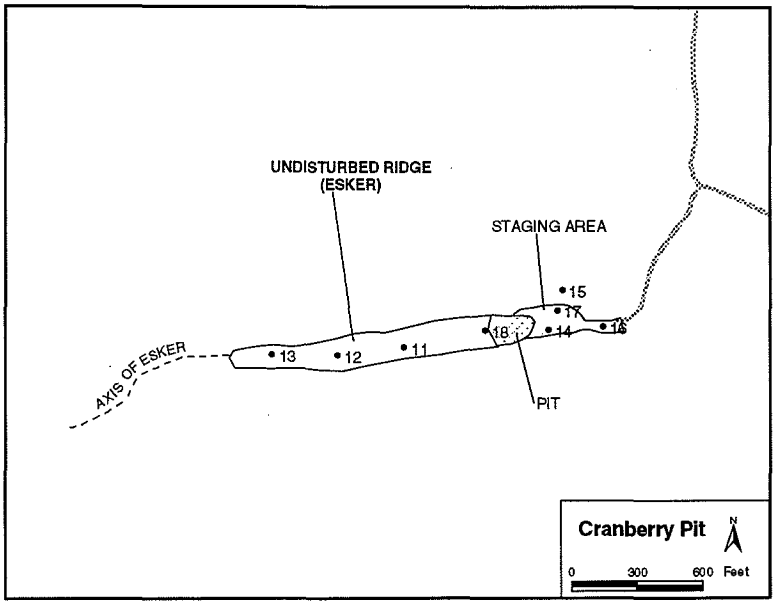


Figure 7. Schematic of the Cranberry Pit showing drill holes and other features. Outlined areas represent the area used in volume calculations. Location 18 is where the pit wall was described and sampled.

Gradations and quality analysis – The gradation data for the undisturbed ridge and the staging area are represented in Figure 8. For illustrative purposes, the data are plotted against MnDOT's typical requirements for Class 5 material. Note: These are only general guidelines that are useful for planning. Specific testing, if necessary, should be done for each pile of class 5 made. After crushing the values will be slightly different because the material larger than 3/4 inch will be incorporated into the smaller sizes. Also note that particles larger than 4 inches are not included

Table 3. Estimates of the quantity of gravel (in-place) at the Cranberry pit based on simple calculations. The 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 for the top and bottom, but the width of the esker is less certain.

Locale	Area (ft^2)	Acres	Feet of gravel	Volume (cubic yards)	
				Total Resource	Error (+/-)
Ridge	160,100	3.6	19-22	62,000	20/25
Staging area	39,200	0.9	7	10,000	45/25
Pit	23,300	0.5	Trace	minor	NAp
Total		4.5	NAp	72,000	NAp

in these gradations.

The gradation curves for the two different locations parallel each other closely. The only difference between the two is the gravel from the staging area has less rock that is larger than one inch as compared to the gravel from the ridge.

Table 4 shows the data used to construct the graphs. Raw data from individual drill holes are presented in Appendix B.

Lab tests for deleterious materials such as shale, soft particles, and iron oxides were not run on these gravels. Tests for deleterious materials are more important for bituminous or concrete uses. Gravels such as this derived from the Superior Lobe usually are of high quality such that this gravel may be acceptable for most uses. No shale or carbonates were observed during drilling, sampling, or reconnaissance of the pit slopes.

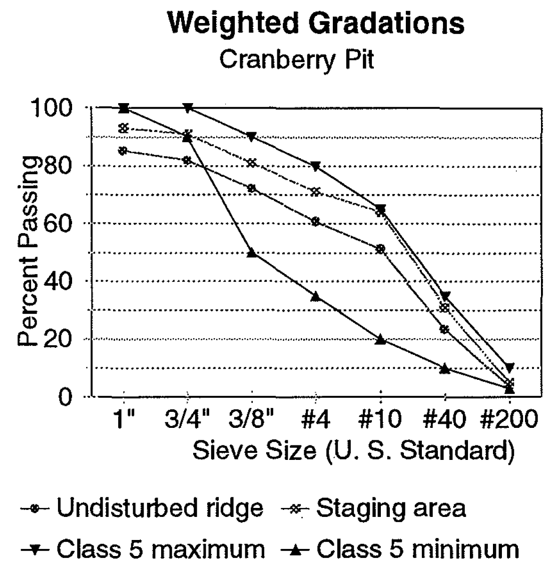


Figure 8. This graph compares the size gradations of the two locations to MnDOT's gradation requirements for class 5 aggregate. This graph is intended to provide a point of reference to a familiar gravel product (class 5). A project may require material meeting a different gradation. Percent passing refers to the proportion of the sample that passes through a particular sieve size. Particles larger than 3/4 inch would be crushed.

Table 4. Weighted average gradations for the Cranberry site. 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 the undisturbed ridge then, 51% of the sample, by weight, passed through the #10 sieve. This means that this gravel has an average of 49% gravel (100 - 51 = 49).

	Percent of Material Passing Respective Sieve							Weight Percent Retained on Respective Sieve	
	1"	3/4"	3/8"	#4	#10	#40	#200	gravel (+#10)	crushable (+3/4")
Undisturbed ridge	85	82	72	61	51	23	3.5	49(41-54)	18(11-24)
Staging area	93	91	81	71	64	31	4.9	36(26-53)	9(6-13)
Class 5 maximum	100	100	90	80	65	35	10	35	NAp
Class 5 minimum	100	90	50	35	20	10	3	80	NAp

Mining Plan

Development of a mining plan requires consideration for production of a desired product or products, economics, scale and scope of operations, and reclamation. Every gravel deposit has its own unique geometry, variation in quality, and setting within the landscape, and each landowner has their own vision of how the final reclaimed landscape should look. Therefore, mining plans are unique for each pit. There are, however, five steps that are necessary for any mining activity. They are: permitting, clearing, stripping, mining, and reclamation. These steps are discussed below for the Olson and Cranberry Pits.

Olson Pit

This mining plan encourages and anticipates that all of the gravel resource, including that below water, will eventually be mined over numerous phases. This plan presents a basic design for mining of the gravel and of the final reclaimed area. Custom designs or particular management plans for the site are left to the discretion of the land manager. It is important to consider special (custom) landscaping plans in the early phases of mining, if possible, so that there is enough non-gravel material in appropriate locations to complete the design.

It is proposed that the gravel above the water table be mined on a third to half of the ultimate pit extent before mining below water is considered. The primary reason for this is because additional space is necessary when mining the gravel below water. When about half of the pit has been mined, there is enough room on the flat bottom portion of the pit to accommodate all the activities for mining below the water table. Then the permanently reclaimed perimeter slopes could remain undisturbed. Note that the gravel extends past the drill holes, so it is probable the gravel extends past the proposed pit extent as drawn in Plate 1. Therefore, some mining and the final slopes for reclamation could project past the pit extent in places, especially in an easterly direction.

It is proposed that mining the gravel below the water table be done with a large backhoe or excavator. With this method no pumping or ditching of water, which require permits, is needed.

About 12 acres of wetland and pond could ultimately be created from mining the gravel below the water table. Consultation with a representative from the Board of Water and Soil Resources (BWSR) and appropriate DNR personnel is needed prior to excavating below the water table to ensure credit for the created wetlands.

When multiple options are presented below, the most appropriate option is dependant on the scale of the project and timing, and is left to the discretion of the landowner

<u>Permitting</u>– Mille Lacs County zoning rules stipulate that the landowner shall obtain a "Conditional Use Permit" prior to mining. If other permits are needed that usually is revealed during the process of procuring the conditional use permit. Additional permits likely are required

if water is drained or pumped from the pit or if wetlands are impacted (Fact Sheet 1 in Appendix E). An Environmental Assessment Worksheet (EAW) is not mandatory since the ultimate pit size is less than 40 acres.

Clearing– Timber of economic value should be logged prior to pit expansions. Brush and unsaleable timber should be reserved in piles for upland or under water habitat, for visual screening, or disposed of away from the proposed and future mining areas at the discretion of the landowner.

Stripping– An average of three feet of overburden overly the gravel. The overburden should be removed and stockpiled (not merely pushed into a windrow) prior to each phase of mining. These piles should be sited outside of the area to be mined, outside of areas to be mined in the future, if practical, inside the pit once the pit grows larger, or along the slopes at the perimeter of the ultimate mine. The idea is to keep from moving the overburden any more than necessary and also to place it as close as practical to where it will be ultimately used. Ideally, the material stripped should be placed immediately in an adjacent area that is depleted of gravel or will not be mined any more (perimeter slopes) and is ready for reclamation.

Chances of successful revegetation of the site are increased by stripping and piling the dark topsoil portion of the overburden separately from the underlying subsoils. Then, at sites ready for permanent reclamation, the materials could be spread in reverse order. This gives the best practical growing medium for vegetation. To minimize erosion and weed growth, the overburden and topsoil piles can be seeded with a cover (nurse) crop of oats (spring and summer), winter wheat (fall), or other species at the discretion of the landowner.

Stripping must extend far enough past the expected toe of the pit so that final or temporary sloping can be done during active mining. After each mining phase is complete, the working face cannot be steeper than ½ :1 for safety (and to comply with permit stipulations). This means the overburden should be stripped far enough past the expected pit edge to allow for proper sloping as the mining phase ceases. Stripping a little further than necessary in areas that will be mined in the future may be wise.

This same approach to stripping is used along the perimeter of the pit. This accomplishes the task of completing final sloping during active mining (excavation). Assuming the final slopes above water along the perimeter will be 3:1 (the approved permit may require a more gentle slope), and the water table is about 18 feet down, then the final slopes must extend about 54 feet outward from the bottom of the pit face. The edge of the stripped area is usually quite visible, so it also serves as a good boundary for the mining operation.

It may not be necessary to strip all of the overburden. As mining moves toward the center of the gravel deposit, where there are no slopes to permanently reclaim, less overburden is needed for reclamation because this area will be a pond. If the desired aggregate product is class 5, the bottom 1, 2, or 3 feet of overburden (excludes black topsoil) can be blended into the gravel during mining to increase the percentage of silt. Whether it is important to strip all of the overburden subsoils mostly depends on the final reclamation plan for the site. Extra overburden could be used to fill part of the pond to create shallow areas, to create humps, an irregular shoreline, or islands in the resulting pond, or be used for filling areas where slopes are steeper than desired, for example. If islands are proposed for the pond, then plans must be made to retain sufficient amounts of overburden in the vicinity for construction of the islands after the gravel is mined completely. Note: the water would be 6 to 12 feet deep in the northeastern one third of the ultimate pit, so islands constructed in this area are the least costly.

If the long-term plan does not include mining below the water table, more overburden is needed for permanent reclamation. In this situation, the final reclaimed surface should be about 4 feet above the water table for a forested upland habitat. Therefore, the ultimate mining depth relative to the water table is dependant on the amount of overburden that will be spread during reclamation. For example, the gravel could be mined to within one foot of the water table if plans are made to reclaim the area by spreading three feet of topsoil and overburden.

Mining– A mining strategy is partly dependent on the scale of the mining operation. A company planning to mine 100,000 yards or more at a time has more flexibility than when mining 10,000 yards at a time. Regardless of the size, it is necessary to mine the entire gravel interval above the water table as a single lift or layer, and similarly for the gravel below the water table. This method of mining creates the most uniform product, and is the quickest way to deplete portions of the pit so they can be reclaimed.

Mining in small increments on the order of 10,000 yards at a time will occur intermittently, at least for the near term as demands for gravel warrant. The existing pit is very near the southern limit of mining due to private property on the south. Zoning ordinances specify that mining can not occur deeper than a 6:1 slope projected from the property line (Appendix D). Initial pit expansion would progress westward from the existing pit. This first expansion should include establishment of the 6:1 slope in the existing pit at the proper distance from the southern property line so that this slope can be permanently reclaimed. After mining has reached the western extent, the next phase would move north and then phases after that would move eastward, paralleling the previously mined areas (Figure 9). During early phases, as active mining occurs, the southern slope should be graded for final reclamation. Then, when stripping is done for the subsequent phase of mining, overburden (after the topsoil has been piled separately) can be pushed onto the prepared slope and spread.

A 50 foot setback along the property line on the south was chosen as a reasonable trade off in regards to the gravel that is not mined in this area and economics. At a distance of 50 feet from the property line, a 6 to 1 slope projects to a depth of 8 feet. Assuming 3 feet of overburden overlies the gravel, then 5 feet of gravel could be mined at this distance. If mining occurred closer yet to the property line less gravel could be mined relative to the amount of stripping needed, making it uneconomical.

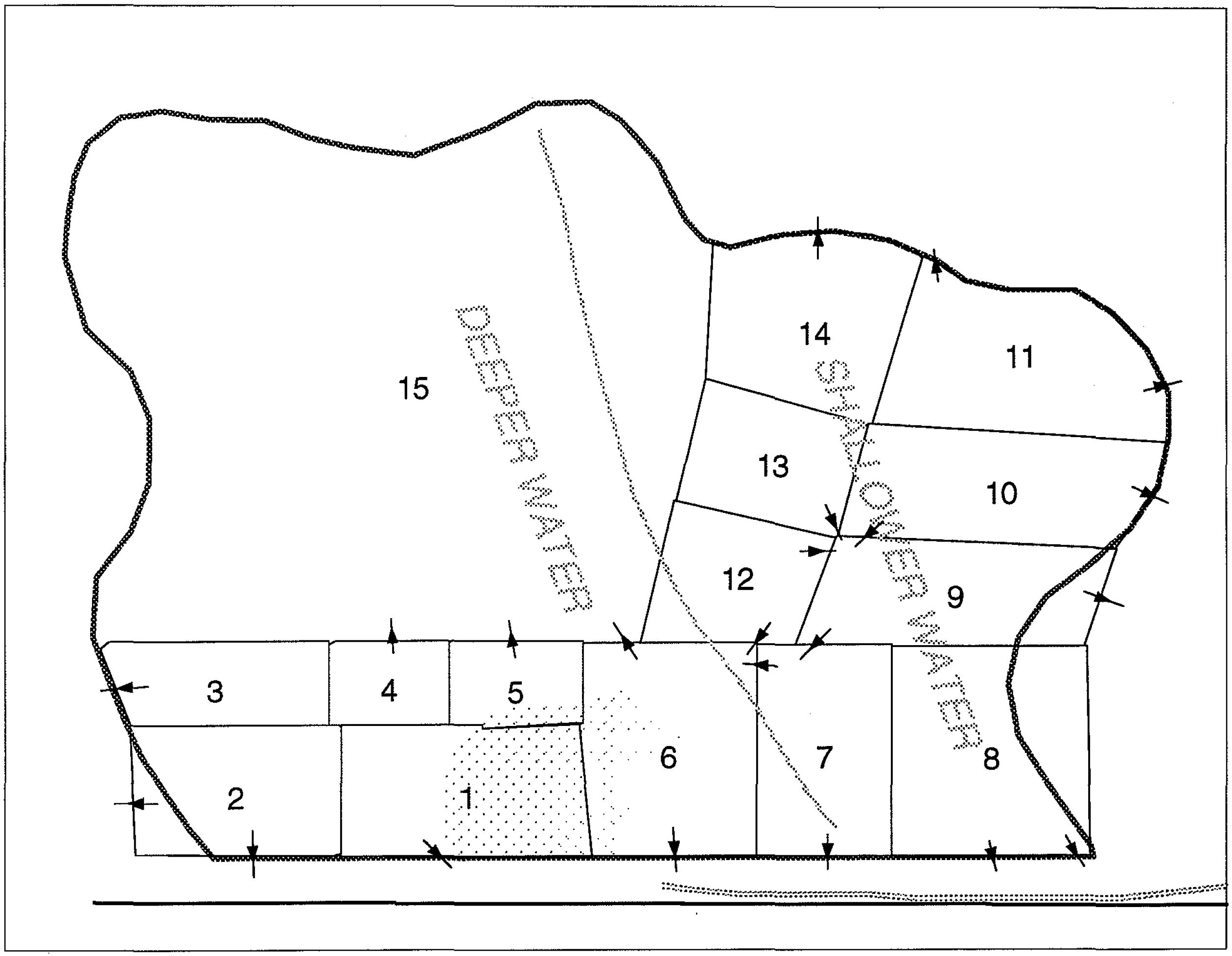


Figure 9. This schematic illustrates a possible mining strategy covering numerous phases of mining above the water table. Each phase is numbered to represent the order in which they would be mined. Phases 1 through 5 represent approximately 10,000 cubic yards of gravel each, and phases 6 through 12 represent roughly 20,000 cubic yards of gravel each. The arrows indicate possible locations for stockpiling of the topsoil and overburden. The first mining phase would start at the existing pit (stippled area) and move westward. Note that stockpiling is not recommended in the area east of phase 8. This is because there is room for more mining between there and the road to the east if gravel occurs there. Digging one or two test pits with a backhoe east of phase 8, prior to stripping for phase 8, would verify whether gravel occurs there or not. If gravel occurs, then another mining phase east of phase 8 could be planned. Mining below the water table should start in the northeast concurrent with the mining of phases 12 through 14 or after phase 14 is completed. Once the gravel below the water table is mined in portions of the northeast, materials from clearing (brush) and stripping (topsoil and overburden) in phases 12 through 15 could be placed to form islands or peninsulas in the mined out portions to provide a growing medium and to create a diverse habitat. The most economical place to build islands is in the "shallower water" area.

Within this gravel deposit, it is probable that sandy pockets of variable thickness and extent will be encountered sometime during mining, most likely when mining below the water table. When mining above the water table, the sandy zones, if encountered, can be blended with rockier material exposed further along the pit face to produce a quality product. Out of 19 gravel samples collected from above the water table, the worst one in terms of gravel content is graphed in Figure 10. This one falls well within the recommended guidelines for class 5, so when mining above the water table, it is reasonable to expect good quality gravel throughout the site. Of the 8 gravel samples collected from below the water table, the worst one is borderline for meeting the class 5 guidelines (Figure 10). This sample is representative of the western one third of the site. Blending with additional rock or screening out some of the sand may be necessary if the desired product from this part of the pit is class 5.

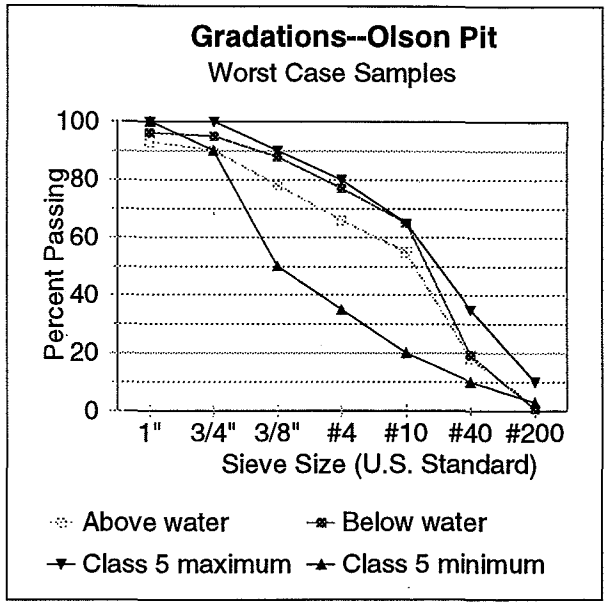


Figure 10. This graph shows how the worst samples collected while drilling above and below the water table compare to MnDOT's gradation recommendations for class 5 gravel. The worst case sample from above water falls well within the guidelines, but the worst case sample from below the water table is borderline for meeting the guidelines.

This gravel deposit, especially the portion above the water table, has enough rock that the rocks larger than 4 inches, for example, could be screened off during the crushing operation and piled separately. This rock should be saved so it can be crushed with the gravel that is mined from below the water table as needed to increase the gravel content. It could also be used for rip rap or crushed to make "100% crushed" aggregate which is used to make a high-value bituminous product, for example. Keeping the material larger than 4 inches in diameter out of the class 5 pile will still result in an acceptable class 5 product. Large boulders, about 2 feet in diameter and larger, can be piled separately and crushed someday, or used as barriers, large rip rap, or for wildlife habitat.

Reclamation– The final pit perimeter should be sloped no steeper than 3:1 and covered with a minimum of 6 to 12 inches of topsoil. Along these slopes gravel will still remain in most areas beneath the spread topsoil. Gravel does not hold much moisture and is a poor growing medium, which may be stressful to vegetation during dry hot spells. Along the perimeter slopes, then, it is best to spread overburden as a subsoil before spreading the topsoil to optimize vegetative growth.

Placement of six inches or more of black topsoil in the shallow portions (6 feet or less of water) of the new pond will help vegetation establish in the shoreline area. Advice on creating wetlands is available from personnel at BWSR and DNR Division of Ecological Services. All reclaimed areas need to be seeded to keep out weedy species and accelerate the reclamation process.

Four fact sheets on aggregate mining are attached in Appendix E. Additional information is presented in the publication by Cynthia G. Buttleman, 1992, "A Handbook for Reclaiming Sand and Gravel Pits in Minnesota", Minnesota Department of Natural Resources.

Additional advice is available from DNR Division of Lands and Minerals personnel at the Hibbing or St. Paul offices.

Cranberry Pit

This plan presents a basic design for mining of the gravel and of the final reclaimed area. Custom designs or particular management or reclamation plans for the site are left to the discretion of the land manager. The final reclaimed landscape will be a relatively flat upland area nearly level with the adjacent undisturbed areas. The site contains enough topsoil (overburden) for only a relatively thin veneer for reclamation.

This gravel deposit consists of a ridge of gravel. The edges of the deposit are fairly well defined and it is relatively narrow, so portions of the pit can be permanently reclaimed after each phase of mining. The basic strategy is to mine the entire thickness and width (toe to toe) to within about 1 foot of the underlying glacial till and move westward as mining progresses. With each mining phase, the staging area will move westward with the pit face, and the staging area from the previous phase can be permanently reclaimed.

When multiple options are presented below, the most appropriate option is dependant on the scale of the project and timing, and is left to the discretion of the landowner

Permitting– Mille Lacs County zoning rules stipulate that the landowner shall obtain a "Conditional Use Permit" prior to mining. If other permits are needed that usually is revealed during the process of procuring the conditional use permit. Additional permits likely are required if water is drained or pumped from the pit or if wetlands are impacted (Appendix E). An Environmental Assessment Worksheet (EAW) is not mandatory since the ultimate pit size is less than 40 acres.

Clearing– Timber of economic value should be logged prior to pit expansions. Brush and unsaleable timber should be reserved in piles for upland or under water habitat, for visual screening, or disposed of away from the proposed and future mining areas at the discretion of the landowner.

Stripping– The thickness of overburden (all topsoil) is less than 6 inches. The black topsoil blends into gravel with depth. The overburden should be removed and stockpiled (not merely pushed into a windrow) prior to each phase of mining. One strategy to retain as much topsoil as possible for reclamation is to push the topsoil into a couple of piles near the toe on each side of the ridge prior to each mining phase. If the top 4 inches on average are scraped, then approximately 140 yards could be piled on each side of the ridge for every 10,000 yards of gravel mined (about 150 feet of ridge). To minimize erosion and weed growth, the topsoil piles can be seeded with a cover (nurse) crop of oats (spring and summer), winter wheat (fall), or other species at the discretion of the landowner.

At the conclusion of each mining phase, the working face cannot be steeper than ½ :1 for safety (and to comply with permit stipulations). The overburden must be stripped far enough past the expected pit edge to allow for proper sloping. Stripping further westward than necessary will ensure that space exists to properly slope the working face as the mining phase winds down.

Mining– This gravel deposit can be envisioned as a ridge of gravel that was laid upon a relatively smooth pre-existing landscape of glacial till. The point where the toe of the ridge ends and the landscape begins is obvious on the north side. The point where the toe of the ridge ends along the south side is less obvious than on the north side. The ridge should be mined to just above the till and laterally to the toes of the ridge.

The amount of gravel remaining in the existing pit appears minimal based on the depth of excavation. Therefore, the existing pit face and the staging area will move westward with each phase of mining.

As a rule of thumb when mining westward, for the first 750 feet up to the location of hole #12, about 140 to 160 feet of ridge need to be mined for every 10,000 cubic yards of gravel. The ridge is narrower just west of hole #12.

The base of the gravel is relatively level with perhaps a slight slope to the south. A relatively flat staging area could be left after mining by leaving or spreading a small amount of sand and gravel (6 to 12 inches) on the pit floor above the till. The potential for water accumulating in the pit is minimized or eliminated if the ridge is mined completely down to the toes.

Within this gravel deposit (undisturbed ridge), it is probable that sandy pockets of variable thickness and extent will be encountered sometime during mining. Most of these should be relatively small and occur as intervals sandwiched between rockier intervals. The gradation data indicate that within the entire 22 feet of gravel there is enough rock in the rocky layers to make up for the deficiency of rock in the sandy layers. Figure 11 shows that the worst sample from the ridge (out of 4 samples) in terms of gravel content falls within the recommended guidelines for class 5. When mining the ridge, then, it is reasonable to expect good quality gravel throughout the site as long as the entire thickness is mined as a single layer.

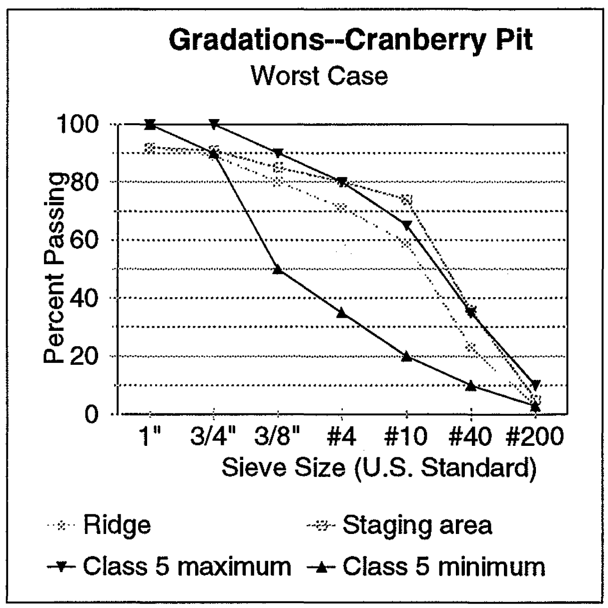


Figure 11. This graph shows how the worst samples collected while drilling on the ridge and the staging area compare to MnDOT's gradation requirements for class 5 gravel. The worst case sample from the ridge (esker) falls within the guidelines, but the worst case sample from the staging area falls outside the guidelines because it is too sandy.

There are about 10,000 cubic yards of gravel remaining in the previously mined area (staging area on Figure 7 and Plate 2) east of the current pit. This gravel is borderline for meeting the class 5 guidelines. Of the 3 gravel samples collected from this area, the worst one falls outside the guidelines for class 5 (Figure 11). Blending with additional rock or screening out some of the sand may be necessary if the desired product is class 5. This material may be acceptable for the minimum-use roads within the WMA. If a sandy gravel with occasional pebbles and small cobbles up to about 3 inches in diameter are okay, then crushing is not necessary. Pockets with numerous large pebbles and cobbles encountered could be piled separately, or left in place. They could be mined with the next crushing operation.

Reclamation– Once mining activities, including staging activities, have moved past a given area, the area undergoes final grading, if necessary. Then the piles of topsoil adjacent to the area are pushed and spread onto the adjacent mining area. It will be necessary to keep a "road" passing through this area for access to the current mining area.

All reclaimed areas need to be seeded to keep out weedy species and accelerate the reclamation process.

Four fact sheets on aggregate mining are attached in Appendix E. Additional information is presented in the publication by Cynthia G. Buttleman, 1992, "A Handbook for Reclaiming Sand and Gravel Pits in Minnesota", Minnesota Department of Natural Resources.

Additional advice is available from DNR Division of Lands and Minerals personnel at the Hibbing or St. Paul offices.

Glossary

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

cobble– a stone larger than 64 mm (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.

drumlin– a streamlined hill or ridge of glacial deposits with its long axis paralleling the direction of flow of the former glacier

esker– serpentine ridges of sand and gravel. They are formed by streams flowing on or in glacial ice and when the ice eventually melts, the sediments from the stream bed form a ridge.

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

GIS– stands for **geo**graphic **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.

landform– any naturally occurring recognizable physical form or feature on the earth's surface, such as hill, valley, esker, plain, plateau, mountain.

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-E

Appendix A: Locations of drill holes and comments.

Appendix B: Detailed descriptions for each drill hole.

Appendix C: Complete gradation data.

Appendix D: Mille Lacs County zoning guidelines.

Appendix E: Four fact sheets on aggregate mining.

Appendix A. Locations of drill holes and comments.

pit id	hole id	utm_easting	utm_northing	location and comments
Olson	1	457447	5098708	just NE of pit and ~300 ft N of prop line, met refusal on rocks at 5, 4, and 5 ft. Excavated a 8.5 ft deep trench with a backhoe and drilled from there, lots of 6-9" cobbles and two 1.5-2 ft bldrs in hole
Olson	2	457531	5098754	~300 ft E of #1 and ~300 ft W of road, met refusal on rocks at 3 ft, 3 attempts. Excavated an 8 ft deep trench with a backhoe and drilled from there, a few 12-18" bldrs in hole
Olson	3	457404	5098827	~485 ft N of #1, end of trail, there is a small (30x50ft) grassy area ~30 ft E of the hole
Olson	4	457372	5098663	combined description of backhoe trench on pit wall (0-14ft) and drilling in bottom of pit
Olson	5	457329	5098752	~300 ft N of #4
Olson	6	457254	5098828	~400 ft NNW of #5, near end of trail, swamp is ~75 ft N of here, passed by several big boulders in trail--largest was 4x3.5x3 ft
Olson	7	457465	5098813	~250 ft SE of #3
Olson	8	457266	5098679	on old trail, ~150 ft E of wetland, ~350 ft N of cornfield, ~350 ft W of #4
Olson	9	457304	5098617	on trail ~30 ft N of cornfield and SW of pit
Olson	10	457504	5098601	on trail leaving pit area, ~120 ft E of clearing and 10 ft N of corn
Cranberry	11	453109	5093378	top of esker ~350 ft W of pit face, top of esker is ~25 ft wide, N and S slopes are ~40 and ~50 ft
Cranberry	12	453014	5093367	~350 ft W of #11, esker is ~40 ft wide, N and S slopes are ~40 and ~60 ft
Cranberry	13	452922	5093368	~350 ft W of #12, esker is ~30 ft wide, N and S slopes are ~40 ft, about 150 ft W of here the esker continues westward but is much smaller--it is only 5-15 ft high and narrow
Cranberry	14	453311	5093403	on flat staging area about 50ft E of edge of excavation
Cranberry	15	453330	5093460	Northern toe of esker, north of flat staging area
Cranberry	16	453387	5093408	on road near E end of older staging area
Cranberry	17	453323	5093430	on flat staging area about 100ft NE of #14
Cranberry	18	453222	5093402	hand-trenched area on W face of gravel pit at the highest point of the esker
Cranberry		452649	5093266	gps point along axis of small uneconomic esker, point A
Cranberry		452701	5093288	gps point along axis of small uneconomic esker, point B
Cranberry		452746	5093343	gps point along axis of small uneconomic esker, point C
Cranberry		452800	5093361	gps point along axis of small uneconomic esker, point D
Cranberry		452865	5093364	gps point at west end of esker with mineable gravel outlined in the report, point E

Appendix B. Detailed descriptions for each drill hole. Abbreviations used: lt = light, dk = dark, gry = gray, blk = black, brn = brown, yel = yellow, org = orange, ob = overburden, grvl = gravel, sd = sand, slt = silt, vf = very fine grained, f = fine grained, m = medium grained, c = coarse grained, ft = feet, est = estimate.

Hole id	From (ft)	To (ft)	Color	Sediment	Layer	% Gravel (field est)	Dominant gravel (inches)	maximum gravel (inches)	Comments
1	0	0.25	black	topsoil	ob				occasional 1 ft boulder at surface
1	0.25	3	lt brown	slty vf sd	ob	3			occasional granules
1	3	8.5	lt brown	slty grvl	grvl	45	1	4	lots of cobbles from 3 - 5 ft
1	8.5	19	dk brown	grvl	grvl	45	0.5	3	grinding rocks from 8.5 - 17 ft, less silt in lower 2 ft, water table at 17 ft
1	19	25	gry brn	slty grvl	grvl	30			muddy
1	25	37.5	gray	grvly silt	till	15			stiff drilling below 25 ft, refusal on rock at 37.5 ft, material is soft
2	0	2	lt brown	slty vf sd	ob	3			
2	2	8	brown	slty c grvl	grvl	50	1.5	9	very cobbly
2	8	23	red brn	slty grvl	grvl	45	0.5	2.5	no cobbles below 10 ft, water table at 17 ft
2	23	25	gry brn	sandy slt	till	5			soft, refusal on flat rock at 25 ft
3	0	0.3	black	topsoil	ob	0			
3	0.3	3.5	lt brn org	slty f sd	ob	2			
3	3.5	7.5	dk brown	slty c grvl	grvl	50	2	4	moist, numerous cobbles at 3-4 ft
3	7.5	9	dk brown	slty f sd	grvl	0			moist
3	9	16	brown	f grvl	grvl	45	2	6	moist, good gradation, cobbles at 14-15 ft, water at 16 ft
3	16	28.5	brown	f grvl	grvl	35	0.375	2	gravel content varies in layers, dk red to orange stain at 24-25 ft, easy drilling
3	28.5	30	gray	clay silt	till	5	0.375		upper few inches is brown
4	0	0.25	black	topsoil	ob				
4	0.25	1.5	lt brown	slty f sd	ob	2			cliff former
4	1.5	11.5	brown	slty c grvl	grvl	60	1.5	9	cobbly grvl, muddy when wet, rare white agates, some friable schist and granites
4	11.5	14	red gry	c sd & grvl	grvl		0.25	1	no silt
4	14	21.5	brown	grvl	grvl	45	1.5	6	water at 19.5 ft
4	21.5	24	brown	grvly m sd	grvl	20	0.25	1.5	
4	24	47	brown	f grvl	grvl	40	0.375	1.5	occasional 6-12 inch sand layers, granules comprise 20% red colored and 70% dk gray, orange layer at 27 ft

Hole id	From (ft)	To (ft)	Color	Sediment	Layer	% Gravel (field est)	Dominant gravel (inches)	maximum gravel (inches)	Comments
4	47	49	gray	sandy silt	till	7			conspicuous red and gray granules
5	0	0.25	black	topsoil	ob				
5	0.25	1	lt brown	slty f sd	ob	2			
5	1	5	dk brown	slty grvl	grvl	50	1	6	red and gray pebbles
5	5	7	dk brown	slty m sd	grvl	5			
5	7	21	red brn	c sd & grvl	grvl	40	0.375	2	fairly clean, moist at 7-10 ft
5	21	43	red brn	c sd & grvl	grvl	35	0.25	2	water at 21 ft
5	43	45	brown	sandy silt	till	5	0.25		stiff drilling
6	0	2	lt brown	slty f sd	ob	2			some coarse grains
6	2	4	red brn	slty grvl	ob	40			dry, lots of slty f sand
6	4	5.5	brown	cobbly sdy slt	ob	15			
6	5.5	9	red brn	slty sand	grvl	10			
6	9	17	brown	c sd & grvl	grvl	35	0.25	2.5	good gradation, varied layers, tight drilling at 15-16 ft
6	17	18.5	yel org	c sd & grvl	grvl	35			water at 17 ft
6	18.5	20	gray	c sd & grvl	grvl	35	0.25	2	fairly clean, smooth drilling until 39 ft
6	20	35	gray	m sd & grvl	grvl	30	0.25	1.5	sandier than above, lower 5 ft has more grvl than upper
6	35	40	red brn	sandy silt	till	10			contains red pebbles
7	0	1.5	brown	slty sd/grvl	ob	25	0.5	3	
7	1.5	6	dk red brn	grvly silt	ob	45	0.5	3	soft, friable to dense silt, maybe could blend with class 5
7	6	7	dk red brn	slty grvl	grvl	40	0.5	2	grind on cobbles 6-7 ft
7	7	10	dk red brn	m sand	grvl	15	0.125	0.375	slightly silty
7	10	15	brown	slty grvl	grvl	35	0.375	2	rocks at 12-15 ft, some silt layers
7	15	25	red brn	c sd & grvl	grvl	35	0.25	1.5	fairly clean, water at 17.5 ft
7	25	29	lt gray	silt	till	10	0.5	1	stiff drilling below 25 ft, lots of gray pebbles, no red pebbles
8	0	3	lt brown	slty f sd	ob	2			
8	3	9	gry brn	slty grvl	grvl	35	0.5	5	cobbles at 3-4 ft, big rock at 4 ft--skidded rig 5 ft
8	9	12	gry brn	c sd & grvl	grvl	40	0.25		
8	12	15	brown	m sand	grvl	5			has thin silt layer
8	15	21	brown	c sd & grvl	grvl	35	0.25	3	cobbles from 16 - 21 ft
8	21	27	gray	c sd & grvl	grvl	30	0.25	1	water at 21 ft
8	27	38	green gry	grvly sand	grvl	20	0.125	0.5	stiff drilling below 29 ft, refusal on rock at 38 ft
9	0	3	lt brown	slty f sd	ob				
9	3	10	brown	slty c grvl	grvl	50	2.5		cobbles from 3 - 4 and 9-10 ft, slightly muddy, one sand layer at 8 ft

Hole id	From (ft)	To (ft)	Color	Sediment	Layer	% Gravel (field est)	Dominant gravel (inches)	maximum gravel (inches)	Comments
9	10	12	red gry	c sd & grvl	grvl	35			clean
9	12	20	brown	grvl	grvl		1.5	4	cobbly, good gradation, some silt
10	0	3	lt brown	slty f sd	ob	2			occasional cobble
10	3	8	brown	slty c grvl	grvl	50	2.5	8	
10	8	20	gry brn	c sd & grvl	grvl	50	1	3	clean, coarser than other sites, crunching rocks 8-20 ft
11	0	0.3	black	topsoil	ob				
11	0.3	3	brown	slty sd & grvl	grvl	30	0.5		a few cobbles, m sand matrix
11	3	12	brown	m sd & grvl	grvl	40	0.5	3	graded, cleaner than above
11	12	21	brown	m sd & grvl	grvl	40	1.5	6	hard grinding at 12-18 ft
11	21	23	red brn	slty sd & grvl	grvl	20			wet--perched water
11	23	30	brn red	silt	till	10	0.5	3	stiff drilling below 24 ft, dry, occasional wet zones
12	0	0.25	black	topsoil	ob				
12	0.25	5	brown	m sd & grvl	grvl	45	0.375	3	m sand matrix, layers of sand, graded
12	5	10	brown	grvl	grvl	35			layers of clean sand to pea grvl
12	10	17	brown	grvl	grvl	35		6	cobble layer at 11-14 ft
12	17	23	red brn	c sd & grvl	grvl	25	0.125	0.5	clean, tighter drilling below 21 ft with cobbles
12	23	27	brn red	sandy silt	till	10			pebbly
13	0	0.25	black	topsoil	ob				
13	0.25	4	brown	sandy grvl	grvl	25			slightly silty
13	4	9	red brn	grvl	grvl	45	0.75	4	cobbles below 4 ft
13	9	13	brown	grvl	grvl	45	0.75	8	layer of large cobbles at 9-13 ft
13	13	19	gry brn	grvl	grvl	30	0.25	6	easy drilling 13-17 ft, alternating layers of brown m sand and gray pea grvl, cobble layer at 17-18 ft, wet at 17-19 ft
13	19	20	brn red	sandy silt	till	10			
14	0	7	brown	grvly sand	grvl	20	0.25		
14	7	10	brown	m sd & grvl	grvl	32	0.5	3	
14	10	12	brown	grvl	grvl	40	0.75		cobbles at 10-11 ft, sli silty
14	12	14	red	sandy silt	till	10	0.75		
15	0	4	org brn	sandy silt	till	10		1	
16	0	6	brown	grvl	grvl	35	0.5	3	graded, sli silty, layer (1ft) of c sand
16	6	7	red	sandy silt	till	10			friable
17	0	7	brown	grvl	grvl	35	0.5	3	well graded
17	7	9	red brn	m sand	sand	5			
17	9	10	brn red	sandy silt	till				

Hole id	From (ft)	To (ft)	Color	Sediment	Layer	% Gravel (field est)	Dominant gravel (inches)	maximum gravel (inches)	Comments
18	0	9	brown	grvl	grvl	35			varied layers, unable to sample below 9 ft from crest of pit wall

Appendix C. Complete gradation data for each sample sieved.

Sample #	Hole ID	From (ft)	To (ft)	Feet of material	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
Olson pit (above water)																								
33414.01001	1	3	8.5	5.5	100	100	100	82	77	72	66	62	59	56	51	42	36	34	27	18	13	8	3	1.3
33414.01015	1	8.5	19	10.5	100	100	100	92	87	86	81	76	71	67	61	51	44	42	32	19	12	7	2	0.6
33414.02013	2	2	8	6	100	100	100	100	89	86	81	75	71	66	59	44	37	35	27	20	16	13	6	3.0
33414.02014	2	8	23	15	100	100	100	100	96	91	86	80	76	70	63	45	38	36	26	15	11	8	4	2.0
33414.03002	3	3.5	9	5.5	100	100	89	83	73	69	66	62	60	56	52	42	36	34	28	20	17	14	8	4.3
33414.03003	3	9	16	7	100	100	100	100	96	93	89	83	79	75	69	54	43	41	31	20	14	9	3	1.6
33414.04021	4	1.5	11.5	10	100	100	100	93	82	78	72	66	63	58	52	40	32	30	23	13	8	4	1	0.2
33414.04022	4	11.5	14	2.5	100	100	100	100	98	97	93	90	87	83	78	66	58	55	44	28	18	10	3	1.7
33414.04005	4	14	21.5	7.5	100	100	100	100	97	92	87	82	78	74	70	59	53	51	43	29	21	13	3	1.1
33414.05007	5	1	7	6	100	100	100	96	94	92	88	84	81	76	71	59	52	51	44	35	29	22	11	5.4
33414.05008	5	7	21	14	100	100	100	100	97	95	92	88	84	81	75	62	55	53	45	32	24	16	4	1.4
33414.06011	6	5.5	17	11.5	100	100	100	98	93	90	88	83	80	77	72	62	54	51	43	35	29	21	9	4.6
33414.07017	7	7	15	8	100	100	100	100	96	91	88	83	79	75	70	60	54	51	41	29	24	19	10	5.8
33414.08018	8	3	9	6	100	100	100	100	96	94	90	84	80	76	71	59	53	51	42	30	23	15	4	1.4
33414.08019	8	9	21	12	100	100	100	100	98	97	94	89	86	81	74	58	53	51	43	30	22	15	6	2.1
33414.09023	9	3	10	7	100	100	100	94	89	86	82	76	72	66	60	47	42	40	34	24	19	13	4	1.9
33414.09024	9	10	20	10	100	100	100	98	94	92	88	84	80	77	71	57	49	47	37	26	20	14	4	1.1
33414.10025	10	3	8	5	100	100	95	93	90	85	77	69	63	55	48	35	29	27	22	15	12	8	4	2.0
33414.10026	10	8	20	12	100	100	100	98	92	90	85	79	74	69	62	46	40	38	29	17	11	6	2	0.9
average				161	100	100	99	97	92	89	85	80	76	71	65	52	45	43	35	24	18	12	5	2.1
Olson Pit below water																								
33414.01016	1	19	25	6	100	100	100	88	84	78	76	74	71	67	61	50	44	42	33	24	19	15	8	4.8
33414.03004	3	16	28.5	12.5	100	100	100	100	98	96	94	89	86	83	77	65	56	54	44	28	18	10	3	1.1
33414.04006	4	21.5	44	22.5	100	100	100	100	99	97	96	92	90	87	82	68	59	57	46	30	21	12	3	1.3
33414.05009	5	21	35	14	100	100	100	98	98	97	96	95	94	92	88	77	68	65	52	31	19	9	1	0.6
33414.05010	5	35	43	8	100	100	100	98	97	96	94	90	88	86	81	68	57	54	40	21	12	6	1	0.5

Sample #	Hole ID	From (ft)	To (ft)	Feet of material	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
33414.06012	6	17	35	18	100	100	100	99	99	98	97	95	93	91	86	73	66	64	56	45	34	21	4	1.7
33414.07018	7	15	25	10	100	100	100	100	98	95	92	86	82	77	72	57	46	43	32	18	12	8	3	1.7
33414.08020	8	21	38	17	100	100	100	98	97	97	96	94	93	91	87	75	66	63	50	30	19	9	2	0.7
average				108	100	100	100	99	97	96	94	91	89	86	82	69	60	57	46	30	21	12	3	1.3
Cranberry Pit (esker)																								
33414.11027	11	0.3	23	22.7	100	100	92	90	86	83	80	76	73	70	66	54	50	48	42	31	25	19	8	3.6
33414.12028	12	0	23	23	100	100	100	100	97	95	92	89	87	84	80	71	62	59	48	32	23	16	7	2.9
33414.13029	13	0	19	19	100	95	91	91	88	86	83	80	78	75	70	57	48	46	37	27	22	17	8	4.2
average				64.7	100	98	95	94	91	88	85	82	79	76	72	61	53	51	42	30	23	17	8	3.5
Cranberry Pit (pit face)																								
33414.18033	18	0	9	9	100	100	92	88	87	86	84	81	79	76	72	62	52	49	41	28	22	16	9	6.0
Cranberry Pit (staging area)																								
33414.14030	14	0	12	12	100	100	100	97	94	94	92	91	89	87	85	80	75	74	65	48	36	23	8	5.1
33414.16031	16	0	6	6	100	100	100	100	97	96	93	87	83	76	69	54	48	47	40	31	25	20	8	3.5
33414.17032	17	0	7	7	100	100	100	100	96	96	95	94	92	89	85	72	64	60	48	33	25	19	10	5.8
average				25	100	100	100	99	96	95	93	91	89	85	81	71	66	64	54	40	31	21	9	4.9

Appendix D. Mille Lacs County Zoning Regulations for Gravel Pits.

Zoning/Environmental Services
Department

BARB KIEL, Administrator

Mille Lacs County
635 2nd Street S.E.
Milaca, MN 56353

Phone 320-983-8205 Fax 320-983-8258
Toll Free 1-888-850-8205

704 Gravel Pits - Excavations - Mines and Processing

704.1 Purpose

The excavation, processing, and stockpiling of earth materials is a basic and essential activity making an important contribution to the economic and general welfare of the County. The excavation, stockpiling, and processing of material may create undesirable land and water conditions which can be detrimental to the health, safety, welfare, and property rights of the citizens of the County. This ordinance will provide for the economical development of sand, gravel, rock, soil, minerals, and other earth materials vital to the continued growth of the region and the County. It establishes reasonable and uniform limitations, safeguards and controls in the County for the future production of earth materials, minerals, and ores. It will control and minimize pollution caused by erosion or sedimentation, noise, and dust all in the furtherance of the health, safety, and general welfare of the citizens of Mille Lacs County.

704.2 Conditional Use Permit Required

A conditional use permit shall be required for all mining operations; and no landowner shall open, operate, or maintain a gravel pit excavation, mine, or allow others to do so on his land without a permit. Said permit applications shall be made by the property owner, who may lease to individual contractors. Proof of ownership, and copies of all lease agreements must be filed with the Zoning Administrator at the time of application. After a conditional use permit is granted, all future lease agreements must also be filed with the Zoning Administrator.

Conditional use permits are subject to review on a yearly basis. At such time, the Zoning Administrator may revoke a permit for a site which is found to be operating in violation of the regulations of this Ordinance or of the requirements of the conditional use permit. The land owner is responsible for the conduct of all persons leasing property, and the proper rehabilitation of all lands excavated.

704.3 Information Required

The following information shall be provided by the person requesting a mining conditional use permit or a license.

1. Name and address of applicant/land owner.

2. Legal description of property and mine site.

3. Type of mining and processing operation and duration.

4. Signed lease agreements from all contractors mining and processing on site.

5. Property maps to scale of at least 1" = 200' showing existing and proposed excavated area, bottom of pit elevation, natural drainage and outlet elevation, existing water surface elevation, or ground water elevation, adjacent land use, ownership, and access roads.

6. A statement describing the method to be used to control soil erosion, sediment, dust, and noise.

7. A plan for the rehabilitation or restoration of all disturbed land including projected land use, drainage, slopes, plantings, and approximate elevations all of which shall be in accord with the requirements set forth in this Ordinance.

8. Applicants for conditional use permits shall furnish information on proposed structures, sediment control units, parking areas, stockpiles, equipment storage, tailings deposits, and type and location of proposed screening.

9. Any other information requested by the Zoning Administration or the Planning Commission shall be submitted.

704.4 Renewal of Conditional Use Permits

Conditional use permit renewal maybe granted by the Zoning Administrator or by the Planning Commission for this section. A public hearing shall be conducted for conditional use permit renewal when, in the judgement of the Zoning Administrator, the regulations setforth herein for extraction, or the conditions mandated by the permit are violated.

704.5 Use Restrictions

In stone quarries the production or manufacture of cut to size or ground to size or shape shall be identified in the application for a conditional use permit.

The manufacturer of concrete building blocks, formal concrete products, or production or manufacture of lime products, the production of ready-mixed concrete shall be included in the application for a conditional use permit and be in all districts considered a conditional use.

The County may impose additional performance standards by written notice to the owner as part of the granting of a permit or the renewal of the same as the County deems necessary and reasonable to protect the health, safety, and general welfare of the citizens of Mille Lacs County.

704.6 Performance Standards

Every person to whom a permit is issued shall comply with the regulations set forth as follows:

1. No excavation shall be made beyond the limits for which the particular license is granted and in no case shall any excavation made within a 6:1 slope from any right-of-way or property line without the written approval of the road authority or adjacent land owner being on file at the Zoning Office.

2. All reasonable means shall be employed by the applicant to reduce dust, noise, and nuisances.

3. All active excavations other than the working face shall be sloped at a maximum slope of 1/2:1, all non-active slopes shall be to a maximum of 4:1 where feasible until the area is restored. Areas that must be steeper than 1/2:1 and the working face shall be fenced.

4. Existing trees and gravel cover shall be preserved to the extent feasible by transporting and replanting of trees, shrubs, and other natural ground cover along all setback areas, the cutting of trees is allowed.

5. The perimeter of the mining site shall be planted or otherwise screened from adjacent private and public land as practical or specifically required as a condition of the permit.

6. Abandoned machinery and rubbish shall be removed from the site regularly and at the termination of the permit or extraction, except composting, dead tree storage, blacktop and concrete storage for reuse, and demolition debris shall be allowed when incorporated into the permit application or if included as part of an approved site rehabilitation plan and operated in conformance with state regulations.

7. All wells found or installed on the property and not incorporated into the reuse plan shall be capped upon termination of the permit or extraction.

8. Operating Standards:

   a. Noise - the maximum noise level at the perimeter of the site shall be within the limits set by the Minnesota Pollution Control Agency of the United States.

   b. Hours - All mining operations shall be conducted between 7 a.m. and 7 p.m.

   c. Explosives - the use of explosives shall not be allowed.

   d. Dust - operators shall utilize all practical means to reduce the amount of dust caused by the operation. In no case shall the amount of dust or other particulate matter exceed the standards established by the Minnesota Pollution Control Agency.

   e. Water pollution - operators shall comply with all applicable Minnesota Pollution Agency regulations and Federal and Environmental Protection Control Agency regulations for the protection of water quality. No waste products or process residue, including untreated wash water, shall be deposited in any natural lake, or natural drainage system, except that lakes or ponds created by the mining wholly contained within the extraction site may be so utilized.

   f. Topsoil preservation - sufficient topsoil to provide cover shall be retained at the site until complete rehabilitation of the site has taken place according to the rehabilitation plan.

9. All waste water used on site for processing shall be disposed of in such a manner that it will not adversely affect adjoining property.

10. Dust control shall be used on public roads when the number of trucks exceeds twenty (20) per hour.

11. Adequate and safe access and entrances shall be provided and maintained.

12. County and township road limits shall be obeyed.

13. If operations cease for or no apparent or substantial operations are conducted for a period of one year, the County at its' option may, upon written 30 day notice, terminate the permit to operate.

14. The applicant shall require any other person operation in said pit to be bound by all requirement, agreements and regulations in effect as required by this ordinance or this permit.

15. Fencing shall be installed around permanent or intermittent ponding areas where the water ponds to a depth of over 18 inches for 30 days or in such a way as to cause a hazard to the surrounding residents.

704.7 Land Rehabilitation

1. Rehabilitation shall be a continuing operation occurring as quickly as possible after the mining operation has moved sufficiently into another part of the extraction site.

2. Slopes - all banks and slopes shall be left in accordance with the rehabilitation plan submitted with the permit application.

3. Cover and Planting - slopes, graded, and backfilled areas shall be surfaced with at least three (3) inches of topsoil. Such ground cover shall be tended as necessary until it is self-sustained.

4. Water Bodies - all water areas resulting from excavation shall be rehabilitated as follows:

   The bottom contour must be gradually sloping from the shoreline to the deepest portion at a maximum slope of ten (10) feet with no dropoffs.

5. Final elevation - no part of the rehabilitated area which is planned for utilization for uses other than open space or agriculture shall be at an elevation lower than that required for gravity connection to a natural drain except for ponds as designated above.

6. Active Gravel pit or Active Excavation - restoration and rehabilitation are not mandatory in an active gravel pit area, but may be concurrent with other operations if possible.

7. Restoration Area - restoration and rehabilitation are mandatory and must take place according to the approved restoration and rehabilitation plan and schedule or within 30 days of the execution of a permit, and each day's violation shall be deemed a separate offense.

8. Within a period of three months of termination of a conditional use permit, all buildings and plants incidental to the operation shall be removed by the owner. A temporary variance may be granted for hardships of a plan for the pits future use or restoration is submitted and approved by the Zoning Administrator.

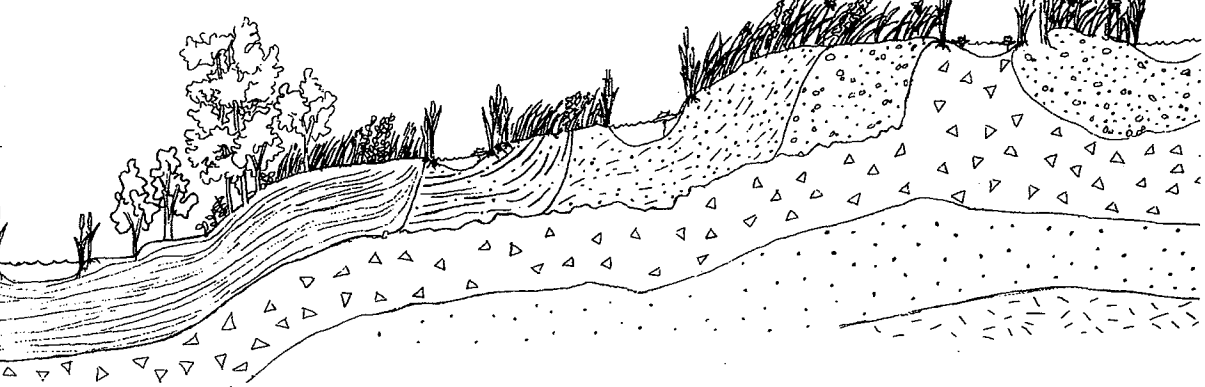
9. The Zoning Administrator shall approve in writing, the final rehabilitated site and may waive inconsistencies to, the original rehabilitation plan as might be necessary to obtain a well-graded, gently rolling topography consistent with the site and adjacent land and land use. Any ponds or slopes greater than 6:1 shall be specified noted as accepted if approved.

Appendix E. Four fact sheets on aggregate mining.

Environmental Regulations for Aggregate Mining

Fact Sheet 1
January 2001

Prepared by the Minnesota Department of Natural Resources
Division of Lands and Minerals
500 Lafayette Road
St. Paul, MN 55155-4045
http://www.dnr.state.mn.us/lands_and_minerals/
Contact: (651) 296-4807



SIZE AND SCOPE OF AGGREGATE MINING OPERATIONS VARY

There is a wide variability in the size and scope of aggregate mining operations in Minnesota. Some are active only for one season to serve road construction projects. Others are long-term sites that operate continuously over several years. The materials being mined and the mining methods also vary greatly. Some operations mine unconsolidated sand and gravel materials left by glaciers; others produce crushed rock blasted from bedrock. Some operations mine within the groundwater table and others remain above the water table. There are various types of auxiliary facilities used at an aggregate operation, such as crushers, wash plants and asphalt plants. Permits required for aggregate mining depend on the size, scope and location of the operation.

LOCAL PERMITS

Counties, townships or municipalities have the primary authority for regulating extractive uses like aggregate mining. In many counties, aggregate mining requires a Conditional Land Use Permit (CLUP) from the county planning and zoning office. A township or municipality may also require a permit in addition to (or instead of) a county permit. Local permits are generally required for new operations that exceed a certain threshold of activity, or for expansion of an existing operation. The threshold for triggering a permit varies from one county to the next and may be related to area, production volumes, or length of time. Operations that were active before the effective date of a required permit may be exempt.

Local permits may address issues such as: hours of operation, noise, traffic, dust, and reclamation. Performance bonds or some other form of financial assurance may be required. The term of local permits can vary from one year to the life of the mine. Increasingly, local authorities are requiring a mining and reclamation plan along with the permit. For more information on the local permits required for aggregate mining, contact the local county zoning or planning office.

STATE PERMITS

In general, state agencies have no regulatory role in administering or reviewing local permits. Depending on the size and scope of the mining operation, however, some state and federal permits may apply to certain aggregate mining operations.

Minnesota Department of Natural Resources (DNR)

Water Appropriation Permit A permit from the Department of Natural Resources - Division of Waters may be required if there is a need to appropriate water as part of the mining operation. Appropriation permits are required for activities such as pit dewatering or aggregate washing plants that consume water at a rate of 10,000 gallons per day or 1,000,000 gallons per year. Contact: Jim Japs (651) 297-2835

Work in the Bed of Protected Waters Permit. If the mining activity will impact a protected body of water, a *Work in the Bed of Protected Waters* permit may also be needed. For more information about these permits, contact the area hydrologist at the local area DNR office (see the website at http://www.dnr.state.mn.us/waters/resources/index.html for the closest office, or call the general number for the division (651) 296-4800) or contact Ron Anderson at the DNR central office, Division of Waters, St. Paul, at (651) 296-0520.

Burning Permit. A burning permit may also be required if the applicant needs to burn brush from clearing and stripping operations. Burning permits are available at many locations throughout the state. For more information, contact your local DNR office: http://www.dnr.state.mn.us/regions/

Shorelands, Floodplains, Wild and Scenic Rivers. DNR is responsible for three other programs established by law which might affect certain aggregate operations. The Shoreland Management Act, the Floodplain Management Act, and the Minnesota Wild and Scenic Rivers Act, are "land use" or "zoning" type laws that require the DNR to institute minimum statewide development standards for shoreland, floodplains and on certain rivers designated as Wild and Scenic Rivers. These standards must then be adopted through local zoning or land use ordinance. The shoreland regulations, for example, require that aggregate mining be a permissible land use within a given shoreland zoning use district. If it is a permissible use, a plan must be prepared that addresses dust, noise, hours of operation, possible pollutant discharges, erosion control, mitigation of environmental impacts, and reclamation. The law allows local units of government to be more restrictive than the minimum standards. For information on how these regulations might affect a specific operation within a shoreland, floodplain or wild and scenic river, contact your local county planning and zoning office.

Minnesota Board of Water and Soil Resources (BWSR)

Wetland Permit. The Wetland Conservation Act requires a permit for certain activities that impact wetlands. The Act requires that the project proposer follow a sequence of development steps that includes avoiding impacts to wetlands, minimizing unavoidable impacts, and mitigating for the loss of wetlands due to a specific regulated activity. The overall authority for the Wetlands Conservation Act is through the Minnesota Board of Water and Soil Resources (BWSR) with implementation through a local governmental unit. For more information, contact BWSR (central office) at (651) 296-3767 or contact your local Soil and Water Conservation District Office: http://www.bwsr.state.mn.us/

Minnesota Pollution Control Agency (MPCA)

Fuel and Hazardous Materials Management. The containment, storage, recycling and disposal of used oil, lubricants, antifreeze, paint, solvents, vehicle clean wastes, recovered Freon, asbestos, PCBs, shop wastes and other hazardous materials must be in compliance with MPCA requirements. For more information, contact MPCA (general number) at (800) 657-3864 or (651) 296-6300.

Liquid Storage Tanks. Management of liquid storage tanks, whether above ground or underground must be in compliance with MPCA requirements. For more information, contact MPCA.

Air Quality Aggregate mining facilities must meet minimum standards for dust and noise. Crushing operations may have to meet federal standards for emissions of particulates from processing equipment. Depending on production capacity, an air emission permit may be required. For more information, contact MPCA at (651) 282-6143 or (800) 657-3938.

Water Quality. The following activities at aggregate operations require a water quality permit from MPCA:

- Discharge from washing plants that leave the mine, whether by gravity flow or pumping.
- Pumping or siphoning out a mine to create a dewatering discharge.
- Storm water runoff from mine stockpiles and pit walls, as well as from equipment like rock crushers, hot mix asphalt, and concrete production plants.
- Generation of wastewater by air emission control systems.

For more information, contact MPCA at (651) 296-7238.

FEDERAL PERMITS

U.S. Army Corps of Engineers (COE)

Section 404 Permit. The Army Corps of Engineers is a federal agency that regulates the discharge of dredged or fill material within waters or wetlands. At aggregate mining operations, activities in wetlands that might trigger a 404 permit include mining activities, the construction of access roads, building sites, storage areas, or water retention ponds. Each county has its own project manager. General information is available from the District Office of the Army Corps of Engineers at (651) 290-5375.

ENVIRONMENTAL REVIEW

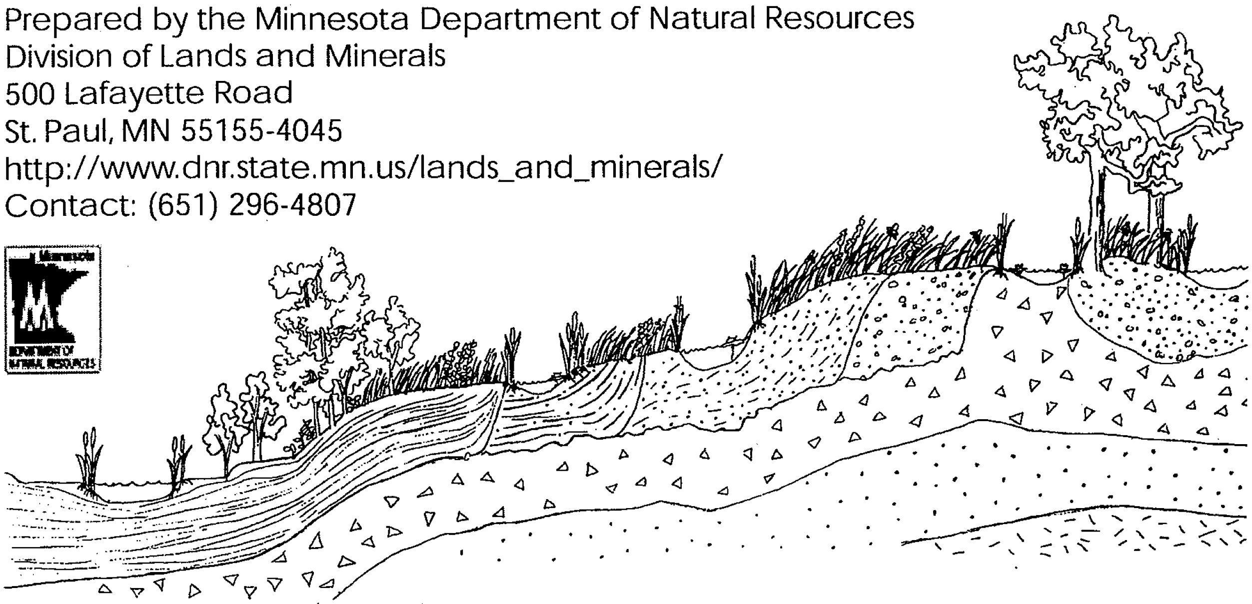
Environmental Quality Board (EQB)

Environmental Review. Rules developed by the state Environmental Quality Board determine when environmental review is needed for development projects. Environmental review in the form of an Environmental Assessment Worksheet (EAW) is required when an aggregate mining operation is expected to exceed 40 acres in size to a mean depth of 10 feet. Environmental Impact Statements (EIS) are mandatory for operations exceeding 160 acres. EAWs can be conducted on a discretionary basis if a proposed project is below the mandatory threshold under certain conditions. The EQB rules specify the governmental unit that is responsible for completing environmental review. For aggregate mining proposals, completing environmental review is the responsibility of local government, most often the county planning or zoning office in which the proposed project is located. For more information about environmental review, contact EQB at (800) 657-3794 or (651) 296-8253 or the local county zoning and planning office.

Mining Plans for Aggregate Operations

Fact Sheet 2
January 2001

Prepared by the Minnesota Department of Natural Resources
Division of Lands and Minerals
500 Lafayette Road
St. Paul, MN 55155-4045
http://www.dnr.state.mn.us/lands_and_minerals/
Contact: (651) 296-4807



WHAT IS A MINING PLAN?

A mining plan is a combination of maps and written information that describes every aspect of the proposed operation from inventory of the gravel resource to post-mining management of the site. The mining plan describes activities to be conducted at the mine site over the life of the operation. A mining plan is prepared before mining begins, often as a requirement for a permit.

The purpose of a mining plan is to ensure environmentally sound mining, including leaving the area in a safe, nonpolluting condition, and preserving as much land value as possible. A mining plan may consider view, noise, dust, hours of operation, traffic, final reclamation, and many other concerns. The requirements and provisions of plans vary with the local authority.

Because there is market fluctuation in the aggregate industry, the mining plan must be sufficiently flexible to accommodate such changes. The plan should be updated to reflect operating plan changes. Many operating permits also require updates. A mining plan ensures that activities progress according to a general concept that includes site reclamation.

A mining plan aids the cost efficiency and minimizes the environmental impact of the site. It allows for early identification of environmental concerns, efficient removal of the aggregate, and cost-effective reclamation. Through planning, materials can be placed in the appropriate location during stripping operations. Areas requiring fill material can be identified. Final landforms can be constructed during active mining.

ARE MINING PLANS REQUIRED FOR AGGREGATE OPERATIONS?

Currently, there is no state or federal mining permit in Minnesota that requires aggregate operators to submit a mining plan or to reclaim the site after mining. Aggregate mining operations are reviewed at the local unit of government–county, township or municipality, not at the state or federal level. Zoning ordinances and land use planning are employed to control mining operations. The local permits frequently address view, noise, dust, hours of operation, traffic, and final reclamation. Increasingly, local aggregate operation permits require a mining plan.

WHAT INFORMATION IS INCLUDED IN A MINING PLAN?

A mining plan is geared to the size and scope of the project. Small projects generally will require a simpler plan; larger operations will need a more elaborate one. Aggregate mining operations share certain characteristics, but each one is unique and needs a mining plan tailored to its site. The information needed for a mining plan generally includes the following:
Inventory of the aggregate resource including the shape, extent and depth of the aggregate deposit and its relationship to the groundwater.

General knowledge of the aggregate deposit is important. The best available information about the deposit must be collected from water well logs, existing surveys or maps, and previous testing work in the area. The most complete inventory data is obtained from drilling or test pitting on the site, but such data is not always available or necessary. Additional site specific work may be needed.

Characteristics of the deposit will determine in part the layout of the mine, the sequence for mine development, and the plan for how to blend the various aggregate materials to meet specifications. Economic considerations likely to influence the rate of mining should also be discussed in the plan, such as the thickness of the overburden, the quality of the aggregate, and haul distance.

Assessment of pre-mining conditions, including current land uses, ownership, infrastructure, previous excavations, existing vegetation and water features among others
An "assessment of pre-mining conditions" describes the setting before mining begins. This may include, among other things: the direction of flow in surface waters; the depth to and direction of groundwater flow; location of buildings and other infrastructure (roads, wells), existing land uses, presence of endangered species and cultural resources. An assessment can identify and mitigate environmental problems and public concerns associated with the project.

Description of mining methods including processing methods
A description of mining methods addresses how the resource will be mined and processed, and describes any proposed mitigation measures. This could include proposed operation hours, how complaints will be addressed, specific erosion control measures to be used, or how screening will be utilized.

Discussion on the staging and sequencing of operations
This discussion is closely linked with the above and is directed at how the mining operation will develop over time. Some mining operations remove the resource in several discreet stages over a short period of time, and others mine it in one stage for a longer period of time. The staging of operations has implications for reclamation. Can reclamation be accomplished progressively throughout the operation or is it best accomplished at the end of active mining?

Proposed reclamation, schedule, and post-mining management
Proposed reclamation describes the intended end uses of the site. Reclamation can consist of simply stabilizing slopes or it can include steps to restore wildlife habitats or preparation of the land for residential construction. When an operator has an end use goal in mind, mining activities like clearing, stripping, stockpiling, and landform construction can be directed toward the planned reclamation throughout the mining phase.

WHAT DOES A MINING PLAN LOOK LIKE?

Mining plans typically employ maps, an effective way to convey the needed information. The vicinity of a proposed operation is often shown on a topographic quadrangle map at a scale of 1:24,000. Specifics of the plan for mining the site are most often depicted on a more detailed plan view map. Proposed features of the mining operations (such as stripping areas, cuts, excavations, processing facilities, roads, stockpiles, ditches, berms, water control structures, etc.) and reclamation features (screened areas, areas to be revegetated, final slopes and grades, etc.) can be depicted on the detailed map. Vertical details are shown with contour lines and cross sections. A series of sequential maps can illustrate how operations will proceed over time. A base map with overlays can effectively show the proposed stages of the operation

Reclamation at Aggregate Mining Sites

Fact Sheet 3
January 2001

Prepared by the Minnesota Department of Natural Resources
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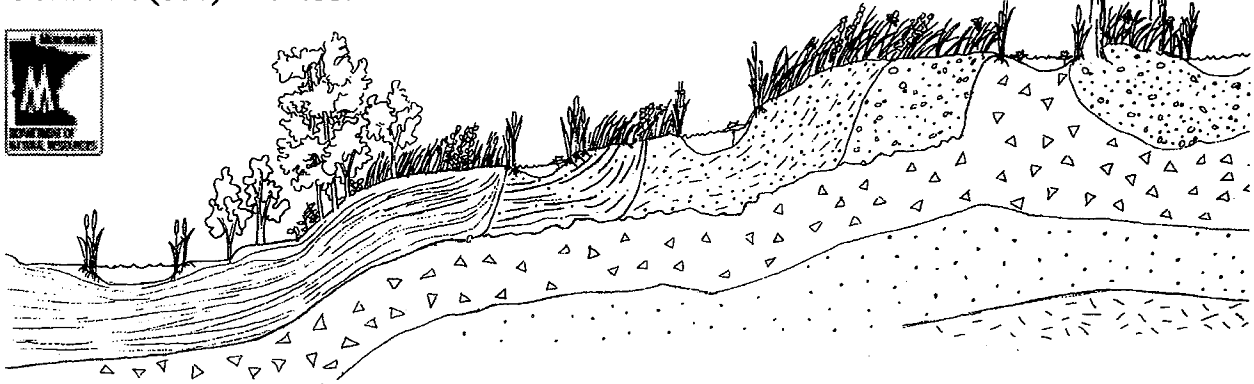

WHAT IS RECLAMATION?

Reclamation, at its most basic level, is a process that results in a safe and non-polluting mining site that will retain some land value. For example, gravel operations may be graded after closure to remove hazardous steep slopes. Revegetation, erosion control, and site cleanup are included in basic reclamation operations.

Sometimes reclamation is employed to prepare a site for a subsequent use ("end use") after mining operations are completed. For example, if the planned end use of a site is for green space, landscaping may be used to restore the site to a state that is aesthetically pleasing, or if the site will be used for residential development, areas may be left unfilled to prepare for installation of water and sewer connections.

A mining plan, when required, would normally include a description of post-mining management necessary to support the end use. It would also identify the party responsible for conducting it.

IS RECLAMATION OF AGGREGATE MINING SITES REQUIRED?

Currently, there is no state or federal mining permit in Minnesota that requires aggregate mining operations to be reclaimed. Reclamation at active aggregate mining sites is most often addressed in a local permit or through leasing agreements between landowners and mining companies. The most extensive review of aggregate mining operations takes place at the local unit of government –county, township or municipality. In Minnesota, there are 87 counties, 1,802 townships and 855 cities. Each of these entities has the authority to regulate aggregate mining through zoning ordinances and land use planning. Operating concerns such as view, noise, dust, hours of operation, traffic, and final reclamation are frequently addressed in local permits. There are differences in the ways in which local governments regulate aggregate mining and final reclamation. The standards for reclamation vary by county, township, and city.

RECLAMATION IS A PUBLIC CONCERN

Aggregate mining is the most common form of mining in Minnesota. Because aggregate is relatively inexpensive to mine but expensive to transport, most operations are located close to where the resource will be used. As a result, aggregate sites are found in every county and are highly visible along roadways. There are an estimated 4,000 gravel pits and 1,500 rock quarries in Minnesota.

Whether in populated areas or in rural settings across the state, aggregate mining is often regarded as an unwelcome neighbor. Conflicts between aggregate mining and other land uses are escalating. At the same time, the need for aggregate materials for construction projects and infrastructure is increasing commensurate with the strong economy and burgeoning population in Minnesota. Reclamation is a key concern voiced by the public.

RECLAMATION AT ACTIVE MINING OPERATIONS

Methods used to reclaim active operations can differ greatly from those used to reclaim abandoned sites. Although the precise numbers change yearly, an estimated 1,500 of the 4,000 gravel pits and about 150 of the 1,500 quarries are active operations where public concerns are usually addressed through a local permit. For active operations, final reclamation is most often considered in a local permit or through leasing agreements between landowners and mining companies.

RECLAMATION AT ABANDONED OR INACTIVE MINING OPERATIONS

Prior to the 1980s, reclamation of aggregate mining sites was not a routine practice. Today, there are an estimated 2,500 gravel pits and 1,350 rock quarries in Minnesota that are either permanently abandoned or intermittently active and often fall outside the regulatory authority of the counties. Problems associated with these sites may include: 1) safety concerns such as steep pit walls and deep water, 2) colonization by noxious weeds and other unwanted vegetation, and 3) unauthorized activities such as illegal dumping, target shooting, off-road vehicle use, and parties. There are increased problems at unreclaimed sites.

Abandoned sites are difficult to reclaim. When reclaimed, the results can be disappointing compared to reclamation done at the time of mine closure as part of a mining plan. There may be no responsible party and/or no money to do reclamation on abandoned sites. Costs to reclaim these sites may be higher because unwanted vegetation must be cleared and landforms reconstructed. Topsoil is needed for revegetation, and often the topsoil has been removed from unreclaimed sites.

AGGREGATE MATERIAL TAX

In Minnesota, a possible funding source for reclaiming abandoned pits on public land is the Aggregate Material Tax (Minn. Stat 298.75) which is a production tax on the removal of aggregate material. At present, 23 of the 87 counties in Minnesota have authority to collect the tax. In

1998, three townships in St. Louis County were authorized to collect the tax. In 1999, a total of $2,885,716 was collected by those counties and townships. The tax imposed on operators is ten cents per cubic yard. According to the statute, 90 percent of the tax is distributed to county or township road funds and the remaining 10 percent is allocated to individual county reserve funds for restoring abandoned pits or quarries on public land in those counties that collect the tax.

The reserve funds have not been frequently used for reclamation in part because few proposals have been identified. There is relatively little experience in the public or private sector in reclaiming aggregate sites that have been abandoned for a long period of time.

To add to the existing expertise and experience in the state, the DNR Division of Lands and Minerals initiated and managed several reclamation projects involving abandoned aggregate sites on public lands in northwestern Minnesota using partnerships and revenue generated by the aggregate material tax. This work is an effort to develop cost effective methods for reclaiming active and abandoned aggregate sites using conventional and native plant materials.

Using Native Prairie Species for Reclaiming Aggregate Mining Sites

Fact Sheet 4
January 2001

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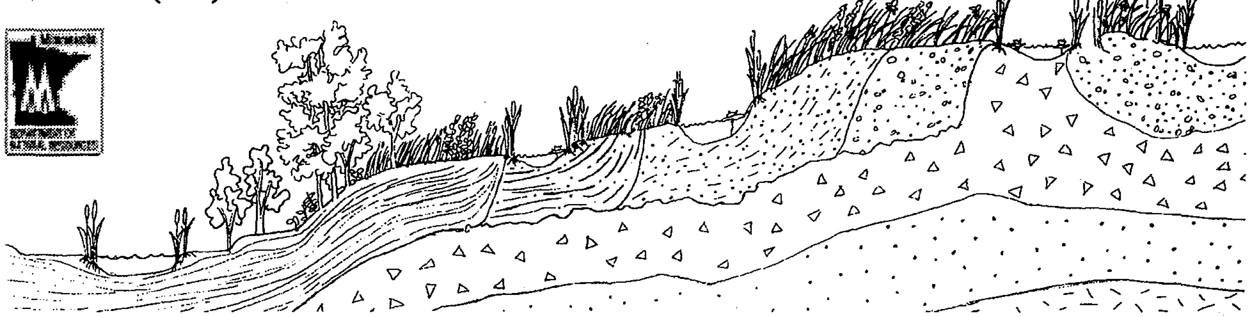

WHAT IS PRAIRIE?

"Prairie," in the simplest of terms, is a community of plants. Prairie plants are specially adapted to the climate and conditions found in western and southern Minnesota including extremes of temperature and weather, and high winds. Before European settlement 150 years ago, prairie covered much of southwestern and western and northwestern Minnesota. The extreme conditions and constant grazing by bison kept competing plants to a minimum. Prairie plants have long roots that hold the soil in place and allow the plants to survive drought. They are perennial, surviving the winter.

There are several different types of prairie in the Midwest. The tallgrass (or mesic) prairie, common in areas of moderate soil moisture levels, was typically found in western Minnesota where prairie grasses sometimes grew six feet high. Prior to European settlement, almost the entire Red River Valley consisted of tallgrass prairie.

USING PRAIRIE SPECIES FOR RECLAMATION

At depleted aggregate mining sites in areas where tallgrass prairie occurs, it is reasonable to consider revegetating with native prairie plants. Certain key characteristics of prairie plants make them a good choice for former mining sites. Because they are perennial, native prairie grasses, once established, can provide a long-term cover that is self-sustaining and requires little maintenance. Mowing may be needed, and prescribed burning is recommended on a rotation starting three or four years after planting.

Although a former aggregate site restored with native species offers many benefits, it does not restore native prairie. Restoring more than a fraction of the species found in a native prairie is beyond present capabilities because seed sources are not readily available in commercial quantities for all prairie species.

In places where tallgrass prairie does not occur, and in certain other locations, native prairie plants may be inappropriate for reclamation projects. Most warm-season prairie grass seed germinate late, most need prolonged moisture and warm soil. Areas seeded with native prairie plants may not germinate until the spring after initial seeding. Warm-season prairie grasses establish an extensive root system during the first year. The top growth is limited to small leaves that can be difficult to identify. Full scale plants develop during the second year. To compensate for slow establishment of prairie plants, a cover crop of wheat or oats can be planted along with the native seeds. Cover crops grow quickly, providing protection for the slower establishing native species. In addition, cover crops tend to die off rapidly, within one or two years, and therefore do not compete with more permanent native cover.

The slow initial growth of native plantings makes them less effective in erosion-prone locations. They are, therefore, not recommended on steep slopes composed of erodible soils. In addition to possible problems with slow development, prairie seed can be relatively expensive and can be difficult to find. Sometimes, a specially-adapted seed drill is needed for large areas. Adequate site preparation and regular weed control are essential for establishment. Due to the increasing popularity of native prairie plantings, however, these difficulties are quickly being overcome. Although the initial costs may be higher, the long term benefits of native plantings are great. Provided below are basic guidelines for planting native species.

GENERAL GUIDELINES

Site preparation:
Native plantings need a firm weed-free seed bed. Several herbicide applications followed by disking or mowing may be necessary on sites where vegetation is already established.

Seed source:
Seed harvested from as close to the project site as possible will preserve genetic characteristics and establish the vegetation types best adapted to the site.

Seed mixture and seeding rate:
The seed mixture and the seeding rate used for a reclamation project should be selected based on the site characteristics. In general, a diverse mix of grasses and forbs will provide the best results at a seeding rate in the range of 15 lbs/acre to 30 lbs/acre. If seed is harvested from a nearby site and used for reclamation, an analysis of the seed harvest should be conducted and additional seeding may be needed to complement the planting. Seed purchased from vendors can be blended to contain a diversity of species. The Minnesota Department of Transportation (Mn/DOT) has developed several general seed mixes for use on roadsides and ditches. The mixes are a baseline that can be modified as appropriate for local conditions. For more information on native species seed mixes, consult Mn/DOT's Year 2000 Specifications for Construction or contact Mn/DOT at (651) 284-3750.

Seeding method:
Native seed can be planted using a specially adapted drill that accommodates the light fluffy native seed. The final planting depth should be 1/2 to1 inch and maximum row spacing of about 8 inches, at right angles to surface drainage. An alternative to drilling is to till the site and broadcast the seed. Planting depth should be from 1/4 to 1/2 inch. After seeding, the site should be dragged with a rake or harrow and packed. Hand seeding is a good method for small areas.

Hydroseeding is an acceptable seeding method on steep slopes or other areas inaccessible to a seed drill. Hydroseeding is not recommended if the weather is hot and dry.

Cover crop:
A cover crop can be seeded with native seed mixtures. The type of cover crop depends on the season. Some possible cover crops are oats at a rate of 20 lbs/acre in the spring plantings, winter wheat at 20 lbs/acre for fall plantings, and annual rye grass at 10 lbs/acre for dormant seedings.

Timing:
Native grasses should be planted from May 1 to June 30. Seeding may be done in the fall, but the seeding rates should be increased slightly to account for seed mortality over the winter. Many species of wildflowers require a cold period to break dormancy and are best seeded late in the fall. If seeded in the spring, they may not be seen until the second year after planting. Seedling plants can be used to add diversity to the plantings. Some desirable species are difficult to propagate from seed and are only available as seedlings.

Maintenance:
During the first growing season, if the cover crop or annual weeds reach 18 inches or more in height, the site should be mowed to a height not less than 6 inches with a rotary mower. Prescribed burns can be implemented on a three to five year rotation starting the third or fourth year after planting. Fall haying is an alternative in areas where burning is not possible.

For more information:
Contact your local DNR area office, local Natural Resource Conservation Service office, or the U.S. Fish and Wildlife Service.