Aggregate Resource Evaluation of a Portion of the Talcot Wildlife Management Area, Cottonwood County, MN

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

Project 334-20
August 2004

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ACKNOWLEDGMENTS

Many persons contributed to different phases of this project. Bob Hobart and Dennis Martin, DNR Division of Lands and Minerals, and Mark Gulick, DNR Wildlife, and Tim Stahl, Jackson County, developed the idea. County highway engineers Tim Stahl and Gerry Engstrom of Jackson and Cottonwood Counties, respectively, coordinated sieve analyses and ground survey work. Neal Johnson, Jackson County, collected the topographic data. Mark Gulick and Judy Markl, managers at the Talcot WMA provided useful site-specific and logistical information and were responsive to questions. Ricco Riihiluoma, DNR, ably provided field assistance as the drill rig operator. Ricco also did some sieving. Sue Saban entered data and printed and assembled this report. The assistance all these people gave is sincerely appreciated.

EXECUTIVE SUMMARY

This report summarizes the results of an aggregate resource evaluation for about 112 acres within the Talcot Wildlife Management Area (WMA). The Minnesota Department of Natural Resources (DNR), Division of Wildlife (Wildlife), manages the WMA. DNR Wildlife requested that the evaluation be done with an emphasis on data collection to aid in setting a value for the resource and an emphasis on developing a mining and reclamation plan that incorporates Wildlife's post-mining goals.

The goal of reclamation during and after mining is for wildlife habitat with an emphasis on shallow water environments. This report includes supplemental information on the gravel deposit and recommendations for the reclaimed landscape emphasizing wildlife habitat.

The area evaluated occurs in the SW quarter of Section 7, T. 105N., R. 38W., Southbrook Township, southwestern Cottonwood County, MN (Figures 1 & 2). The Murray County line is contiguous with the western edge of the parcel. The Jackson County line is 4 miles south.

Findings

- Large diameter (10 inch) auger drilling (78 test holes) verified that aggregate occurs throughout the evaluation site (112 acres).
- The portion that would be mined (ultimate pit size) covers 103 acres, allowing for setbacks along the perimeter of the parcel.
- The overburden (stripping material) is topsoil with an average thickness of 2 feet (range 1-3.5 feet).
- The average depth to water table is 9 ft (range 2.5-14.5 feet) and slopes toward the northeast—toward the Des Moines River. These measurements represent a snap shot in time. The water table likely rises and falls over time due to variations in precipitation and seasonal conditions.
- Drilling identified two gravel deposits, labeled here as primary and secondary. The primary deposit occurs just beneath the topsoil. The secondary deposit typically occurs below a silt to clay layer below the primary deposit, and below the water table. It occurs in 12 test holes primarily near the eastern portion of the parcel.
- The primary gravel deposit averages 14 feet thick (range 2-20.5 feet).
- The secondary gravel deposit is a relatively small volume and averages 6 feet thick (range 2.5-10 feet). It occurs over 12 acres.
- ***Volume of the primary gravel deposit:***
    - Above the water table: 950,000 cubic yards.
    - Below the water table: 1,050,000 cubic yards.
    - Grand total: **2,000,000 cubic yards.**
- The volume of the secondary gravel deposit is 100,000 cubic yards.
- The secondary gravel deposit is a resource that could be mined. Silt and/or clay overburden ranging in thickness from 1.5 to 3.5 feet overlie the secondary gravel. If the overlying silt

and clay are amenable to blending with the primary gravel, it is probable the secondary gravel could be mined. If not, future economics will dictate whether the silt and clay overburden will be removed to get at this gravel. It is not known at this time whether any, a portion of, or all of the secondary gravel will be mined.

- The mining and reclamation plan is written as though all of the primary gravel will be mined and none of the secondary gravel will be mined.
- *Gradations:* The primary deposit average is within MnDOT's recommendations for Class 5 material (Table 2, Figure 6).
    - The percent of crushable material (greater than ¾ inch) averages 8% (range 2-25%) by weight.
- *Quality:* Deleterious materials, which determine suitability for bituminous or concrete, at this site are primarily shale and are present in moderate amounts. Tests indicate roughly half of the primary deposit could meet MnDOT specifications for general purpose concrete (Table 2).
    - The evaluation site was separated into 4 quarters (Figure 3). Each quarter, except #2, was further divided into samples representing shallow (S) and deep (D) gravel (Figure 4). Tests indicate the shallow gravel (S) in quadrants 1, 2, and 3 is of high quality and meets MnDOT portland cement concrete general use specifications. The shallow gravel (S) begins beneath the topsoil, averages 8 feet in thickness, and represents the upper portion of the primary deposit. The deep gravel (D) has more shale than the shallow gravel (S) and therefore is of lower quality. The deep gravel (D) represents the lower portion of the primary deposit and 9 of the 12 holes that encountered the secondary deposit. Gravel (D) may not meet specifications for concrete.

Recommendations for Mining and Reclamation

- A special permanent mining buffer is established at the northeastern and northwestern corners of the mining area. This permanent buffer is set to guard against the possibility of the Des Moines River, during flood stage, flooding the pit via bank failure. It is important to maintain the 75 and 100-foot no disturbance buffers, so marking these two areas with permanent steel fence posts or equivalent is recommended.
- The mining area is divided into three phases, with each phase separated by a dike (Figure 7). Each phase will take a number of years to mine. After mining is complete, each will have a wetland separated from each other by the dikes. The wetland acreage will total about 87 acres.
- There is sufficient overburden topsoil on site to reclaim all the disturbed upland areas and backfill all of phase 1 resulting in a water depth of about 3 feet. Phases 2 and 3 will be deep-water wetlands after mining is complete unless fill is imported.
- A high priority should be given to stabilize from erosion the shorelines along the dikes that divide the three created wetlands. Some areas may receive high wave energy and experience will decide whether a topsoil application and seeding with ground cover is sufficient to prevent erosion. If not, other measures to control erosion and facilitate revegetation are recommended. Examples of measures to control erosion include using a front-end loader to

transplant sod patches from future mining areas and place them along the shorelines, placement of erosion blankets, and riprap.

- Mining at steeper than a 3:1 (horizontal to vertical) slope along the mine perimeter and then backfilling to restore a 3:1 or gentler slope is not recommended due to a shortage of backfill material. Alternatively, mining at steeper slopes would require imported fill to reestablish the gentler slopes.
- The mining plan assumes no dewatering occurs. The flood plain setbacks are established as though dewatering does not occur.

INTRODUCTION

The site evaluated is located within the Talcot Wildlife Management Area (WMA) and managed by the Minnesota Department of Natural Resources (DNR), Division of Wildlife (Wildlife). Wildlife desires to acquire nearby acreage to complement the WMA. Jackson County wishes to purchase gravel. The evaluation site was proposed as having sufficient aggregate quantities. DNR Wildlife requested that DNR Lands and Minerals conduct an aggregate evaluation of sufficient detail for an appraisal as a primary step of a process to negotiate a transaction agreeable to all parties.

The evaluation site covers about 112 acres in the SW quarter of Section 7, T. 105N., R. 38W., Southbrook Township, southwestern Cottonwood County, MN (Figure 1). The Murray County line is contiguous with the western edge of the parcel. The Jackson County line is 4 miles south.

Purpose

The site was evaluated to determine the extent, depth, quality and quantity of aggregate present to provide a basis for determining value and for developing a mining and reclamation plan. Jackson and Cottonwood Counties intend to use of the aggregate for roads.

This report includes the data, results of material tests, interpretations, modeled volume calculations, and a mining and reclamation plan. The mining and reclamation plan considers Wildlife's goal of shallow-water habitat for diving ducks as a primary post-mining land use.

Infrastructure

Road access to the parcel is excellent. County Road 15 (CR 47 in Murray County) is paved and bounds the southern edge of the parcel (Figure 2). This road leads westerly about 7 miles to US Hwy 59 and easterly about 17 miles to Windom and US Hwy 71. Paved roads lead southeasterly about 14 miles from the site to Heron Lake, MN and State Hwy 60. Low maintenance WMA roads bound the west and east boundaries of the parcel. The nearest municipalities include Dundee, about 4 miles to the south and Fulda, about 8 miles to the southwest.

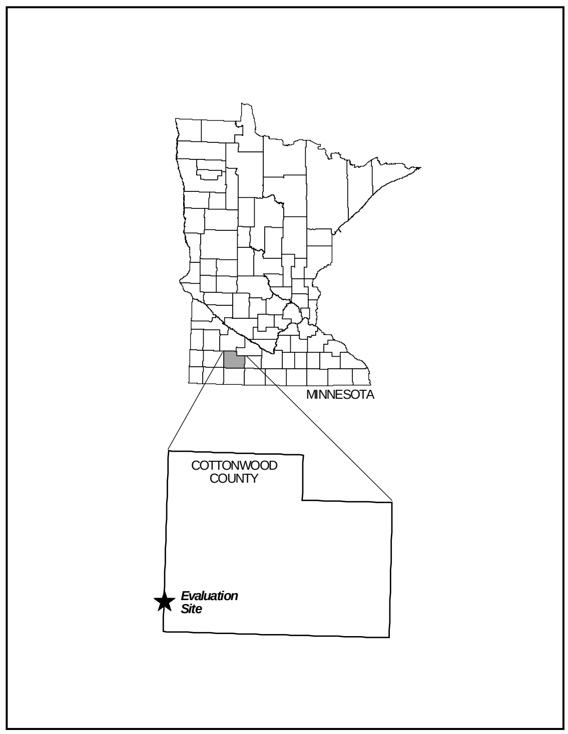

Figure 1. Index map showing the location of the evaluation site.

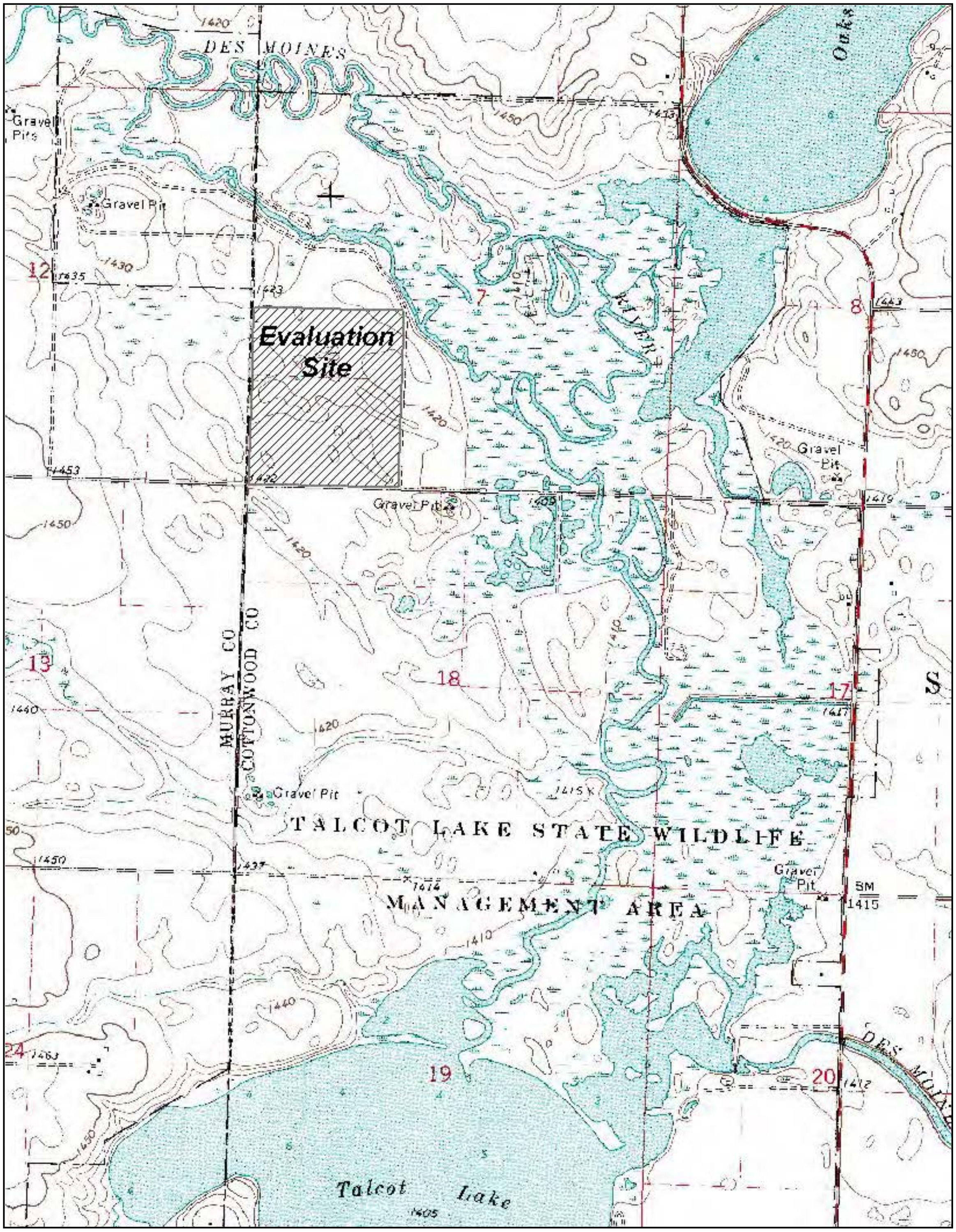

Figure 2. A portion of the USGS 7.5 minute Heron Lake NW Quadrangle with the evaluation site indicated. The evaluation site covers about 112 acres within the Talcot Wildlife Management Area. The width of this map represents about 2.5 miles.

Dates of field work

Test holes were drilled between July 14 and July 25, 2003. Data for the topographic survey were collected on April 30, 2003.

GEOLOGIC SETTING

The Talcot WMA is in an area that has undergone numerous glacial advances in the last 2 million years. The aggregate deposit associated with the evaluation site is interpreted to be part of the last glacial advance in this area of the Des Moines lobe called the Bemis phase. This glacier originated in Canada and entered Northwestern Minnesota. The axis of the glacier generally followed the Red River Valley and then the Minnesota River Valley as it flowed southward. According to the Minnesota Geological Survey (Patterson, 1995), the Bemis moraine, which represents the maximum extent of this glacier, occurs 20 to 25 miles west southwest of the evaluation site. In this area, the Bemis moraine represents the southwestern flank of the glacier. The thickest part of the glacier was towards the Minnesota River Valley to the northeast.

As the glacier melted back, the ice, locally, receded towards the east-northeast. The glacier melted back at different rates and sometimes may have readvanced. One significant melting event allowed for floodwaters to channel along the present-day Des Moines River valley, which includes the evaluation site, and created a glacial outwash deposit. Flood flow concentrated here because the glacier was still present immediately to the northeast and there was higher topography to the southwest. Flood flow direction was from the northwest to the southeast. The aggregate in the evaluation site is part of this outwash deposit.

METHODS

Map interpretation

U. S. Geological Survey (USGS) Quadrangle maps (Heron Lake NW, Dundee, and Lime Creek) and digital orthophotos (DOQ's) were analyzed for geological interpretations and the identification of features and landforms on the property and vicinity.

Auger drilling

Auger drilling was used to determine the extent (edge), depth, and geology of the gravel deposit, and for collection of samples that were tested to determine texture (gradations) and quality. Seventy-eight test holes were drilled with a Mobile Drill Model B80 drill truck on loan from the Minnesota Department of Transportation (MnDOT). This is the same rig MnDOT uses to evaluate their aggregate deposits. The rig uses a ten-inch diameter auger on a 20-foot mast.

The geology of each hole was logged based on sediments retrieved with the auger and by recognizing distinguishing auger behavior. The drill and retrieve method was used. The drill operator regulated the auger's penetration rate to be approximately equal to the rotation speed of the drill stem. Over spinning was avoided as much as possible. The auger was retrieved in 10-foot increments typically. Allowances for sample lag on the auger were made when necessary. Samples were collected off the auger as it was retrieved and placed on a tarp. Large samples were mixed and split before bagging for gradation analyses. After mixing but prior to bagging, small representative samples were collected from each hole and placed in another bag for quality testing.

Depth to water table was measured to the nearest ¼ foot by determining the water-mark on the auger stem. The water table measurements made here represent a snap shot in time. The water table likely rises and lowers over time due to longer-term variations in precipitation and climate.

Spacing of test holes followed a grid pattern of approximately 250 feet by 250 to 300 feet. East west transects were established about 250 feet apart and test holes were spaced at 250 to 300 feet along them (Figure 3). The entire area was drilled according to this pattern, except for two locations in the wetland in the north central portion of the parcel that were inaccessible and not drilled due to soft moist soils. Each test hole represents 20,000 to 30,000 cubic yards of material, on average.

Gradations and quality analysis

Gradation results are presented in a format that allows comparison to MnDOT's Class 5 guidelines. Cottonwood County, Jackson County, and DNR personnel, following MnDOT protocol, sieved and washed 91 aggregate samples from 71 test holes.

Spall and other deleterious materials were measured in seven representative samples and compared against the requirements for concrete and bituminous. These measurements give an indication if portions of the deposit may be of greater value than others.

The seven samples were obtained by dividing the evaluation site into quarters (Figure 3) and the aggregate deposit into two layers—a shallow layer (S) and a deep layer (D). The two layers were differentiated by texture. Layer S typically contained noticeably less coarse sand and fine pea gravel than layer D. Layer S averages 8 feet in thickness and represents the upper portion of the deposit. The two layers were sampled separately by quarters to give the seven samples. Layer D in the northwest quarter was too thin and discontinuous to obtain a large enough sample for testing (resulting in seven samples instead of eight).

GIS

Neal Johnson, Jackson County surveyor, captured approximately 540 points within the evaluation area along a grid of approximately 100 feet for a topographic survey. The average spacing between all survey points was 66 feet. The horizontal and vertical data were collected with a Leica 500 RTK survey grade GPS unit on April 30, 2003. The Jackson County NAD 83 coordinate system was used for the x-y (horizontal) location.

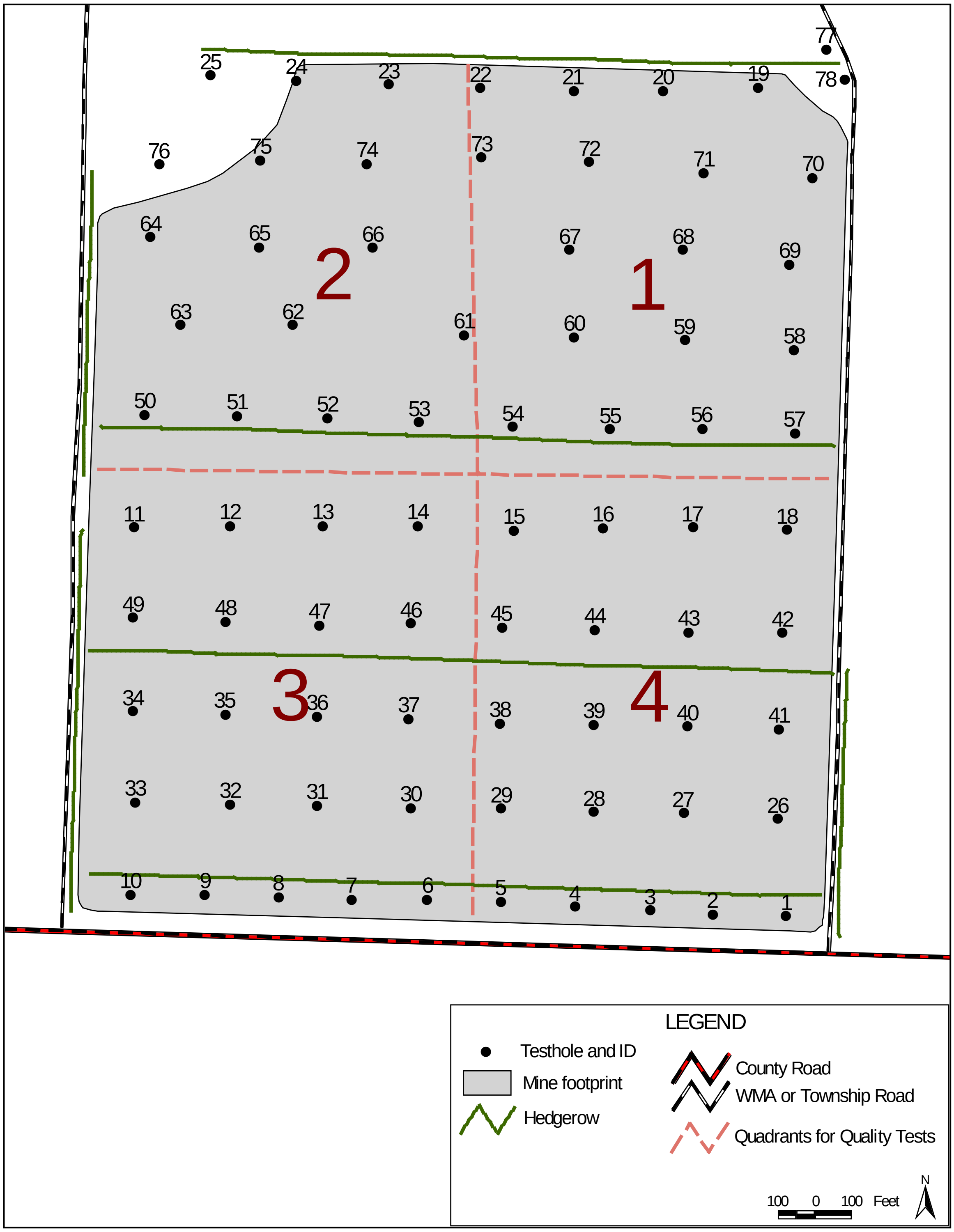

Figure 3. Distribution of test holes within the evaluation site. The site was divided into 4 quadrants to determine whether the quality of the aggregate (deleterious materials) varied across the parcel.

WGS 84 was the vertical datum used. Accuracy is +/- 0.02 inches horizontal and +/- 0.1-inch vertical. There were no nearby geodetic markers to tie the data to benchmarks, so the GPS unit captured a location (using the “find” feature) on a temporary benchmark.
The accuracy of the “find” feature is 5-10 meters horizontal and 10-20 meters vertical. This means, for a data point, its GPS’d (field) location and elevation relative to a USGS Quad map may not match closely. The data relative to each other are very accurate, however. Horizontal accuracies are +/- 0.02 inch and vertical is +/- 0.1 inch. The horizontal coordinates were shifted 19 feet North and 24 feet West to obtain a good match with the base photo.

Coordinates of test holes and other features were captured with a Garmin 76S Map GPS unit with WAAS (Wide Area Augmentation System) differential correction on July 25, 2003. Approximate horizontal accuracy is 10 feet or better.

The color orthophoto backdrop used for analysis and some maps was from the Farm Services Administration (FSA). This photo was taken in the summer of 2002 as part of the National Agricultural Imaging Program (NAIP). The photo was scanned and digitally rectified at a resolution of approximately two meters.

Pit Perimeter

The pit perimeter was established upon the following facts. The right of way for County and Township roads are 50 and 33 feet, respectively, from the road centerline. Adding a 10 foot buffer to the right of ways, the pit perimeter along the south and west sides is about 60 feet and 43 feet from the road center lines, respectively. The pit perimeter on the east side is about 15 feet from the access road centerline, and on the north side about 10 feet south of the hedgerow (Figure 3).

Additional setbacks or buffers at the northwest and northeast corners were set for ecologic and safety reasons. The buffers are based on maintaining a safe separation distance, based on hydraulic gradient, between predicted water levels in the pit and potential maximum high-water levels of the Des Moines River during flood stage (based on the topographic spill points). The primary goal of these buffers is to keep the Des Moines River, during flood stage, from flooding the pit once mining starts. These buffers are discussed further in the “Mining and Reclamation Plan” section below.

Computer modeling

Modeling assumes that the test holes reasonably represent the character of the entire deposit and that drilling tested the perimeter of the evaluation site sufficiently to project the resource to the proposed pit boundaries.

This aggregate deposit is a blanket deposit with textural variations with depth in some places. In some places, the portion below the water table is sand or has lenses of silty clay that overlie deeper gravel. Prior to modeling, a distinction was made between the most likely mineable gravel interval, called the primary gravel, and deeper, saturated sand or gravel called the secondary gravel deposit (Figure 4). Whether an interval of sand and gravel was considered primary or secondary was based on gradation data, geologic interpretation, and economic assumptions. Details of this distinction are in Appendix E.

Computer models of the land surface, and top and bottom of the mineable gravel interval, and the water table were generated using KRIGE and INVERSE algorithms with software from TECHBASE International. From these modeled surfaces, estimates of stripping volumes, gravel volumes above and below water, and depth of water were made. Gradation values for the +3/4", #4, #10, and minus #200 mesh sizes were also modeled.

The secondary gravel deposit was modeled for volume calculations, but not considered in the mining and reclamation plan. The secondary gravel occurs in 12 test holes (Figure 5).

The collar (ground) elevations for the test holes were estimated from the topographic survey data. First, the original topographic data were modeled with a kriging algorithm to a 25-foot grid. Then the elevations for each test hole were interpolated from the 4 closest points using an INVERSE modeling program.

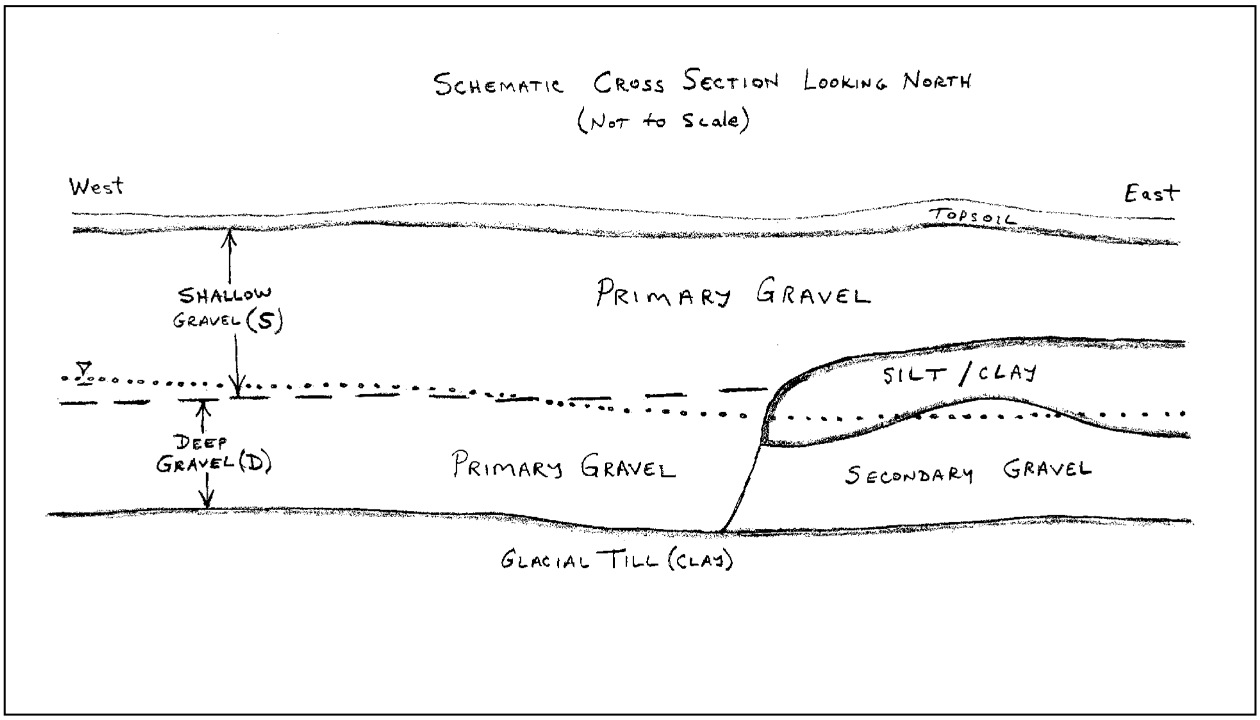

Figure 4. This representative cross section explains the terminology of the primary and secondary gravel as used in this report. Within the primary gravel deposit, the dashed line distinguished between the shallow gravel (S) and the deep gravel (D). The shallow gravel (S) is better graded with more medium sand and pebbles. The deep gravel (D) is poorly graded, with more coarse sand and shale. The dotted line represents the water table.

Test hole #77 (see Figure 3) was excluded from modeling because there was not an accurate ground elevation for it. This is because it was outside the elevation survey grid and outside the proposed mine. The purpose of the hole #77 was to determine the soils present in the buffer zone between the Des Moines River flood plain and the proposed mine.

Depth to water table measurements for six test holes, holes #2, 8, 22, 23, 28, and 65, were not included when modeling the water table. Water levels in these holes either were noted as approximate in the field notes or they were suspect as being perched because the levels were coincident with silt or clay layers.

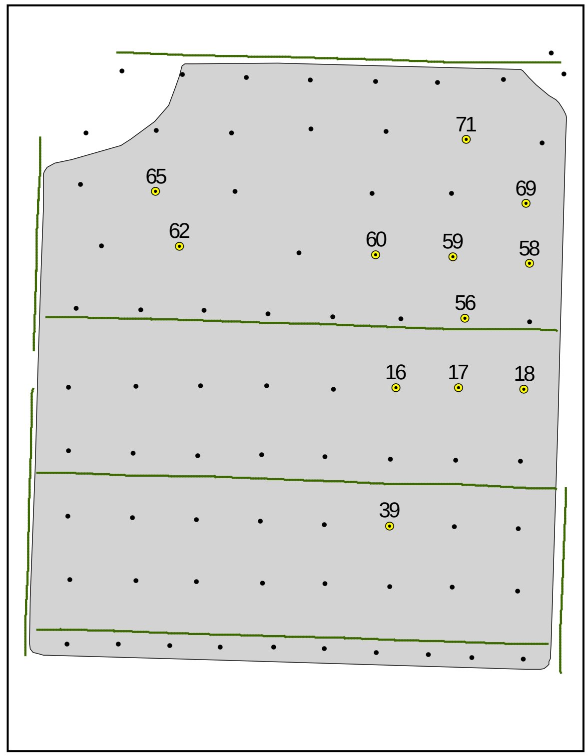

Figure 5. Test holes that encountered the secondary gravel deposit are indicated and labeled with their ID number. The ultimate pit extent is shaded in gray. Dashed lines indicate existing hedgerows.

RESULTS

Drilling Observations

Gravel occurred in every test hole. The gravel interval varies in thickness from one hole to the next. It is generally thinnest in the northwest part of the site and thickest in the southern one-third (Plate 2—Figure 4).

Drilling indicated that the basic stratigraphy of this site is as follows. Topsoil lies directly on the gravel and the gravel lies upon a clayey glacial till. The topsoil is considered overburden at this site and consists of mostly dark sandy loam and dark brown sandy silt. Topsoil ranges from 1 to 3.5 feet in thickness with an arithmetic average of 1.7 feet (modeled average is 1.7 ft).

Drilling identified two gravel deposits, a primary and a secondary. The primary deposit occurs just beneath the topsoil. The primary gravel deposit ranges from 2 to 20.5 feet in thickness with an arithmetic average of 13.9 feet (modeled average is 13.6 feet).

At the top of the primary deposit, several feet of pebbly gravel were encountered in most holes. Beneath the pebbly gravel, the deposit often varied between alternating layers of medium sand to gravel with occasional thin silty sand and gravel to clay zones.

Within the lower half of the primary deposit, most of the test holes showed a change in the texture of the sand. The upper part, which averages 8 feet in thickness, is rich in medium sand and usually contains more pebbles than the lower part and is here labeled shallow gravel. The lower part has noticeably more coarse sand and fine pea gravel than the upper part with varying amounts of rock and minimal fines and is labeled deep gravel. This was the basis for dividing the deposit into two layers—a shallow layer (S) and a deep layer (D)—for quality testing.

The secondary gravel deposit ranges from 2.5 to 10 feet in thickness with an arithmetic average of 5.8 feet (modeled average is 5.8 feet). The secondary deposit typically occurs below a fine sand, silt, or clay layer and below the water table. This gravel is similar to the primary gravel except it usually has less coarse aggregate and is more often associated with sand layers above or below. It occurs in 12 test holes primarily along the eastern quarter of the parcel (Figure 4). The mining and reclamation plan that follows later in this report does not consider mining the secondary deposit.

The depth to water table varies from 2.5 to 14.5 feet with an average depth of 8.7 feet (modeled depth of 8.2 feet). The water table slopes (gradient is approximately 0.002) to the northeast toward the Des Moines River.

Quantity

There are about 2,250,000 cubic yards of in-place gravel within the proposed pit outline representing the primary gravel deposit. Allowing for an undisturbed 3:1 slope along the pit perimeter, there are about 2,000,000 cubic yards of mineable aggregate. Slightly more than half of this is below water (Table 1).

The overburden totals about 250,000 cubic yards within the pit outline. The stripping ratio is about 13% or 1 foot of overburden to 8 feet of aggregate.

The mineable secondary deposit totals about 100,000 cubic yards.

Table 1. Modeled estimates of the quantity of gravel (bank measure, in-place volume) at the evaluation site. All volumes are rounded down to the nearest 50,000 cubic yards. The volume error is an estimate of potential error associated with the volume. It is based on the uncertainty of the data used for the calculations to derive the volumes for each layer. Volume is a 3-dimensional shape. A source of volume error is that the base of the aggregate varies between test holes. Good estimates exist for the top and edges of the deposit. NA = not analyzed.

Gravel Layer	Area (square ft)	Acres	Feet of Material (modeled estimate)	Volume (cubic yards)		
				Total Resource (within pit perimeter)	With 3:1 Sloping	Error (+/-)
Stripping-Topsoil	4,485,600	103	1.7	250,000	NA	20
Primary above water	NA	NA	6.6	NA	950,000	20
Primary below water	NA	NA	7.1	NA	1,050,000	25
Primary Total	4,485,600	103	13.6	2,250,000	2,000,000	20
Secondary below water	522,700	12	5.8	NA	100,000	30

Gradations and quality analysis

The average weighted gradation results for the primary and secondary gravel deposits are represented in Figure 6. For illustrative purposes, the data are plotted against MnDOT's typical requirements for Class 5 material. Both averages meet the gradation requirements. The data for the 1-inch sieve plot outside the range because these samples were not crushed prior to sieving and the MnDOT range is based on a crushed product. After crushing the results (curves) may be slightly different because the material larger than ¾ inch will be incorporated into the smaller sizes. Note: These are general guidelines that are useful for planning. Specific testing, if necessary, should be done for each pile of aggregate processed.

The gradation curves for the two deposits parallel each other with the secondary gravel plotting higher on the graph. The main difference between the two overall is the secondary deposit has less rock (is sandier) than the primary deposit.

Table 2 lists the data used to construct the graphs. Raw data from each test hole are presented in Appendix B.

Another criterion MnDOT uses for Class 5 is that at least 10% of the particles shall be crushed. The primary deposit has a better chance of meeting this than the secondary deposit.

Limited gradation data indicate the texture of the gravel deposit varies with depth. Two samples, one from the upper and one from the lower portion of the aggregate interval were collected for 18 test holes. Gradation results for these test holes indicate that most of the test holes (11 of 18) had 2 to 27% more crushable rock (+3/4 inch) in the upper roughly half of the interval as compared to the lower half. Three other test holes had 3 to 10% more crushable material in the lower half of the interval. The gradations for the upper and lower intervals were similar for the remaining four test holes. There was no discernable trend or distribution pattern to any of the above relationships.

Lab tests indicate the primary deleterious material, which determines quality or suitability for bituminous or concrete, at this site is shale. These tests indicated that the upper about 8 feet of the primary deposit, the shallow gravel (S), may meet MnDOT specifications for general purpose portland cement concrete if it is mined from quadrants 1, 2, or 3 (Table 3). The deep gravel (D) and all of the gravel in quadrant 4 has higher quantities of deleterious materials.

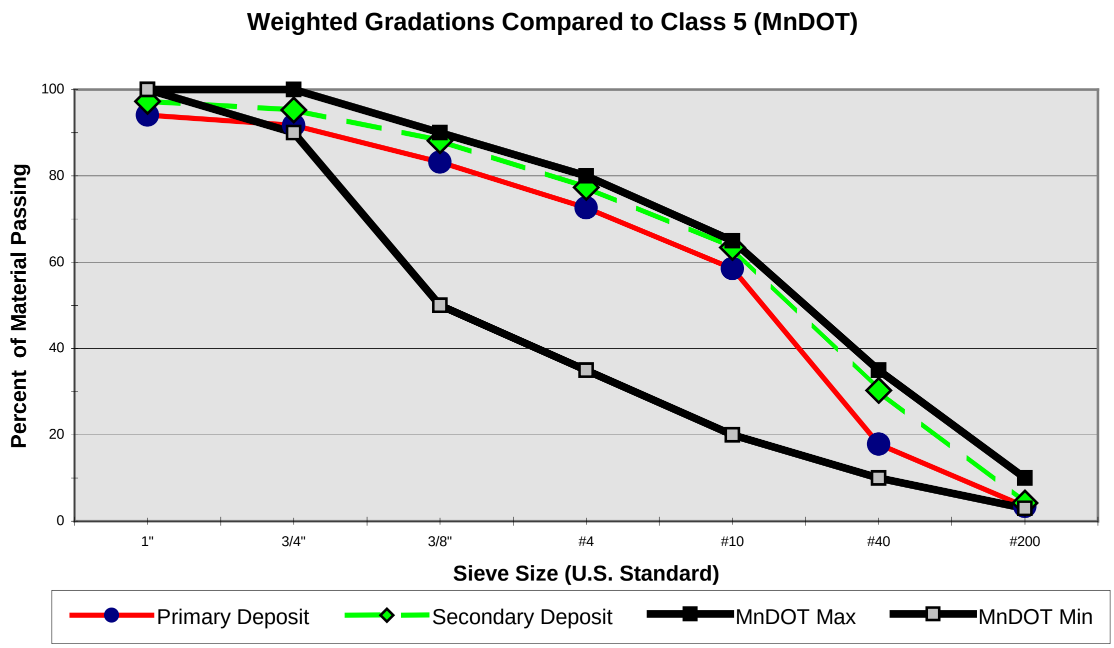

Figure 6. Summary graph that shows the weighted average for the entire 103-acre primary and secondary deposits are within MnDOT's acceptable range for Class 5. This graph is intended to provide a point of reference to a familiar gravel product (Class 5). Specific projects may require material meeting a different gradation or even more than one. Percent passing refers to the proportion of the sample by weight that passes through a given sieve size. Note: Typically crushing operations are set up to crush all particles larger than ¾ inch (sometimes 1 inch) as the aggregate is processed.

Table 2. Weighted (by thickness) average gradations for the evaluated parcel. The sieve sizes get smaller moving to the right in the table. The values below each sieve size are the percent, by weight, of the total sample that falls through (passes) that sieve. The cutoff we use for the gravel fraction is material larger than the #10 sieve (2 millimeters). For the primary deposit, 59% of the sample, by weight, was smaller (passed through) the #10 sieve. Stated another way, the primary deposit has an average of 41% gravel (100-59=41). The three columns on the right show the percent of material retained (bigger) than the respective sieves. Values in parentheses represent the range for all the test holes or their composites if there was more than one sample per hole.

	Percent of Material ***Passing*** Respective Sieve							Weight Percent ***Retained*** on Respective Sieve		
	1"	3/4"	3/8"	#4	#10	#40	#200	crushable +3/4"	+#4	gravel +#10
Primary Deposit Average	94	92	83	73	59	18	3.4	8 (2-25)	27 (17-53)	41 (28-62)
Secondary Deposit Average	97	95	88	77	63	30	4.2	5 (3-16)	23 (17-41)	37 (27-53)
Class 5 upper range	100	100	90	80	65	35	10	0	20	35
Class 5 lower range	100	90	50	35	20	10	3	10	65	80

Table 3. Laboratory test results for deleterious materials in the **primary gravel deposit**. All values are in percent, by weight. The primary gravel deposit was separated into 4 quarters. Each quarter, except #2, was further divided into two samples representing shallow (S) and deep (D) gravel layers. Tests indicate the shallow gravel (S) in quadrants 1, 2, and 3 is of high quality and meets DOT portland cement concrete general use specifications. The shallow gravel (S) begins just below the topsoil and has an average thickness of 8 feet. The deep gravel (D) has more shale than the shallow gravel (S) and therefore is of lower quality. It may not pass specifications for concrete, but is acceptable for non-concrete uses such as road base, for example. Items in the first column identified with a +1/2", +4, or -4 refer to the portion of the sample retained on (larger than) a ½" sieve, a #4 sieve, and passing through (smaller than) a #4 sieve, respectively. Criteria for Class 5 base, bituminous, and concrete were taken from MnDOT specification #3138, #3139, and #3127, respectively.

Material	Talcot Sample Composite Results (%) by Quadrant and Layer							MnDOT Specifications (maximum %)					
								Class 5	Bituminous			Concrete	
	1-S	2-S	3-S	4-S	1-D	3-D	4-D		Type 31	Type 41, 47	Type 61	General use	Bridge Super-structures
+1/2" shale	0	0	0	0.4	0	1.2	0					0.4	0.2
+#4 shale	0.2	0.3	0.1	0.6	0.8	0.9	0.4					0.7	0.3
Soft iron oxide	0	0	0	0	0	0	0					0.3	0.2
+1/2 total spall[b]	0	0	0.7	0.5	0.4	1.9	0.4					1.0	-
+#4 total spall[b]	0.5	1.2	1.2	1.5	1.8	1.3	1.3			2.5		1.5	0.3
Soft particles	0.3	0.2	0.1	0.7	0.5	0.1	2.4					2.5	2.5
Sum of spall, soft particles, clay lumps[c]	0.7	1.4	1.3	2.2	2.3	1.4	3.7					3.5	3.0
Carbonate	9.6	7.4	1.6	1.5	1.2	1.2	2.5					-	30
#4 Lightweight particles	0.2	0.2	0.2	0.4	0.7	0.6	0.7			5.0			
Total spall[d]	0.7	1.4	1.4	1.9	2.5	1.9	2.0	7 or 10[a]	5.0		1.0	-	-

[a] Maximum is 10% shale except when the part passing the 200 sieve exceeds 7%, the shale shall not exceed 7%.
[b] Total spall includes shale, soft iron oxide, other iron oxide particles, unsound chert, pyrite, and other materials having similar characteristics. It excludes soft particles and clay lumps.
[c] Clay lumps were not tested here. They are important in bituminous and concrete aggregate. Concrete aggregate is always washed during processing—that is the appropriate time to test this criterion.
[d] Spall in the total sample (includes +#4 and -#4 fractions).

MINING AND RECLAMATION 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 land manager 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.

Overview

This mining plan encourages and anticipates that all of the aggregate resource identified as the primary deposit, including that below water, will be mined eventually. This plan is written as though the secondary gravel is not mined. Final discretion is left to negotiations between the land manager and the lessee or purchaser. Mining will occur in phases because of the large quantity of aggregate available relative to demand. This plan presents a basic design for mining of the gravel and for final reclamation.

Custom designs, specific pit management, and timing of reclamation plans for the site are left to the discretion of the land manager. Once mining is complete, the final reclaimed landscape goal is three wetlands separated by upland dikes. At least one and possibly two are proposed to have a water depth of about 3 feet and one will be deeper. All will have undulating shorelines with gentle slopes.

This gravel deposit occurs as a layer of sand and gravel of varying thickness and rock content buried just below the topsoil. Drilling has determined that the edges of the deposit extend beyond the pit boundary.

The aggregate in the primary deposit, as an overall average, meets Class 5 gradations. Some portions of the site, however, do not quite meet Class 5 gradations. This is addressed further in the mining section below.

Permitting

Generally the state is exempt from local permitting. However, if local zoning ordinances or other rules exist for borrow pits or extraction of aggregate, such as setbacks from roads or property lines, the land manager should be aware of and consider them when developing the pit plan. Currently, Cottonwood County zoning allows mining to the right-of-way of roads. FEMA maps indicate the 100-year flood plain of the Des Moines River is contiguous with the northeastern corner of the evaluation site and includes the wetland identified in the extreme northwest corner of the parcel. All proposed mining is outside this floodplain.

Permits likely are required, however, if water is drained or pumped from the pit or if wetlands are impacted (Appendix D). Pumping is not needed according to this plan. This plan considers that one small wetland (approximately 0.3 acres), and one larger one (approximately 3 acres) in the north central part of the site will be lost to mining. Replacement of these wetlands may occur with part of the estimated 92 acres of wetlands that will be created by mining.

An Environmental Assessment Worksheet (EAW) is needed for this site since the ultimate pit size is more than 40 acres. This plan estimates the ultimate pit size will be 103 acres. An Environmental Impact Statement would be needed if the mine were 160 acres or more.

Site preparation/clearing

Brush and unmarketable timber may be reserved in piles for upland or under-water habitats, for visual screening, burned, or disposed of away from the proposed and future mining areas at the discretion of the land manager.

Each hedgerow may remain intact until mining approaches it. Leaving existing hedge rows will provide visual and sound barriers to the mining operation.

Stripping

Topsoil occurs over the aggregate everywhere and must be stripped prior to mining. Stripping shall occur in phases every one or two years to limit the total land disturbance. The topsoil may be stockpiled in broad mounds to minimize doughty conditions and wind erosion. These piles should be located outside of the area to be mined now or in the future, or spread on areas ready for permanent reclamation or placed in the water to backfill those areas already mined, depending on the phase of mining. The goal is to move the stripped material as few times as possible and also to place it as close as practical to where it will be ultimately spread during reclamation. Ideally, the stripped material should be placed in an adjacent area that is ready for reclamation–an area where the gravel is depleted or a decision was made to no longer mine that particular area. Most of the stripped material may be placed directly in adjacent mined out areas.

Topsoil piles that are not spread (for reclamation) in a timely fashion may be seeded with a cover (nurse) crop of oats (spring and summer seasons), winter wheat (fall season), or other species at the discretion of the land manager to minimize erosion and weed growth.

Stripping shall extend far enough past the expected tops of pit walls so that final or temporary sloping can be done during or at the close of active mining without incorporating topsoil or other deleterious materials into the slope where further mining will occur. After each mining season—probably the fall, the working face shall be sloped at 1:1 or gentler for safety.

Mining

A mining strategy is partly dependent on the scale, or annual production rate, of the mining operation. An operator who plans to mine 100,000 yards or more per year has greater opportunity and flexibility in utilizing the entire resource, especially when the deposit is variable, than someone who mines small quantities at a time. Regardless of the production, however, to maximize the amount of gravel ultimately mined from this pit prior to final reclamation, one recommended approach is to start at one end of the parcel, and mine the entire deposit, from top to bottom, before advancing laterally. This technique removes the chance of cutting off access to parts of the deposit because of the water table. Where mining starts and the direction it advances should follow a logical sequence so that access to remaining aggregate always exists and that some permanent reclamation, if practical, may occur after each mining phase.

If details of the final reclaimed landscape desired are known, much of those landscaping goals can be met during mining resulting in economic savings and more efficient reclamation.

The desired **reclaimed landscape goal** for this site is shallow wetlands with gentle slopes along the shorelines. The water depth in the wetlands shall be 3 feet or shallower to promote habitat for diving waterfowl, along with many other wetland species, and at the same time minimize the chance that species of rough fish would become established.

The **mining goal** is to mine all of the primary aggregate deposit at the site. Mining will extend well below the water table over most of the site and up to about 14 feet deep in places. This plan proposes that excess topsoil stripping material be backfilled into those portions of the pools that are depleted of aggregate as mining progresses.

This plan recommends that a 30-foot wide corridor along the proposed dikes remain intact to serve as the core for the dikes. Along this corridor, mining would not go deeper than 3 feet above water. This provides a more stable condition as compared to mining the deep areas and then backfilling them to build the dikes. The amount of aggregate not mined along the 30-foot corridors is about 29,000 cubic yards. This quantity is well within the rounding errors of the total resource estimate and therefore does not affect the mineable quantities presented in this report (Table 1).

There is not enough stripping material at the site to completely backfill all areas to a water depth of 3 feet. As a compromise and to improve management opportunities, the site is partitioned into 3 areas divided by dikes (Figure 7). The dikes will not be mined deeper than 3 feet above the water table, so they are located where the aggregate either does not extend below water or where it extends a relatively short distance below water. Modeling predicts that there is sufficient stripping material (topsoil) to backfill all of phase 1 to a water depth of 3 feet, and reclaim the shoreline along the dikes and mine perimeter. This plan allows the dikes to extend about 3 feet above the water. The other two phases would be deep-water wetlands unless clean fill is imported to the site for backfill.

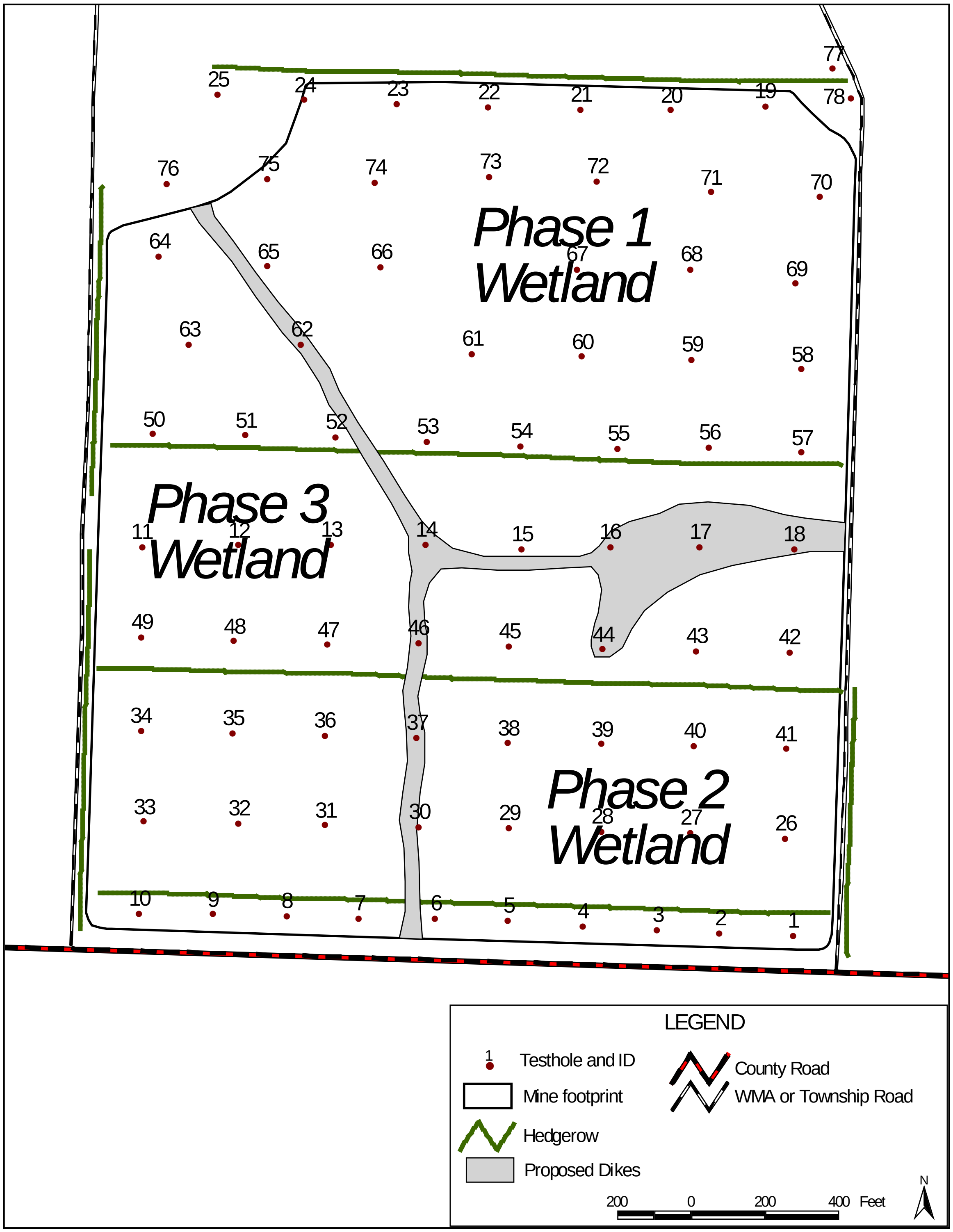

Figure 7. Locations of the three major wetland phases associated with mining. Approximate location and orientation of proposed dikes that separate each wetland are indicated in gray shading. The dikes are about 30 feet wide and placed in locations where the mining depth relative to the water table is relatively shallow or above water. The wide irregular dike between phases 1 and 2 is where mining is not expected to go below the water table resulting in an irregular low upland area.

To increase the potential of meeting the reclamation and mining goals, mining is proposed to start at the north end of the deposit, mine southward, and eventually finish at the southwestern end of the deposit adjacent to County Road 15 following the three phases as indicated in Figure 7. This plan will allow sufficient material to create a shallow-water wetland in phase 1. If imported material is allowed as backfill, over time, it may be possible to create a shallow wetland in phase 2 as well. As mining comes to a close, it is probable that much of phase 3 will be a deep-water habitat. Table 4 provides estimates of dimensions and backfill quantities needed for various conditions.

The mine footprint will be about 103 acres. After reclamation, up to about 16 acres will be above water (10.5 acres around perimeter, and 5.5 acres of dikes)

As mining progresses, the overburden shall be backfilled promptly into the mined out areas and along the pit perimeter. The pools created by excavating gravel from below the water table shall be backfilled as directed to a level within 3 feet of the water surface.

Modeling was based on the assumption that, along the pit perimeter, the mining slope will be 3:1 extending to the base of the gravel including that below water. Mining at steeper slopes along the mine perimeter and later backfilling to create the 3:1 slopes was not considered an option due to a shortage of backfill materials.

Water occurs from 2.5 to 14.5 feet below the surface and half of the aggregate lies below water. The deepest that mining would go below water is 14.7 feet. In the areas where the water table is relatively deep and aggregate extends deep below the water table, mining may occur in two stages. For example, the first stage would mine an area (100 foot swath, for example) to a depth of just above the water table to create a bench. Then concurrently, or afterwards, an excavator would mine the aggregate below the water table from the recently created bench. In those areas where the water table is near the surface, the entire gravel interval could be mined in a single operation. Dewatering is not needed with this mining technique.

Ditching from the pit to the river for any reason is not allowed. Dewatering the pit by pumping to facilitate mining is an option if the applicable permits are obtained.

This gravel deposit varies in texture both laterally and with depth, and has an undulating bottom. The base of the primary gravel ranges from 2.8 feet above the water table to 14.7 feet below water. In some places the upper part of the gravel is coarsest and in other places, the opposite is true. Variations with depth may be managed by mining the gravel deposit as a single lift from top to bottom. This allows for the varied layers of gravel and sand to be blended during the excavation phase. This creates the most uniform product, eliminates high grading, utilizes the entire resource, and is the quickest way to deplete sections of the pit for reclamation.

An exception to the idea of mining as a single lift could be if concrete aggregate is needed. Testing showed that the upper approximately 8 feet in quadrants 1, 2, and 3 (the NE, NW, and SW quarters) may meet the quality requirements for portland cement general purpose concrete, whereas the deeper aggregate in these quadrants does not.

Figure 8 shows gradation results of the four worst test holes where the particle size gradations fall outside MnDOT's recommendations for Class 5 aggregate (see also Table 5). The graph shows there is a shortage of material larger than the #10 sieve (2 millimeter diameter). In other words, these samples are sand-rich, or "sandy".

All of these "sandy" holes occur apparently randomly on the eastern third of the proposed mining area. Most holes adjacent to these "sandy" holes do not have these deficiencies. It is anticipated that material from the "sandy" areas may be used in situations where Class 5 material is not necessary or they may be blended with materials nearby to make the desired aggregate product.

Table 4. Details on the three proposed created wetlands, designated as phases 1, 2, and 3, that will be created during the three major phases of the mining operation. There is enough topsoil overburden to create the wetland in phase 1 and topdress all the shoreline/upland areas, but not enough to also topdress the wetlands in phases 2 and 3. If it is desirable to use topsoil from on site as topdressing for the wetlands in phase 2 and 3, then about 90,000 cubic yards of imported fill are needed in phase 1 to replace the 90,000 cubic yards of topsoil needed to topdress (1 foot thick) the wetlands in phases 2 and 3. C.y. = cubic yards.

	Phase 1	Phase 2	Phase 3	Totals
Area (acres)	42	28	33	103
Estimated wet area (acres)	38	25	29	92****
Primary Gravel (c.y.)	755,000	590,000	680,000	
Secondary Gravel (c.y.)	83,000	24,000	3,600	
Available Topsoil overburden (c.y.)	120,000	69,000	93,000	282,000
Backfill to water depth of 2 feet (c.y.)	315,000	185,000	285,000	785,000
Backfill to water depth of 3 feet (c.y.)	255,000	150,000	240,000	645,000
Topsoil for uplands (1 foot thick) (c.y.)				25,000
Topsoil needed for 1 ft topdressing of phase 2 and 3 wetlands (c.y.)		40,000	47,000	
Quantity to import (c.y.)	0	150,000*	240,000*	
Primary gravel left in place for dikes 3 ft high (c.y.)***	17,000	12,000	Nap	29,000**
Modeled Avg water elevation (ft)	1315.2	1316.4	1317.5	Nap

*The quantity for 1 foot of topdressing is included in this figure.
**Add 4,000 cubic yards for each additional foot of core dike height (about 2.4 acres).
*** A minimum of 30 foot wide undisturbed corridor to serve as the core of the dikes. The in-place gravel will project 3 feet above the water table. This will result in a more stable situation as compared to backfilling of soils into the deep areas to create the dike.
****This acreage includes about 5 acres of dikes and upland adjacent to the dikes.

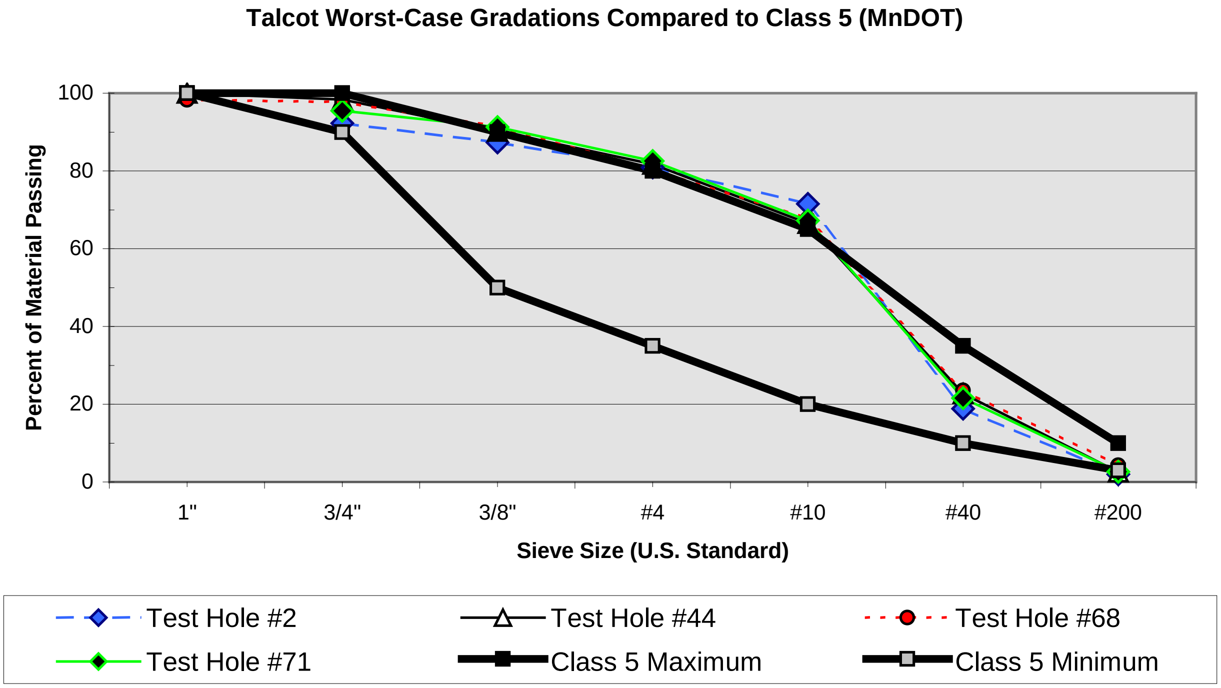

Figure 8. This graph shows 4 test holes with the poorest gradations as compared to MnDOT's gradations for Class 5 aggregate. Aggregate with lots of gravel and coarse particles (rock) will plot lower on this graph than aggregate comprised mostly of sand. Percent passing refers to the proportion of the sample, by weight, that passes through a particular sieve size.

Table 5. Samples from four test holes that represent the poorest gradations in the evaluation area, as compared to MnDOT's Class 5 limits.

Test Hole	Percent of Material Passing Each Respective Sieve						
	1"	3/4"	3/8"	#4	#10	#40	#200
#2 (1.3-8.5 ft)	-	97	93	88	81	24	2.9
#2 (8.5-17 ft)	-	88	82	75	64	14	1.2
#2 combined	-	92	87	81	72	19	2.0
#44 (1-12 ft)	100	98	90	82	66	23	2.5
#68 (1.8-19 ft)	98	98	91	80	68	24	4.3
#71 (2-13 ft)	-	95	91	83	67	22	2.6
Class 5 upper limits	100	100	90	80	65	35	10
Class 5 lower limits	100	90	50	35	20	10	3

Mining Buffers along the Des Moines River Floodplain. The soil profile near the banks of the flood plain consists of sand and gravel (granular soils), so there is a risk of bank failure from a process called piping if mining occurs too close to the edge of the flood plain. The mining buffer in the NW and NE corners of the parcel are set to guard against the possibility a flooding Des Moines River could cause bank failure from a mechanism called piping (not overtop) in these two locations and flood the pit. The Wildlife manger does not want a physical connection between the pit and the river system, so it is important to prevent this from happening.

When the Des Moines River floods, piping could occur when water on the riverside of the buffer strip seeps through the granular soils towards the pit. If the seepage velocity is high enough, the bank on the pit side will wash out and begin to erode towards the river. The seepage velocity (or the potential for piping) is dependent on the type of soil materials, the relative difference in water levels on either side of the buffer, and the width of the buffer.

To eliminate the chance of piping, no-disturbance buffers of 75 and 100 feet for the NW and NE corners, respectively, shall be maintained from the edge of the pit to the bank crest (see Table 6). This also assumes a 3H:1V slope on either side of the buffer. These buffers were set using a rule-of-thumb where, during maximum flood stage, the maximum phreatic surface (slope) between the floodwater and the water in the pit (water table) is about 10% or less. Stated another way, the slope of an imaginary line from the maximum flood stage projected to the water level in the pit should be 10 feet or less per 100 feet of distance. The exit velocity of the seepage waters was then determined using standard engineering methods using the buffer width and maximum difference in water levels. This number is 14%--low enough to prevent piping.

The granular soils in the NW buffer are siltier than in the NE, which lessens the chance of piping, so the greatest concern is on the NE area. Calculations for the NE example indicate an exit gradient of about 14% may occur under worst-case conditions, which is OK. This conclusion is based on the head differential indicated in the table and a permeability of k= 1 ft/minute. If these parameters are found to be different, this should be reexamined.

Raising the banks in these two areas would be ineffectual because if the Des Moines River reached this level, much of the immediate countryside would already be flooded.

RECLAMATION

During mining or at the conclusion of each mining phase, areas where future mining will occur should undergo interim reclamation and permanent reclamation should occur where mining will not occur again.

General provisions.

Interim reclamation. Interim reclamation shall consist of sloping all pit faces or walls to provide a safe condition (recommended slope angles are 1:1, horizontal to vertical or gentler).

Table 6. Input parameters and calculations used to estimate the no-disturbance buffers for the northeast and northwest corners of the parcel. Potential maximum high-water levels are based on the topographic spill points at which the Des Moines River would spill onto the countryside.

See appendix XX for more information. This data does not allow for drawdown of the water in the pit during flood stage. If pumping occurs, additional safeguards will be necessary. An example of additional safeguard is placing an impermeable geomembrane (<= 25 mil thick) on the riverside of the buffer and covering it with 1 foot of soil.

	Northeast Corner	Northwest Corner
Spillway elevation of the flood plain bank	1324.5	1322
Approximate water elevation	1312.5-1313.5	1314.5-1316
Difference between spillway and water elevation	11-12	6-7.5
Difference used	10****	7.5
Calculated no-disturbance buffer (slope = 0.10) *	100 feet	75 feet

Note: Assumed K = 1 ft/minute, graded granular soils.
* Using the formula: buffer distance (x) = difference in elevation between pit water and floodwater divided by 0.10. In the field, the buffer distance is measured from the closest point where floodwaters would encroach before overtopping the banks. The buffer width does not include the slope into the pit.
** The water table slopes to the northeast. Once the entire northern part of the pit has been mined, the water table will equalize across the pit to an intermediate level between approximately 1312.5 and 1316 feet.
****If the floodwaters reached an elevation of 1322 feet, the river would overtop the banks on the NW corner and flood everything. Therefore, 1322 feet, instead of 1324.5, is the critical elevation to use at the NE corner.

This includes the banks adjacent to water. The topsoil and overburden shall be stripped far enough past the expected pit edge to allow for proper sloping without incorporating overburden or other deleterious material into the slopes.

Permanent reclamation. All topsoil shall be retained for reclamation. All slopes along the pit perimeter shall be graded to a 3:1, horizontal to vertical, or gentler slope. The shoreline and shallow-water areas adjacent to the shoreline shall be graded to a 10:1 slope. The 10:1 slope shall project into the water at least 20 feet from shore. This is important for public safety, slope stability, and to create a larger littoral zone (shallow water). Materials such as overburden and fine sand that are not needed for the mining operation may be placed in parts of the water-filled areas to create a shallow-water habitat and to create islands. All disturbed areas shall be covered with about 12 inches of topsoil prior to seeding. Slopes should be covered with available clay- and silt-rich overburden subsoils, if any, and then covered with topsoil.

This plan recommends that stripping materials (the sod layer) from the existing wetlands be transplanted immediately upon nearby shorelines or problem areas where mining is completed and quick establishment of vegetation is desired.

Haul roads, staging areas, and similar areas that undergo permanent reclamation may require preparation (loosening) of the soil prior to the addition of topsoil if they are highly compacted. All reclaimed areas above water shall be seeded at the direction of the land manager to minimize the spread of weedy species, minimize erosion, and accelerate the reclamation process.

Gates at the ends of the dikes and signage in certain areas may be needed to limit entry into sensitive areas by unauthorized vehicles.

Advice on creating wetlands and banking the acres of wetland created are available from personnel at the Minnesota Board of Water and Soil Resources (BWSR) and DNR Division of Ecological Services.

Four fact sheets on aggregate mining are attached in Appendix F. 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.

Leasing, reclamation, and mining recommendations are available from DNR Division of Lands and Minerals.

GLOSSARY

boulder– a stone (usually rounded) larger than 256 mm (10 inches) in diameter.

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

crevasse– a fissure or open break within glacial ice.

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 form when streams occur on or in sediment-rich glaciers. When the ice eventually melts, the sediments in the streambed form a ridge.

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

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

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

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

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

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

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

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.

Appendix A: **Test holes with location coordinates, feet of aggregate, and water table information.**

Appendix B: **Detailed geologic descriptions for each test hole.**

Appendix C: **Complete gradation data for each sample.**

Appendix D: **Aggregate quality data.**

Appendix E: **Notes on the criteria for classification of the aggregate deposit.**

Appendix F: **Four DNR fact sheets on aggregate mining.**

Appendix A: Test holes with location coordinates, feet of aggregate, and water table information.

Test_hole	collar_elev_ft	water_elev_ft	ft_to_water	primary_grvl_ft	ov_burden_ft	Jackson_y_ft	Jackson_x_ft	latitude	longtitude	x_coord_utm	y_coord_utm
1	1325.1	1314.7	10.4	4.5	2.0	251671	103328	43.90618536	-95.45505272	302856	4864383
2	1325.3			15.7	1.3	251673	103129	43.90618150	-95.45580575	302796	4864384
3	1326.8	1316.8	10	16	1.0	251682	102960	43.90619877	-95.45644797	302744	4864388
4	1329.1	1316.8	12.3	16.8	1.2	251689	102758	43.90620564	-95.45721618	302682	4864391
5	1331.2	1316.7	14.5	21.5	2.0	251701	102557	43.90623037	-95.45797775	302621	4864395
6	1330.3	1316.3	14	17.5	1.5	251705	102359	43.90623171	-95.45872869	302561	4864397
7	1329.6	1316.6	13	18.5	2.0	251703	102154	43.90621453	-95.45950787	302498	4864397
8	1328.9			14	2.0	251706	101958	43.90621495	-95.46025277	302439	4864399
9	1327.6	1317.1	10.5	12.5	1.5	251710	101759	43.90621344	-95.46100689	302378	4864400
10	1327.6	1316.9	10.7	15	1.0	251708	101560	43.90619894	-95.46176277	302317	4864401
11	1322.9	1316.4	6.5	16	1.0	252700	101556	43.90892054	-95.46184684	302320	4864703
12	1324.6	1319.3	5.3	12.5	3.5	252707	101817	43.90895189	-95.46085627	302399	4864704
13	1325.5	1317.2	8.3	16	1.0	252711	102066	43.90897561	-95.45991045	302475	4864705
14	1324.6	1314.1	10.5	6.5	1.0	252715	102322	43.90899799	-95.45893983	302553	4864705
15	1322	1316.5	5.5	14	1.0	252704	102581	43.90898257	-95.45795554	302632	4864701
16	1323.5	1315.2	8.3	5	2.0	252714	102821	43.90902146	-95.45704711	302705	4864703
17	1325.1	1313.8	11.3	7.5	1.0	252718	103064	43.90904409	-95.45612619	302779	4864703
18	1323.8	1314.3	9.5	6	1.5	252715	103318	43.90904761	-95.45516261	302857	4864701
19	1324.2	1313.2	11	20.5	2.5	253909	103226	43.91231781	-95.45559344	302833	4865066
20	1323.7	1313	10.7	15	1.5	253896	102971	43.91226936	-95.45656138	302755	4865062
21	1322.2	1314.2	8	11.3	1.7	253894	102729	43.91225302	-95.45747878	302681	4865063
22	1320			2	3.0	253898	102477	43.91225159	-95.45843340	302605	4865065
23	1319.5			5.5	2.0	253905	102230	43.91225863	-95.45937284	302529	4865068
24	1322.3	1313.6	8.7	12.5	1.5	253913	101981	43.91226676	-95.46031790	302453	4865071
25	1318.6	1314.4	4.2	11	1.5	253924	101747	43.91228621	-95.46120412	302382	4865075
26	1327.6	1315.6	12	19	1.5	251933	103304	43.90690218	-95.45516253	302850	4864463
27	1324.5	1316.7	7.8	13	2.0	251945	103048	43.90692372	-95.45613273	302772	4864468
28	1325.9			16	2.0	251946	102807	43.90691291	-95.45704778	302698	4864469
29	1327.1	1319.1	8	15	2.0	251952	102556	43.90691944	-95.45799896	302622	4864472
30	1329.3	1316.8	12.5	15.5	2.0	251952	102313	43.90690545	-95.45892097	302548	4864472
31	1329	1317.5	11.5	19	2.5	251954	102059	43.90689933	-95.45988539	302470	4864474
32	1328.3	1317.8	10.5	16	2.5	251955	101824	43.90688927	-95.46077647	302399	4864475
33	1327.7	1318.7	9	11.5	1.5	251958	101568	43.90688458	-95.46174718	302321	4864477
34	1326.7	1318.2	8.5	11	3.0	252203	101558	43.90755697	-95.46180191	302319	4864552
35	1327.7	1317.9	9.8	18.5	2.5	252199	101807	43.90755747	-95.46085711	302394	4864549
36	1327.7	1317.4	10.3	17.5	2.5	252196	102055	43.90756108	-95.45991599	302470	4864548
37	1327.9	1317.9	10	15.5	2.0	252192	102304	43.90756267	-95.45897436	302546	4864545
38	1326	1316	10	17	1.0	252181	102550	43.90754725	-95.45803827	302621	4864541
39	1324.2	1315.2	9	12	1.5	252181	102803	43.90755974	-95.45707771	302698	4864541
40	1324.5	1314.5	10	17	1.0	252180	103055	43.90756711	-95.45612292	302775	4864539

41	1328.1	1317.1	11	21	1.0	252174	103302	43.90756477	-95.45518365	302850	4864537
42	1326.4	1315.9	10.5	22.5	1.0	252436	103309	43.90828243	-95.45517870	302853	4864616
43	1326	1315.7	10.3	17	1.0	252435	103057	43.90826734	-95.45613105	302776	4864617
44	1328.2	1316.7	11.5	9	1.0	252438	102804	43.90826306	-95.45709170	302699	4864619
45	1325.5	1316.7	8.8	16	3.0	252442	102552	43.90826248	-95.45805026	302622	4864621
46	1326	1317.5	8.5	12.5	2.0	252449	102305	43.90826851	-95.45898534	302547	4864624
47	1327.7	1317.7	10	15.7	2.3	252442	102059	43.90823599	-95.45991976	302472	4864622
48	1325.8	1317.1	8.7	15.7	1.3	252448	101807	43.90824077	-95.46087706	302395	4864625
49	1324.2	1317.7	6.5	15.7	1.3	252456	101557	43.90825015	-95.46182614	302319	4864629
50	1324.4	1318.1	6.3	18.5	1.5	253004	101582	43.90975554	-95.46176797	302329	4864796
51	1323.3	1317.5	5.8	15	1.0	253004	101831	43.90976745	-95.46082224	302405	4864795
52	1319.9	1316.9	3	11	1.5	253002	102075	43.90977424	-95.45989679	302479	4864793
53	1322.2	1315.9	6.3	12.5	2.0	252993	102323	43.90976300	-95.45895550	302554	4864790
54	1323.2	1315.9	7.3	16	2.0	252984	102575	43.90974943	-95.45799896	302631	4864786
55	1322.5	1315.7	6.8	16	1.0	252980	102838	43.90975236	-95.45700110	302711	4864784
56	1324	1316.5	7.5	8	1.0	252986	103086	43.90978010	-95.45606073	302787	4864785
57	1325.6	1314.6	11	18.8	1.2	252975	103336	43.90976225	-95.45511198	302863	4864781
58	1324.8	1315.3	9.5	9	2.5	253200	103333	43.91037949	-95.45513989	302863	4864849
59	1324.1	1314.1	10	10.5	1.5	253223	103036	43.91042870	-95.45626634	302773	4864857
60	1320.5	1314	6.5	9.3	1.7	253227	102738	43.91042450	-95.45739781	302682	4864860
61	1319.9	1315.6	4.3	16.7	2.3	253231	102442	43.91042073	-95.45852216	302591	4864862
62	1320.9	1318.4	2.5	5	1.5	253252	101979	43.91045426	-95.46028018	302450	4864870
63	1325.9	1316.1	9.8	15	2.0	253248	101676	43.91042979	-95.46142976	302358	4864870
64	1323.6	1317.6	6	12	2.0	253484	101592	43.91107259	-95.46176260	302333	4864942
65	1321.6			4.8	1.2	253461	101885	43.91102239	-95.46065141	302422	4864934
66	1318.6	1314.1	4.5	14.5	1.5	253464	102191	43.91104585	-95.45948775	302516	4864934
67	1318.9	1315.1	3.8	15.2	2.8	253463	102722	43.91107159	-95.45747576	302678	4864932
68	1323.5	1314.5	9	17.2	1.8	253467	103029	43.91109640	-95.45631101	302771	4864932
69	1324.9	1313.6	11.3	13.2	1.8	253431	103316	43.91101141	-95.45522036	302859	4864920
70	1324.5	1313.3	11.2	20.5	1.5	253666	103377	43.91166109	-95.45500327	302878	4864991
71	1323.3	1313.5	9.8	11	2.0	253675	103082	43.91167039	-95.45612502	302788	4864995
72	1321.5	1314.7	6.8	16	2.0	253702	102773	43.91172814	-95.45729907	302694	4865004
73	1320.2	1315.2	5	11.2	1.8	253711	102482	43.91173828	-95.45840188	302605	4865008
74	1322.1	1316.1	6	7.7	2.3	253691	102174	43.91166838	-95.45956830	302512	4865003
75	1322.2	1315.7	6.5	15.2	1.8	253697	101884	43.91166997	-95.46066918	302423	4865006
76	1320.4	1315.4	5	13.5	1.0	253682	101612	43.91161675	-95.46169932	302340	4865002
77	1321.2	1314.2	7	18.2	2.8	254014	103409	43.91261461	-95.45490746	302889	4865097
78	1321.7	1312.2	9.5	20	1.0	253933	103459	43.91239576	-95.45471015	302904	4865072

Appendix B: Geologic descriptions of each test hole.

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
1	0	2		blk	s		sdy loam		topsoil				d	
1	2	6.5		brn	c	w	sd w/ grvl	SW	grvl_1	30	3/8	2.5		
1	6.5	9		brn	c	p	m sd	SP	sd	3	1/4	1/2		
1	9	10		brn	c	w	c sd	SW	sd	tr			w	
1	10	10.5	10.4	lt gry			lean/fat clay	CL-CH	silt_1					mottled rusty streaks, water level meas. 10 minutes after drlg
1	10.5	12		dk gry			lean/fat clay	CL-CH	silt_1	0				stiff
1	12	14		brn		p	f-m sd	SP	sd_2	tr			w	
1	14	15		gry			silt/lean clay	ML-CL	clay	0				not till
2	0	1.3		blk	s		sdy loam		topsoil	5	3/8	2	d	
2	1.3	6		brn	c	w	sd w/ grvl	SW	grvl_1	20	1/4	3	d	silty in upper
2	6	8.5		brn	c	w	c sd w/ occ grvl	SW	grvl_1	10	1/8	1/2		finer in upper
2	8.5	11		org	s	w	f grvl	GW-GM	grvl_1	55	3/8-1	4	w	stiff drlg at 6-9", small cobbles at 8.5-10', water at ~10.5'
2	11	14.5		brn	c		c sd w/ f grvl	SW	grvl_1	35	1/8-1/4	1.5	w	
2	14.5	17		gry	c		c sd w/ f grvl	SW	grvl_1	30	1/8	1/2	w	
2	17	18		brn gry	c	p	m sd	SP	sd	tr		1/8	w	tite drlg 17-19', lower foot is finer
2	18	21.5		blue gry	c	p	vf sd & silt	SP-ML	sd	0			w	
3	0	1		blk			sdy loam		topsoil					
3	1	4.5		org brn	c	w	sd w/ grvl	SW	grvl_1	40	3/8-1.5	2.5		silty in top 1'
3	4.5	5.5		org brn	c	p	m sd w/ grvl	SP	grvl_1	20		3/4		
3	5.5	8		lt brn	c	p	m sd	SP	grvl_1	tr		3/4		iron streaks at 5.5-7'
3	8	10.5	10	gry brn	c	w	c sd w/ grvl	SW	grvl_1	20	1/8	1/2	w	
3	10.5	15		brn gry	c	w	c sd w/ f grvl	SW	grvl_1	40	1/4	1/2	w	coarser w/ depth
3	15	17		brn gry	c	w	f grvl	GW	grvl_1	55	3/8	1	w	c sd, some silt
3	17	21.5		blue			till-fat clay	CH	clay					stiff
4	0	1.2		blk			sdy loam		topsoil					
4	1.2	6		org brn	c	w	sd w/ grvl	SW	grvl_1	40	3/8-1	2		hi % of crushable 1-1.5" pebble in upper ft.
4	6	7.5		lt brn	c	p	m sd	SP	grvl_1	tr		1		tite drlg 5-10'
4	7.5	10.5		brn	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	2		red streaks
4	10.5	12.5	12.3	brn	c		sd & grvl	SW-GW	grvl_1	50	3/8		w	
4	12.5	14		lt gry		p	silt/lean clay	ML-CL	grvl_1				w	soft, red streaks
4	14	18		brn gry	s	w	sd & f grvl	SW-GW	grvl_1	50	1/4-1/2		w	good
4	18	21		blue	s	p	vf sd - f sd	SP	sd	0				
4	21	21.5		blue gray			till-fat clay	CH	clay	tr				white carb grains
5	0	1.5		blk			sdy loam		topsoil				d	loess
5	1.5	2		yel brn	s	p	f sd		topsoil	10	1/8	1/2		subsoil? Transition into grvl.
5	2	5		org brn	c	w	sd w/ f grvl	SW	grvl_1	40	1/2	2.5	d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
5	5	8		org	c	w	sd w/ grvl	SW	grvl_1	20	1/8-1/4	1	d	rx at 5-6.5'
5	8	10		lt brn	c	w	sd w/ grvl	SW	grvl_1	20	1/8	1	d	
5	10	15	14.5	gry brn	c	w	sd w/ f grvl	SW	grvl_1	40	1/4	1.5	m	
5	15	18		gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	1	w	
5	18	21		lt gry	c	w	c sd w/ occ grvl	SW	grvl_1	10	1/8	3/8	w	
5	21	23.5		yel gry	c	w	sd & pea grvl	SW-GW	grvl_1	50	1/4	1/2	w	
5	23.5	26		blue gry			till-fat clay	CH	clay	tr				
6	0	1.5		blk					topsoil				d	
6	1.5	8.5		org brn	c	w	sd & grvl	SW-GW	grvl_1	45	1/2	2	d	best crushable material so far
6	8.5	10		lt brn	c	p	sd w/ occ grvl	SP	grvl_1	10	1/8	1/2	d	
6	10	17	14	brn	c	w	m-c sd w/ grvl	SW	grvl_1	20	1/8	3/4	w	some coarser layers
6	17	19		gry brn	s	w	sd & f grvl	SW-GW	grvl_1	50	1/4	2	w	
6	19	21.5		blue gry			till-fat clay	CH	clay					stiff drlg
7	0	1.5		blk			sdy loam		topsoil					
7	1.5	2		yel brn	s	p	silty f sd		topsoil	5			d	
7	2	5		org brn	c	w	sd w/ f grvl	SW	grvl_1	30	3/8	1	d	upper 1-2' sli silty
7	5	10		org brn	c	w	sd w/ f grvl	SW	grvl_1	25	3/8	2		
7	10	12		white	c	p	m sd	SP	grvl_1	0				gradational lower
7	12	15.5	13	gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	1	w	fining upward sequence
7	15.5	20.5		gry brn	c	w	c sd w/ f grvl	SW	grvl_1	40	1/4	3/4	w	varied layers, basal foot has yel-org granules
7	20.5	21.5		blue			till-fat clay	CH	clay	tr				
8	0	2		blk			topsoil		topsoil	tr				
8	2	4		brn	c	w	sd w/ grvl	SW	grvl_1	40	1/4	1		
8	4	6		lt brn	c	p	sd w/ occ grvl	SP	grvl_1	10	1/8	1/2		
8	6	11		org brn	c	w	sd w/ f grvl	SW	grvl_1	20	1/8	1.5		
8	11	13		gry brn	c	p	silt to m sd	ML-SP	grvl_1	0				water at ~13'
8	13	16		gry brn	c	w	f grvl	GW	grvl_1	60	1/4-1/2	3	w	pea grvl, pebbles at 13-14', generally coarsens w/ depth
8	16	21		blue gry			till-fat clay	CH	clay					upper 6" has yel brn carb granules
9	0	1.5		blk			topsoil		topsoil					
9	1.5	6		brn red	c	w	sd & c grvl	SW-GW	grvl_1	45	3/4	3		good crushable - best so far
9	6	10		red brn	c	p	sd w/ occ grvl	SP	grvl_1	10	1/8	1/2		layers
9	10	14	10.5	gry brn	c	w	c sd w/ f grvl	SW	grvl_1	25	1/4	1	w	yel org stained granules at base
9	14	15.5		blue		p	silt	ML	silt_1	0				
10	0	1		blk			sdy loam		topsoil	5				
10	1	9		org brn	c	w	sd & f grvl	SW-GW	grvl_1	50	1/2-1	3		
10	9	10		lt brn	c	p	sd w/ occ grvl	SP	grvl_1	10	1/8	1/8	w	
10	10	16	10.7	dk brn gry	c	w	c sd w/ f grvl	SW	grvl_1	30	1/8	1		finer in btm
10	16	21		blue gry			till-fat clay	CH	clay					

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
11	0	0.5		blk			topsoil		topsoil					1" pebbles on surface
11	0.5	1		dk brn	s		silty f sd w/ grvl		topsoil					
11	1	11	6.5	org brn	c	w	sd & grvl	SW-GW	grvl_1	50	3/4	2.5	d/w	pebbles conc in upper 1'; varied layers, crunching at 6-8'
11	11	15		grn gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	3/8	1	w	
11	15	17		grn gry	c	w	f grvl & c sd	SW-GW	grvl_1	45	3/8	1.5	w	coarsest at base
11	17	21.5		blue gry			till-fat clay	CH	clay					
12	0	3.5		blk			sdy/silty loam		topsoil	5				
12	3.5	9	5.25	yel brn	s	w	sd & f grvl	SW-GM	grvl_1	50	3/4	1.5	m/w	some +1" pebbles
12	9	11		gry	c	p	sd w/ occ grvl	SP	grvl_1	10	1/4	1.5	w	occ pebbles
12	11	16		grn gry	c	w	f grvl	GW	grvl_1	55	3/8	1.5	w	c sd, pebbles at base
12	16	20		blue			till-fat clay	CH	clay					Tite drlg at 18-20'
13	0	1		blk					topsoil					
13	1	4		org brn	c	w	sd w/ grvl	SW	grvl_1	40	1/2	2		
13	4	6.5		lt brn	c	p	m sd w/ occ grvl	SP	grvl_1	15	1/4	1/2		
13	6.5	11	8.3	brn gry	c	p	sd w/ occ grvl	SP	grvl_1	15	1/4	1.5		varied sd & pea grvl layers
13	11	14		gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/4	1		
13	14	15		gry brn	c	p	m sd w/ occ grvl	SP	grvl_1	15	1/4	1		
13	15	17		gry	c	w	sd w/ occ grvl	SP	grvl_1	10	1/4	1/2		sand is graded
13	17	20		blue			till-fat clay	CH	clay	tr				sparse granules
14	0	1		blk			grvly loam		topsoil	15	3/8			
14	1	3		brn	s	w	f grvl	GW	grvl_1	55	3/8	2		
14	3	6		lt brn	c	p	m sd	SP	grvl_1	tr				
14	6	7.5		brn	s	w	grvl	GW-GM	grvl_1	60	1/2-1	2		
14	7.5	11	10.5	gry brn	vs	w	clayey grvl	GC	silt_1	75	1/4	1.5		stiff, grvly till
14	11	12		org brn	c	w	grvl	GW	grvl_3	70	1/4	2		pea grvl
14	12	15		brn gry	c	p	m sd	SP	sd	0				iron staining at 15'
14	15	19.5		dk red-brn	c	p	m sd	SP	sd	tr	1/8	1/8		2-3' of iron staining
14	19.5	21.5					silt/fat clay	ML-CH	clay					mixed layers
15	0	1		blk			grvly loam		topsoil	10	1/2			loess
15	1	5.5	5.5	brn-brn org	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	1.5		
15	5.5	15		brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/8-1/4	1		f pea grvl
15	15	21		blue	c	p	vf sd	SP	sd	0				no till
16	0	2		blk			sdy loam		topsoil					loess
16	2	5		org brn	c	p	sd w/ grvl	SP	grvl_1	20	1/8	1		silty in upper 1'
16	5	7		org brn	c	w	sd w/ f grvl	SW	grvl_1	40	3/8	1.5		
16	7	9	8.3	gry	vs		f sd, silt & till		silt_1					sticky
16	9	11		gry brn	vs	w	slty sd & grvl	SM-GM	grvl_2	45	1/2	1	w	sticky

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
16	11	14		gry brn	s	w	f grvl	GW	grvl_2	55	1/4	1	w	Lower ft is yel org stained, spin on rock at 14', refusal
17	0	1		blk					topsoil					
17	1	3		dk brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	1/2	1.5		
17	3	5		brn org	c	w	c sd w/ f grvl	SW	grvl_1	40	1/2	1.5		
17	5	8.5		lt brn	c	p	sd w/ grvl	SP	grvl_1	25	3/8	2		
17	8.5	11		lt gry			lean clay	CL	silt_1					1.75" ribbon, no granules
17	11	14	11.3	lt brn	c	p	m sd	SP	grvl_2	5	1/4	1.5		
17	14	15		org	s	w	c sd & f grvl	SW-GM	grvl_2	50	1/8	1		
17	15	17.5		org	s	w	c sd & f grvl	SW-GM	grvl_2	50	1/8	1		
17	17.5	18.5		lt gry			silt	ML	grvl_2	0				
17	18.5	20		gry	vs	w	silty sd & f grvl	SM-GM	grvl_2	50	3/8			
17	20	21.5		blue gry			till-fat clay	CH	clay					3/8" carb granules
18	0	1.5		blk			topsoil		topsoil				d	
18	1.5	2.5		brn gry	s		sd w/ grvl	SW	grvl_1	40		2.5	d	
18	2.5	5		brn org	c		c sd w/ grvl	SW	grvl_1	35	1/2	3.5		
18	5	7.5		org brn	c		c sd w/ grvl	SW	grvl_1	20	1/8	1	d	crunching at 5-8', damp at 7.5'
18	7.5	10	9.5	gry			silt	ML	silt_1	0				grn brn lower 1'
18	10	11		gry	vs	w	silty grvl	GM	silt_1	50	1/4	1		muddy, sticky
18	11	17.5		brn gry	c	w	f grvl	GW	grvl_2	55	1/8-1/4	1		pea grvl, coarser at base. Yel org at base.
18	17.5	20		blue			till-fat clay	CH	clay					
19	0	2.5		blk					topsoil					
19	2.5	3.5		brn blk	s	w	sd & grvl	SW-GW	grvl_1	45				rocky at 2'
19	3.5	5		brn org	c	w	sd w/ grvl	SW-GW	grvl_1	35	3/4-1	3	d	sandier in lower ft
19	5	10.5		brn	c	p	sd w/ occ grvl	SP	grvl_1	15	1/8	1/2	d/m	
19	10.5	15	11	gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/8	2.5	w	coarser w/ depth
19	15	21		gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/8-1/4	1	w	
19	21	23		gry brn	c	w	f grvl	GW	grvl_1	55	3/8	1.5	w	
19	23	26					till-fat clay	CH	clay					v stiff drlg 24-26
20	0	1.5		blk			topsoil		topsoil					
20	1.5	4		brn	c	w	sd & grvl	SW-GW	grvl_1		1/2	1	d	sdy in lower
20	4	5		brn	c	w	c sd w/ grvl	SW	grvl_1	20	1/4	1	d	
20	5	9		brn	c	w	c sd w/ f grvl	SW	grvl_1	35	1/4	1	m	
20	9	9.5		red	s	w	grvl	GW-GM	grvl_1	55	1	2.5	m	resistant layer at 9-9.5'
20	9.5	10.5		white gry	c	p	f-m sd	SP	grvl_1	0			m	mostly qtz
20	10.5	14	10.7	lt grn gry	c	p	f-m sd	SP	grvl_1	0			w	sharp lower contact
20	14	16.5		brn gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/8	1.5	w	
20	16.5	18		blue			fat clay	CH	clay	0				not till, top is olive color, 2.5" ribbon
20	18	21.5		brn gry	c	p	m sd	SP	sd_2	tr	1/8	1/8		
21	0	1.7		blk			topsoil		topsoil					grvly at lower 9"

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
21	1.7	3		org brn	s	w	sd w/ grvl	SW-SM	grvl_1	35	3/8	1.5	d	
21	3	4.5		brn	c	p	m sd w/ occ grvl	SP	grvl_1	10	1/8	1/2	d	
21	4.5	5.5		org	c	w	sd w/ grvl	SW	grvl_1	30	1/2	2	m	
21	5.5	10	8	brn	c	w	sd w/ f grvl	SW	grvl_1	35	1/8-1/4	1	m/w	c sd at 8.5-10'
21	10	13		brn	c	w	sd w/ f grvl	SW	grvl_1	30	1/8	3/4		blk & rusty org stain layer at ~ 12.5'
21	13	15		gry brn	c	p	f-m sd	SP	sd	3		1/2		
21	15	19		brn & gry	s	p	mixed silt, f & m sd		sd	tr				one 6" cobble in muddy matrix at base
21	19	21		blue			till-fat clay	CH	clay					numerous carb granules
22	0	3		blk			sdy loam		topsoil				d	
22	3	5		brn	s	w	sd & grvl	SW-GM	grvl_1	50	1/4	1.5	d/m	
22	5	5.5		lt brn	vs	p	silt w/ occ grvl	ML	silt_1	15	1/4	1/2	w	water at 5'
22	5.5	9		gry	vs		grvly silt & m sd	ML-SM	silt_1	25	1/2	1	w	
22	9	10		org	s	w	grvl	GW-GM	grvl_3	50	1/2	3	w	
22	10	13		olive/blue			till-clay	CL-CH	clay	tr				top several inches is olive color
23	0	2		blk			silt loam		topsoil	tr				
23	2	5.5		org brn	s	w	c sd & grvl	SW-SM	grvl_1	45	1/2	2		water at ~4.5'
23	5.5	7.5		gry brn	vs	w	silty c sd & grvl	SM-GM	grvl_1	45	1/4	2		muddy, some sticky
23	7.5	10		blue			till-clay	CL-CH	clay					
24	0	1.5		blk			sdy loam		topsoil					pebbles in lower 6"
24	1.5	4		brn	c	w	c sd w/ grvl	SW	grvl_1	25	1/4	1	d	
24	4	5		yel brn	c	p	f-m sd	SP	grvl_1	tr				
24	5	10	8.7	brn	s	w	sd & grvl	SW-GM	grvl_1	45	1/2	2		
24	10	10.5		org brn	vs	w	silty sd & grvl	SM-GM	grvl_1	50	1/2	1.5		
24	10.5	14		org brn	s	w	f grvl	GW-GM	grvl_1	55	3/4	2		variable silt content
24	14	15.5		gry			till-fat clay	CH	clay					stiff, upper few inches is brn
25	0	1.5		blk					topsoil					
25	1.5	7	4.2	yel brn	vs	w	silty sd w/ grvl	SM	grvl_1	40	1/2	2		sticky
25	7	9.5		blue	vs	w			grvl_1					
25	9.5	10.5		blue	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	1.5		c-sd layers
25	10.5	12.5		blue	s	w	f grvl	GW-GM	grvl_1	55	1/2	1		variable sands
25	12.5	15.5		blue			till-fat clay	CH	clay					carb granules
26	0	1.5		blk			sdy loam		topsoil					
26	1.5	5		yel brn	s	w	grvl	GW-GM	grvl_1	70	1	2		good
26	5	6		lt brn	c	w	c sd w/ grvl	SW	grvl_1	20	1/8			
26	6	10		lt brn	c	w	sd w/ occ grvl	SW	grvl_1	15	1/8	1/2		
26	10	16	12	gry brn	c	p	sd	SP	grvl_1	3	1/8	1		occ thin f grvl & m sd layers
26	16	20.5		gry brn	c	w	f grvl	GW	grvl_1	60	1/8-1/4	1		
26	20.5	21.5		blue			silt/lean clay	ML-CL	clay					
27	0	2		blk			sdy silt		topsoil					

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27	2	6		org brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	3/8	1.5		
27	6	9.5	7.8	brn	c	p	sd w/ occ grvl	SP	grvl_1	15	3/8	3/4		
27	9.5	11.5		gry brn	c	w	c sd & grvl	SW-GW	grvl_1	45	1/8-1/4	1		
27	11.5	15		org	s	w	f grvl	GW-GM	grvl_1	60	3/8	2		pea grvl
27	15	15.5		blue			till-clay	CL	clay					
28	0	2		blk			silty loam		topsoil					some grvl at base
28	2	4.5		brn org	s	w	sd & grvl	SW-SM	grvl_1	45	1/2	2	d	
28	4.5	11.5		lt brn	c	w	sd w/ occ f grvl	SW	grvl_1	10	3/8	1/2	d	wet at 10', scattered thin f grvl
28	11.5	13.5		gry grn	c	w	f grvl	GW	grvl_1	60	1/4	1.5	w	
28	13.5	14.5		blue			till-clay	CL	grvl_1					6" silt over till
28	14.5	15.5		blue gry	vs	w	silty sd & grvl	SM-GM	grvl_1	50	1/2	1.5		muddy
28	15.5	18		org	s	w	f grvl	GW-GM	grvl_1	55	1/2	1		
28	18	20		blue			till-fat clay	CH	clay					diamicton
29	0	2		blk			silty sdy loam		topsoil					firm
29	2	7.5		brn org	c	w	sd w/ grvl	SW	grvl_1	40	3/8-3/4	2	d	
29	7.5	10	8	brn	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/4	1	w	
29	10	17		brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	3/8	1.5	w	
29	17	21.5		blue			till-fat clay	CH	clay					stiff, numerous carb granules
30	0	2		blk			loamy sd		topsoil				d	loose
30	2	5		brn org	s	w	sd & grvl	SW-SM	grvl_1	45	3/4	3	d	
30	5	12		lt brn	c	w	sd w/ grvl	SW	grvl_1	40	3/8 & 1	2.5	d	org at 12'
30	12	17.5	12.5	gry brn	c	w	c sd w/ grvl	SW	grvl_1	35	1/4	1.5	w	
30	17.5	21.5		blue			till-fat clay	CH	clay					stiff, smooth drlg
31	0	1		blk			sdy loam		topsoil					
31	1	2.5		yel brn	vs		grvly silt	ML	grvl_1	20		1.5	d	hard, firm
31	2.5	5		org brn	c	w	sd w/ f grvl	SW	grvl_1	30	1/4-3/4	1	d	loose
31	5	10		brn red	c	w	sd w/ grvl	SW	grvl_1	40	3/8-3/4	2	d	
31	10	15	11.5	lt gry	c	w	c sd & grvl	SW-GW	grvl_1	45	1/4-1/2	2		
31	15	20		dk gry	c	w	f grvl	SW	grvl_1	60	1/8-1/4	1.5	w	
31	20	21		blue			till-fat clay	CH	clay					
32	0	1		blk			silt loam		topsoil					stiff
32	1	2.5		dk brn			grvly silt	ML	grvl_1					
32	2.5	5.5		red brn	c	w	sd w/ grvl	SW	grvl_1	35	3/8-1/2	1		
32	5.5	8.5		brn	c	w	sd w/ occ grvl	SW	grvl_1	15	1/4	3/4		
32	8.5	11	10.5	brn red	c	w	sd w/ grvl	SW	grvl_1	30	3/8	2		
32	11	15		brn gry	c	w	f grvl	GW	grvl_1	60	1/4-3/8	1.5		crunching at 11-12'+
32	15	17		yel brn			c sd & f grvl	SW-GW	grvl_1	50	1/8-1/4	1		yel staining
32	17	21		blue			till-fat clay	CH	clay					
33	0	1.5		blk			sdy loam		topsoil					

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33	1.5	2.5		dk brn	s	p	sd w/ grvl		topsoil	20	3/8-1/2	1	d	
33	2.5	5		org brn	c	w	sd & grvl	SW-GW	grvl_1	45	1/2-1	2.5	d	rx at 3-4', greater than 50% of pebbles are not carb
33	5	9	9	org brn	c	w	sd & c grvl	SW-GW	grvl_1	45	3/8+	2.5		numerous pebbles
33	9	13		gry	c	w	c sd w/ f grvl	SW	grvl_1	25	1/8	3/4	w	
33	13	14		yel gry	c	w	c sd w/ f grvl	SW	grvl_1	40	1/8-1/4	1	w	
33	14	15		blue			till-fat clay	CH	clay					firm
34	0	2		blk			sdy loam		topsoil				d	
34	2	3		blk			loamy grvl		topsoil	25?		2	d	
34	3	6		lt brn	c	w	sd & grvl	SW-GW	grvl_1	45	3/4	1.5	d	
34	6	8		brn red	c	w	sd & grvl	SW-GW	grvl_1	45	1/2	2	d	
34	8	10	8.5	gry	s	w	c sd & grvl	SW-GM	grvl_1	50		3	w	numerous pebbles
34	10	14		gry to org gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4-3/8	1.5	w	silty and coarser at base
34	14	15		blue			till-fat clay	CH	clay					
35	0	2.5		blk					topsoil					basal 1/2' has numerous pebbles (approx. 1")
35	2.5	5		brn	c	w	sd w/ grvl	SW	grvl_1	35	1/2	2	d	
35	5	9		red brn	c	w	sd w/ grvl	SW	grvl_1	35	3/8	3		
35	9	10	9.8	brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/4	1	w	
35	10	15		gry	c	w	f grvl	GW	grvl_1	55	1/4-3/8	1	w	
35	15	21		brn gry	s	w	f grvl	GW-GM	grvl_1	60	1/8-3/8	1	w	
35	21	21.5		blue			till-fat clay	CH	clay					
36	0	2.5		blk			sdy loam		topsoil	tr				
36	2.5	8.5		brn	c	w	sd w/ grvl	SW	grvl_1	35	1/2-2	2.5	d	crunch rocks at 2.5-4'
36	8.5	10		brn to gry	c	p	sd w/ occ grvl	SP	grvl_1	10	1/8	1/2	m	
36	10	18.5	10.3	gry	c	w	c sd & f gvl	SW-GW	grvl_1	50	1/4	1.5	w	coarsens down
36	18.5	20		blue	vs	w	silty sd w/ grvl	SM	grvl_1	40		1.5	w	sli sticky
36	20	20.5		blue			till-fat clay	CH	clay					
37	0	2		blk			sdy loam		topsoil					
37	2	5		org brn	c	w	sd w/ grvl	SW	grvl_1	35	3/8-1	2		
37	5	10		gry brn	c	p	c sd w/ grvl	SP	grvl_1	20	1/8	1/2		wet at 10'
37	10	15	10	gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	1		coarser w/ depth
37	15	17.5		org brn	s	w	f grvl	GW-GM	grvl_1	55	3/8	1/5		coarser w/ depth
37	17.5	20		blue			till-fat clay	CH	clay					
38	0	1		blk					topsoil					
38	1	4		brn	c	w	sd w/ grvl	SW	grvl_1	40	1/2	2		
38	4	5		red	c	w	sd & grvl	SW-GW	grvl_1	45	3/4	1.5		
38	5	8		red brn	c	w	sd w/ occ grvl	SW	grvl_1	15	1/8	1/2		
38	8	10	10	gry brn	c	w	sd w/ grvl	SW	grvl_1	20	1/4	3/4		
38	10	15		gry brn	c	w	sd w/ grvl	SW	grvl_1	20	1/8	1		silty at 13-15'

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38	15	18		gry brn	s	w	sd w/ grvl	SW-SM	grvl_1	25	1/8-1/4	1		coarser at lower 1', yel stain in lower 2'
38	18	20.5		blue			till-fat clay	CH	clay					
39	0	1.5		blk			sdy loam		topsoil				d	
39	1.5	4		brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	1/2	2	d	
39	4	6		gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	3/8	1	d	
39	6	8		brn red	c	w	sd w/ grvl	SW	grvl_1	30	3/8	1		
39	8	10	9	gry brn	c	w	c sd w/ f grvl	SW	grvl_1	40	1/8	1	w	
39	10	13.5		brn gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/4	1	w	
39	13.5	16.5		blue			lean clay w/ grvl	CL	silt_1	30		2.5	w	flow till--soft, sandy, mostly friable
39	16.5	18		blue gry	vs	w	sd & grvl	SM-GM	grvl_2	50	1/2	2	w	
39	18	19		org brn	s	w	sd & grvl	SW-GM	grvl_2	50	1/2	1.5	w	
39	19	21.5		blue			till-fat clay	CH	clay				d	firm
40	0	1		blk			loamy sd		topsoil				d	loose
40	1	1.5		brn blk	s	w	sd & grvl	SW-GM	grvl_1	50	1/2	2	d	pebbly, hard
40	1.5	3		brn	s	w	sd & grvl	SW-GM	grvl_1	50	1/2	2.5	d	pebbly
40	3	5		lt brn	c	p	sd w/ grvl	SP	grvl_1	20	1/8	1/2	d	
40	5	9		brn	c	w	sd w/ grvl	SW	grvl_1	25	1/4	1	d	
40	9	10	10	gry brn	s	w	c sd & f grvl	SW-SM	grvl_1	45	1/8-3/8	1.5	m	
40	10	15		gry brn	c	w	c sd w/ f grvl	SW	grvl_1	40	1/8-3/8	1	w	
40	15	18		gry brn	s	w	f grvl	GW-GM	grvl_1	55	3/8	1	w	
40	18	20		blue			till-fat clay	CH	clay					top 3" is olive color
41	0	1		blk			loamy sd		topsoil				d	loose
41	1	5		brn	s	w	sd & grvl	SW-GM	grvl_1	50	1/4-1	2	d	pebbly, finer in lower
41	5	10		org brn	c	w	sd w/ f grvl	SW	grvl_1	20	1/4-3/8	1.5	m	
41	10	12	11	org brn	c	w	sd w/ grvl	SW	grvl_1	35	1/4	1.5	w	
41	12	13		gry			till?-clay	CL	grvl_1					stiff
41	13	15.5		lt gry	s	p	sd w/ occ grvl	SP-SM	grvl_1	15	3/8	1	w	
41	15.5	18		lt gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	3/8	1	w	
41	18	19		gry			silt/lean clay	ML-CL	grvl_1	0				soft, olive color in upper
41	19	22		brn gry	s	p	c sd & f grvl	SP-GM	grvl_1	50	3/8	1	w	
41	22	26		gry		w	till-fat clay	CH	clay	2				
42	0	1		blk			loamy sd		topsoil				d	loose
42	1	5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	35	1/4-1	2.5	d	pebbly
42	5	11.5	10.5	brn org	c	w	sd & f gvl	SW-GW	grvl_1	45	1/4	4	d	moist at 10'
42	11.5	12		lt gry			silt	ML	grvl_1	tr				
42	12	14		gry	c	p	sd w/ occ grvl	SP	grvl_1	15	1/8	1/2	w	coarser at 14-15'
42	14	15		gry	s	w	sd w/ grvl	SW-SM	grvl_1	30	1/4	1.5	w	
42	15	17		brn gry	s	w	f grvl	GW-GM	grvl_1	55	1/4	1.5	w	
42	17	18		blue gry	vs	p	f sd to silt	SM-ML	grvl_1	0			w	
42	18	23.5		brn gry	s	w	f grvl	GW-GM	grvl_1	55	1/4	1	w	
42	23.5	26.5		blue			till-fat clay	CH	clay	2		1/2		

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43	0	1		blk			loamy sd		topsoil				d	loose
43	1	5		brn	s	w	sd & grvl	SW-SM	grvl_1	45	1/2-3/4	3	d	pebbly
43	5	10		brn gry	c	w	sd w/ grvl	SW	grvl_1	25	1/4-3/8	3	d	org at approx. 7'
43	10	13	10.3		s	w	c sd w/ grvl	SW-SM	grvl_1	40	1/8-1/4	1/2	w	
43	13	13.5		olive gry			silt/lean clay	ML-CL	grvl_1	0				stiff
43	13.5	15		lt brn gry	s	p	m sd w/ occ grvl	SP-SM	grvl_1	15		3/4	w	
43	15	18		yel gry	s	w	c sd & f grvl	SW-SM	grvl_1	45	1/4	1	m-w	coarser at base
43	18	21.5		blue			till-fat clay	CH	clay					stiff
44	0	1		blk			loamy sd		topsoil				d	loose
44	1	3		brn	s	w	sd & grvl	SW-GM	grvl_1	50	1/2	1.5	d	firm
44	3	5		org brn	c	w	c sd w/ grvl	SW	grvl_1	20	1/4	1	d	
44	5	8.5		org brn	c	p	m sd w/ occ grvl	SP	grvl_1	15	1/2	3/4	d	
44	8.5	10		org brn	s	w	sd w/ grvl	SW-SM	grvl_1	30	3/8	1		
44	10	12	11.5	gry brn	c	p	m sd w/ occ grvl	SP	sd	10	3/8	1/2	w	
44	12	13		olive			lean clay	CL	silt_1	0				
44	13	15.5		dk blue gry			vf sd, silt & lean clay		silt_1	tr				some pebbles in lean clay
44	15.5	17		org brn	vs	w	silty sd & grvl	SM-GM	grvl_3	50	3/4	3	w	muddy
44	17	21.5		gry			sdy silt & clay	ML-CL	clay	tr				sdy zones
45	0	3		blk					topsoil				d	dk brn in lower 9"
45	3	5		brn	c	w	sd w/ gvl	SW	grvl_1	40	1/2	2	d	pebbly
45	5	8.5		org	c	w	sd w/ grvl	SW	grvl_1	20	3/8	1.5	d	varied sand layers
45	8.5	10	8.8	brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	3/4	w	
45	10	19		gry	s	w	f grvl	GW-GM	grvl_1	55	1/8-3/8	1	w	uniform, yel staining & coarser in lower 2'
45	19	21.5		gry	s	p	vf sd & silt	ML	clay	0				
46	0	2		blk			sdy loam		topsoil				d	
46	2	5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	30	3/4	3	d	pebbly
46	5	9.5	8.5	brn	c	p	sd w/ occ gvl	SP	grvl_1	15	1/4	1	d/w	varied layers
46	9.5	10		lt gry			silt/lean clay	ML-CL	grvl_1	tr			w	sticky-stiff
46	10	14.5		brn gry	s	w	f grvl	GW-GM	grvl_1	55	1/4	1	w	
46	14.5	15		brn/blue	c	p	f-m sd	SP	sd	0				upper 3" is brn
46	15	22		blue	vs	p	lean clay-f sd w/ occ grvl	CL-SP	clay	10		2	w	occ soft grvly till, siltier w/ depth
46	22	26		blue			till-fat clay	CH	clay					
47	0	2.3		blk			loamy sd		topsoil	tr			d	loose
47	2.3	5		brn	s	w	sd & gvl	SW-SM	grvl_1	45	3/4	3	d	crunch rx 3-5', sdy in top ft., pebbly
47	5	9		org brn	c	w	sd w/ f grvl	SW	grvl_1	30	1/2	1.5	m	1 cobble at approx. 8'
47	9	12	10	lt gry	c	p	m sd w/ occ grvl	SP	grvl_1	10	3/8		w	
47	12	14		org gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/4	3/4	w	sharp upper contact
47	14	15		gry	s	p	sd w/ grvl	SP-SM	grvl_1	20	1/4	1/2	w	
47	15	18		yel gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/8-3/8	1	w	
47	18	21.5		blue			till-fat clay	CH	clay					firm

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
48	0	1.3		blk			loamy sd		topsoil					loose
48	1.3	7.5		org brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	1	2		
48	7.5	11	8.7	lt gry	c	p	m sd w/ occ grvl	SP	grvl_1	15	3/8	1		fines upward
48	11	17		org brn	s	w	c sd & f grvl	SW-GM	grvl_1	50	3/8	3		
48	17	21.5		blue			till-fat clay	CH	clay	3	1/4-3/8			
49	0	1.3		blk			loamy sd		topsoil				d	loose
49	1.3	5.5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	3/4	2	d	pebbly - crunching
49	5.5	10	6.5	gry brn	c	w	sd w/ grvl	SW	grvl_1	40	1/8-3/8	1.5	d/w	fines upward
49	10	14		org gry	s	w	sd w/ f grvl	SW-SM	grvl_1	35	1/8-1/4	1	w	4" silt layer
49	14	17		brn gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	3/8	1	w	
49	17	21		blue			till-fat clay	CH	clay					firm
50	0	1.5		blk			sdy loam		topsoil					loose
50	1.5	7	6.3	brn	s	w	sd w/ grvl	SW-SM	grvl_1	35	3/4	1.5		
50	7	13		gry brn	s	w	sd w/ grvl	SW-SM	grvl_1	30	3/4	2		some c sd & grvl zones
50	13	14		gry			till-fat clay	CH	grvl_1	3				stiff-firm
50	14	20		gry	s	w	sd & grvl	SW-GM	grvl_1	50	3/4	2.5		
50	20	21.5					till-fat clay	CH	clay					firm - white carb granules
51	0	1							topsoil				d	
51	1	4.5		yel brn	s	w	sd w/ grvl	SW-SM	grvl_1	20	3/8	1.5	d	
51	4.5	6	5.8	yel brn	s	w	sd w/ f grvl	SW-SM	grvl_1	30	1/4	1.5	d	
51	6	7.5		yel brn	s	w	sd w/ grvl	SW-SM	grvl_1	20	1/4	3	w	
51	7.5	10.5		yel gry	vs	w	sd w/ grvl	SM	grvl_1	20	3/8	2.5	w	
51	10.5	13		org	s	w	grvl	GW-GM	grvl_1	60	1/2	1.5	w	
51	13	16		brn gry	s	w	c sd & f grvl	SW-SM	grvl_1	45	3/8	1	w	
51	16	21		blue gry			interbedded till & silty grvl		clay	*50	*1/4	*2	w	*refers to grvl part only totaling ~1' in thickness
52	0	1.5		blk			silty loam		topsoil					sticky
52	1.5	4.5	3	gry brn	s	w	sd w/ occ grvl	SW-SM	grvl_1	15	1/4	3/4		
52	4.5	10		brn gry	vs	w	silty grvl	GM	grvl_1	60	3/4	2		occ thin silt (flow till) layers, muddy
52	10	12.5		brn gry	s	w	c sd & f grvl	SW-GM	grvl_1	50	1/8-1/4	1.5		
52	12.5	15		blue gry			till-lean clay	CL	clay	tr				flow till - firmer at base
53	0	2		blk			loamy sd		topsoil				d	loose, pebbles in lower part
53	2	7	6.3	brn	s		sd & grvl	SW-SM	grvl_1	45	1/2	2	d	pebbles
53	7	8		gry			till-clay	CL	grvl_1					stiff
53	8	14		brn to org	vs	w	silty grvl	GM	grvl_1	55	1	2.5	w	
53	14	14.5			s	w	c sd & f grvl	SW-GM	grvl_1	50	1/4	1	w	
53	14.5	15.5		blue			till-fat clay	CH	clay					stiff
54	0	2		blk			sdy loam		topsoil				d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
54	2	4		brn	s	w	sd & grv.	SW-GM	grvl_1	50	3/4	2.5	d	pebbly
54	4	6		brn	c	w	c sd w/ gvl	SW	grvl_1	30	1/4	1	d	c sd in lower ft
54	6	8	7.3	gry	c	p	sd w/ grvl	SP	grvl_1	20		1	w	
54	8	10		gry	c	w	f grvl	GW	grvl_1	55	1/4	1.5	w	
54	10	15		gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	1	w	varied layers
54	15	18		brn gry	c	w	f grvl	GW	grvl_1	55	3/8	1.2	w	coarser in lower
54	18	21.5		blue			till-fat clay	CH	clay					firm
55	0	1		blk			sdy loam		topsoil				d	loose
55	1	6		brn	s	w	f grvl	GW-GM	grvl_1	55	3/8-1/2	1.5	d	not pebbly
55	6	10	6.8	gry brn	c	w	sd & f grvl	SW-GW	grvl_1	50	1/4	1.2	d/w	
55	10	15		gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/8	1	w	
55	15	17		yel gry	c	w	f grvl	GW	grvl_1	55	3/8	1.5	w	
55	17	21.5		blue			till-fat clay	CH	clay					stiff
56	0	1		blk			sdy loam		topsoil				d	
56	1	5.5		brn	c	w	sd w/ grvl	SW	grvl_1	40	1/2	2.5	d	crunch rx at 2-5'
56	5.5	9	7.5	gry brn	c	w	sd w/ occ grvl	SW	grvl_1	15	1/8	3/4	d	
56	9	12		brn to blue			till-clay	CL	silt_1				w	
56	12	15		brn gry	s	w	sd w/ grvl	SW-SM	grvl_2	35	1/4	2	w	
56	15	18.5		brn gry	c	w	f grvl	GW	grvl_2	55	1/4	1.5	w	
56	18.5	20.5		blue			till-fat clay	CH	clay					stiff
57	0	1.2		blk			sdy loam		topsoil				d	
57	1.2	4.5		gry brn	c	w	sd w/ grvl	SW	grvl_1	25	1/4	2	d	
57	4.5	7		org	c	w	sd & grvl	SW-GW	grvl_1	50			d	
57	7	9		brn	c	p	m sd w/ occ grvl	SP	grvl_1	10	1/8	1/2	d	fines upward
57	9	10		org	c	w	sd & f grvl	SW-GW	grvl_1	45	3/8	1.5	m	
57	10	15	11	gry brn	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/4	2.5	w	
57	15	20		lt gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/8-1/4	2	w	
57	20	21.5		blue			till-fat clay	CH	clay					stiff
58	0	2.5		blk			sdy loam		topsoil				d	
58	2.5	4.5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	35	1/4	2	d	
58	4.5	5.5		brn	c	p	m sd w/ occ grvl	SP	grvl_1	10	1/2		d	fines upward
58	5.5	7.5		lt brn	c	w	c sd w/ f grvl	SW	grvl_1	25	1/8	1/2	d	
58	7.5	11.5	9.5	org	s	w	c grvl	GW-GM	grvl_1	55	1-2	3	m	grind rx at 8-10', pebbly - coarsest so far, one 1-1.5" shale pebble
58	11.5	13		gry blue			till-clay	CL	silt_1					stiff
58	13	15		gry brn	c	p	f-m sd	SP	grvl_2	0			w	
58	15	18		gry brn	c	p	m sd w/ occ grvl	SP	grvl_2	15	1/8-1/4	1/2	w	
58	18	22		gry brn	c	w	c sd & f grvl	SW-GW	grvl_2	45	1/4	2	w	coarser down
58	22	26.5		blue			till-fat clay	CH	clay			1		stiff

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
59	0	1.5		blk			sdy		topsoil				d	grvly
59	1.5	6		brn	s	w	sd & grvl	SW-GM	grvl_1	50	3/4	2	d	rx 3-5'
59	6	9		lt brn	c	p	m-c sd w/ occ grvl	SP	grvl_1	10	1/4	1/2	m	
59	9	12	10	lt brn	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	1.5	w	
59	12	14		brn gry/gry			till-fat clay	CH	silt_1					stiff
59	14	15		gry brn	c	p	m sd w/ occ grvl	SP	grvl_2	10	1/4		w	
59	15	17.5		gry brn	c	w	m sd w/ f grvl	SW	grvl_2	25	1/8	1	w	
59	17.5	19.5		org	c	w	c sd & f grvl	SW-GW	grvl_2	50	3/8	1	w	
59	19.5	21.5		blue			till-fat clay	CH	clay					
60	0	1.7		blk			sdy loam		topsoil				d	
60	1.7	5		brn	s	w	c sd & f grvl	SW-SM	grvl_1	45	1/8	1/2	d	
60	5	9.5	6.5	org brn	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	2		silty at 9.5'
60	9.5	10		gry			vf sd & silt	SP-ML	grvl_1	0				
60	10	11		brn	s	w	sd & f grvl	SW-GM	grvl_1	45	1/4	1	w	
60	11	13		yel gry	vs	p	vf sd, silt and lean clay	SM-CL	silt_1	tr				
60	13	15.5		org, blk, gry	s	w	sd & grvl	SW-GM	grvl_2	50	1/2	1	w	some is muddy
60	15.5	17		yel brn	c	w	c sd w/ grvl	SW	grvl_2	20	1/8	1/2	w	
60	17	20.5		blue			till-fat clay	CH	clay					stiff
61	0	2.3		blk			silty loam		topsoil					some pebbles
61	2.3	5	4.3	gry brn	vs	w	grvl	GM	grvl_1	55	1/2	2.5	m	pebbly
61	5	10		org brn	s	w	grvl	GW-GM	grvl_1	60	1	3	w	pebbly
61	10	15		brn	s	w	sd w/ gvl	SW-SM	grvl_1	30	3/8	2.5	w	finer in lower, org layer at approx 13'
61	15	19		gry brn	c	w	c sd & grvl	SW-GW	grvl_1	50	3/8	2.5	w	fines upward, some silty zones
61	19	21.5		blue gry			till-fat clay	CH	clay					stiff
62	0	1.5							topsoil					
62	1.5	5	2.5	yel brn	vs	w	sd & grvl	SM-GM	grvl_1	50	3/4	2	w	
62	5	6.5		yel brn	vs	w	sd & grvl	SM-GM	grvl_1	50	1	2.5	w	pebbly
62	6.5	8.5		gry brn-blue		p	till- grvly lean clay	CL	silt_1	30	3/4	2	w	v muddy, sticky
62	8.5	10.5		gry	s	w	sd & grvl	SW-GM	grvl_2	50	3/8	2.5	w	
62	10.5	12		brn gry	c	w	m-c sd	SW	grvl_2	5	1/8	1/4	w	
62	12	15		blue			till-fat clay	CH	clay					stiff
63	0	2		blk			sdy loam		topsoil				d	
63	2	6.5		org brn	s	w	sd & c grvl	SW-GM	grvl_1	50	1.5	3	d	rx, pebbly, finer in lower ft
63	6.5	7.5		lt gry			silt	ML	grvl_1	0				
63	7.5	10	9.8	org	s	w	grvl	GW-GM	grvl_1	60	1.2	2	m	dense-tough drlg
63	10	12.5		brn gry	c	w	sd & grvl	SW-GW	grvl_1	45	3/8-1/2	2	w	one 3/4" shale
63	12.5	15		brn gry	c	w	c sd w/ grvl	SW	grvl_1	25	3/8	1	w	
63	15	17		yel & gry	c	w	c sd & f grvl	SW-GW	grvl_1	45	1/4	3/4	w	yel stained
63	17	20		blue			till-fat clay	CH	clay					stiff
64	0	2		blk			sdy loam		topsoil					

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
64	2	4.5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	1	3		
64	4.5	5		lt gry			till-lean clay	CL	grvl_1					soft- friable
64	5	10	6	yel brn	s	w	sd & grvl	SW-GM	grvl_1	50	3/8	3		siltiest at top
64	10	14		yel org	s	w	f grvl	GW-GM	grvl_1	55	1/4	1.5		
64	14	18.5		blue			till-fat clay	CH	clay					
65	0	1.2		blk			sdy loam		topsoil				d	
65	1.2	5.5		org brn	c	w	sd w/ grvl	SW	grvl_1	40	3/4	2.5	d	rx at 2'
65	5.5	6		brn	c	p	m sd w/ occ grvl	SP	grvl_1	10	1/8		d	rx at 8-9'
65	6	9.5		lt gry			till-lean clay w/ grvl	CL	silt_1	40	1/2	1.5	m	soft grvly till, friable, water at ~7'
65	9.5	12		gry	vs		silty grvl	GM	grvl_2	55	3/4	2	w	muddy grvl, cleaner w/ depth
65	12	15		blue			till-fat clay	CH	clay					stiff
66	0	1.5		blk			silt loam		topsoil				m	
66	1.5	9	4.5	org brn	s	w	c grvl	GW-GM	grvl_1	55	2	4	m/w	
66	9	13		gry brn	s	w	c sd w/ f grvl	SW-SM	grvl_1	25	1/4	1/2	w	
66	13	15		blue	c	p	sd	SP	grvl_1	5	1/4		w	
66	15	16		blue	c	w	sd & f grvl	SW-GW	grvl_1	45	1/4	1	w	
66	16	20		blue			till-fat clay	CH	clay					occ softer 1" grvl zones
67	0	2.8		blk			silt loam		topsoil					
67	2.8	7	3.8	dk brn	s	w	sd & grvl	SW-SM	grvl_1	45	1	4	w	almost muddy
67	7	9		lt gry			silt & vf sd	ML-SP	grvl_1	0				some is sticky, no ribbon
67	9	10		gry	s	w	sd w/ grvl	SW-SM	grvl_1	40	1/2	1.5	w	
67	10	18		gry	c	w	c sd w/ grvl	SW	grvl_1	30	1/8	3/4	w	
67	18	21		blue			till-fat clay	CH	clay	25	1/8	1.5	w	
68	0	1.8							topsoil				d	
68	1.8	6		brn	c	w	sd w/ f grvl	SW	grvl_1	25	3/8	1.5	d	
68	6	9		brn	c	w	sd w/ occ grvl	SW	grvl_1	15	1/4	1	d	
68	9	13	9	brn gry	c	w	c sd w/ grvl	SW	grvl_1	30	1/8	1/2	w	fines up
68	13	16		brn gry	c	p	m sd	SP	grvl_1	5	1/8	3/4	w	4" silt layer at top
68	16	19		gry	c	w	sd w/ f grvl	SW	grvl_1	30	1/4	1.5	w	f grvl at base
68	19	21.5		blue			till-fat clay	CH	clay					
69	0	1.8		blk			loamy sd		topsoil				d	loose
69	1.8	6		org brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	3/8-1/2	3	d	
69	6	8.5		lt brn	c	p	m sd w/ occ grv.	SP	grvl_1	10	3/8	1/2	d	
69	8.5	10		gry brn	c	w	sd w/ grvl	SW	grvl_1	25	3/8	1	d	
69	10	15	11.3	gry brn	c	w	c sd w/ f grvl	SW	grvl_1	40	1/4	1	w	coarser sd at depth
69	15	17.5		gry			fat clay	CH	silt_1	tr				v stiff
69	17.5	21.5		brn gry	c	p	sd	SP	grvl_2	tr	1/8			mostly f-m sd
69	21.5	23		brn gry	c	w	c sd w/ f grvl	SW	grvl_2	40	1/4	1.5	w	
69	23	26.5		blue			till-fat clay	CH	clay					3" dia rock in till is lt brn f xln ls

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
70	0	1.5		blk			sdy loam		topsoil				d	
70	1.5	4		lt brn	c	w	sd w/ grvl	SW	grvl_1	40	3/4	3	d	
70	4	5		org	c	p	m sd	SP	grvl_1	tr			d	org stain
70	5	9		org brn	s	w	sd & grvl	SW-SM	grvl_1	45	1/2-1	2	d	
70	9	10		gry	c	w	c sd w/ grvl	SW	grvl_1	35	1/8	1/2	m	
70	10	15	11.2	brn gry	c	w	c sd & grvl	SW-GW	grvl_1	45	1/4	1	w	coarser down
70	15	22		brn gry	c	w	c sd w/ grvl	SW	grvl_1	40	1/8	1	w	small 1/2" broken sh. Varied grvl content. 98% less than 1/4"
70	22	26		blue			till-fat clay	CH	clay					
71	0	2		blk			loamy sd		topsoil				d	loose
71	2	4.5		brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	3/4	3	d	pebbly
71	4.5	7		org	c	p	m sd	SP	grvl_1	tr			d	
71	7	10	9.8	org brn	s	w	sd w/ occ grvl	SW-SM	grvl_1	15	1/4	1.5	m	
71	10	11.5		gry	c		f-m sd	SP	grvl_1	tr			w	
71	11.5	13		brn gry	c	w	c sd w/ f grvl	SW	grvl_1	35	1/8	1	w	
71	13	15		blue			lean clay	CL	silt_1	0				soft - 2" ribbon
71	15	17.5		brn gry	c	p	f-m sd	SP	grvl_2	tr	1/8	1/4	w	
71	17.5	25		brn gry	c	w	c sd & f grvl	SW-GW	grvl_2	50	3/8	1.5	w	yel staining
71	25	26		blue			till-fat clay	CH	clay					stiff
72	0	2		blk			sdy loam		topsoil				d	
72	2	5		brn	s	w	sd w/ f grvl	SW-SM	grvl_1	40	3/8	1	d	
72	5	7.5	6.8	org brn	s	p	sd w/ occ grvl	SP-SM	grvl_1	15	1/2	1.5	d	
72	7.5	10		brn gry	s	w	sd & grvl	SW-GM	grvl_1	50	3/8	1	w	sli muddy
72	10	12		lt gry			silt/lean clay	ML-CL	grvl_1	0				smears
72	12	13		gry brn	c	p	f sd	SP	grvl_1	tr			w	
72	13	15		gry brn	s	w	c sd & grvl	SW-SM	grvl_1	45	3/8	3	w	
72	15	18		gry	s	w	c sd & grvl	SW-GM	grvl_1	50	3/8	1.5	w	1/2" shale fragment
72	18	21.5		blue			till-fat clay	CH	clay					
73	0	1.8		blk			sdy loam		topsoil				d	
73	1.8	6	5	brn	s	w	c sd w/ grvl	SW-SM	grvl_1	40	3/8-3/4	3	d/w	
73	6	7		brn	s	p	m sd	SP-SM	grvl_1	tr			w	
73	7	13		brn gry	s	w	sd w/ f grvl	SW-SM	grvl_1	25	1/8-1/2	2.5	w	
73	13	15.5		blue			till-fat clay	CH	clay					stiff
74	0	2.3		blk			sdy loam		topsoil					
74	2.3	7.5	6	org brn	s	w	sd w/ grvl	SW-SM	grvl_1	40	1/2-1	2.5	m	3" v silty grvl layer at 4' (stiff, friable)
74	7.5	10		org gry	c	w	c sd w/ f grvl	SW	grvl_1	40	1/8	1.5	w	
74	10	13.5		gry	c	p	f-m sd	SP	sd	tr				
74	13.5	18		blue	c		f-m sd	SP	sd	tr				
74	18	21		blue			till-fat clay	CH	clay					upper half is soft
75	0	1.8		blk			loamy sd		topsoil					loose

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	USCS Group Symbol	Layer	% Gravel (field estimate)	Dominant clast (inches)	Maximum clast (inches)	Moisture (d, m, w)	Comments
75	1.8	7.5	6.5	brn	c	w	c sd & grvl	SW-GW	grvl_1	45	1/4-3/8	3	d/w	wet - 6'
75	7.5	9		lt brn & blue			till-lean clay	CL	grvl_1					upper & lower is soft
75	9	11		brn	c	w	sd	SW	grvl_1	5	1/8	1/4	w	
75	11	15		brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/4	2	w	
75	15	17		brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	3/8	2	w	
75	17	20		blue			till-fat clay	CH	clay					stiff, clay-rich
76	0	1					sdy loam		topsoil				d	
76	1	4.5		brn	c		sd & grvl	SW-GW	grvl_1	45	3/8	2.5	d/m	pebbly - no binder
76	4.5	8	5	brn gry	c	p	c sd w/ f grvl	SP	grvl_1	40	1/8-1/4	1.3	w	v loose, occ sm pebbles
76	8	12		org	s	w	sd & grvl	SW-GM	grvl_1	50	3/8-3/4	2	w	grind rx at 8-9', pebbly, almost muddy
76	12	14.5		brn gry	s	w	sd & grvl	SW-GM	grvl_1	50	3/8	1.5	w	less silty than above, scattered pebbles
76	14.5	20		blue			till-fat clay	CH	clay					firm, stiff
77	0	2.8		blk			sdy loam		topsoil				d	
77	2.8	7		brn	c	w	sd w/ grvl	SW	grvl_1	25	1/4-2"	2.5	d	pebble layer at 4'
77	7	10	7	brn	c	p	c sd w/ f grvl	SP	grvl_1	35	1/4	2.5	w	fine pea grvl, occ pebbles, varied layers, 6" m sd layer
77	10	18		brn gry	c	w	c sd & f grvl	SW-GW	grvl_1	50	1/8-3/8	2	w	rare pebbles - loose
77	18	21		brn gry	c		c sd w/ occ grvl	SW	grvl_1	15	1/4	3/8	w	loose
78	0	1		blk			sdy loam		topsoil				d	
78	1	7		org brn	c	w	sd w/ grvl	SW	grvl_1	25	3/8-1/2	2	d	varied sd layers
78	7	10	9.5	lt brn	c	w	sd w/ grvl	SW	grvl_1	40	1/4	1.5	w	occ pebbles
78	10	21		brn gry	c	w	c sd w/ f grvl	SW	grvl_1	35	1/8-1/4	1	w	uniform - one 4" m sd layer

Appendix C: Gradation Data

Sample #	Test Hole ID	From	To	Feet of material	Percent by weight of total sample passing respective sieves 1" 25mm	3/4" 19mm	5/8" 16mm	1/2" 12.5mm	3/8" 9.5mm	#4 4.75mm	#10 2.0mm	#20 0.85mm	#40 0.425mm	#80 0.18mm	H//talcot/sieve_talcot_fnl.xls #200 0.075mm
33420.01001	1	2	6.5	4.5		92	91	88	85	75	63	42	19	7	4.4
33420.02002	2	1.3	8.5	7.2		97	96	95	93	88	81	57	24	6	2.9
33420.02003	2	8.5	17	8.5		88	87	85	82	75	64	41	14	5	1.2
33420.03004	3	1	17	16		96	94	92	88	77	61	41	21	5	2.3
33420.04005	4	1.2	18	15.3		93	92	89	86	76	65	42	17	6	4.4
33420.05006	5	2	23.5	21.5		90	89	87	85	75	62	42	18	4	2.5
33420.06007	6	1.5	19	17.5		85	83	80	77	67	58	41	18	5	2.5
33420.07008	7	2	10	8		91	88	86	83	73	56	33	15	4	2.6
33420.07009	7	10	20.5	10.5		99	98	96	93	82	69	52	32	9	2.0
33420.08010	8	2	16	12		98	96	93	90	79	66	44	22	7	4.0
33420.09011	9	1.5	14	12.5		88	87	85	83	76	59	38	17	7	2.8
33420.10012	10	1	16	15		90	88	86	83	75	61	37	13	3	1.9
33420.11013	11	1	17	16		95	94	90	86	73	62	43	22	5	3.2
33420.12014	12	3.5	16	12.5		93	90	86	82	69	55	33	16	6	4.5
33420.13015	13	1	17	16		93	91	88	85	76	65	48	26	5	2.9
33420.14016	14	1	7.5	6.5		89	87	84	81	72	64	54	39	15	4.6
33420.15018	15	1	15	14		97	96	93	90	78	59	30	11	4	2.5
33420.16019	16	2	14	10		95	93	91	87	74	60	40	20	8	5.4
33420.17020	17	1	8.5	7.5		91	89	86	82	67	50	28	10	5	3.7
33420.17021	17	11	20	9		93	92	90	86	74	65	52	37	10	5.2
33420.18022	18	1.5	7.5	6		91	90	88	86	76	63	37	13	5	3.4
33420.18023	18	11	17.5	6.5		97	95	93	91	79	56	29	16	5	3.9
33420.19024	19	2.5	23	20.5		90	88	86	84	76	57	34	13	4	2.1
33420.20025	20	1.5	16.5	15		92	91	89	87	79	69	52	33	9	2.2
33420.21026	21	1.7	13	11.3		91	90	88	86	77	66	48	23	4	2.6
33420.23027	23	2	7.5	5.5		91	89	87	83	71	61	43	17	5	3.2
33420.24028	24	1.5	14	12.5		94	92	89	84	70	59	38	15	3	1.3
33420.25029	25	1.5	12.5	11		93	92	91	88	81	68	43	26	12	7.7
33420.26030	26	1.5	10	8.5		91	89	83	80	68	50	30	13	5	4.0
33420.26031	26	10	20.5	10.5		97	96	94	92	84	72	48	18	3	1.5
33420.27032	27	2	15	13		94	93	91	88	78	65	46	21	6	2.9
33420.28033	28	2	13.5	11.5		95	94	91	88	78	66	50	21	5	3.1
33420.28034	28	15.5	18	2.5		98	97	94	90	74	54	29	12	6	5.2
33420.30036	30	2	17.5	15.5	91	88	86	84	80	70	57		16	3	2.1
33420.31037	31	2.5	20	17.5	95	93	91	88	84	73	57		14	4	2.0
33420.34040	34	3	14	11	97	94	91	87	82	70	58		23	9	6.7
33420.35041	35	2.5	21	18.5	90	87	83	81	77	67	54		16	4	2.2
33420.36042	36	2.5	20	17.5	94	91	89	85	80	68	54		20	6	2.9
33420.37043	37	2	17.5	15.5	96	93	91	88	84	72	51		11	4	3.1
33420.38044	38	1	18	17	99	96	94	92	89	80	63		17	4	2.3
33420.39045	39	1.5	13.5	12	89	86	80	76	69	54	40		14	7	5.2

33420.40048	40	1.5	18	16.5	93	89	87	84	80	70	55		12	4	2.2
33420.41050	41	13	22	9	97	96	94	91	87	75	59		27	8	5.6
33420.44053	44	1	12	11	100	98	97	94	90	82	66		23	5	2.5
33420.45054	45	3	19	16		96	94	93	90	78	56	37	11	3	3.0
33420.46056	46	15	22	7	96	90	83	75	64	46	44		40	33	19.7
33420.47058	47	9	18	9	99	98	96	94	91	81	57		25	3	0.7
33420.49060	49	1.3	5.5	4.2		88	84	78	72	59	54	36	13	6	3.0
33420.56070	56	1	9	8	97	95	93	90	84	74	55		9	3	1.8
33420.56071	56	12	18.5	6.5	98	97	95	93	89	74	59		21	6	3.2
33420.57073	57	10	20	10	97	96	95	93	88	74	52		12	2	1.2
33420.58075	58	13	22	9	97	96	95	93	91	83	73		44	12	4.6
33420.61080	61	2.3	19	16.7	93	84	80	76	69	56	43		11	5	3.2
33420.62081	62	1.5	6.5	5	94	91	85	79	69	50	38		18	12	9.0
33420.63082	63	2	10	8	88	81	77	73	67	54	43		16	9	5.6
33420.63083	63	10	17	7	95	90	84	80	74	61	48		12	6	4.5
33420.64084	64	2	14	12	81	75	71	65	58	47	38		13	7	5.4
33420.66087	66	9	16	7	98	96	95	93	89	79	65		21	4	2.3
33420.67088	67	2.8	7	4.2		81	79	76	74	68	56	35	17	5	2.7
33420.69091	69	1.8	15	13.2	96	94	92	89	85	75	60		16	5	3.3
33420.70092	70	1.5	10	8.5	88	84	82	78	73	63	52		15	5	3.4
33420.71094	71	2	13	11		95	95	93	91	83	67	52	22	5	2.6
33420.71095	71	15	25	10	99	98	97	95	91	81	65		30	6	2.3
33420.73098	73	1.8	13	11.2		89	88	85	83	72	56	32	19	6	2.5
33420.74099	74	2.3	10	7.7		86	84	81	78	67	57	38	13	5	1.9
33420.75100	75	1.8	7.5	5.7	87	78	75	72	67	54	32		7	4	2.8
33420.76102	76	1	14.5	13.5	96	94	92	88	82	69	49		9	4	2.9
Class 5 maximum					100	100			90	80	65		35		10.0
Class 5 minimum					100	90			50	35	20		10		3.0

Appendix C: Gradation data

Sample #	Test Hole ID	From	To	Feet of material	Percent by weight of total sample passing respective sieves 3" 75mm	2.5" 63mm	2" 50mm	1.5" 37.5mm	1.25" 31.5mm	1" 25mm	3/4" 19mm	5/8" 16mm	1/2" 12.5mm	3/8" 9.5mm	#4 4.75mm	#10 2.0mm	#16 1.18mm	#30 0.60mm	#40 0.425mm	#50 0.30mm	#100 0.15mm	H//talcot/sieve_talcot_fnl.xls #200 0.075mm
33420.29035	29	2	17	15	100	100	100	99	99	98	96	95	93	90	79	66	53	29	18	11	6	3.6
33420.32038	32	2.5	17	14.5	100	100	97	96	95	93	90	87	85	82	72	59	48	25	15	9	5	2.6
33420.33039	33	2.5	14	11.5	100	100	98	96	96	93	89	88	86	81	75	62	51	30	16	8	4	2.8
33420.42051	42	1	23.5	22.5	100	100	100	99	98	97	95	94	92	88	79	59	45	25	17	10	7	4.6
33420.46055	46	2	15	13	100	100	100	99	99	96	93	90	87	83	70	61	53	40	28	18	13	5.7
33420.47057	47	2.3	9	6.7	100	100	99	97	95	93	90	88	85	82	73	62	52	35	23	12	7	4.6
33420.48059	48	1.3	17	15.7	100	96	96	94	93	92	88	85	82	78	67	55	47	33	21	12	6	4.1
33420.49061	49	5.5	17	11.5	100	100	100	100	100	99	97	95	93	89	79	64	52	30	18	11	10	3.4
33420.50062	50	1.5	13	11.5	100	100	99	99	98	96	93	90	87	84	75	64	54	30	17	11	10	5.7
33420.50063	50	14	20	6	100	100	98	98	98	96	94	92	89	84	74	60	50	34	21	11	6	4.0
33420.51064	51	1	16	15	100	100	98	98	97	96	93	91	89	85	76	63	55	40	27	16	8	5.3
33420.53066	53	2	14.5	11.5	100	100	94	93	91	86	81	79	75	69	60	45	37	24	16	12	9	6.5
33420.54067	54	2	8	6	100	100	100	100	98	92	83	81	78	75	65	55	46	26	15	10	9	4.6
33420.57072	57	1.2	10	8.8	100	100	100	100	99	99	99	97	95	93	85	74	61	33	16	8	4	3.3
33420.58074	58	2.5	11.5	9	100	100	96	91	90	89	88	86	84	82	71	56	43	23	15	10	6	4.4
33420.59076	59	1.5	12	10.5	100	100	100	99	98	96	94	92	89	86	71	57	45	23	12	7	5	3.5
33420.60078	60	1.7	9.5	7.8	100	100	100	100	100	99	97	96	93	89	81	64	50	24	13	8	7	4.8
33420.65085	65	9.5	12	2.5	100	100	100	95	94	90	84	80	75	68	59	47	39	26	20	16	12	9.8
33420.66086	66	1.5	9	7.5	100	100	100	86	79	74	69	66	62	57	47	38	33	21	16	13	9	5.9
33420.68090	68	1.8	19	17.2	100	100	100	100	99	98	98	96	94	91	80	68	58	38	24	14	7	4.3
33420.70093	70	10	22	12	100	100	100	99	99	98	97	96	94	90	75	56	43	23	13	7	3	2.1
33420.72096	72	2	10	8	100	100	100	100	98	97	95	94	91	87	79	67	55	31	19	12	10	7.7
33420.72097	72	12	18	6	100	100	97	93	90	88	85	83	80	75	67	55	45	32	26	22	16	8.1
33420.75101	75	9	17	8	100	100	100	100	98	96	95	93	90	85	72	53	38	21	14	9	7	4.6
Class 5 maximum										100	100			90	80	65			35			10.0
Class 5 minimum										100	90			50	35	20			10			3.0

Appendix D:

BRAUN
INTERTEC

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11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
Fax: 952.995.2020
Web: braunintertec.com

Aggregate Testing

Date : 9/18/03

Project Number : BL-03-01029

Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Lab ID : 8791

Background Information

Sample Number :	33420-1A	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.2	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.0	
+#4 Total	0.5	
Soft Particles MnDOT 1209	0.3	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	0.7	
Carbonate Content MnDOT 1209	9.6	
Lightweight Particles ASTM C123	0.2	

Remarks:

CC:

Sincerely,
Braun Intertec Corporation

Dallas D. Miner
Aggregate Lab Coordinator

BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
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Aggregate Testing

Date : 9/18/03

Project Number : BL-03-01029

Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Background Information

Lab ID : 8792

Sample Number :	33420-1B	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.8	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.4	
+#4 Total	1.8	
Soft Particles MnDOT 1209	0.5	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	2.3	
Carbonate Content MnDOT 1209	1.2	
Lightweight Particles ASTM C123	0.7	

Remarks:

CC:

Sincerely,
Braun Intertec Corporation

Dallas D. Miner
Aggregate Lab Coordinator

Providing engineering and environmental solutions since 1957

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INTERTEC

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Aggregate Testing

Date : 9/18/03

Project Number : BL-03-01029

Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Lab ID : 8793

Background Information

Sample Number :	33420-2A	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.3	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.0	
+#4 Total	1.2	
Soft Particles MnDOT 1209	0.2	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	1.4	
Carbonate Content MnDOT 1209	7.4	
Lightweight Particles ASTM C123	0.2	

Remarks:

CC:

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Aggregate Testing

Date : 9/18/03

Project Number : BL-03-01029

Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Lab ID : 8794

Background Information

Sample Number :	33420-3A	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.1	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.7	
+#4 Total	1.2	
Soft Particles MnDOT 1209	0.1	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	1.3	
Carbonate Content MnDOT 1209	1.6	
Lightweight Particles ASTM C123	0.2	

Remarks:

CC:

Sincerely,
Braun Intertec Corporation

Dallas D. Miner
Aggregate Lab Coordinator

BRAUN INTERTEC

Braun Intertec Corporation
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Aggregate Testing

Date : 9/18/03

Project Number : BL-03-01029

Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Lab ID : 8795

Background Information

Sample Number :	33420-3B	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	1.2	
+#4 Total	0.9	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	1.9	
+#4 Total	1.3	
Soft Particles MnDOT 1209	0.1	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	1.4	
Carbonate Content MnDOT 1209	1.2	
Lightweight Particles ASTM C123	0.6	

Remarks:

CC:

Sincerely,
Braun Intertec Corporation

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Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Lab ID : 8796

Background Information

Sample Number :	33420-4A	Specification :	
Date Sampled :		Classification :	Granular Material
Date Submitted :	9/10/03	Test Method :	MnDOT
Date Tested :	9/18/03	Sampled by :	Client
Sample Location :		Source :	Talcot Pit

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.4	
+#4 Total	0.6	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.5	
+#4 Total	1.5	
Soft Particles MnDOT 1209	0.7	
Clay Balls and Lumps MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls	2.2	
Carbonate Content MnDOT 1209	1.5	
Lightweight Particles ASTM C123	0.4	

Remarks:

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Client : Glenn Melchert P.G.
MN Department of Natural Resources
Division of Lands and Minerals
1525 Third Avenue East
Hibbing MN 55746

Project : Aggregate Quality Testing

Background Information

Lab ID : 8797

Sample Number : 33420-4B
Date Sampled :
Date Submitted : 9/10/03
Date Tested : 9/18/03
Sample Location :

Specification :
Classification : Granular Material
Test Method : MnDOT
Sampled by : Client
Source : Talcot Pit

Properties		Test Results	Spec's
Shale MnDOT 1209			
+1/2"		0.0	
+#4 Total		0.4	
Soft Iron Oxide	MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls			
+1/2"	MnDOT 1209	0.4	
+#4 Total		1.3	
Soft Particles	MnDOT 1209	2.4	
Clay Balls and Lumps	MnDOT 1209		
Sum of Spall, Soft particles ,Clay balls		3.7	
Carbonate Content	MnDOT 1209	2.5	
Lightweight Particles	ASTM C123	0.7	

Remarks:

CC:

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Dallas D. Miner
Aggregate Lab Coordinator

Appendix E. Notes on the criteria for classification of the aggregate deposit

This large aggregate resource is a blanket deposit with about half of it occurring below the water table. In some places, the portion below the water table is sand or has lenses of silty clay that overlie gravel (Figure 5). It is more difficult to mine below the water table so, given the expanse of the deposit, it is probable that some of the deeper less desirable aggregate may not be mined. Therefore, rather than quantifying the entire resource between the topsoil and the glacial till, efforts were made to distinguish those deeper intervals below the water table that are less likely to be mined.

In some test holes, the lowest portion of the aggregate deposit was poorly graded sand. In these instances, the mineable gravel interval ended just above the sand interval.

In twelve test holes, a relatively thick silt and clay layer occurred within the sand and gravel interval. In these instances, the gravel interval was split into primary and secondary gravels. The bottom of the primary gravel was marked at the top of the silt/clay layer and the secondary gravel was marked as the interval beneath the silt/clay layer.

Primary criteria for placement of gravels into the secondary gravel were based on how deep it occurred, whether it was below the water table, and its relative thickness with respect to the amount of sand or clay above them. If the clay layer was 1.5 feet or thicker, and the ratio of the clay thickness to the underlying aggregate was 50% or higher, then the aggregate below was assigned to the secondary gravel.

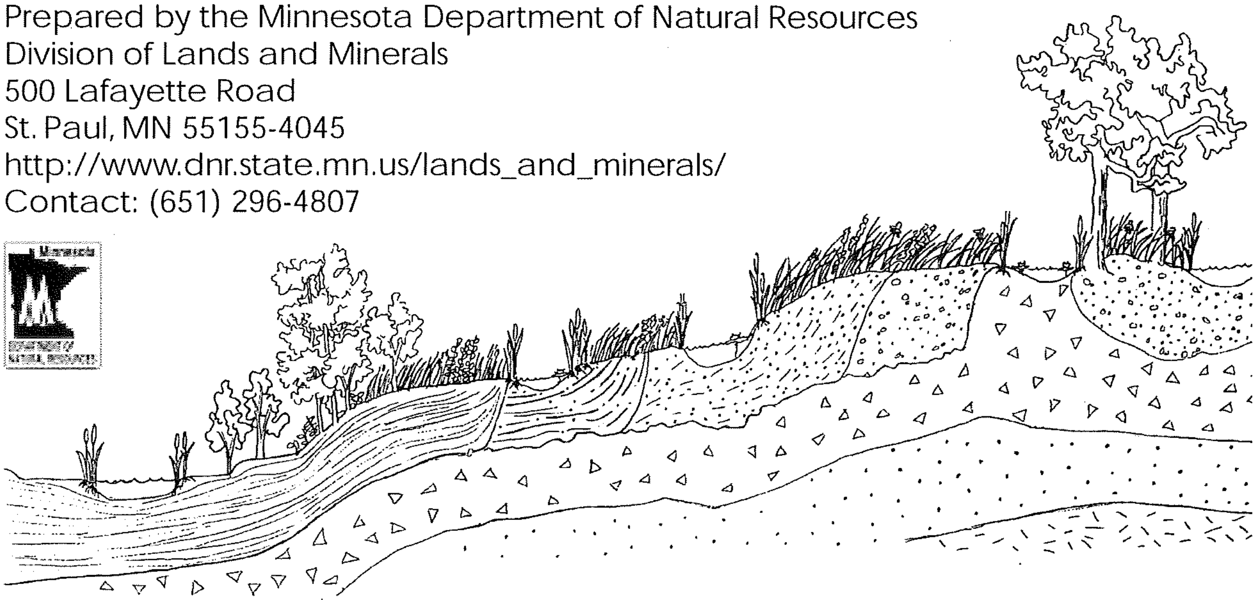
Three occurrences of thin, deeply buried gravels that are 1.5 feet thick or less and are overlain by relatively thick sand or silt/clay are noted in the drilling logs and cross sections as "grvl_3" and not considered for volume or any other resource estimates.

Appendix F:

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

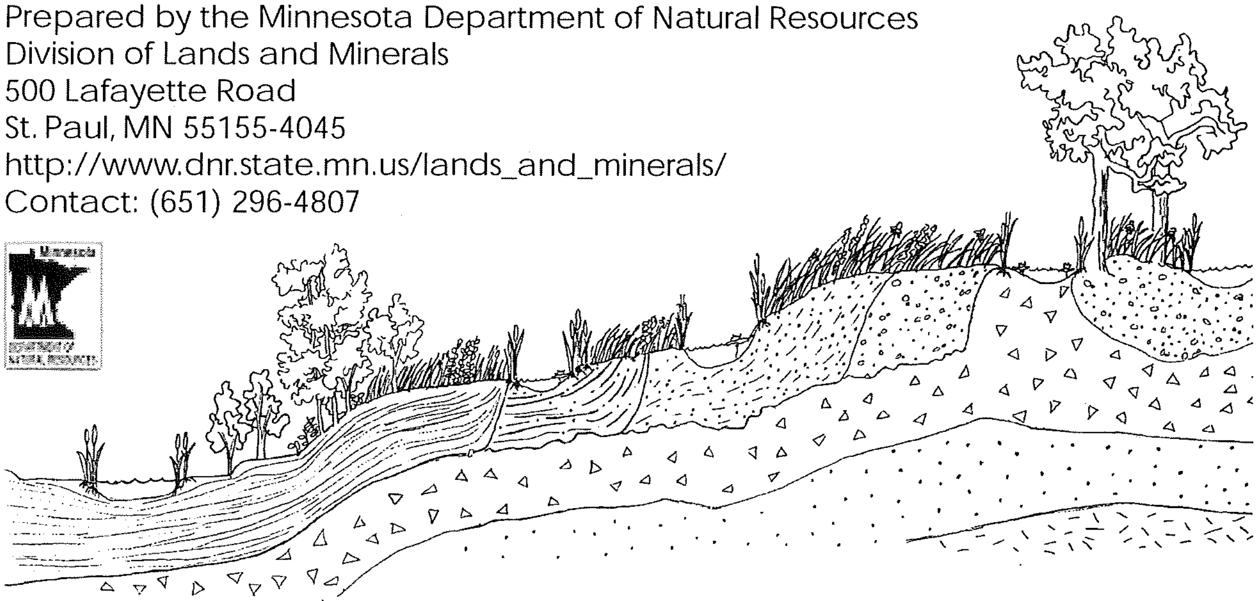
Environmental Quality Board (EQB)

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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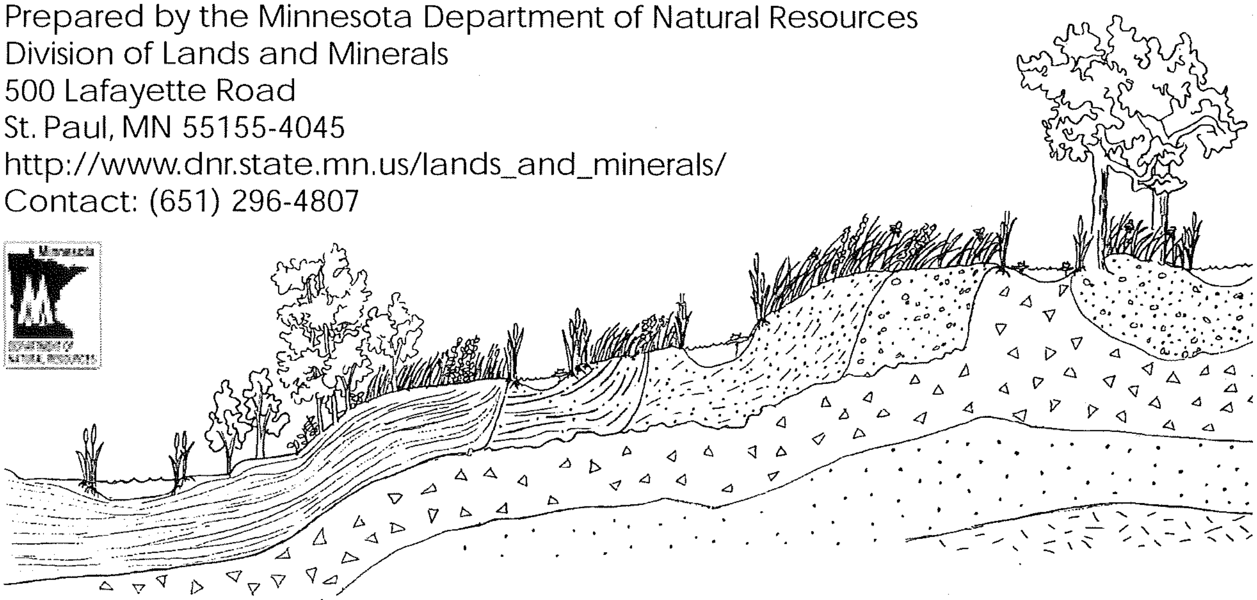

WHAT IS RECLAMATION?

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, 1,792 townships and 853 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

Prepared by the Minnesota Department of Natural Resources
Division of Lands and Minerals
500 Lafayette Road
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http://www.dnr.state.mn.us/lands_and_minerals/
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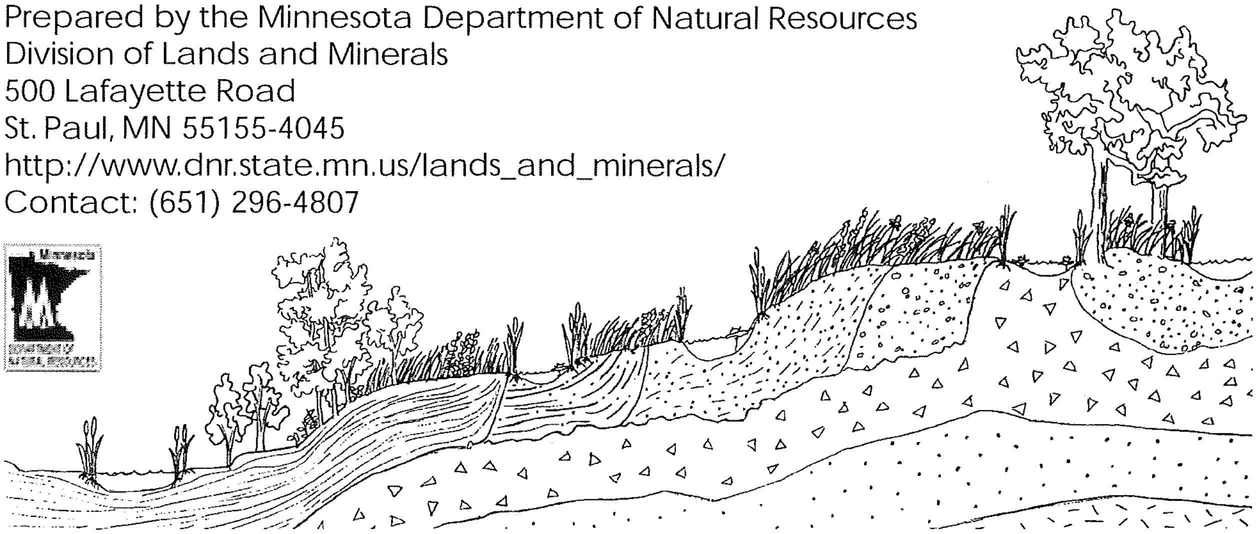


WHAT IS PRAIRIE?

"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 Standard 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.

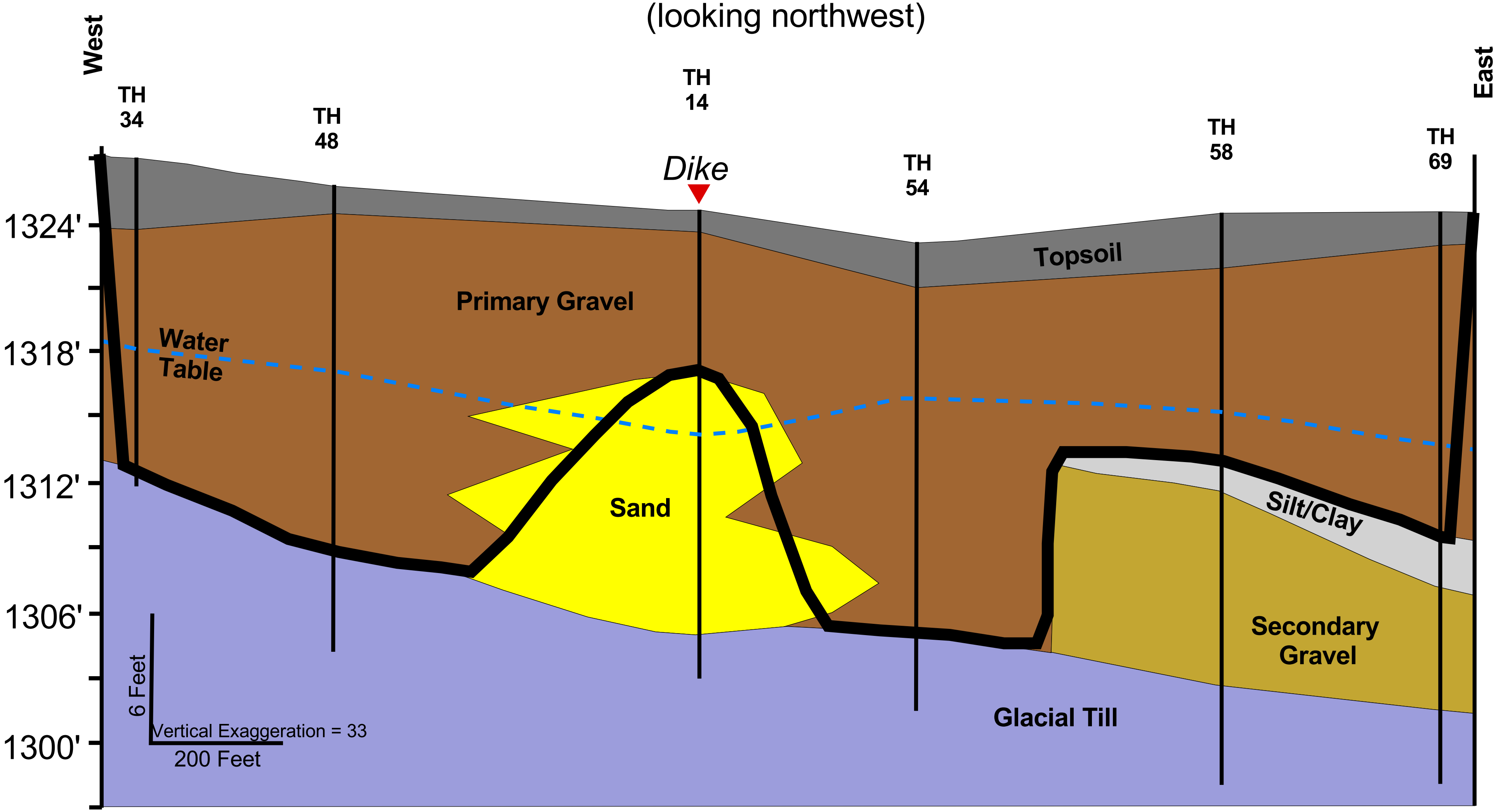
Timing:
Native grasses should be planted from May 1 to June 30. Seeding may be done in the fall, but the seeding rates should be increased slightly to account for seed mortality over the winter. Many species of wildflowers require a cold period to break dormancy and are best seeded late in the fall. 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.

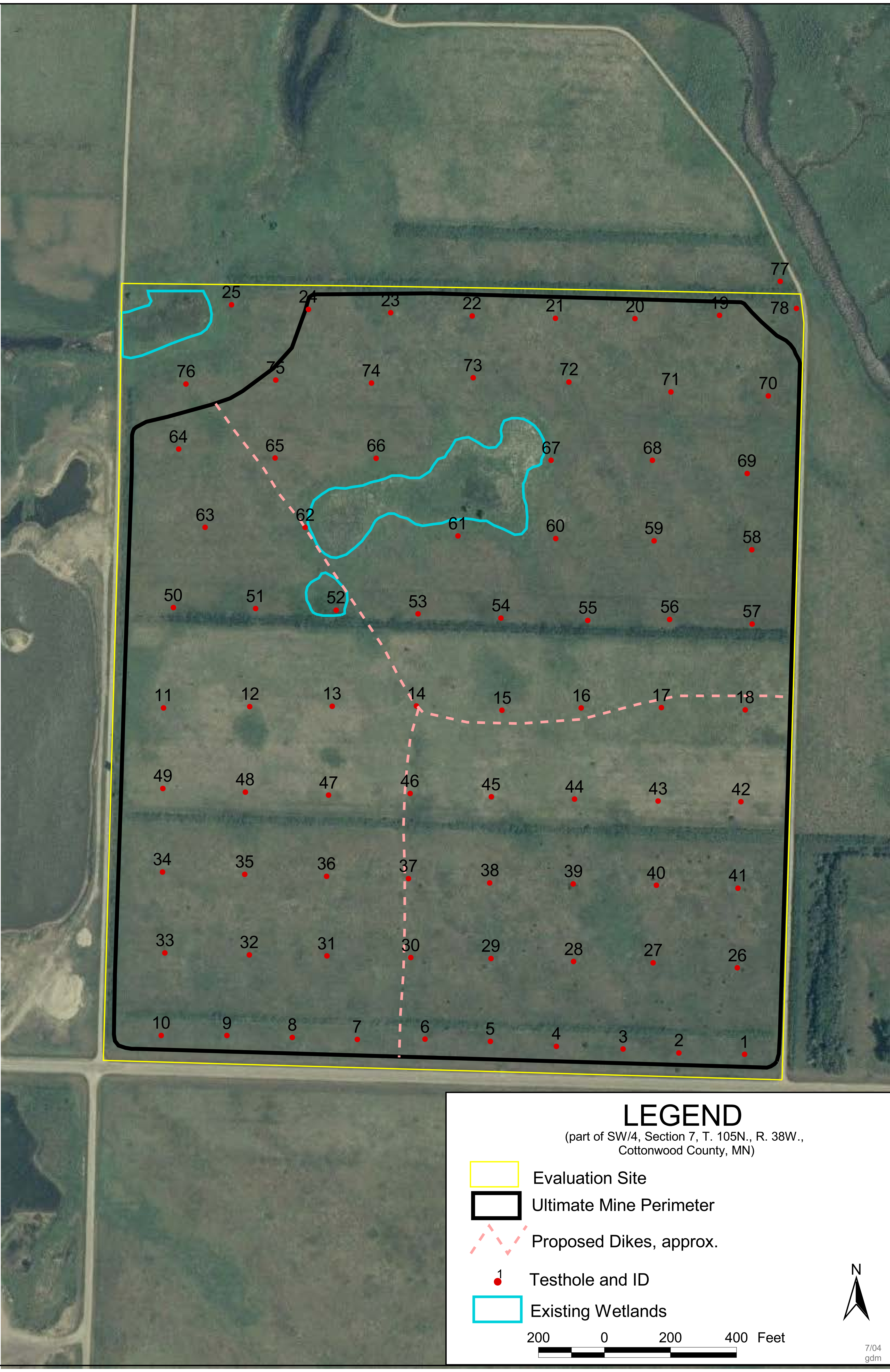
Cross Sectional Profile Across theTalcot Aggregate Deposit

(looking northwest)



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

Plate 1
Project 334-20



This map shows the extent of the evaluation site, test holes, approximate extent of wetlands within the evaluation site, and the proposed maximum extent of the pit. The salmon colored dashed lines indicate the locations of the dikes that will separate the three wetlands that will be created by mining. The background photo was taken in 2002.

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

Talcot WMA

(part of SW/4 Section 7, T 105N, R 38W)

Plate 2

Project 334-20

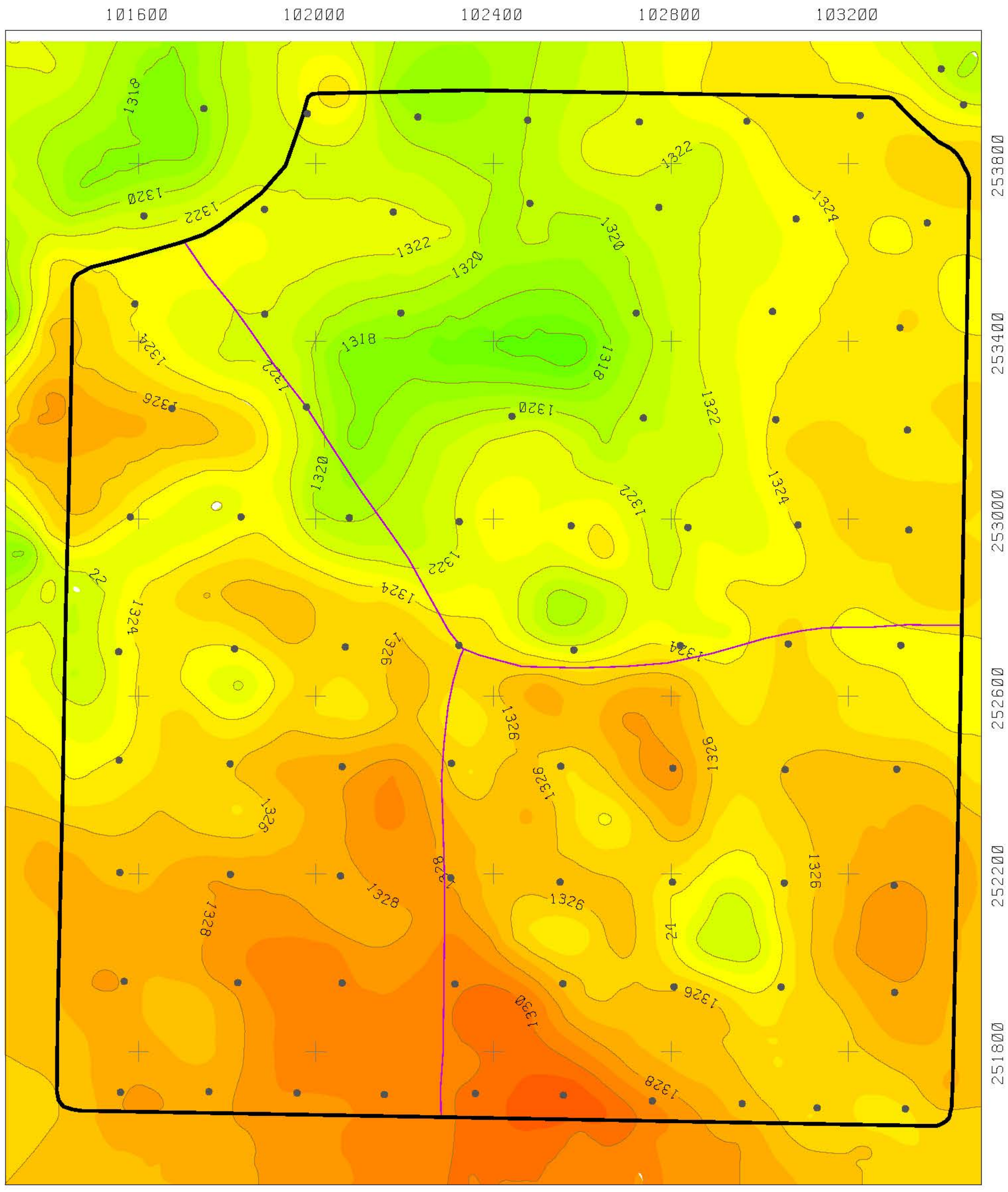


Figure 1. Topographic map of the existing condition. Elevation in feet, WGS 84 datum, not tied to a benchmark. Contour interval = 1 foot.

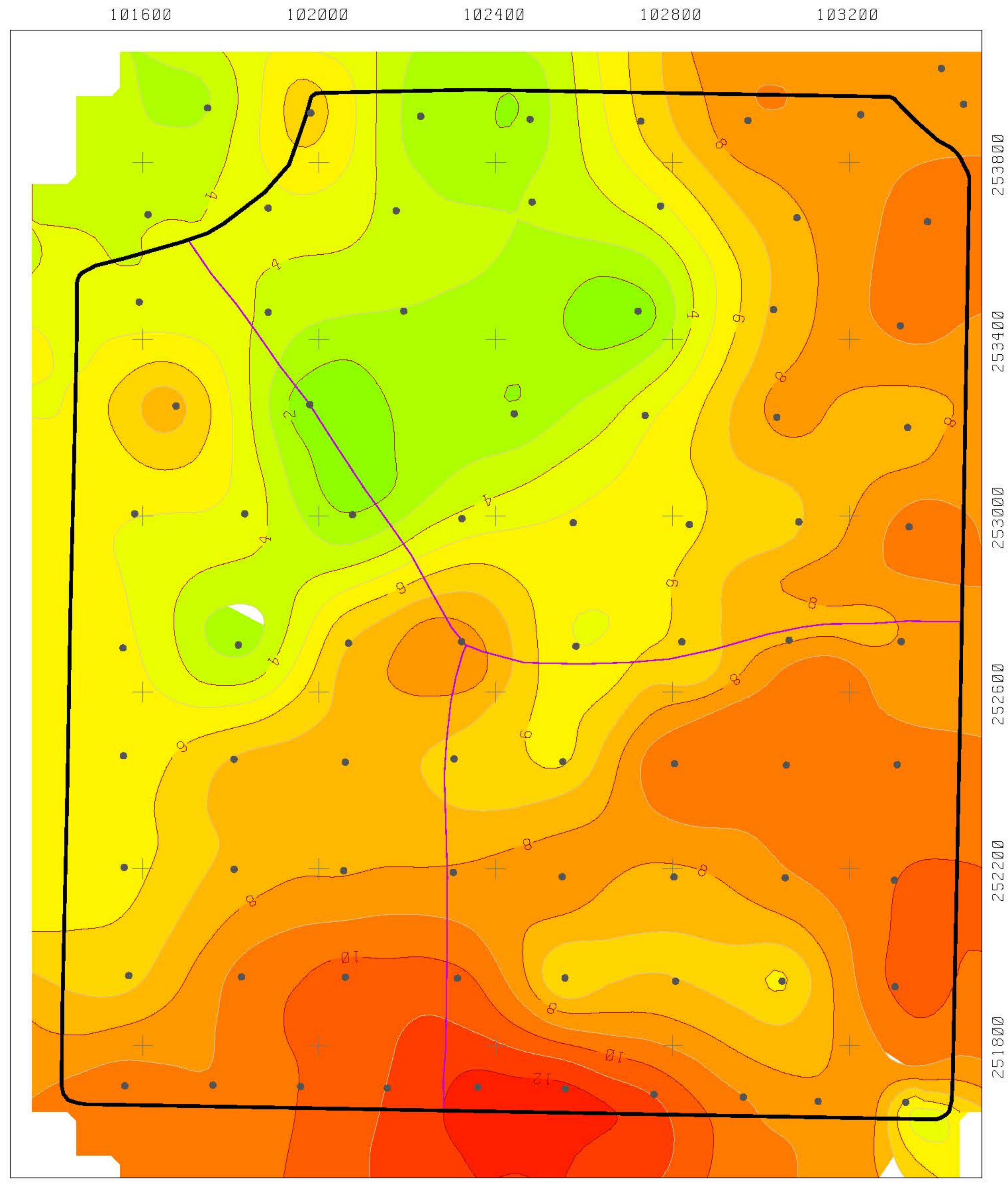


Figure 3. This figure indicates the thickness (ft) of the primary gravel deposit that is above water. This assumes topsoil is already removed. Contour interval = 1 foot.

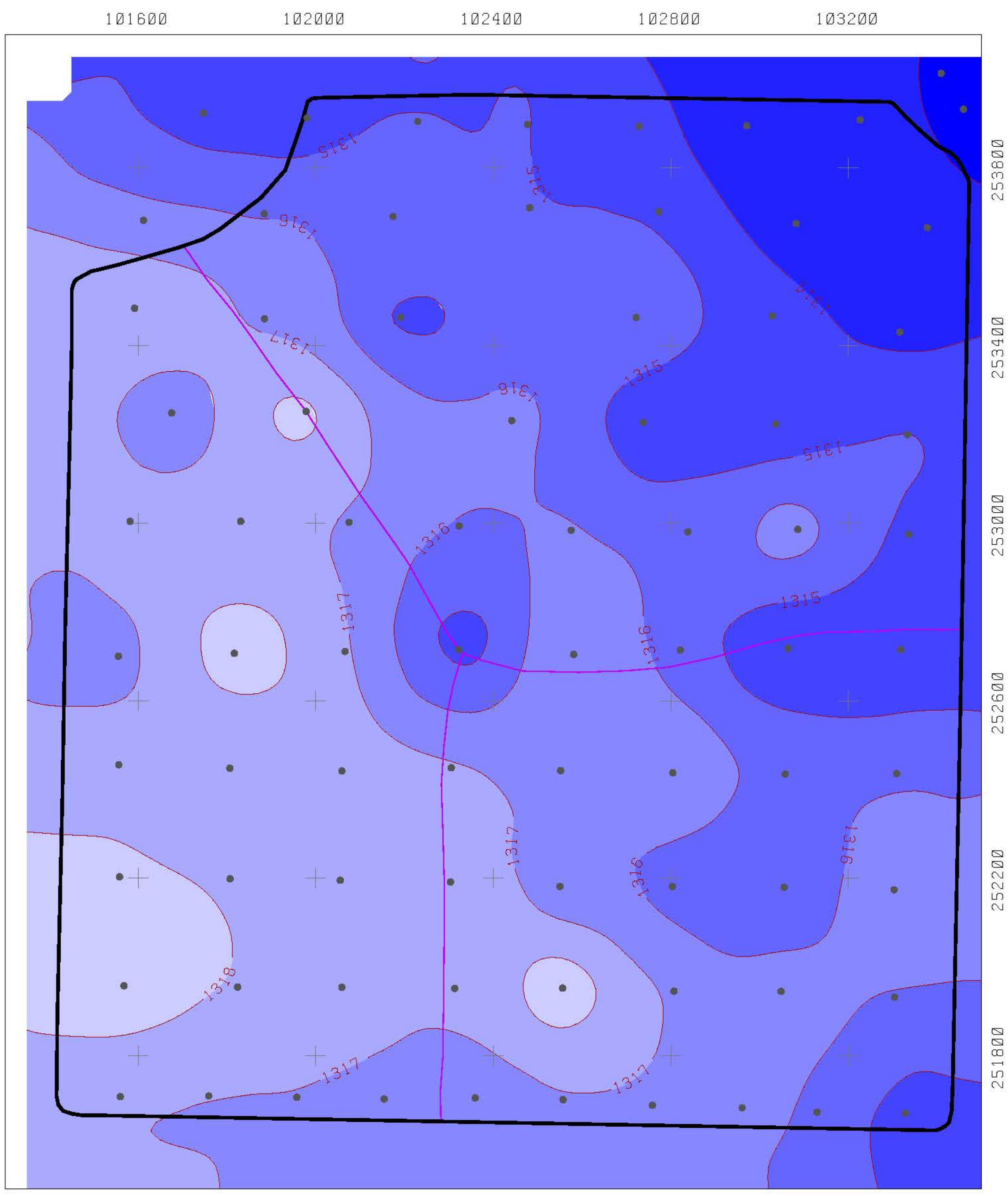


Figure 2. Contour map of the modeled water table based on test hole data. Darker blues indicate deeper/lower elevation. Contour interval = 1 foot.

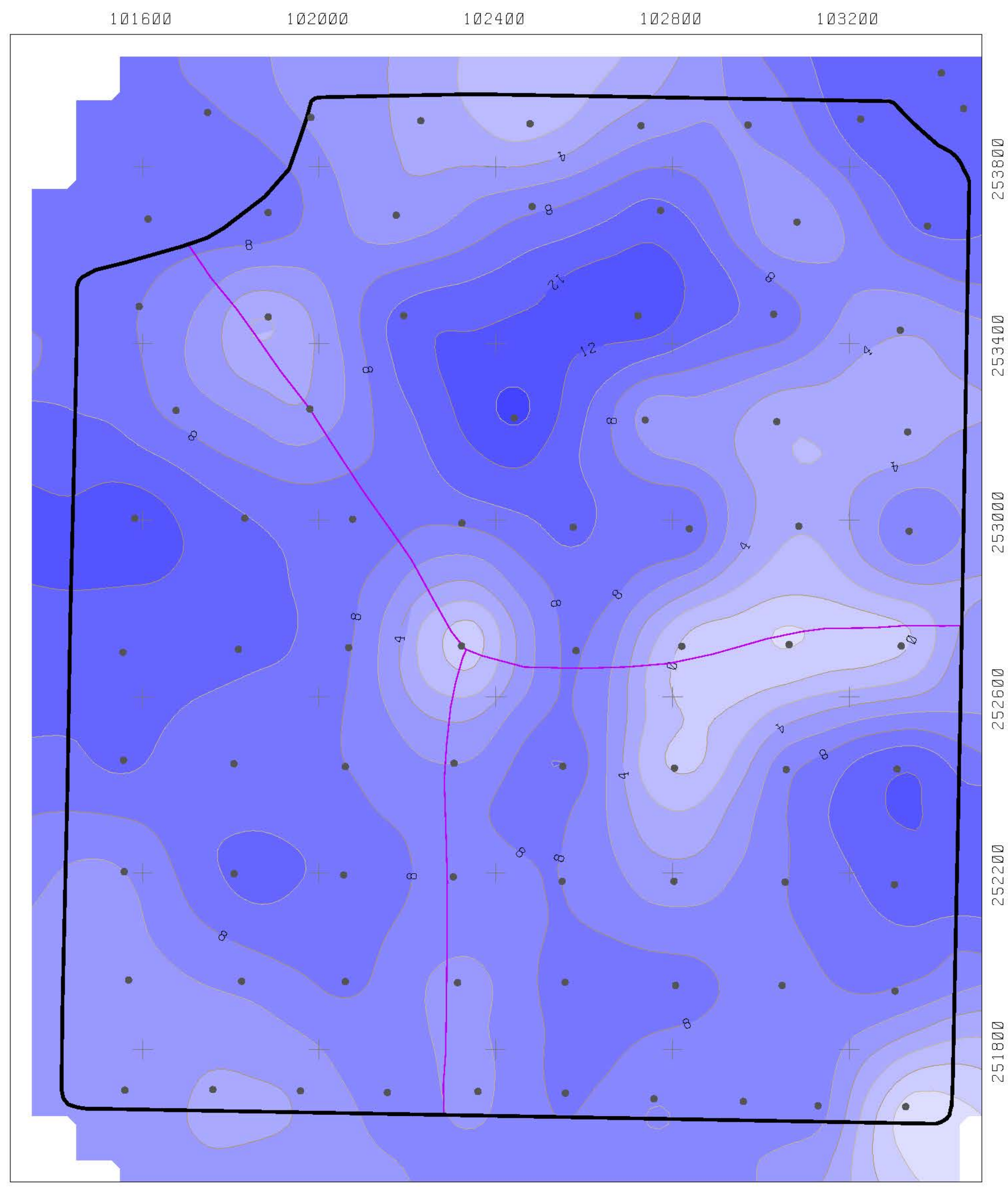


Figure 4. The approximate depth of water after mining and prior to placement of backfill. The lightest areas are shallow water or above water after mining. The negative contour values indicate elevation above water. Contour interval = 2 feet.

Note for all figures: The heavy black line indicates the proposed pit perimeter. The purple lines indicate locations of the dikes. Filled black circles indicate locations of test holes. See plate 1 for test hole id. The reference coordinate system is Jackson County NAD83.

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

Talcot WMA

(part of SW/4 Section 7, T 105N, R 38W)

Plate 3

MnDNR Project 334-20

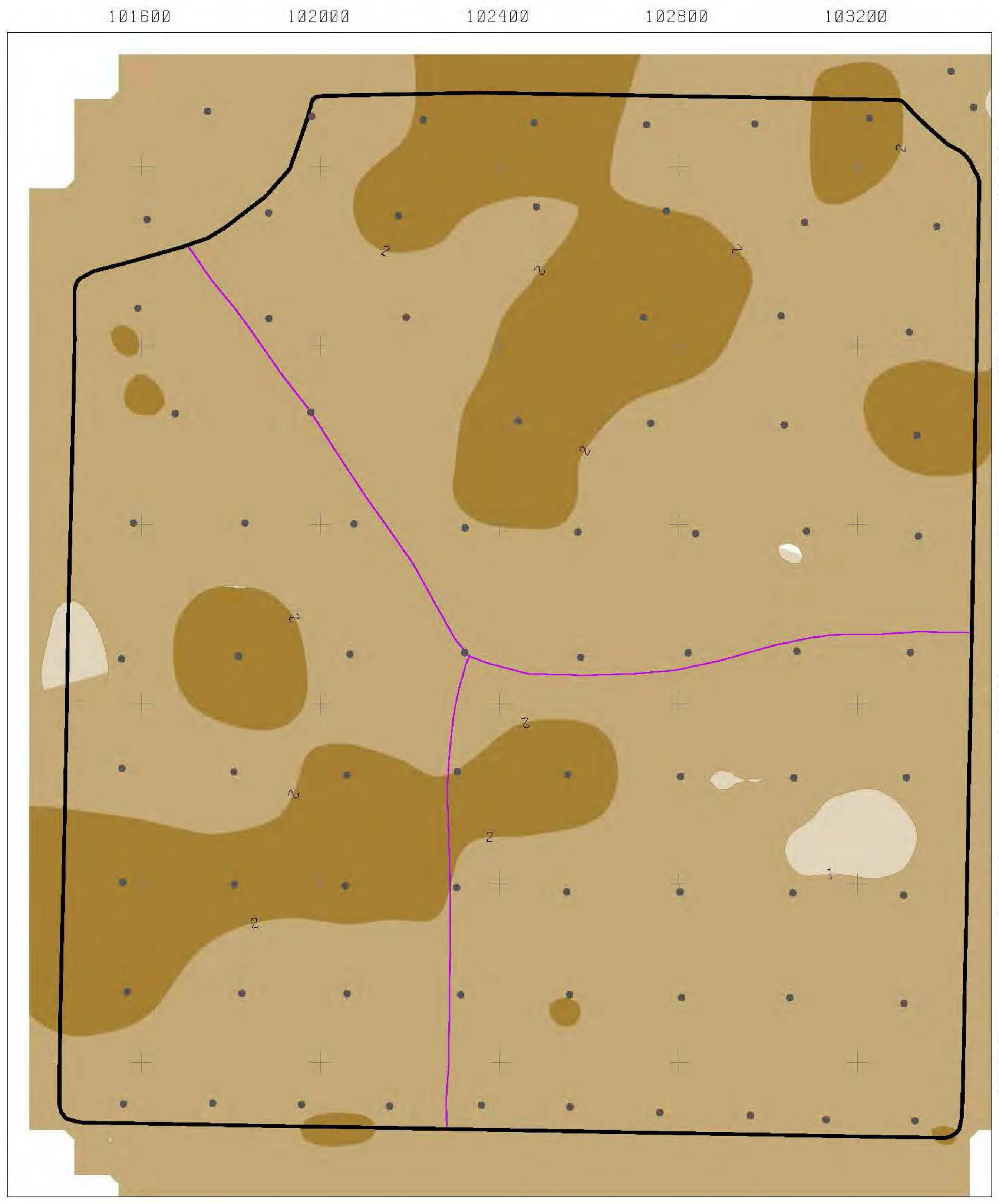


Figure 1. Variations in thickness of the overburden (stripping) across the site. Darker colors indicate thicker areas. Sample spacing may be too large to define any trends, if they exist. Contour interval = 1 ft.

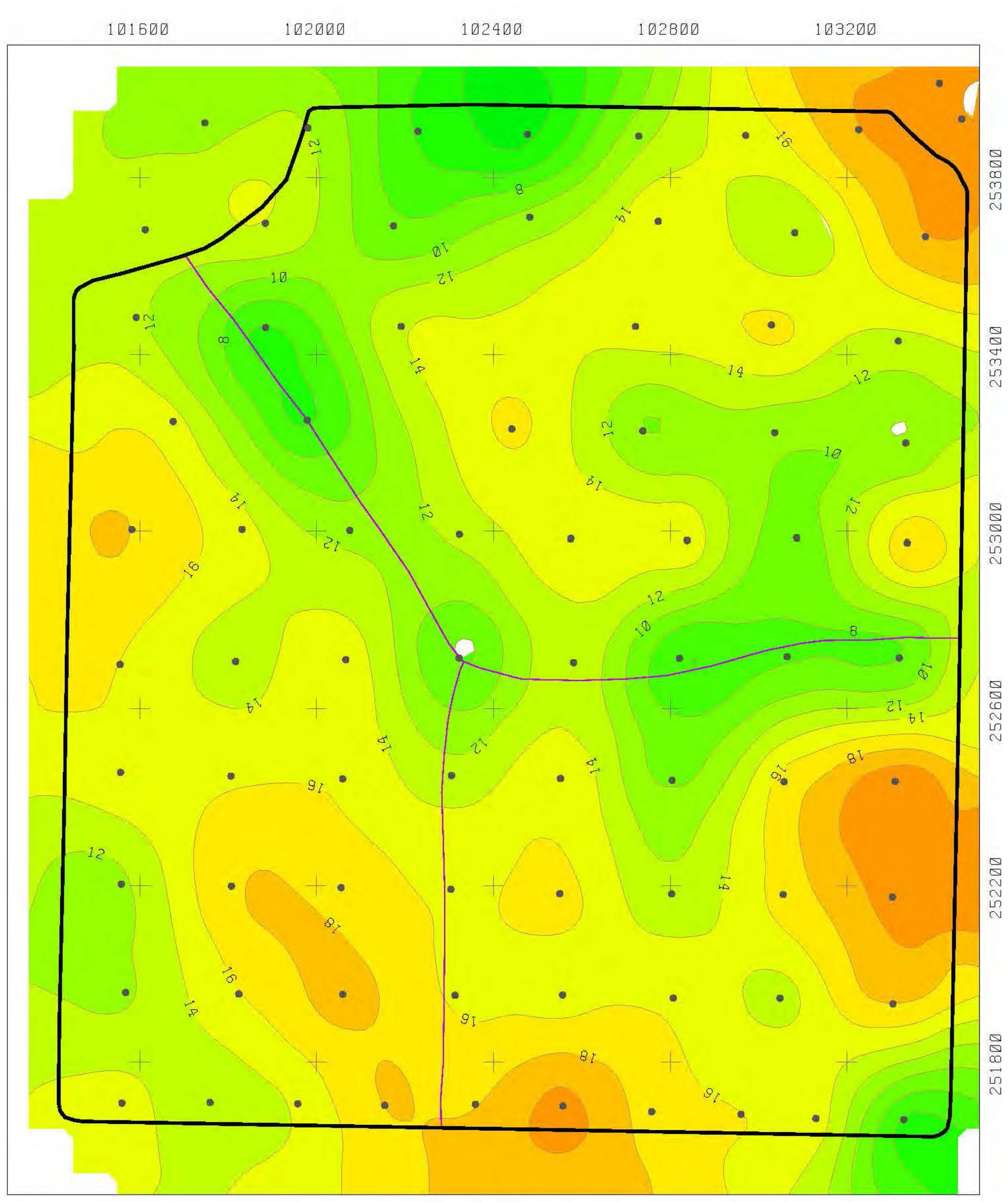


Figure 2. Variations in thickness of the primary gravel deposit across the site. The orange colors indicate where the gravel is thicker and the green colors indicate where the gravel is thinner. Contour interval = 2 feet.

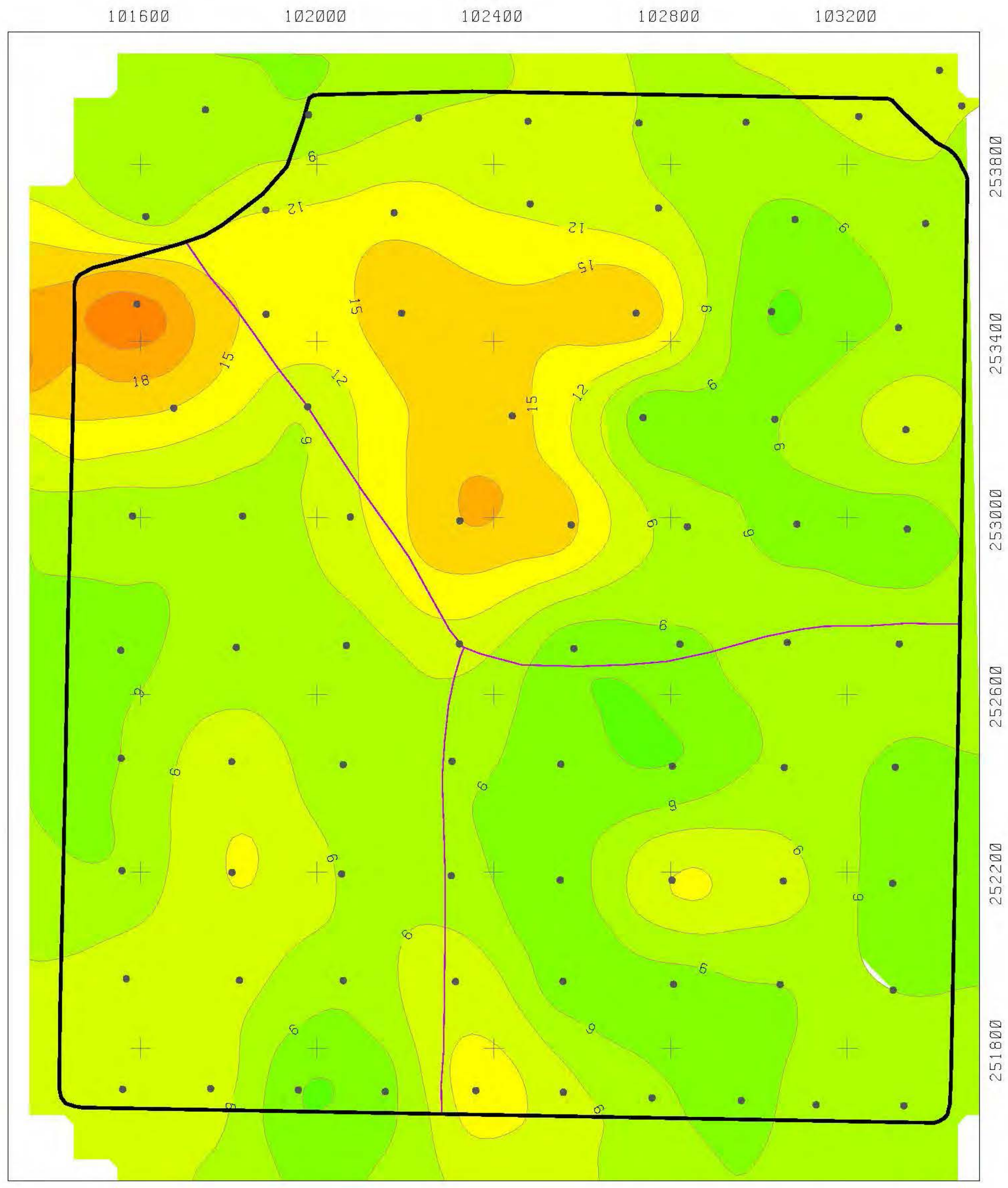


Figure 3. Distribution of the percent crushable (+3/4 inch) aggregate by weight based on sieve data. Orange colors indicate where this value is highest and the green colors indicate where it is lowest. Contour interval = 3%.

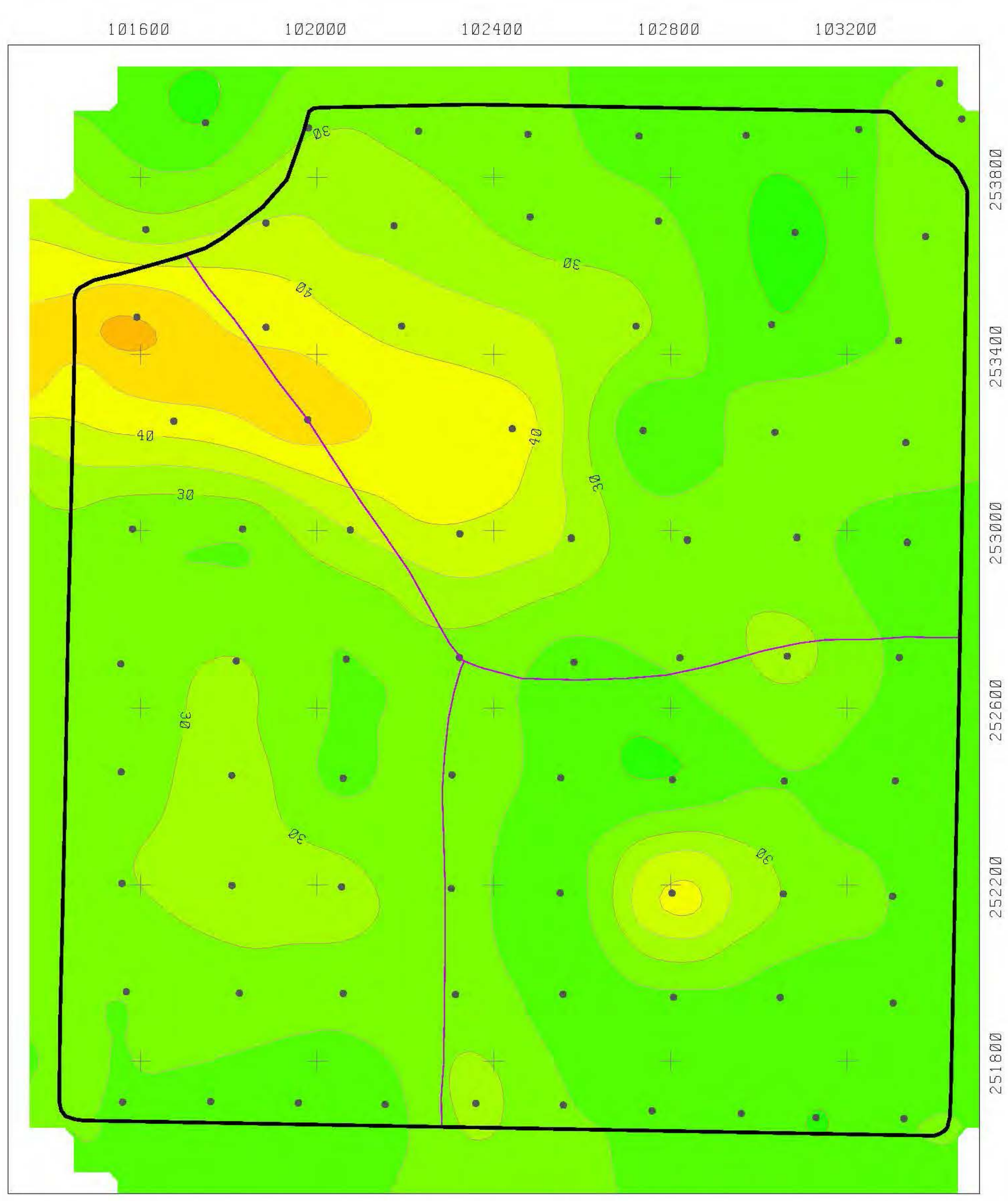


Figure 4. Distribution of the percent of aggregate, by weight, retained on the #4 sieve. The yellow to orange colors indicate where this value is highest and the dark green colors indicate where this value is lowest. Contour interval is 5%.

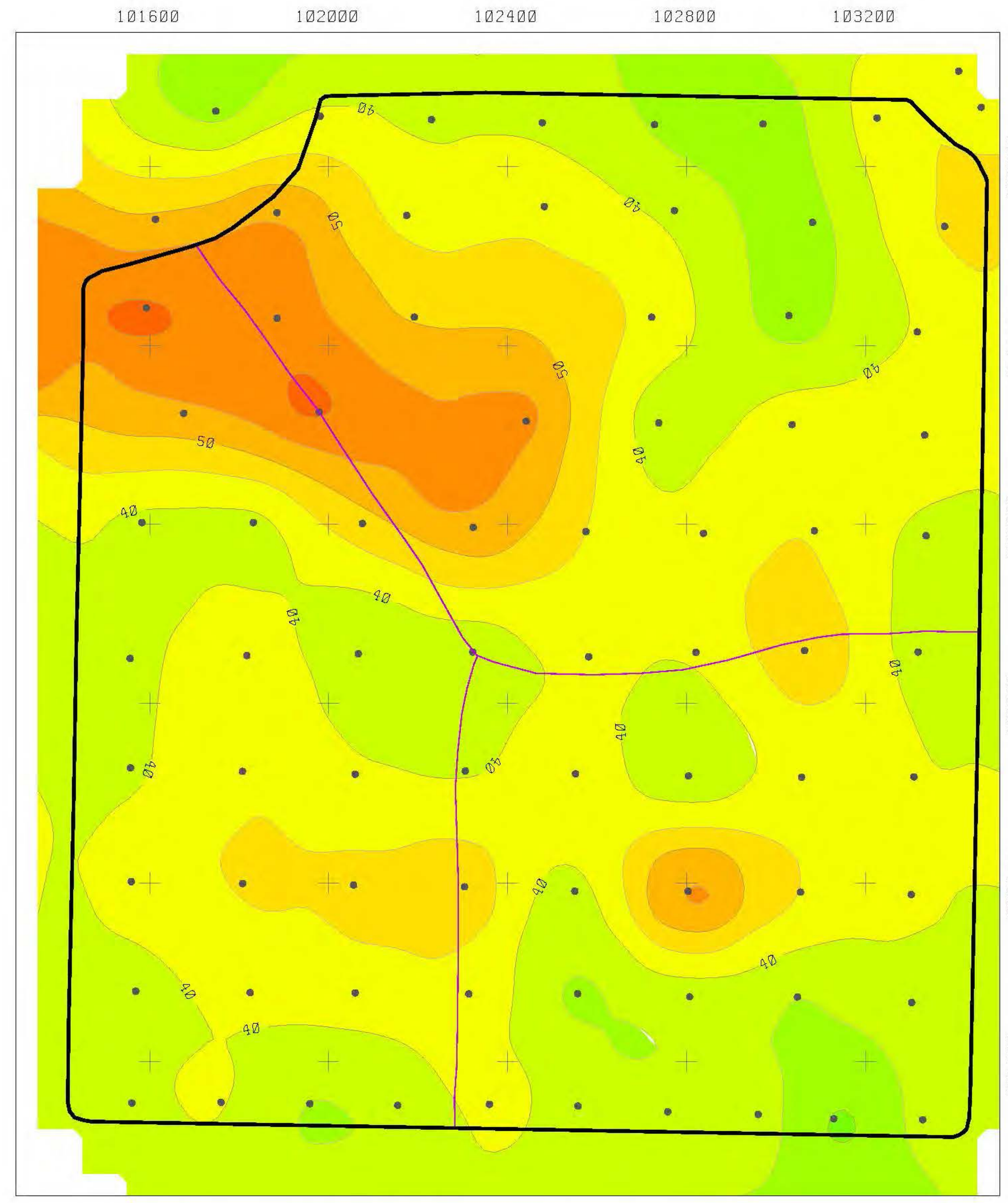


Figure 5. Distribution of the percent of aggregate by weight retained on the #10 sieve. The orange colors indicate where this value is highest and the green color indicates where it is lowest. Contour interval = 5%.

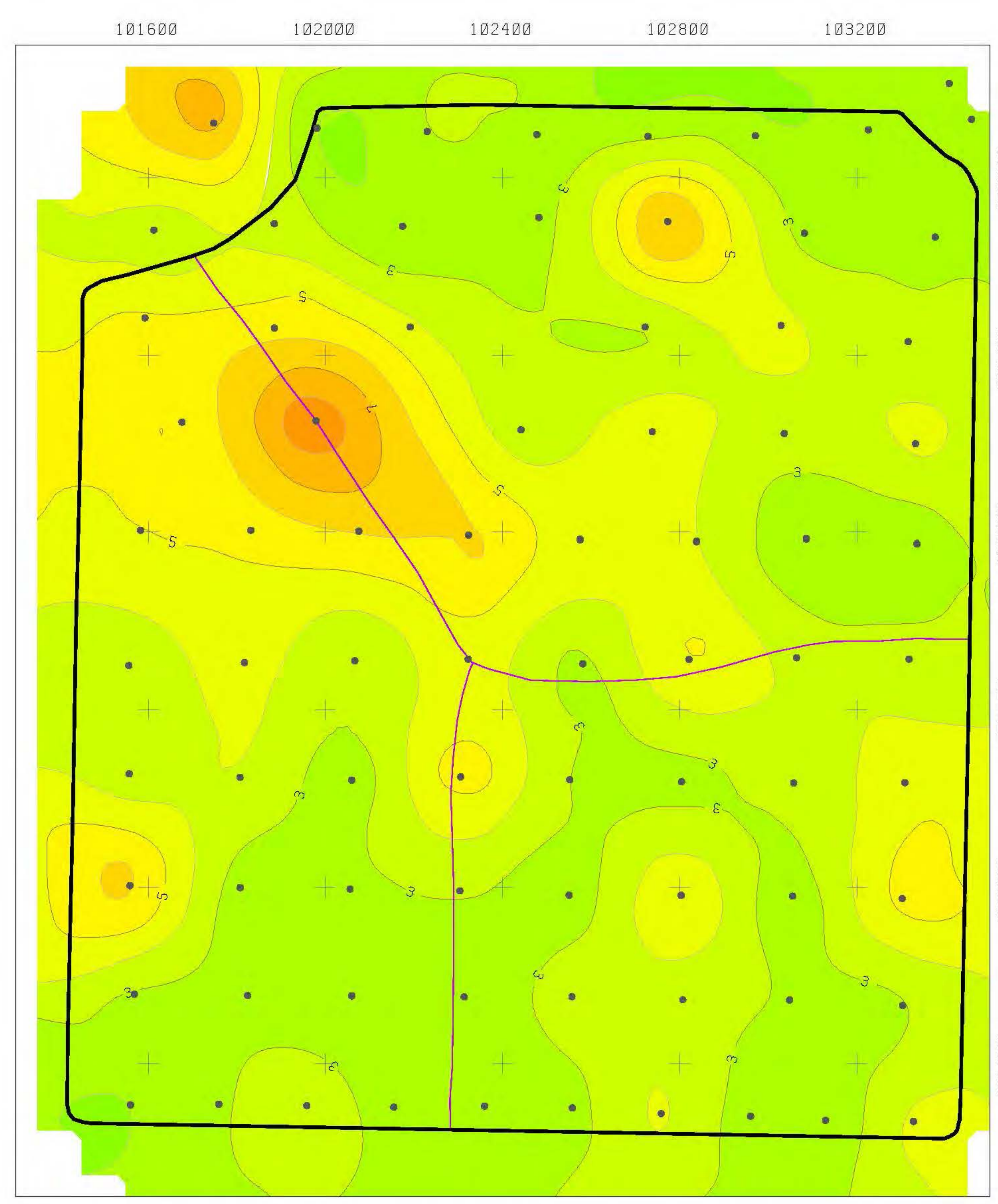


Figure 6. Distribution of the percent of fines by weight passing the #200 sieve. The yellow colors indicate where this value is the highest and the green colors indicate where it is the lowest. Contour interval = 1.0%.

Note for all figures: The heavy black line indicates the proposed pit perimeter. The purple lines indicate locations of the dikes. Filled gray circles indicate locations of test holes. See plate 1 for test hole id. The reference coordinate system is Jackson County NAD83.