Aggregate Resource Evaluation

Sand and Gravel Evaluation For A Site Near Bayport, Washington County, MN

MN Department of Natural Resources
Minerals Division - Minerals Potential
Project and Report #334-1: June, 1998

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SUMMARY

The purpose of this study was to evaluate a sand and gravel resource at a site near Bayport, Washington County, Minnesota. The Bayport site consists of 13.6 acres of state owned land, managed and administered by the MN-DNR, Division of Wildlife. Miller Excavating, who is mining sand and gravel on the land directly adjacent to the south, is looking to expand its mining operation; Miller approached Wildlife about buying or leasing the property in question. This study was therefore completed to determine the value of this resource.

A detailed evaluation was necessary to determine the value of the resource, which included aerial photograph and map interpretation, drilling, logging, sampling, field observation, geophysical studies, labwork, statistical analysis, research, computer aided mapping, etc. The results of this investigation, the conclusions reached, and possible suggestions of how to continue (with the leasing of this resource) are as follows:

Results/Conclusions/Suggestions

- The Bayport site consists almost entirely of sand and gravel (>50 feet in thickness), which was deposited as glaciofluvial outwash on a large terrace within the St. Croix River valley.
- The estimated volumes of sand and gravel material within this deposits are: (± 20%)
  - ~270,000 cubic yards of sand and gravel to an elevation of 820 feet.
  - ~135,000 cubic yards of sand and gravel from 820 to 805 feet in elevation.
  - ~400,000 cubic yards of sand and gravel total (to 805 ft and 4:1 slope).
- The overburden thickness is minimal, ranging from 1 to 6 ft (averaging < 3 ft), except in the extreme southwestern portion of the map area where a thicker silty-clay exists.
- Due to the minimal amount of overburden and the thick gravel deposit, the stripping ratio is very favorable, however is variable due to the elongated-ridge shape of the deposit.
  - 1:10 (820 elevation), 1:15 (805 elevation), however is variable due to the ridge.
- The water table was not encountered in the top 50 feet, thus does not pose a problem for mining.
- Quality testing showed that the aggregate is of very high quality; it meets most of the specifications for concrete aggregate and meets all specifications with very little blending. The Iron Oxide and Spall (½") in composite #3 are slightly higher than the specification, however meet the specifications with blending.
- The average percent gravel within the entire deposit is approximately 27%
- The average percent gravel within the top 10 ft is 38%, and 27% between 10 and 21 ft. in depth.
- Geophysical studies (EM Conductivity) suggest that even coarser material (higher gravel percentages) exists within the deposit , however these areas were not drilled or sampled in this study.
- The sand and gravel is generally well rounded and washed, which is ideal for concrete.
- The highest quality material (greatest percent gravel) lies within the upper 21 feet of the deposit, thus if Wildlife decides to lease the resource only to an elevation of 820 feet, the highest royalty value should be charged (approximately $1.00/cubic yard; some areas are changing up to $1.50 for high quality material).
  - 270,000 cubic yards * $1.00/cubic yard = $270,000 royalties (± 20%)
- If Wildlife decides to let Miller mine the sand and gravel to an elevation of 805, where the gravel % is much less, a lower royalty rate could be incorporated for this material.
  - 135,000 cubic yards * $0.70/cubic yard = $ 94,500 royalties (additional; ± 20%)
- If Wildlife decides to lease the entire deposit (to an elevation of 805 feet with 4:1 post mine slopes) the lease value could be set at an intermediate value ($0.85-$0.90/$yards^3$).
  - 400,000 cubic yards * $0.85/cubic yard = $340,000 royalties (± 20%)
  - 400,000 cubic yards * $0.90/cubic yard = $360,000 royalties (± 20%)
- It is the suggestion of the author/geologist to lease the entire deposit (to a depth of 805 feet, with a post mine slope of 1:4) at an intermediate royalty rate of $0.85-$0.90 per cubic yard. This would maximize the profits obtained from this resource for Wildlife, as well as supply material to Miller Excavating at a more affordable rate. If the lease allows Miller Excavating to mine only to an elevation of 820 feet, which would remove the highest quality aggregate, it is less likely (economically) that another company in the future could/would set up their equipment to mine the remaining lower quality material (<135,000 cubic yards).

INTRODUCTION

The purpose of this project was to evaluate the aggregate resources at a site near Bayport, Minnesota (Figure 1). The Bayport Site consists of 13.6 acres of state owned land, managed and administered by the Minnesota Department of Natural Resources, Division of Wildlife. The MN-DNR Division of Wildlife is currently leasing the adjacent property to Pete Miller of Miller Excavating for sand and gravel excavating. Miller Excavating approached the Division of Wildlife about buying or leasing the property in question to expand his current sand and gravel operation. The purpose of the study is then to determine the value of the property, which consists of accessing the land value as well as the resource value. This report will concentrate only on the value of the sand and gravel resource, the value of the land itself will be completed by the DNR Bureau of Real Estate and Land Management (BREM).

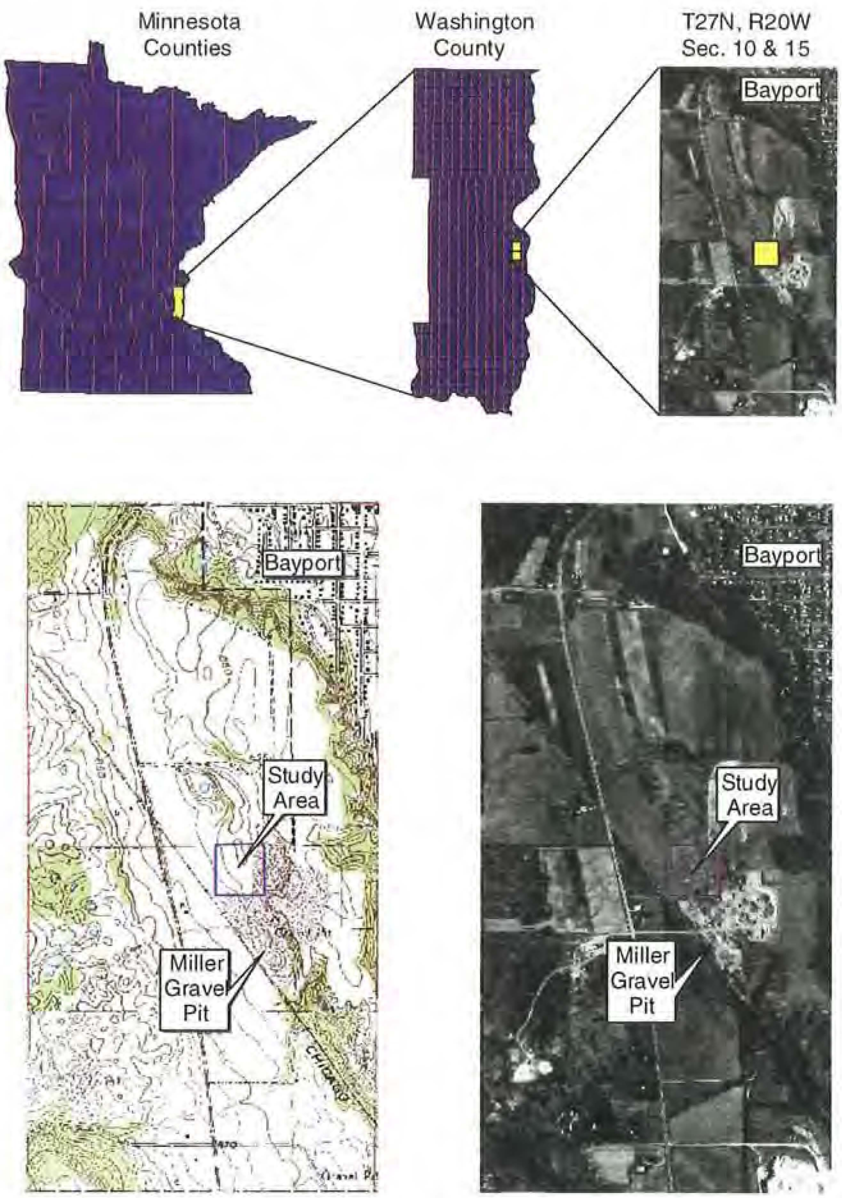


Figure 1. Location of the Study Area: A portion of the NW1/4 of the NE 1/4 of Section 15, T.29N., R.20W., Washington County, Minnesota.

By accessing the value of the sand and gravel resource, Wildlife will have the necessary information (along with the information obtained from BREM) to determine if it is better to lease the sand and gravel and retain the land or to sell the property with the resource intact.

If Wildlife decides to keep the land and lease the sand and gravel, the information herein will provide the necessary information to calculate the royalty rate and volume of material to be removed. If they decide to sell the land, the value of the resource can be added to the value of the land, thus totaling the total value of the property. If the land is sold, the value of the resource must incorporate the quality of the aggregate, the market in the Bayport Area, the volume present, and the potential uses.

REGIONAL GEOLOGICAL SETTING

Large continental glaciers covered Washington County during much of the Pleistocene Epoch. These continental glaciations left behind a wide variety of sediments: lacustrine sands, outwash sands and gravels, ice-contact stratified deposits, terrace deposits, glacial till, etc. (Meyer & et al, 1990). The study area near Bayport consists mostly of sands and gravels, which were deposited by a complex history of terrace deposition and erosion, glacial lakes draining, dammed up rivers, large meltwater channels entering smaller ones, etc.

The study area is located on the uppermost terrace within the St. Croix River valley. This terrace was probably formed by water flowing from Glacial Lake Grantsburg when it was dammed by the Grantsburg sublobe to the north (Wright, 1972); the terrace was primarily cut into Superior lobe outwash and Ordovician dolostone. The sediment within the study area consists mostly of Superior lobe sands and gravels that were slightly reworked by the Grantsburg drainage system. However, a deposit of red silty clay was deposited on top of the sand and gravel outwash in the southwestern corner of the study area. This was formed later as Glacial Lake Agassiz drained through Glacial River Warren, which entered the Mississippi River valley downstream, causing the St. Croix River valley (a tributary stream) to back-up with water, thus depositing finer-grained sediments (slack-water deposits).

METHODOLOGY

The objective of this was study was to complete a detailed evaluation of the sand and gravel resource at this site to help determine the value of the deposit. This was completed by aerial photograph and map interpretation, drilling, logging, sampling, field observations, geophysical studies, labwork, statical analysis, research, and finally computer-aided map and report preparation. This study was completed with only one restriction; the maximum depth (elevation) that Miller was allowed to mine. Miller's proposed to mine to an elevation of 805 feet above sea level, however Wildlife wants to restrict mining to an elevation of 820 ft.

Map Interpretation

Topographic maps, aerial photographs, and previously published information were gathered and analyzed to determine the general geological setting of the Bayport Site. The Stillwater and Hudson topographic maps (U.S.G.S. 7.5' series) were analyzed to determine the general trends of topography and to delineate the different terrace levels (with which this sand and gravel deposit is associated). A large sand and gravel ridge that makes up the majority of the study area was delineated using these topographic maps as well as color inferred aerial photographs (NAPP, 1991). Aerial photographs were also used to find and delineate other gravel pits in the surrounding area, which are associated with the same terrace deposit.

Determining Drilling Pattern

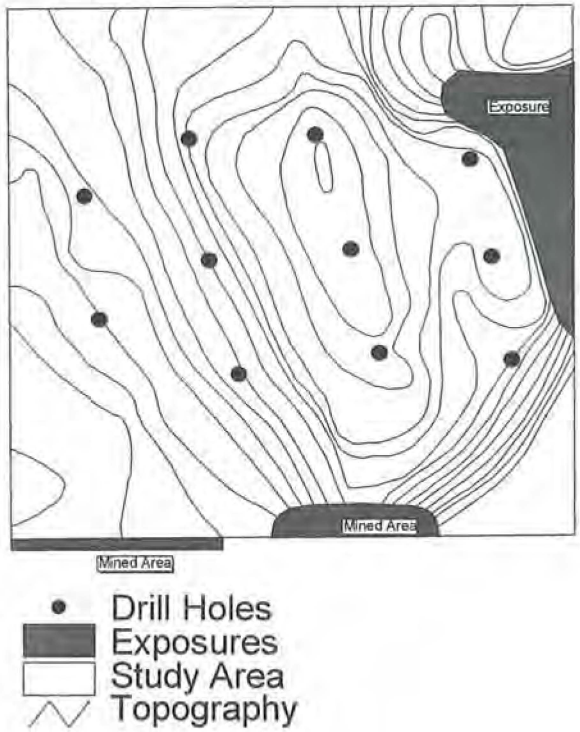
After analyzing the topographic maps, aerial photographs, and previously published data, a drilling plan was constructed. It was determined that a hole needed to be drilled for every acre of land (209 ft^2); the study area consisted of approximately 13.6 acres thus 13 holes needed to be drilled. However, gravel mining had already began on the south side of the study area exposing approximately 25 feet of the deposit, a 20 foot gravel exposure/cut existed on much of the east side of the study area, and the area directly adjacent to the south had been mined/exposed; these exposures provided sufficient information/data that substituted for a few holes. After analyzing these outcrops and their locations, a drill plan was constructed which consisted of 11 drill holes staggered over the remaining unexposed area (figure 2). A row of drill holes was positioned along the major ridge running north-south and along the minor ridge to the east (also running approximately north-south); it was thought the maximum thickness and coarsest sand and gravel would be found on these ridges.

Drilling

Drilling was completed to determine the overburden thickness, determine the deposit thickness, determine the aerial extent of the deposit, describe the sediment encountered (logging), and obtain representational samples that were used to determine the quality of the deposit. The drilling was performed under a cooperative agreement between MNDOT and DNR, where MNDOT provided the drilling equipment and operator to work with a DNR Minerals Division geologist.

The hole locations were staked/surveyed and the drilling began. A total of 11 holes were drilled in 1.5 days using a 10" diameter, 25 foot continuous flight auger (figure 3) with 5 foot sections that were added individually (figure 4) to reach a maximum depth of 46 feet. At the beginning of every hole, the first few feet were pulled up to determine the thickness of the topsoil/overburden. The drill was then advanced in 2.5 to 5 foot increments and pulled up to describe the material and to collect samples.

Figure 2. Drill Hole Pattern



Logging

Logging the hole consisted of making field observations and completing field tests to describe the sediment encountered while drilling (figure 5). Field observations included overburden thickness, overburden characteristics, deposit thickness, sediment encountered, amount of gravel, amount of sand, texture and composition of the sand and gravel, trends, patterns, field gradations, etc. A 2 mm (#10) sieve was used to obtain a rough estimate of the percent gravel encountered in the sediment (figure 6). The field descriptions of the drill holes can be found in Appendix A.

Sampling

A single sample composite (representing the entire granular interval encountered) as well as three individual sample intervals were collected from each hole (except hole #1 where only 2 samples were collected; table 1). Sampling consisted of hand-scrapping material from the auger flight and placing it on a rubber mat. Once the entire interval was placed on the rubber mat, it was mixed using a shovel and approximately 30 pounds were placed in a canvas sample bag. Identification tags were placed both inside and outside of the bags. The identification tags consisted of the project number, date sampled, hole number, sample number, interval sampled, location, and the geologist's name. The samples were then loaded and transported to the Maplewood MNDOT testing laboratory for quality work to be completed.

Geophysical Study

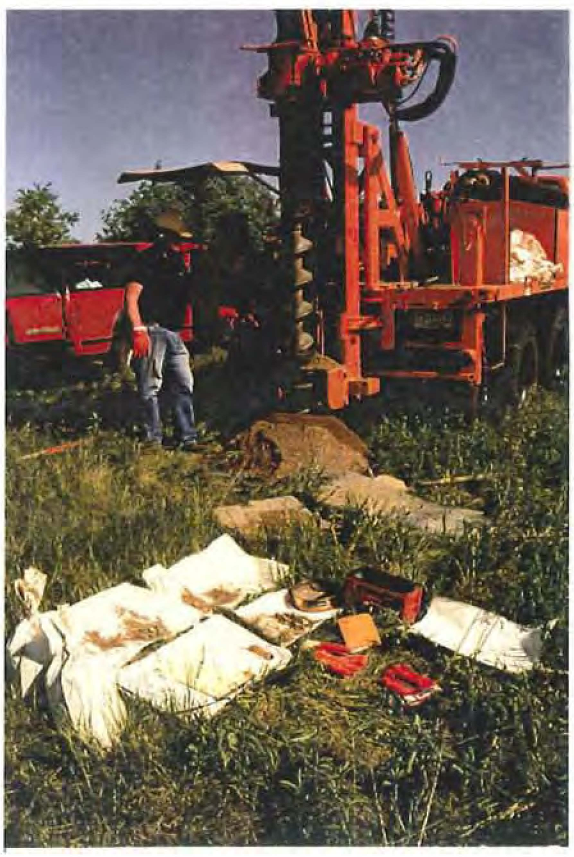
An Electro Magnetic (EM) Conductivity study was completed to help define trends between drill holes, provide information for the areas not drilled, help determine the extent of the deposit, and to correlate the textural characteristics of known areas with those areas in question. EM34-3 equipment was used for this study, which is a two-person portable operation.

Figure 3. Drilling Rig with a 10 inch diameter, 25 ft continuous flight auger (above).

Figure 4. Five foot auger sections were added to the 25 ft auger to reach thicknesses of over 50 feet (right).

Figure 5. Logging Station where sampling, labeling, sieve testing, and observations were completed (lower left).

Figure 6. Sieve Analysis was used to roughly estimate the gravel percent (lower right).



Sample #	*Hole #*	*Depth*	*Hole Composites*	*Site Composites*
1	3	1 to 10	Hole #3 Composite	Composite 1
2	3	10 to 21		
3	3	21 to 46		
4	4	2.5 to 10	Hole #4 Composite	
5	4	10 to 21		
6	4	21 to 31		
7	5	6 to 10	Hole #5 Composite	
8	5	10 to 21		
9	5	21 to 46		
10	2	1.5 to 10	Hole #2 Composite	
11	2	10 to 21		
12	2	21 to 26		
13	1	5 to 15	Hole #1 Composite	
14	1	15 to 26		
15	6	4 to 10	Hole #8 Composite	Composite 2
16	6	10 to 21		
17	6	21 to 46		
18	7	3.5 to 10	Hole #8 Composite	
19	7	10 to 21		
20	7	21 to 31		
21	8	2 to 10	Hole #8 Composite	
22	8	10 to 21		
23	8	21to 36		
24	11	1 to 10	Hole #11 Composite	Composite 3
25	11	10 to 21		
26	11	21 to 46		
27	10	1 to 10	Hole #10 Composite	
28	10	10 to 21		
29	10	21 to 36		
30	9	1.5 to 10	Hole #9 Composite	
31	9	10 to 21		
32	9	21 to 46		

Table 1. Samples collected during drilling including sample number, hole number, interval sampled (feet), hole composites, and site composites.

The first step was to determine the intercoil spacing, which could be either 10, 20, or 40 meters; each of these spacings are capable of exploring different depths. Being we were going to be using both horizontal and vertical dipoles, it was determined that the 20 meter spacing would work best. The 20 meter intercoiling spacing has the capability of exploring up to 15 meters (49 ft) with the horizontal dipole and up to 30 meters (98 ft) with the vertical dipole (McNeill, 1980).

An EM survey was then completed over the entire study area except where the topsoil was already stripped off for mining. The entire area was first staked out with a 20 meter grid pattern. The survey consists of one person operating the transmitter and the next person operating the receiver 20 meters away. The receiver simply follows the transmitter to the next station (so that they are always 20 meters apart); the receiver operator (figure 7) moves the receiver coil backwards or forwards until the meter (figure 8) indicates correct intercoil spacing and then reads the terrain conductivity from the meter (it can also be electronically recorded to a polycorder and latter downloaded; figure 9). Once the horizontal reading had been taken, the coils are laid down horizontally (vertical dipole mode), the correct intercoil spacing was obtained, and the reading was taken; now you have obtained a reading for both the horizontal and vertical. Then both operators move to the next stations and repeat the process, following a line. For this study seven lines were completed with 11 stations each and one additional line with six stations, totaling 83 stations/readings (figure 10).

Figure 7. Receiver operator taking EM conductivity readings (left).
Figure 8. EM Receiver (above).
Figure 9. EM Equipment (below)

Additional Field Work

A Global Positioning System (GPS) was used to determine the locations of the geophysical stations, the mined area, and the area that had been stripped and ready to mine. Differential correction was used with the GPS unit, resulting in accuracy within a few meters. The hole locations and property boundaries were surveyed to get the exact x-, y-, and z-coordinates, which were later used to estimate the volume of the deposit.

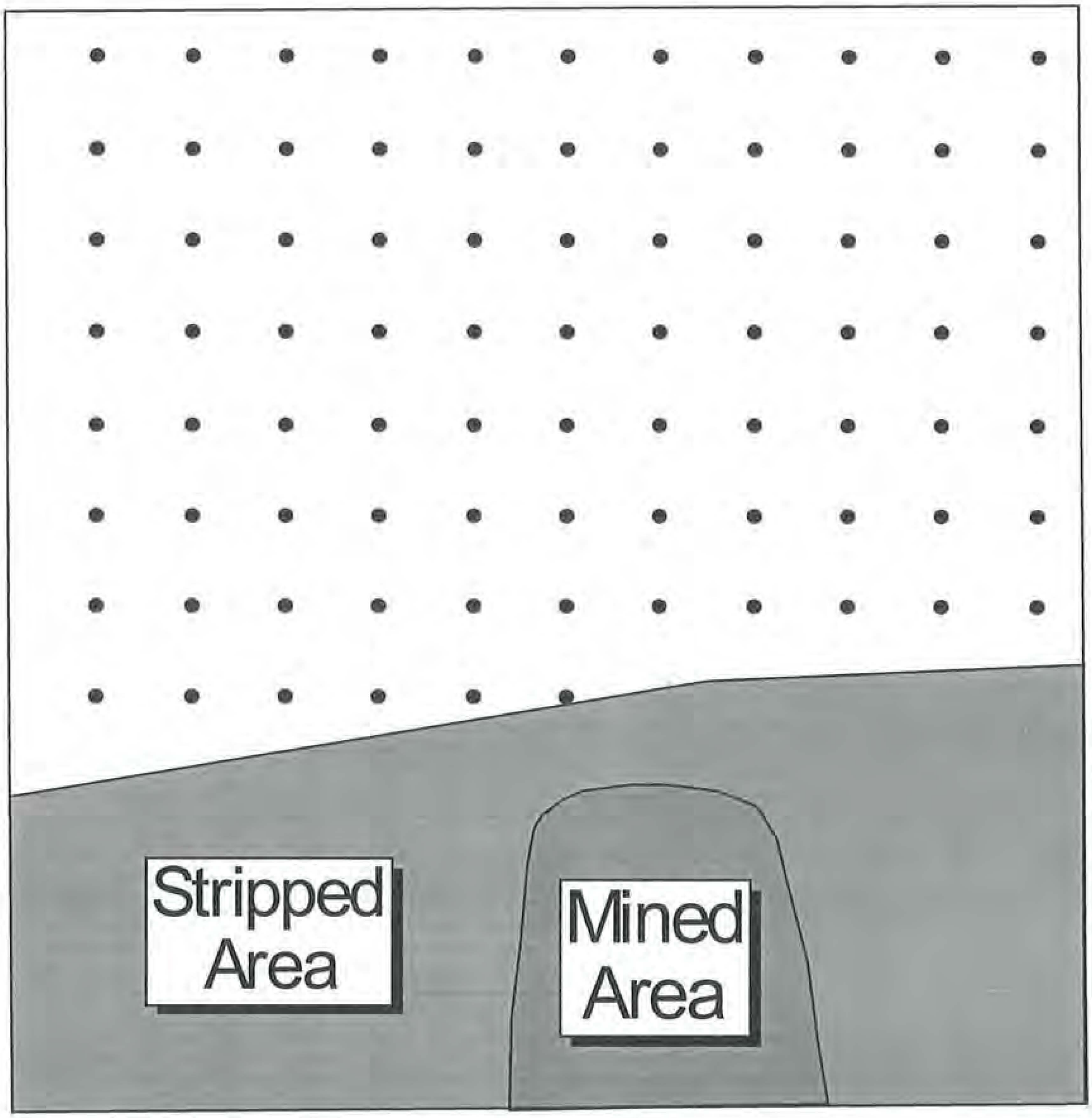


Figure 10. Location of EM Conductivity stations. Eight lines were completed (east-west), seven of the lines contained 11 stations each and the last line contained six stations, totaling 83 stations.

Lab Work

All the quality analysis was completed by the Minnesota Department of Transportation (MNDOT) lab in Maplewood. Coarse- and fine-grained gradations were completed on all 32 samples collected, as well as three composite samples (table 1); this consisted of sieving each sample to determine the particle size distribution (e.g. silt vs. sand vs. gravel). A lithologic examination and shale float test was completed on all three composites to determine the amount of shale, carbonate, iron oxide, unsound chert, sandstone, spall, etc. Bulk Specific Gravity and Absorption were determined for both the coarse- and fine-grained aggregate. The Magnesium Sulfide and Los Angeles Rattler (LAR) tests were also completed to test the soundness and durability of the sediment.

Computer Analysis

The volume of the deposit was estimated using Techbase. Techbase incorporated the topography by digitizing a topographic map supplied by an independent consultant and from the digital elevation model (DEM) produced by the United States Geological Survey (USGS). The bore hole geology (logged data) was then incorporated into the model, and finally the volumes were estimated (assuming a post mine plan to preserve 4:1 side sloped on the east, west, and north sides). Two volume estimates were calculated based on 1) the minimum elevation that Miller Excavating was allowed to mine (Elevation = 820) and 2) the proposed mine plan Miller Excavating constructed (Elevation = 805). With all this data entered into Techbase, cross-sections were completed and the volume estimates were calculated using Kriging (statistical model).

The geophysical data were downloaded to a PC and stored in a database. The x- and y-coordinates were calculated and added to the station readings; the database now consisted of x-coord.(UTM), y-coord.(UTM), the horizontal conductivity (mS/m), and vertical conductivity (mS/m). The program SURFER was then used to grid (using Kriging) and display the data. Word processing was completed in Word Perfect, Quattro Pro and Excel spreadsheets were used to process and summarize the data, and ARCVIEW was used to compile the x, y, and z coordinates, summarize data, and produce figures.

RESULTS

Size Distribution

The Bayport site consists of a very high quality sand and gravel deposit. The drilling, logging, sampling, and geophysical study all confirm the presence of a significant amount of gravel within the deposit; gravel is defined as particles greater than 2.00 mm. The gravel content is very high in the upper 21 feet, ranging from 13 to 54%, and averaging 38.1% in the top 10 ft. and 26.9% between 10 and 21 feet in depth. The gravel %'s are summarized in table 2; the general trend is a decrease in the amount of gravel downward. The average gravel percent for the entire deposit is approximately 27%.

Hole Number	Surface ~top 10 ft	Intermed. ~10-21 ft	Deep ~>21
BH-1	39	24	NA
BH-2	34	20	10
BH-3	35	37	24
BH-4	52	33	29
BH-5	46	41	9
BH-6	13	15	11
BH-7	34	29	34
BH-8	54	23	19
BH-9	39	21	12
BH-10	35	32	22
BH-11	38	21	8
Average	38	27	16

Table 2. Percent gravel found in samples.

The particle size distribution not only shows a valuable gravel content, but also shows that the different particle sizes are present in the combinations that meet product specifications for the Minnesota Department of Transportation (MNDOT; table 3). With screening and blending techniques this aggregate deposit has a significant potential for producing multiple products (Appendix B).

Quality of Aggregate

The sand and gravel was tested to determine the quality of the material (soundness and durability). The quality of the material will ultimately help determine the final end use of the resource. It is important to use a resource to its maximum potential (resource management) to avoid shortages in the future of quality aggregate. For example, if all the quality resource in an area was used for fill (instead of a lower quality resource), and later a quality resource was

Sieve Size mm	Sieve Size inch	Hole #3 Sample #1 1-10 ft	Hole #3 Sample #2 10-21 ft	Hole #3 Sample #3 21-46 ft	Hole #4 Sample #4 2.5-10 ft	Hole #4 Sample #5 10-21 ft	Hole #4 Sample #6 21-31 ft	Hole #5 Sample #7 6-10 ft	Hole #5 Sample #8 10-21 ft	Hole #5 Sample #9 21-46 ft	Hole #2 Sample #10 1.5-10 ft	Hole #2 Sample #11 10-21 ft	Hole #2 Sample #12 21-26 ft	Hole #1 Sample #13 5-15 ft	Hole #1 Sample #14 15-26 ft	Hole #6 Sample #15 4-10 ft	Hole #6 Sample #16 10-21 ft	Hole #6 Sample #17 21-46 ft	Hole #7 Sample #18 3.5-10 ft
102 mm	4"						100												
75 mm	3"	100					89												
63 mm	2 ½"	97		100		100	89	100	100			100		100	100	100			
50 mm	2"		100	97	100	94	89	97	96		100	97		98	98	96			100
37.5 mm	1 ½"	95	97	95	95	89	89	91	94		93	96		96	94	94		100	100
31.5 mm	1 1/4"				91	89	89	88	93	100	91		100		93	94	100	99	97
25 mm	1"	91	94	93	82	85	85	83	85	98	86	94	98	93	91	94	100	97	97
19 mm	3/4"	87	91	90	76	84	83	78	81	98	82	92	98	90	90	93	99	96	95
16 mm	5/8"	86	90	89	74	82	83	77	79	98	81	91	98	87	89	93	99	96	94
12.5 mm	½"	83	87	87	68	81	81	73	75	97	78	89	97	83	88	92	98	95	92
9.5 mm	3/8"	81	84	85	63	79	79	69	72	96	75	88	96	79	83	92	97	94	89
4.75 mm	#4	75	75	81	54	73	75	61	65	94	70	84	93	68	81	91	92	92	80
2.36 mm	#8	68	67	77	50	69	72	55	61	92	67	81	91	63	78	89	87	90	70
2.00 mm	#10	65	63	76	48	67	71	54	59	91	66	80	90	61	76	87	85	89	66
1.18 mm	#16	47	46	66	42	55	62	46	52	90	57	72	85	56	68	71	70	81	45
600 um	#30	18	18	41	28	31	34	25	30	78	17	39	66	27	39	26	32	48	16
425 um	#40	9	9	26	18	16	18	12	16	64	7	21	46	15	19	8	13	26	9
300 um	#50	6	5	14	13	8	7	6	7	42	5	8	20	8	8	3	4	12	6
150 um	#100	2	1	4	8	2	1	2	2	13	2	1	2	3	2	1	1	4	3
75 um	#200	1.1	0.7	1.4	4.6	1.5	0.8	1.6	1.3	4.7	1	0.8	0.8	1.4	1.4	0.8	0.5	0.7	2.2

Sieve Size mm	Sieve Size inch	Hole #7 Sample #19 10-21 ft	Hole #7 Sample #20 21-31 ft	Hole #8 Sample #21 2-10 ft	Hole #8 Sample #22 10-21 ft	Hole #8 Sample #23 21-36 ft	Hole #11 Sample #24 1-10 ft	Hole #11 Sample # 25 10-21 ft	Hole #11 Sample #26 21-46 ft	Hole #10 Sample #27 1-10 ft	Hole #10 Sample #28 10-21 ft	Hole #10 Sample #29 21-46 ft	Hole #9 Sample # 30 1.5-10 ft	Hole #9 Sample #31 10-21 ft	Hole #9 Sample #32 21-46 ft	Composite #1 - Holes 1,2,3,4,5	Composite #2 - Holes 6,7,8	Composite #3 - Holes 9,10,11	Average of all 32 Samples
102 mm	4"	93																	
75 mm	3"	93		100	100														
63 mm	2 ½"	93	100	92	96					100			100		100				98.1
50 mm	2"	93	98	87	93		100	100		97		100	98	100	98	97	96	99	96.9
37.5 mm	1 ½"	93	98	83	90	100	97	98		95		99	96	97	98	95	95	98	94.9
31.5 mm	1 1/4"	93	96	79	90	98	96	96	100	91	100	98	94	96	97	94	94	96	94.4
25 mm	1"	93	92	73	89	96	96	94	99	88	98	97	91	95	97	90	92	95	92.0
19 mm	3/4"	91	88	70	88	95	93	93	98	86	97	95	88	94	96	87	91	93	89.8
16 mm	5/8"	90	86	67	87	94	91	92	98	85	96	94	86	94	96	86	90	92	88.8
12.5 mm	½"	89	84	64	86	93	89	91	97	83	94	92	83	92	95	83	88	91	86.8
9.5 mm	3/8"	87	82	61	85	91	85	90	96	80	91	90	81	91	94	81	86	89	84.5
4.75 mm	#4	81	75	52	81	87	74	86	94	77	82	84	72	87	92	75	81	83	79.0
2.36 mm	#8	74	69	48	79	83	66	81	92	69	72	80	65	81	89	71	77	77	74.2
2.00 mm	#10	71	66	46	77	81	62	79	92	65	68	78	61	79	88	69	74	75	72.1
1.18 mm	#16	51	52	38	64	69	43	64	86	43	47	66	44	65	81	60	60	60	60.1
600 um	#30	14	23	20	26	37	16	21	63	14	15	38	17	25	59	35	27	30	31.3
425 um	#40	6	12	10	8	17	9	9	39	6	7	23	8	10	38	21	12	17	17.3
300 um	#50	3	5	6	3	6	6	5	12	3	3	11	4	4	18	11	5	7	8.5
150 um	#100	2	1	2	1	1	3	1	1	1	1	2	2	1	3	3	2	2	2.4
75 um	#200	1.2	0.7	1.5	0.6	0.3	2.1	0.8	0.5	1	0.8	0.8	1.2	0.8	0.8	1.7	0.9	1	1.3

Table 3. Particle size distribution of samples (the numbers represent the percent material passing through the sieves).

needed for roads, concrete structures, etc., the material would have to be transported from a distance, thus increasing the price of the aggregate, the concrete, and finally the end-product (road). For this reason it is very important to use the material to its maximum potential; the quality tests are performed to determine the properties that help determine that potential.

Table 4 summarizes the quality test results completed by MNDOT. All of the specifications tested for concrete were passed, except for the iron oxide and spall (½") in one of the composites. Soft iron oxide particles are considered deleterious to concrete and MNDOT has a specification "not to exceed 0.3 weight % soft iron oxide" for coarse aggregate for Portland cement concrete. Composite number three has a slightly higher iron oxide percent (0.4), however, with blending this has minimal impact on the value of the deposit. The total spall and average spall passed all specifications, thus with blending has little impact on the value of the aggregate. All other specification tested for concrete were passed (table 4).

Quality Tests Completed by MNDOT Laboratory	Composite Number 1	Composite Number 2	Composite Number 3	Average of Composites	MNDOT Specs.
% Shale, ½"+	0	0	0	0	0.4
% Shale in Sand	N.C.	N.C.	N.C.	N.C.	
% Shale (Total) +4	0	0	0	0	0.7
% Iron Oxide	0.2	0.3	**0.4**	0.3	0.3
% Ochre	0	0	0	0	
% Unsound Chert	0.1	0.2	0	0.1	
% Slate	0	0	0	0	
% Carbonate	3	0	6	3	30.0
% Sandstone	3	8	1.4	4.1	
% Schist	0.06	1.00	1.24	0.77	3.0
% Thin/ Elong.	0	0	0	0.0	
% Clay balls	0	0	0	0.0	
% Other Rock	93.6	90.7	90.8	91.7	
% Spall 1"	0	0	0	0.0	
% Spall ½"	0.3	0.3	1.2	0.6	1.0
% Spall #4	0.6	1.1	0.2	0.6	1.5
% Soft Rock	0.1	0	0.5	0.2	2.5
% Total Spall +4	0.3	0.5	0.4	0.4	1.0
%Spall & Soft Rock	0.3	0.5	0.9	0.6	2.5
% Absorpt (-4)	0.69	0.61	0.74	0.68	NA
Bulk SpG (-4)	2.635	2.654	2.645	2.645	NA
App. Spg (-4)	2.684	2.698	2.698	2.693	NA
% Absorpt 1 ½+	0.55			0.55	1.7
% Absorpt 1 ½-3/4	1.2			1.2	1.7
% Absorpt 3/4-3/8	1.34			1.34	1.7
% Absorpt 3/8-#4	1.56	1.6		1.58	1.7
Bulk SpG 1 ½+	2.772			2.772	
Bulk SpG 1 ½-3/4	2.704			2.704	
Bulk SpG 3/4-3/8	2.684			2.684	
Bulk SpG 3/8-#4	2.659	2.653		2.656	
LAR A-Pct Loss	21.96			21.96	40.0
Mag%Lost 2-1 ½"	7.2			7.2	15.0
Mag%Lost 1 ½-1	0.49			0.49	15.0
Mag%Lost 1-3/4	4.14			4.14	15.0
Mag%Lost 3/4-1/2	4.63			4.63	15.0
Mag%Lost ½-3/8	5.24			5.24	15.0
Mag%Lost 3/8-4	7.4			7.4	15.0
MagSulf Tot % Loss	4			4	

Table 4. Summary of the quality test results completed by MNDOT.

Other Textural Properties

The sand and gravel at the site is generally very clean (washed), moderately to well-rounded, and well sorted. This sediment is ideal for concrete aggregate; these clean-washed sands are some of the best sands in the state for concrete aggregate and are also close to the largest market in the state (Twin Cities Area). According to another company within a few miles of the deposit, the rounded grains of the sands are very good for concrete because it is much easier to finish surfaces with round grains (very good workability), thus requiring less water and cement, thus increasing strength and decreasing costs.

Volume Estimates

Two volume estimates were calculated for the Bayport Site; these were based on the minimum elevation that Miller Excavating was allowed (by Wildlife) to mine (Elevation = 820) and the proposed mine plan Miller Excavating constructed (Elevation = 805). The volumes were estimated assuming a post mine plan to preserve 4:1 side slopes on the east, west, and north sides. The volume of the sand and gravel resource above 820 feet in elevation is approximately 270,000 cubic yards. The volume of sand and gravel between 820 and 805 feet in elevation is approximately 135,000 cubic yards. The total volume of sand and gravel for the Bayport Site is thus approximately 400,000 cubic yards, assuming an excavation elevation of 805 feet and a 4:1 post mine plan slope. The volume estimates and cross-sections are summarized in Plate 1.

Geophysical Study

The geophysical EM Conductivity study helped define the trends between drill holes, provided information for the areas not drilled, helped determine the extent of the deposit, and was used to correlate the textural characteristics of know area with those areas in question. The information obtained from this study corresponded very well with the textural characteristics (percent gravel) found within the drill holes. The geophysical data obtained from this study showed that there are areas containing a higher gravel percent than the areas drilled (>54%). The geophysical (EM Conductivity) data is summarized in appendix C.

CONCLUSIONS

- This detailed aggregate evaluation was completed on 13.6 acres of state owned land, managed and administered by the MN-DNR, Division of Wildlife.
- The evaluation included aerial photograph and map interpretation, drilling, logging, sampling, field observation, geophysical studies, labwork, statistical analysis, research, computer aided mapping, etc.
- The Bayport site consists almost entirely of sand and gravel (>50 feet in thickness), which was deposited as glaciofluvial outwash on a large terrace within the St. Croix River valley.
- The estimated volumes of sand and gravel material within this deposit are: (± 20%)
  - ~270,000 cubic yards of sand and gravel to an elevation of 820 feet.
  - ~135,000 cubic yards of sand and gravel from 820 to 805 feet in elevation.
  - ~400,000 cubic yards of sand and gravel total (to 805 ft and 4:1 slope).
- The overburden thickness is minimal, ranging from 1 to 6 ft (averaging < 3 ft), except in the extreme southwestern portion of the map area where a thicker silty-clay exists.
- Due to the minimal amount of overburden and the thick gravel deposit, the stripping ratio is very favorable, however is variable due to the elongated-ridge shape of the deposit.
  - 1:10 (820 elevation), 1:15 (805 elevation), however are variable-due to ridge.
- The water table was not encountered in the top 50 feet, thus does not pose a problem.

- Quality testing showed that the aggregate is of very high quality; it meets most of the specifications for concrete aggregate and meets all specifications with very little blending. The Iron Oxide and Spall (½") in composite #3 are slightly higher than the specification, however meet the specifications with blending.
- With blending and screening, the material meets and exceeds the specifications for any of the typical sand and gravel products, such as those listed on the example price list in Appendix B (Aggregate Product and Specification Guide).
- The gravel content is very high in the upper 21 feet of the deposit, ranging from 13 to 54%, and averaging 38.1% in the top 10 ft. and 26.9% between 10 and 21 feet in depth.
- The average percent gravel within the entire deposit is approximately 27%.
- Geophysical studies (EM Conductivity) suggest that even coarser material (higher gravel %'s) exists within the deposit , however it was not drilled or sampled in this study.
- The sand and gravel is generally well rounded and washed, which is ideal for concrete.
- The estimated total royalty or lease value of deposit (mined to an elevation of 805 ft):
    - Assuming estimated royalty of $1.00/ cubic yard of aggregate = $400,000
    - Assuming estimated royalty of $0.90/ cubic yard of aggregate = $360,000
    - Assuming estimated royalty of $0.80/ cubic yard of aggregate = $320,000
    - Assuming estimated royalty of $0.70/ cubic yard of aggregate = $280,000
- The highest quality material (greatest percent gravel) lies within the upper 21 feet of the deposit, thus if Wildlife decides to lease the resource only to an elevation of 820 feet, the highest royalty value should be charged (approximately $1.00-$1.50/cubic yard).
    - 270,000 cubic yards * $1.00/cubic yard = $270,000 royalties (± 20%)
- If Wildlife decides to let Miller mine the sand and gravel to an elevation of 805, where the gravel % is much less, a lower royalty rate could be incorporated for this material.
    - 135,000 cubic yards * $0.70/cubic yard = $ 94,500 royalties (additional; ± 20%)
- If Wildlife decides to lease the entire deposit (to an elevation of 805 feet with 4:1 post mine slopes) the lease value could be set at an intermediate value ($0.85-$0.90/yards^3).
    - 400,000 cubic yards * $0.85/cubic yard = $340,000 royalties (± 20%)
    - 400,000 cubic yards * $0.90/cubic yard = $360,000 royalties (± 20%)
- It is the suggestion of the author/geologist to lease the entire deposit (to a depth of 805 feet, with a post mine slope of 1:4) at an intermediate royalty rate of $0.85-$0.90 per cubic yard. This would maximize the profits obtained from this resource for Wildlife, as well as supply material to Miller Excavating at a more affordable rate. If the lease allows Miller Excavating to mine only to an elevation of 820 feet, which would remove the highest quality aggregate, it is less likely (economically) that another company in the future could/would set up their equipment to mine the remaining lower quality material (<135,000 cubic yards).
- This Study was completed with a > 80% certainty (margin or error ± 20%). Although drilling gives us a fairly accurate representation of the deposit, variations within the deposit may exist that were not encountered. For example, the geophysical study showed that coarser (better quality) material exists within the deposit, however this sediment was not drilled or tested. Fluvial systems also tend to have more variability within them than other deposits.
- Additional information that could be incorporated into the lease to benefit both parties:
    - Allow Miller to mine a little extra material (on the adjacent property) on the east side of the study area where otherwise a small ridge would be left behind. This would improve the esthetics and increase the possibilities for other land uses after mining, as well as supply Miller with additional material.

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APPENDICES

Appendix A. Field Descriptions of Drill Holes (11 Holes).

Driller: Gene Tormanen MNDOT
Geologist: Jon Ellingson DNR-Minerals
Dates Drilled: May 13th and 14th, 1998

Bayport-Hole #1

Depth (ft) From	To	Description
0	5	Stripping-Overburden: silty clay grading downward to gravel.
5	8	Coarse Sand and Gravel: cobbly-, pebbly-, granular-gravel and coarse-grained sand most dominant textures, clean-washed gravel and sand, "very nice looking gravel", approximately 40% gravel (>2mm), nice grain size distribution of gravel, low shale and carbonate content.
8	11	Coarse Sand and Gravel: slightly more sand than above, however is still a cobbly-, pebbly-, granular-gravel and coarse-grained sand most dominant textures, clean-washed gravel and sand, "very nice looking gravel".
11	15	Coarse Sand and Pebbly Gravel: most material less than 1.5 in, pebbles very abundant throughout, sandier than above with a gradual increase in the amount of sand downward, cobbles are rare but occur.
15	21	Coarse Sand and Granules: Clean-washed coarse sand dominates the sediment, however, granules and pebbles occur throughout, occasional cobbles (<3 in.) Occur throughout.
21	23	Cobble Layer: difficult to drill through, several 3 in cobbles and a few very large cobbles (up to 8 in.), took several minutes to penetrate this layer with the drilling rig.
23	26	Medium- to Coarse-Grained Sand: Easy drilling, coarse-grained sand dominant with medium-grained sand layers, pebbles and granules occur throughout sediment, occasional cobble.

Samples Collected: Sample #13 (5ft-15ft), Sample #14 (15ft-26ft), & Composite #1 (5ft-26ft).

Bayport-Hole #2

Depth (ft) From	To	Description
0	1.5	Stripping-Overburden: light brown, silty clay.
1.5	5	Coarse Sand and Gravel: clean-washed coarse sand and granules most dominant, pebbles abundant, occasional cobble.
5	7	Coarse Sand and Granules: Easy drilling, clean-washed granules and coarse sand dominant, pebbles occur throughout, rarely cobbles (3 inch).
7	10	Granules and Coarse Sand: decrease in the number of pebbles downward, cobbles are absent, washed-clean, most material less than pea sized.
10	19.5	Coarse Sand and Granules: Easy drilling, washed clean, occasional pebbles and cobbles.
19.5	21	Cobbly Layer: Difficult drilling (5 minutes to penetrate), large and small cobbles ranging from 2.5 to 6 inches, mixed with washed-clean coarse sand and granules.
21	26	Fine- to Medium-Grained Sand: Sand drills very easily, layers and lenses of coarse-grained sand and granules, light brown to tan in color, well- to moderately-sorted, pebbles rare, and cobbles absent.

Samples Collected: Sample #10 (1.5ft-10ft), Sample #11 (10ft-21ft), Sample #12 (21ft-26ft), & Composite #2 (1.5ft-26ft).

Bayport-Hole #3

Depth (ft) From	To	Description
0	1	Stripping-Overburden: black organic at surface; gravelly & rocky.
1	5	Coarse Sand and Gravel: pebbles and granules abundant, most material in less than 0.5 in, very clean-washed coarse sand and less than pea sized gravel is most dominant, occasional rounded to well-rounded cobble (usually less than 4-5 in.), low carbonate content, low shale content, approximately 40% gravel (>2mm).
5	7.5	Coarse Sand and Gravel: more sand than the above, pebbles and granules abundant, most material in less than 0.5 in, very clean-washed coarse sand and less than pea sized gravel is most dominant, occasional rounded to well-rounded cobble (usually less than 4-5 in.), low carbonate content, low shale content.
7.5	10	Coarse Sand with less Gravel: more sand than the above, sand is coarsening downward, a decrease in the number of pebbles and granules downward, most material in less than 0.5 in, very clean-washed coarse sand and less than pea sized gravel is most dominant, occasional rounded to well-rounded cobble (usually less than 4-5 in.), low carbonate content, low shale content.
10	15	Coarse Sand and Granules: clean-washed coarse sand and granules, with some coarser gravel, most gravel is less than 1.5 in., occasional pebbles and cobbles-sub-rounded to rounded, low carbonate and shale content.
15	21	Coarse Sand and Granules: clean-washed coarse sand and granules, with some coarser gravel, most gravel is less than 1.5 in., occasional pebbles and cobbles, decrease in the amount of coarse gravel downward-gradation, granules most abundant form of gravel, low carbonate and shale content.
21	37	Coarse Sand with some Fine-Gravel: Increase in coarse sand downward as well as a decrease in the amount of gravel downward-gradational, medium-grained sand layers and lenses(thin; <6 inches), occasional to rare pebbles and cobbles, well sorted sand.
37	38	Cobbly and Pebbly Layer: thin one foot layer of coarse material-difficult drilling.
38	43	Coarse Sand with some Fine-Gravel: same material as above the cobble layer, coarse sand very prominent, medium-grained sand layers and lenses, occasional to rare pebbles and cobbles, well sorted sand.
43	46	Gravelly and Cobbly: very coarse grained material (pebbles and cobbles most dominant), difficult to drill through, coarse sand and granules very abundant, occasional clay balls and sand layers.

Samples Collected: Sample #1 (1ft-10ft), Sample #2 (10ft-21ft), Sample #3 (21ft-46ft), & Composite #3 (1ft-46ft).

Bayport-Hole #4

Depth (ft) From	To	Description
0	2.5	Stripping-Overburden: topsoil-black, organic, grading to silty clay.
2.5	10	Gravel: Granules and pebbles are very abundant, with thin cobbly layers throughout, >40% gravel, most material less than 2 inches in diameter, very nice gravel, nice gradation spread, coarse sand occurs throughout, with very little medium- to fine-grained sand.

Bayport-Hole #4 *(Continued)*

Depth (ft) From	To	Description
10	15	Coarse Sand and Gravel: washed-clean pebbles, granules, cobbles, and coarse sand, pebbles (1-1.5 in) are the most dominant gravel size along with granules, however coarse sand dominates the sediment, less than 30% gravel, low to no shale, low carbonate content.
15	21	Coarse Sand and Granules: sandier than above, less gravel, occasional small cobble and rarely a large cobble, granules very abundant, no shale, low carbonate.
21	30	Coarse Sand and Granules: the amount of gravel is decreasing downward, cobbles and pebbles are rare if not absent.
30	31	Gravely Cobbly Layer: Pebbles and small cobbles dominant with one larger cobble (5 in).

Samples Collected: Sample #4 (2.5ft-10ft), Sample #5 (10ft-21ft), Sample #6 (21ft-31ft), & Composite #4 (1.5ft-26ft).

Bayport-Hole #5

Depth (ft) From	To	Description
0	6	Stripping-Overburden: silty clay, increase in gravel downward.
6	10	Pebbly Gravel and Coarse Sand: granules and pebbles very abundant, with cobbles occurring occasionally, the sediment is well rounded, and most of the gravel is between 0.5 - 0.75 inches, the sand is a little finer than in holes 3 & 4, no shale, little limestone.
10	15	Coarse Sand and Gravel: pebbles and granules very abundant, most gravel was 0.5 to 0.75 inches in diameter, washed coarse sand, cobbles occurring occasionally, pebbles are well rounded, no shale was found, rarely carbonates.
15	21	Coarse Sand and Gravel: decrease in the amount of granules downward (less than above), pebbles are very abundant, with cobbles occurring occasionally, washed-clean coarse sand.
21	25	Gravel and Coarse Sand: same as above with the amount of gravel decreasing downward.
25	38	Medium- to Coarse-Grained Sand and Granules: smooth, easy drilling; fine-, medium-, and coarse-grained sand, with granules throughout, well sorted sand, light brown to tan in color, pebble, clay, and silt layers are present but rare.
38	40	Gravel and Cobbles: Thin 1-2 foot layer of pebbles, small cobbles, and large cobbles with a sand matrix, rough drilling.
40	46	Medium- to Coarse-Grained Sand and Granules: smooth, easy drilling; gravel and cobbles occur throughout, coarsening sequence downward; coarse sand and granular gravel gradually become more dominant downward.

Samples Collected: Sample #7 (6ft-10ft), Sample #8 (10ft-21ft), Sample #9 (21ft-46ft), & Composite #5 (6ft-46ft).

Bayport-Hole #6

Depth (ft)		
From	**To**	**Description**
0	4	Stripping-Overburden: black topsoil over silty clay.
4	5	Cobbles, Gravel, and Coarse Sand: washed-clean coarse sand and granules are most prominent, with abundant cobbles throughout (Storm Delay- Rain, Lighting- 1 hr.).
5	10	Coarse Sand and Granules: washed-clean coarse sand and granules with pebbles occasionally occurring and rarely cobbles, low limestone, no shale, 25% gravel.
10	15	Coarse Sand and Granules: washed-clean granules and coarse sand with pebbles scattered throughout, cobbles are rare but occur, approximately 25% gravel.
15	21	Granules and Coarse Sand: washed-clean granules and coarse sand with the amount of pebbles increasing downward, coarser than above sediment, rounded to well-rounded cobbles occur throughout.
21	41	Medium- to Coarse-Grained Sand and Granules: smooth, easy drilling; fine-, medium-, and coarse-grained sand, with granules throughout, moderately to well sorted sand, light brown to tan in color, pebble, clay, and silt layers are present but rare, not much gravel.
41	42	Gravel and Cobbles: Thin 1 foot layer of pebbles, small cobbles, and large cobbles with a sand matrix, rough drilling.
42	46	Medium- to Coarse-Grained Sand and Granules: same as above cobble layer, smooth, easy drilling; fine-, medium-, and coarse-grained sand, with granules throughout, moderately to well sorted sand, light brown to tan in color, pebble, clay, and silt layers are present but rare, not much gravel.

Samples Collected: Sample #15 (4ft-10ft), Sample #16 (10ft-21ft), Sample #17 (21ft-46ft), & Composite #6 (4ft-46ft).

Bayport-Hole #7

Depth (ft)		
From	**To**	**Description**
0	3.5	Stripping-Overburden: black topsoil and silty clay; layered.
3.5	10	Gravel and Coarse Sand: approximately 40% gravel, pebbles and granules are very abundant with occasional cobbles, most gravel is less than 1.25 inches in diameter, washed-clean coarse sand makes up the remaining 60 % of the sediment, no shale found, little limestone.
10	15	Gravel and Coarse Sand: a little less gravel than above, pebbles and granules are very abundant with occasional cobbles, most gravel is less than 1 inch in diameter, washed-clean coarse sand makes up the remainder of the sediment, no shale found, little limestone.
15	21	Gravel and Coarse Sand: still approximately 35-40% gravel, however more granules and less pebbles occur downward, the coarse sand is washed-clean and well sorted.
21	31	Medium- to Coarse-Grained Sand and Granules: abundant pebbles are scattered throughout the sediment with cobbles occurring occasionally.

Samples Collected: Sample #18 (3.5ft-10ft), Sample #19 (10ft-21ft), Sample #20 (21ft-31ft), & Composite #7 (3.5ft-31ft).

Bayport-Hole #8

Depth (ft)		
From	**To**	**Description**
0	2	Stripping-Overburden: silty clay layers.
2	4	Gravel and Coarse Sand: well-rounded pebbles and small cobbles very abundant, occasional medium sized cobble (<4.5 inches), approximately 40% gravel, the sediment is dominated by coarse sand and granules, low limestone and no shale found.
4	11	Coarse Sand and Gravel: clean-washed coarse sand and granules are most prominent, pebbles and cobbles are very abundant, a cobble layer encountered from 6 to 7 feet.
11	15	Coarse Sand and Gravel: clean-washed coarse sand and granules dominate sediment, pebbles occur throughout but less than above, less cobbles than above but still present (decreasing in size and abundance downward), cobbles becoming rare to absent near base, occasion layer of small and medium sized cobbles (< 5 inches), most gravel is less than 1.5 inches.
21	36	Coarse Sand and Granules: easy drilling, no cobbles encountered, washed-clean coarse sand and granules dominate sediment, some medium-grained sand layers and lenses, less than 25% gravel, occasional pebbles and rarely a cobble towards the bottom, thin layers (< 1 ft.) of gravel occur where pebbles are abundant.

Samples Collected: Sample #21 (2ft-10ft), Sample #22 (10ft-21ft), Sample #23 (21ft-36ft), & Composite #8 (2ft-36ft).

Bayport-Hole #9

Depth (ft)		
From	**To**	**Description**
0	1.5	Stripping-Overburden: black topsoil over silty clay; layered.
1.5	13	Gravel and Coarse Sand: nice spread out (grain size) gravel, gravel percent approximately 40-45%, washed-clean, coarse sand, granules, abundant pebbles, occasional cobbles and cobble layers, this as a very nice gravel, no shale found, low carbonate %.
13	21	Gravel and Coarse Sand: washed-clean coarse sand and granules are dominant, abundant pebbles, cobbles and cobble layers occur but are rare, the amount of gravel decreases downward, pebbles are smaller and fewer than above (<1.25 in).
21	25	Coarse Sand and Granules: washed-clean sediment, the amount of gravel is decreasing downward, occasionally pebbles and pebble layers occur, cobbles rare, similar to above, just less gravel.
25	29	Medium- and Coarse-Grained Sand: well-sorted, medium grained sand, tan to light brown in color, coarse-grained sand present throughout, as well as in layers and lenses, rarely pebbles and pebbly layers, very little gravel, decrease in gravel downward.
29	31	Gravely Cobbly Layer: pebbles and small and medium sized cobbles dominant.
31	46	Medium- and Coarse-Grained Sand: similar to above cobble layer, well-sorted, medium grained sand, tan to light brown in color, coarse-grained sand present throughout, as well as in layers and lenses, rarely pebbles and pebbly layers, very little gravel, decrease in gravel downward.

Samples Collected: Sample #30 (1.5ft-10ft), Sample #31 (10ft-21ft), Sample #32 (21ft-46ft), & Composite #9 (1.5ft-46ft).

Bayport-Hole #10

Depth (ft)		
From	**To**	**Description**
0	1	Stripping-Overburden: black silty topsoil.
1	5	Gravel and Coarse Sand: washed-clean sediment, nice spread out gravel distribution, granules abundant, pebbles abundant, occasional cobble, approximately 30 % gravel, coarse-grained sand is prominent sediment.
5	10	Gravel and Coarse Sand: similar to above with less gravel, washed-clean sediment, spread out gravel distribution, granules abundant, pebbles abundant, occasional cobble (less than above), coarse-grained sand is prominent sediment.
10	21	Gravel and Coarse Sand: decrease in gravel % downward, still a very nice gravel, washed-clean sediment, spread out gravel distribution, granules abundant, pebbles abundant, occasional small cobble (less than above), coarse-grained sand is prominent sediment.
21	29	Coarse Sand and Granules: easy drilling through coarse sand and fine-gravel, clean-washed, granules very abundant, pebbles throughout, occasional cobble, nice gravel, little sandy.
29	32	Gravelly Cobbly Layer: Layer of small and medium sized cobbles with a pebbly gravel matrix, took 5 minutes to drill through-tough drilling.
32	36	Medium- and Coarse-Grained Sand: well-sorted, medium grained sand, tan to light brown in color, coarse-grained sand present throughout, as well as in layers and lenses, rarely pebbles and pebbly layers, very little gravel.

Samples Collected: Sample #27 (1ft-10ft), Sample #28 (10ft-21ft), Sample #29 (21ft-36ft), & Composite #2 (1ft-36ft).

Bayport-Hole #11

Depth (ft)		
From	**To**	**Description**
0	1	Stripping-Overburden: black topsoil; very thin.
1	5	Gravel and Coarse Sand: very nice gravel, approximately 40% gravel content, no shale detected, low carbonate %, washed-clean coarse sand and granules very abundant, pebbles abundant, cobbles layers occur throughout.
5	10	Gravel and Coarse Sand: nice gravel, similar to above with a decrease in gravel percent downward, approximately 30-35% gravel content, no shale detected, low carbonate percent, washed-clean coarse sand and granules very abundant, pebbles abundant, cobbles layers occur throughout.
10	16	Granules and Coarse Sand: washed-clean coarse sand and granules dominate to sediment, occasional layer of pebbles, most pebbles are less than 1.25 inches, cobbles occur throughout as well as in thin layers.
16	17.5	Cobble Layer: thin layer of coarse material, mostly pebbles and cobbles (<4 inches), matrix consists of similar sediment to above.
17.5	27	Granules and Coarse Sand: similar sediment to what was above the cobble layer, washed-clean coarse sand and granules dominate to sediment, occasional layer of pebbles, most pebbles are less than 1.25 inches, cobbles occur throughout as well as in thin layers.

Bayport-Hole #11 *(Continued)*

Depth (ft) From	To	Description
27	30	Gravelly Cobbly Layer: Layer of small and medium sized cobbles with a pebbly gravel matrix, difficult drilling.
30	46	Medium- and Coarse-Grained Sand: well-sorted, medium grained sand, tan to light brown in color, coarse-grained sand present throughout, as well as in layers and lenses, rarely pebbles and pebbly layers, very little gravel.

Samples Collected: Sample #24 (1ft-10ft), Sample #25 (10ft-21ft), Sample #26 (21ft-46ft), & Composite #11 (1ft-46ft).

Appendix B. Aggregate Product and Specification Guide.

Aggregate Product And Specification Guide

CAMAS

Shiely Division

SAND - (Percent Passing)

Sieve Size (Inches)	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200	Product Meets	Application	Available at:
Sieve Size (Millimeters)	9.5	4.75	2.36	2.00	1.18	600μm	425μm	300μm	150μm	75μm			
Microfine Sand					100	65-85		15-30	0-3	0-1	U.S.G.A.	Golf Course, Top Dressing, Soil Mixture	Lakeland
Masonry Sand		100	95-100		70-100	40-75		10-35	2-15	0-5	ASTM C-144 MN DOT 3128	Masonry, Soil Mixtures, Golf Course	Lakeland, Lakeville East, Lakeville West, St. Paul, Elk River
Stucco Sand (Nelson Fine)		100	95-100		70-100	40-75		10-35	2-15	0-5	ASTM C-144	Masonry, Stucco	St. Paul
Concrete Sand	100	95-100	80-100		55-85	30-60		5-30	0-10	0-3	ASTM C-33 MN DOT 3126 MN DOT 3127	Concrete Mixes Backfill	Lakeland, Lakeville East, Lakeville West, Maple Grove, St. Paul, Mpls., Elk River
Limestone Sand (Manufactured)	100	70-90								0-6		Bituminous Mixes, Architectural Concrete	Larson, Shakopee
Fine Filter Aggregate	100	90-100		45-90			15-45			0-3	MN DOT 3149 2.J	Edgedrains, Backfill	St. Paul, Lakeland, Lakeville East, Lakeville West, Maple Grove
Safety Grit Ice Control	100	90-100	50-95		15-50	30-60		0-5	0-5			Ice Control	St. Paul, Lakeville East

GRAVEL - (Percent Passing)

Sieve Size (Inches)	2"	1-1/2"	1-1/4"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#50	Product Meets	Application	Available at:
Sieve Size (Millimeters)	50	37.5	31.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	300μm			
#4 Roofing Gravel (2" to 1/4")	100	90-100		20-55	0-15		0-5					ASTM C-33	Roofing, Landscaping, Bedding	Lakeville West
#4 Gravel (1-1/2" to 3/4")		100	85-100		5-35		0-5					MN DOT 3137 CA-1 & CA-3	Concrete, Bedding, Roofing, Landscaping, Drainfield	Lakeland, Lakeville East, Lakeville West, Maple Grove, St. Paul, Mpls, Elk River
#6 Gravel (1" to 1/2")				100	90-100	20-55	0-15	0-5				ASTM C-33	Bedding, Landscaping	St. Paul, Mpls, Elk River
#67 Gravel (1" to 1/4")				100	85-100		30-60	0-12				MN DOT 3137 CA-50, 3149 2.H ASTM C-33	Concrete, Bedding, Landscaping, Coarse Filter	Lakeland, Lakeville East, Lakeville West, Maple Grove, St. Paul, Mpls, Elk River
#7 Gravel (5/8" to #4)					100	90-100	40-70	0-15	0-5			MN DOT 3127 FA-4 MN DOT 3137 CA-70 ASTM C-33	Exposed Aggregate, Concrete, Roofing	St. Paul, Mpls, Maple Grove, Elk River
#89 Gravel (1/2" to #8)						100	90-100	20-55	5-30	0-10	0-5	ASTM D-448	Exposed Aggregate, Concrete, Precast Concrete	Lakeville East, Maple Grove
#CA-8 Gravel (3/8" to #8)							100	70-95			0-5	MN DOT 3137 CA-8	Sealcoating, Backfill, Concrete Block Core Fill	Maple Grove, Nelson, St. Paul, Mpls
Boulder Rip Rap			18" 100		9" 50-70		6" 40-60		2" 0-20			MN DOT 3601 Class II Rip Rap	Stone Walls, Erosion Control, Landscaping	Lakeville West
Gabion					9" 100		6" 35-70		2" 0-20				Erosion Control, Gabion Baskets	Nelson

LIMESTONE - (Percent Passing)

Sieve Size (Inches)	4"	2"	1-1/2"	1-1/4"	1"	3/4"	1/2"	3/8"	#4	#8	#10	#16	#40	#50	#60	#200	Product Meets	Application	Available at:
Sieve Size (Millimeters)	100	50	37.5	31.5	25.0	19.0	12.5	9.5	4.75	2.36	2.00	1.18	425μm	300μm	250μm	75μm			
#2 Keystone (4" to 3/4")	100	35-70	0-15			0-5												Landscaping, Stabilizing Soft Areas	St. Paul, Larson
#CA-3 Keystone (1-1/2" to 3/4")			100	85-100		5-35		0-5									MN DOT 3137 CA-3	Concrete, Landscaping, Bedding	St. Paul, Larson, Mpls, Shakopee
#67 Keystone (1" to 1/4")					100	90-100		20-55	0-10	0-5							ASTM C-33	Concrete, Landscaping, Bedding	St. Paul, Larson, Mpls, Shakopee
#7 Keystone (5/8" to 1/4")						100	90-100	40-70	0-15	0-5							ASTM C-33	Concrete, Bedding, Architectural Concrete	Larson, Shakopee
#8 Keystone (1/2" to #16)							100	85-100	10-30	0-10		0-5					ASTM D448 #8	Architectural Concrete, Bituminous Mixes	Larson, Savage, Shakopee, St. Paul
#89 Keystone (3/8" to #30)							100	90-100	20-55	5-30		0-10		0-5			ASTM D448 #89	Concrete Block, Architectural Concrete, Bituminous Mix	St. Paul, Larson
3" Minus	100	90-100				30-70			10-40				10-25			0-7		Stabilizing Soft Areas, Temporary Road	Shakopee
1-1/2" Class 5 Modified			100		65-90	40-75		35-55	20-40		15-30		10-25			3-10		Streets, Hwys, Industrial Areas	St. Paul, Larson, Shakopee
1" Class 5 100% Crushed Rock					100	90-100		50-90	35-70		20-55		10-35			3-10	MN DOT 3138 Class 5	Parking Areas, Hwys, Streets, Tennis Courts	Lakeland, Maple Grove, St. Paul, Mpls, Shakopee, Larson
Class 2						100		65-90	35-70		25-45		12-30			5-13	MN DOT 3138 Class 2	Shouldering	Shakopee
3/8" Minus								100	80-100		35-70		20-55			10-25		Bike Trails, Running Trails	Larson, Shakopee
Aglime									100	90-100					40-80	15-25		Neutralizing Soils	Larson, Shakopee
Rip Rap																	MN DOT 3601 Class II-V	Erosion Control, Landscaping	Larson - Class II, III, IV & V Shakopee - Class III, IV & V

NOTE: Use this information as a guide only. CAMAS's service representatives can assist you on specific product information.

- ★ **East Lakeville** — 5000 160th St., Sand, Gravel, Recycled Base
- ★ **Elk River** — 2170 Highway 169, Sand & Gravel
- ★ **Lakeland** — 16164 Hudson Blvd., Sand, Gravel, Recycled Base
- ★ **Larson** — 10120 Grey Cloud Island Dr., St. Paul Park, Crushed Stone, Rip Rap
- ★ **Maple Grove** — 11600 County Rd #109, Sand, Gravel, Recycled Base
- ★ **Minneapolis** — 26th & Pacific, Sand, Gravel, Crushed Stone
- ★ **Nelson** — 11250 Grey Cloud Island Dr., Cottage Grove, Sand, Gravel
- ★ **Shakopee** — 6896 Hwy. 101 (1 mile East of Valley Fair), Crushed Stone, Recycled Base
- ★ **St. Paul Yard** — 1177 Childs Road, Sand, Gravel, Crushed Stone
- ★ **West Lakeville** — 11963 West 205th St., Sand, Gravel, Recycled Base

1998
Contractor Price List

Prices Effective January 1, 1998

Sales: **612-683-0600**

Product delivery: **612-423-7004**

Minnesota WATS Line: **1-800-338-3943**

CAMAS
Shiely Division
2915 Waters Road, Suite 105
Eagan, Minnesota 55121
Supplying Quality Aggregates Since 1914

PRODUCTS — F.O.B. SHIELY LOCATIONS - ALL PRICES PER TON - 2,000 POUNDS

SAND No moisture deductions	ST. PAUL	MPLS.	ELK RIVER	LAKELAND	EAST LAKEVILLE	WEST LAKEVILLE	MAPLE GROVE	NELSON Grey Cloud	LARSON Grey Cloud	SHAKOPEE
Masonry	7.55	8.25	6.50	7.60	7.15	7.50				
Micro Fine				10.50						
Concrete	6.05	6.50	2.05	4.10	2.65	4.30	4.40	4.25		
Fill	3.65	4.15	1.80	2.40	1.70	2.80	3.25	2.60		
Salted Sand (Ice Control)	16.15		16.15		16.15					
Safety Grit / Ice Control Rock	5.70				2.75					
Fine Filter Aggregate	7.85			6.80	7.45					
GRAVEL										
4 Gravel (1-1/2" to 3/4")	10.70	11.30	7.85	10.35	9.15	10.25	10.40	10.40		
1-1/2" Roofing Ballast			11.50			11.40	12.00			
67 Gravel (1" to 1/4")	10.70	11.30	8.05	10.35		11.40	10.40	10.40		
7 Gravel (5/8" to 1/4")	12.25	13.25	12.25				12.25			
6 Gravel (1" to #8)	10.15				9.15		10.05			
CA-8 Gravel (3/8" to #8)	8.10	8.85	9.50	9.70		9.75	9.10	7.10		
89 Gravel (1/2" to #8)					9.95					
3/4" Sand & Gravel Mix (50/50)	9.25		8.40	8.05	8.05		8.50			
Gabion (Call City Desk for sizing)			30.00	30.00	30.00	30.00		13.50		
KEYSTONE - Crushed Rock										
2 Key (4" to 1-1/2")	7.70								7.70	
CA-3 (1-1/2" to 3/4")	8.65	9.15	16.65	16.65			16.65			7.20
67 Key (3/4" to 1/4")	10.00	10.55	16.65	16.65			16.65			7.20
6 Key (1" to #8)	10.00									
8 Key (3/8" - #16)									8.50	
89 Key (1/2" to #8)									8.50	
3" Minus (Stabilizing Base)										5.80
1-1/2" Minus (Class 5 Modified)	5.35								5.35	5.00
Class 5 - 100% Crushed	5.45	6.05	10.25	9.75	9.75		10.50		5.45	5.10
Class 2 Shouldering										5.60
3/8" Minus									4.85	
Rec Rock (Ball Fields)	7.20									
Aglime	7.00	7.60							6.80	8.25
Manufactured Sand									5.75	5.75
Filter Blanket for Rip Rap	8.35								8.05	
Rip Rap I - III									11.00	11.00
Rip Rap IV - V									11.75	11.75
Class 5 Recycled Concrete & Bituminous				4.35	4.55	4.55	4.55			4.25
Class 5 Sand and Gravel			3.15							
LANDSCAPE & MISC AGGEGATES										
Red # Limestone			37.00	37.00			37.00			
Gray # Granite			37.00							
Gray # Trap Rock			37.00	37.00			37.00			

TERMS: A 2% discount is allowed on materials only if paid within 15 days of the date on the weekly invoice. Net 30 days. The above prices are based on availability and are subject to change without notice.

TAXES: Add $0.07 per ton to the above prices for the State Aggregate Tax. Add Minnesota State sales taxes of 6 1/2 % and an additional 1/2% sales tax when purchasing materials in Minneapolis and St. Paul.

WINTER HEATING CHARGES: MAPLE GROVE, MINNEAPOLIS and ST. PAUL - $5.65/ton. EAST LAKEVILLE - $5.15/ton.

Appendix C. Geophysical Data Summarized

Geophysical Study #1: Preliminary Study of the Bayport Site - Reconnaissance Study

- Consisted of 5 randomly placed lines and 46 stations
- Stations are displayed as plus signs on the graphical representations

Geophysical Study #2: Final Study of the Bayport Site - Final Detailed Study

- Consisted of a 20 meter grid pattern with 8 lines and 83 stations
- Stations are displayed as stars on the graphical representations

- The darker shades on the graphical representation of the geophysical study represent areas of lower conductivities (coarser material- more gravel).
- The black dots represent test hole locations.
- The horizontal dipole represents the near surface sediment.
- The vertical dipole represents the deeper material.

Geophysical Study #1: Preliminary Study of the Bayport Site (Electromagnetic Conductivity)

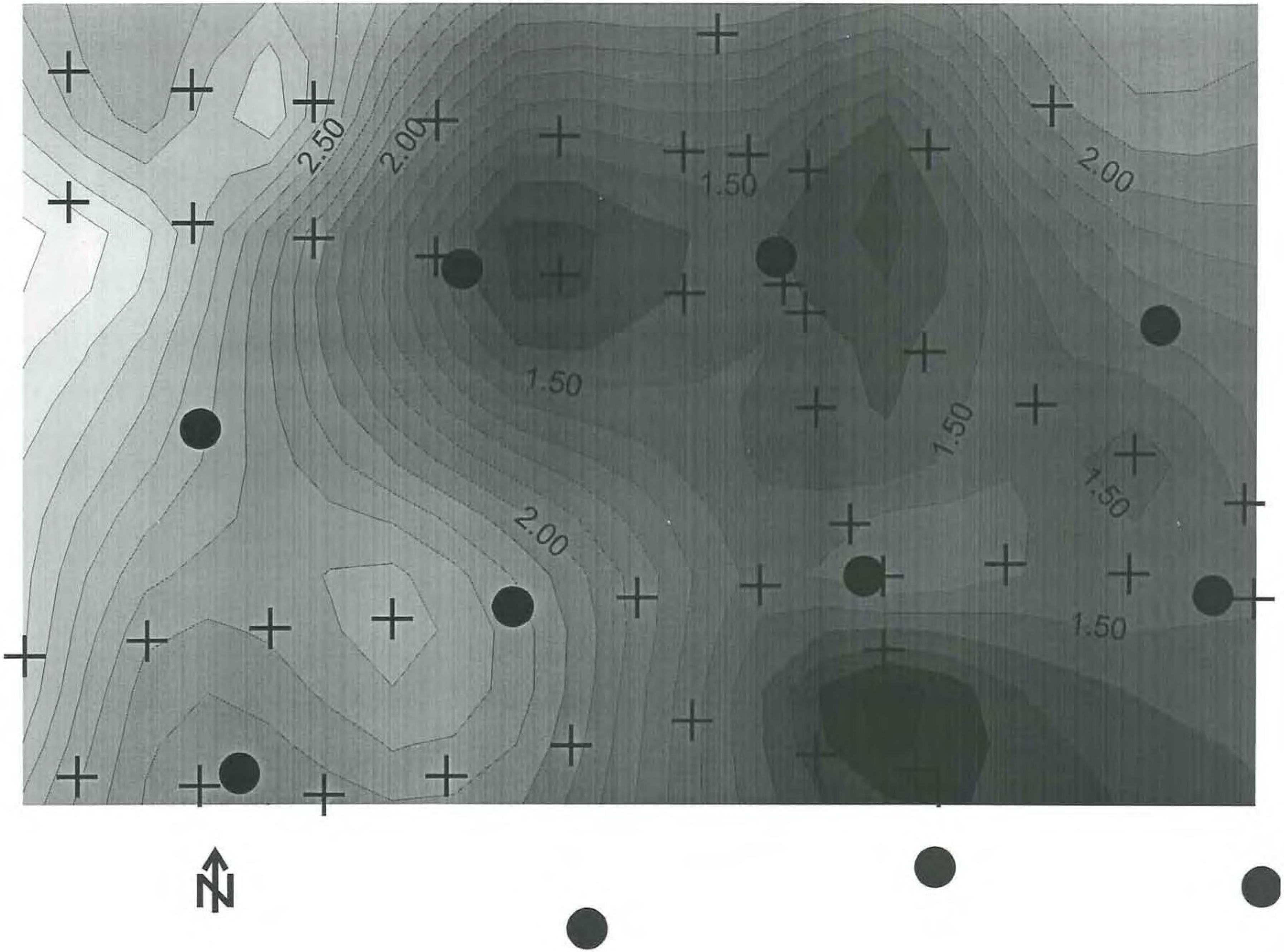
Line Number	Station Number	Station ID	X-Coord. UTM (m)	Y-Coord. UTM (m)	Horizontal Reading (volts)	Horizontal (mS/m)	Vertical Reading (volts)	Vertical (mS/m)
1	1	L1S1	516483.5	4983719.1	-0.26	2.6	-0.228	2.28
1	2	L1S2	516503.6	4983716.2	-0.226	2.26	-0.216	2.16
1	3	L1S3	516523.4	4983714.0	-0.329	3.29	-0.17	1.7
1	4	L1S4	516543.5	4983711.1	-0.158	1.58	-0.042	0.42
1	5	L1S5	516563.2	4983708.4	-0.166	1.66	-0.186	1.86
1	6	L1L6	516583.4	4983705.9	-0.151	1.51	-0.087	0.87
1	7	L1S7	516603.7	4983703.0	-0.12	1.2	-0.153	1.53
1	8	L1S8	516623.4	4983706.5	-0.124	1.24	-0.137	1.37
1	9	L1S9	516643.2	4983713.3	-0.224	2.24		
2	1	L2S1	516483.5	4983697.8	-0.316	3.16	-0.183	1.83
2	2	L2S2	516503.8	4983694.7	-0.284	2.84	-0.131	1.31
2	3	L2S3	516523.4	4983691.8	-0.203	2.03	-0.153	1.53
2	4	L2S4	516543.3	4983688.9	-0.156	1.56	-0.18	1.8
2	5	L2S5	516563.4	4983686.0	-0.1	1	-0.142	1.42
2	6	L2S6	516583.7	4983682.9	-0.155	1.55	-0.12	1.2
2	7	L2S7	516603.3	4983680.0	-0.15	1.5	-0.07	0.7
2	8	L2S8	516622.8	4983673.6	-0.135	1.35	-0.136	1.36
2	9	L2S9	516640.8	4983665.1	-0.165	1.65	-0.068	0.68
2	10	L2S10	516656.9	4983657.1	-0.142	1.42	-0.074	0.74
2	11	L2S11	516675.0	4983648.8	-0.169	1.69	-0.096	0.96
3	1	L3S1	516676.6	4983633.5	-0.149	1.49	-0.142	1.42
3	2	L3S2	516656.1	4983637.4	-0.157	1.57	-0.115	1.15
3	3	L3S3	516636.0	4983638.9	-0.164	1.64	-0.114	1.14
3	4	L3S4	516616.1	4983637.2	-0.173	1.73	-0.119	1.19
3	5	L3S5	516596.1	4983635.3	-0.157	1.57	-0.165	1.65
3	6	L3S6	516576.0	4983633.7	-0.189	1.89	-0.186	1.86
3	7	L3S7	516555.7	4983631.8	-0.227	2.27	-0.198	1.98
3	8	L3S8	516536.3	4983630.2	-0.255	2.55	-0.116	1.16
3	9	L3S9	516516.4	4983628.5	-0.233	2.33	-0.198	1.98
3	10	L3S10	516496.3	4983626.6	-0.221	2.21	-0.26	2.6
3	11	L3S11	516476.3	4983624.1	-0.288	2.88	-0.19	1.9
4	1	L4S1	516484.9	4983604.3	-0.247	2.47	-0.282	2.82
4	2	L4S2	516504.9	4983603.0	-0.201	2.01	-0.24	2.4
4	3	L4S3	516525.2	4983601.3	-0.218	2.18	-0.254	2.54
4	4	L4S4	516545.1	4983604.7	-0.222	2.22	-0.159	1.59
4	5	L4S5	516565.2	4983609.4	-0.213	2.13	-0.169	1.69
4	6	L4S6	516585.0	4983613.6	-0.153	1.53	-0.146	1.46
4	7	L4S7	516605.3	4983608.1	-0.131	1.31	-0.168	1.68
4	8	L4S8	516625.2	4983603.0	-0.114	1.14	-0.113	1.13
5	1	L5S1	516621.6	4983605.3	-0.117	1.17	-0.075	0.75
5	2	L5S2	516616.3	4983624.8	-0.094	0.94	-0.125	1.25
5	3	L5S3	516610.7	4983645.4	-0.132	1.32	-0.098	0.98
5	4	L5S4	516605.2	4983664.7	-0.143	1.43	-0.088	0.88
5	5	L5S5	516599.9	4983684.7	-0.145	1.45	-0.076	0.76
5	6	L5S6	516594.1	4983705.5	-0.168	1.68	-0.111	1.11
5	7	L5S7	516589.0	4983724.8	-0.211	2.11	-0.115	1.15

Geophysical Study #2: Final Study of the Bayport Site (Electromagnetic Conductivity)

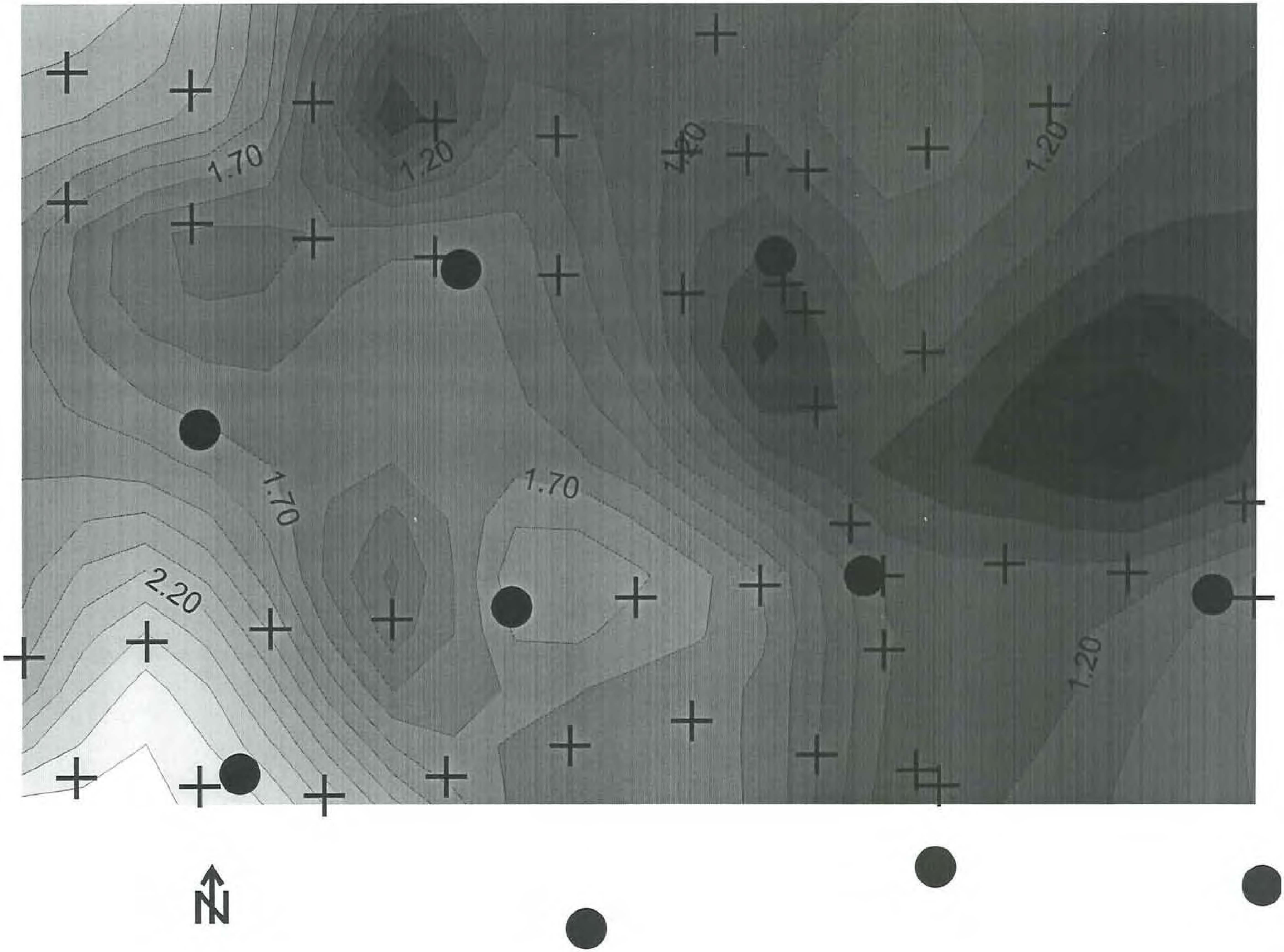
Line Number	Station Number	Station ID	UTM (m) x-coord	UTM (m) y-coord	Horizontal Reading	Horizontal (mS/m)	Vertical Reading	Vertical (mS/m)
1	1	L1S1	516493	4983736	-0.267	2.67	-0.678	67.8
1	2	L1S2	516513	4983736	-0.23	2.3	-0.476	47.6
1	3	L1S3	516533	4983736	-0.12	1.2	-0.421	42.1
1	4	L1S4	516553	4983736	-0.138	1.38	-0.439	43.9
1	5	L1S5	516573	4983736	-0.24	2.4	-0.311	31.1
1	6	L1S6	516593	4983736	-0.145	1.45	-0.221	22.1
1	7	L1S7	516613	4983736	-0.208	2.08	-0.219	21.9
1	8	L1S8	516633	4983736	-0.261	2.61	-0.249	24.9
1	9	L1S9	516653	4983736	-0.226	2.26	-0.198	19.8
1	10	L1S10	516673	4983736	-0.168	1.68	-0.186	18.6
1	11	L1S11	516693	4983736	-0.093	0.93	-0.132	13.2
2	1	L2S1	516493	4983716	-0.272	2.72	-0.187	18.7
2	2	L2S2	516513	4983716	-0.248	2.48	-0.664	6.64
2	3	L2S3	516533	4983716			-0.099	9.9
2	4	L2S4	516553	4983716	-0.322	3.22	-0.833	8.33
2	5	L2S5	516573	4983716	-0.11	1.1	-0.259	2.59
2	6	L2S6	516593	4983716	-0.113	1.13	-0.338	3.38
2	7	L2S7	516613	4983716	-0.072	0.72	-0.366	3.66
2	8	L2S8	516633	4983716	-0.174	1.74	-0.214	2.14
2	9	L2S9	516653	4983716	-0.238	2.38	-0.013	0.13
2	10	L2S10	516673	4983716	-0.117	1.17	-0.347	3.47
2	11	L2S11	516693	4983716	-0.067	0.67	-0.328	3.28
3	1	L3S1	516493	4983696	-0.374	3.74	-0.105	10.5
3	2	L3S2	516513	4983696	-0.291	2.91	-0.383	3.83
3	3	L3S3	516533	4983696	-0.191	1.91	-0.343	3.43
3	4	L3S4	516553	4983696	-0.145	1.45	-0.259	2.59
3	5	L3S5	516573	4983696	-0.132	1.32	-0.219	2.19
3	6	L3S6	516593	4983696	-0.118	1.18	-0.171	1.71
3	7	L3S7	516613	4983696	-0.126	1.26	-0.202	2.02
3	8	L3S8	516633	4983696	-0.121	1.21	-0.218	2.18
3	9	L3S9	516653	4983696	-0.156	1.56	-0.129	1.29
3	10	L3S10	516673	4983696	-0.206	2.06	-0.169	1.69
3	11	L3S11	516693	4983696	-0.224	2.24	-0.172	1.72
4	1	L4S1	516493	4983676	-0.244	2.44	-0.309	30.9
4	2	L4S2	516513	4983676	-0.282	2.82	-0.32	3.2
4	3	L4S3	516533	4983676	-0.214	2.14	-0.242	2.42
4	4	L4S4	516553	4983676	-0.184	1.84	-0.212	2.12
4	5	L4S5	516573	4983676	-0.188	1.88	-0.2	2
4	6	L4S6	516593	4983676	-0.161	1.61	-0.126	1.26
4	7	L4S7	516613	4983676	-0.173	1.73	-0.14	1.4
4	8	L4S8	516633	4983676	-0.196	1.96	-0.136	1.36
4	9	L4S9	516653	4983676	-0.145	1.45	-0.061	0.61
4	10	L4S10	516673	4983676	-0.105	1.05	-0.167	1.67
4	11	L4S11	516693	4983676	-0.046	0.46	-0.186	1.86
5	11	L5S11	516693	4983656	-0.07	0.7	-0.171	1.71
5	10	L5S10	516673	4983656	-0.204	2.04	-0.131	1.31
5	9	L5S9	516653	4983656	-0.178	1.78	-0.084	0.84
5	8	L5S8	516633	4983656	-0.186	1.86	-0.112	1.12

5	7	L5S7	516613	4983656	-0.146	1.46	-0.091	0.91
5	6	L5S6	516593	4983656	-0.157	1.57	-0.12	1.2
5	5	L5S5	516573	4983656	-0.132	1.32	-0.204	2.04
5	4	L5S4	516553	4983656	-0.2	2	-0.207	2.07
5	3	L5S3	516533	4983656	-0.243	2.43	-0.124	1.24
5	2	L5S2	516513	4983656	-0.297	2.97	-0.284	2.84
5	1	L5S1	516493	4983656	-0.285	2.85	-0.736	7.36
6	1	L6S1	516493	4983636	-0.416	4.16	-0.115	11.5
6	2	L6S2	516513	4983636	-0.335	3.35	-0.334	3.34
6	3	L6S3	516533	4983636	-0.266	2.66	-0.191	1.91
6	4	L6S4	516553	4983636	-0.247	2.47	-0.237	2.37
6	5	L6S5	516573	4983636	-0.183	1.83	-0.195	1.95
6	6	L6S6	516593	4983636	-0.198	1.98	-0.165	1.65
6	7	L6S7	516613	4983636	-0.143	1.43	-0.117	1.17
6	8	L6S8	516633	4983636	-0.148	1.48	-0.139	1.39
6	9	L6S9	516653	4983636	-0.116	1.16	-0.106	1.06
6	10	L6S10	516673	4983636	-0.093	0.93	-0.137	1.37
6	11	L6S11	516693	4983636	-0.104	1.04	-0.179	1.79
7	11	L7S11	516693	4983616	-0.233	2.33	-0.188	18.8
7	10	L7S10	516673	4983616	-0.107	1.07	-0.179	1.79
7	9	L7S9	516653	4983616	-0.114	1.14	-0.05	0.5
7	8	L7S8	516633	4983616	-0.124	1.24	-0.125	1.25
7	7	L7S7	516613	4983616	-0.142	1.42	-0.104	1.04
7	6	L7S6	516593	4983616	-0.134	1.34	-0.194	1.94
7	5	L7S5	516573	4983616	-0.199	1.99	-0.24	2.4
7	4	L7S4	516553	4983616	-0.24	2.4	-0.147	1.47
7	3	L7S3	516533	4983616	-0.255	2.55	-0.222	2.22
7	2	L7S2	516513	4983616	-0.233	2.33	-0.375	3.75
7	1	L7S1	516493	4983616	-0.275	2.75	-0.101	1.01
8	1	L8S1	516493	4983596	-0.365	3.65	-0.917	9.17
8	2	L8S2	516513	4983596	-0.313	3.13	-0.432	4.32
8	3	L8S3	516533	4983596	-0.233	2.33	-0.306	3.06
8	4	L8S4	516553	4983596	-0.3	3	-0.184	1.84
8	5	L8S5	516573	4983596	-0.252	2.52	-0.229	2.29
8	6	L8S6	516593	4983596	-0.22	2.2	-0.181	1.81

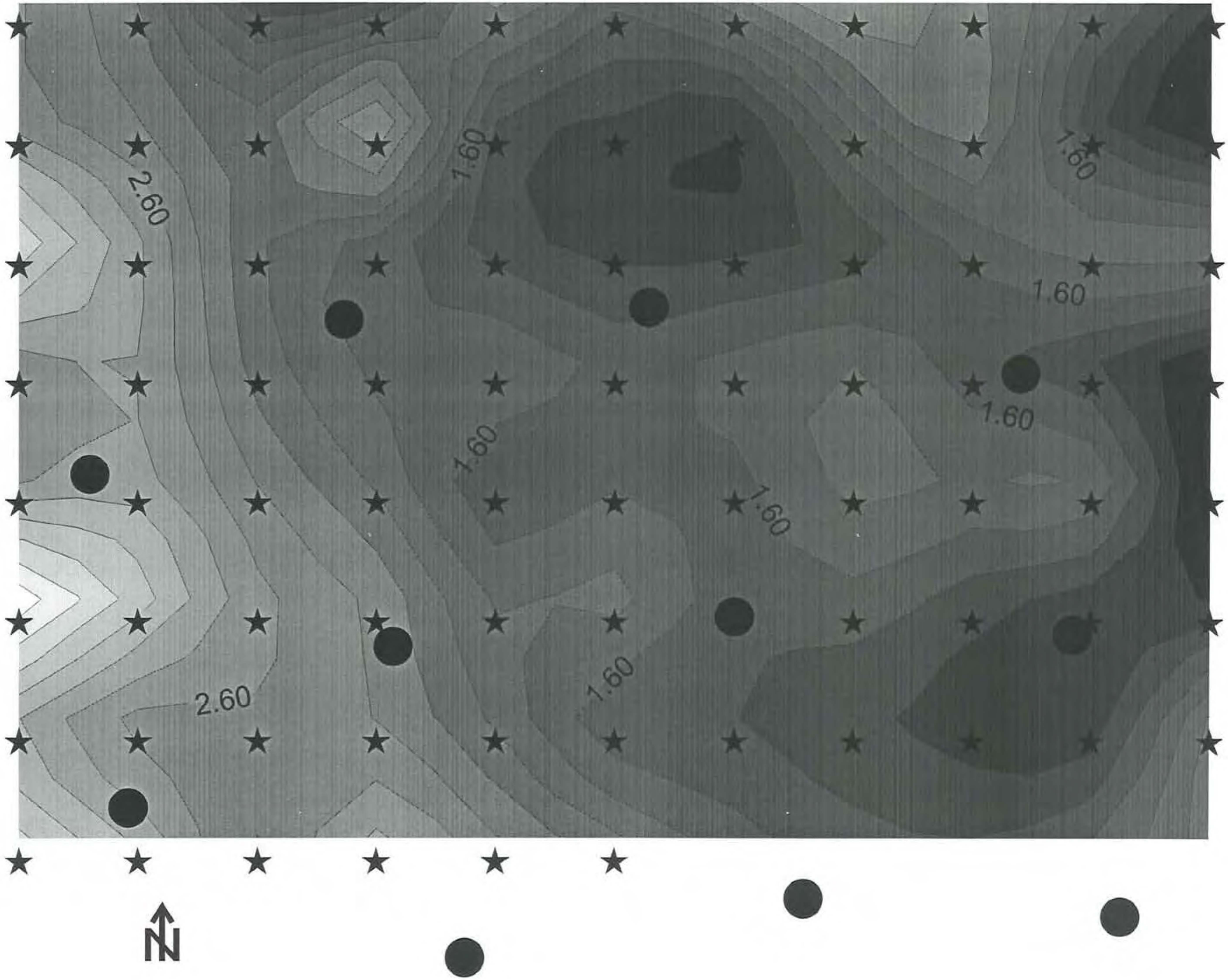
Geophysical Study #1: Horizontal Conductivity (mS/m)



Geophysical Study #1: Vertical Conductivity (mS/m)



Geophysical Study #2: Horizontal Conductivity (mS/m)



Geophysical Study #2: Vertical Conductivity (mS/m)

*The data gathered along the North and West Edges of the map is void due to interference caused by a fence constructed after study #1.