Assessing Differences in Ravine Erosion in Seven Mile Creek Park and the Surrounding Area: Implications for Sediment in the Minnesota River

By

Laura Danczyk

A thesis submitted in partial fulfillment of the requirements of the degree of

Bachelor of Arts

(Geology)

At

Gustavus Adolphus College

2018

Assessing Differences in Ravine Erosion in Seven Mile Creek Park and the Surrounding Area: Implications for Sediment in the Minnesota River

By

Laura Danczyk

Under the supervision of Laura Triplett

Abstract

The Minnesota River is characterized by a high suspended sediment load, which reduces water clarity and can negatively impact the ecosystem of a river. In south-central Minnesota, ravines are locally important sources of fine-grained sediment for the Minnesota River. In the Seven Mile Creek watershed, these narrow, steep-sided valleys are underlain by unconsolidated silt, clay, and sand. Most ravines in this area are actively eroding, but some appear to be stable for intervals of time. Knowing what factors contribute to ravine erosion will help understand controls on sediment from these to the Minnesota River. One question is whether or not grain size affects the erosion of ravines. Grain size distribution was evaluated in actively eroding ravines and non-eroding ravines in the study area, using a particle size analyzer (PSA). Average grain size, average skewness, and average kurtosis were determined to compare eroding ravines versus non-eroding ravines in Seven Mile Creek Park and at a nearby private property (Fredricks' ravines). Results indicate that grain size distributions in eroding and non-eroding ravines are not significantly different. This result suggests that there may be a similarity between similar till material from one site to another based on grain size, but a difference in grain size from the clay material from one site to another. We conclude that grain size distribution is not the key factor in controlling whether a ravine is eroding or non-eroding. This conclusion is based on a small number of samples; more data are needed to confirm these findings.

ACKNOWLEDGEMENTS

I would like to thank my thesis advisor Dr. Laura Triplett for helping me formulate a project and collect data. I thank Dr. Julie Bartley for helping with the writing and editing of my thesis. I acknowledge Dr. Rory McFadden and Dr. Andrew Haveles for their feedback and help with the writing process. Also I would like to thank the geology department for access to the Particle Size Analyzer and the biology department for letting me use their shaker table. Finally, thanks to the Fredricks' family for access to their land for fieldwork.

Table of Contents

Page Number

Introduction……………………………………………………………... 7

Geologic Setting……………………………………………...……. 11

Methods………………………………………………………......... 12

Results……………………………………………………………... 14

Discussion………………………………………………………… 23

Conclusion……………………………………………………… 27

References…………………………………………………......... 28

Figures and Tables

Figure/Table	Title	Page
Figure 1	Seven Mile Creek Ravine Sites 1, 2, and 3	10
Figure 1.1	Map of Fredricks' property relative to SMC	11
Figure 1.2	Map of Minnesota River and tributaries	12
Figure 2	Image from Ravine 1	14
Figure 3	Image from Ravine 1	14
Figure 4	Image from Ravine 1	15
Figure 5	Image from Ravine 1	15
Figure 6	Image from Ravine 2	16
Figure 7	Image from Ravine 2	16
Figure 8	Image from Ravine 2	16
Figure 9	Image from Ravine 2	17
Figure 10	Image from Ravine 3	17
Figure 11	Image from Ravine 4	18
Figure 12	Image from Ravine 4	18
Figure 13	Image from Ravine 5	19
Table 1	Table showing ravine material	19
Table 1.1	Average grain size for Ravine 1	19
Table 2	Average skewness for Ravine 1	19
Table 3	Average kurtosis for Ravine 1	19
Table 4	Average grain size for Ravine 2	20
Table 5	Average skewness for Ravine 2	20
Table 6	Average kurtosis for Ravine 2	20
Table 7	Average grain size for Ravine 3	21
Table 8	Average skewness for Ravine 3	21
Table 9	Average kurtosis for Ravine 3	21

Table 10	Average grain size for Ravine 4&5	22
Table 11	Average skewness for Ravine 4&5	22
Table 12	Average kurtosis for Ravine 4&5	22
Figure 14	Average grain size in eroding vs. non-eroding	24
Figure 15	Average grain size of Fredricks' ravines vs. SM Ravines	24
Figure 16	Sample taken near head of SMC Ravines	25
Figure 17	Sample taken near middle of SMC Ravines	25
Figure 18	Sample taken near mouth of SMC Ravines	26
Figure 19	Grain size distribution graph	26

Introduction

The Minnesota River is expected to have a high sediment load because it cuts down into unconsolidated fine-grained glacial sediment. The Minnesota Rivers sediments then flows to the Mississippi River and Lake Pepin. Lake Pepin records show that sedimentation rates are higher than the pre-settlement rates. The Minnesota River contributes 82%-92% of sediment to Lake Pepin (Gran et al., 2011). The main sediment source is coming from bluff erosion which contributes 20% to the annual sediment loads. Ravines and streambanks contribute around 10% for each annually to the sediment load entering the Mississippi River and Lake Pepin (Gran et al., 2011). These till covered areas have the potential for rapid erosion and since the European settlement human activity has increased in this area.

Elevated rates of suspended sediment due to human activity is a concern in the Minnesota River because it can affect water clarity and have negative impacts on the ecosystem of a river. High levels of total suspended solids (TSS) will increase water temperatures. TSS also limits light penetration which then limits plant life and decreases the amount of oxygen produced in the water. Low dissolved oxygen levels can make the water hypoxic, and some organisms cannot survive in this. If sunlight is being blocked due to turbidity this can also stop photosynthesis from happening. This can also decrease some plants survival and then also affect the dissolved oxygen. Increased sediment in the water can also reduce habitat for organisms, by decreasing water clarity, it reduces organisms vision and their ability to find food (Environmental Measurement Systems, 2017).

South-central Minnesota is a good study area because the Minnesota River in this region has tributaries that are steep ravines cut into unconsolidated glacial till material. Seven Mile

Creek and its tributary ravines are a good place for ravine analysis because this watershed is a main contributor of sediment to the Minnesota River (Gran et al., 2011).

Previous work shows there has been a significant increase in sediment supply from ravines over the past 150 years (Tran et al., 2015). Ravines, streambanks, and bluffs contribute the most sediment material from the tributaries leading to the river (Gran et al., 2011). The alluvial material is more easily eroded than the till on the ravine floor and walls. It is also established that vegetation matters when it comes to how actively a ravine is eroding (Lenhart et al., 2015). A ravine that is not as actively eroding will have more vegetation cover. Several previous studies have examined the stream tributaries leading into the Minnesota River. There was a study done in 2011 about how to stabilize the ravines of the Minnesota River Valley. The study goes over how the sedimentation rate has increased ten-fold over the last 150 years. This is why the paper focuses on near-channel sources or sediment (Tran et al, 2011). This work is important to my project because they gave a background on how to find ravines and specified how to stabilize ravines that are eroding.

A study done by Wilcock et al. (2009) identified sources of sediment in the Minnesota River Basin. Instead of a majority of sediment coming from agricultural fields, Wilcock concludes it is coming more from ravines, bluffs, and streambanks. Although a lot of the erosion is natural, the erosion rates have increased due to altering the land. The article concludes that erosion rates in the Minnesota River basin will increase because the mean annual precipitation and peak flows have increased in the basin. This study is important to my project because it talks about where most of the erosion is coming from (ravines, etc.) and how it will increase.

Another study done by Lenhart et al. (2015) identified the effects of soil and vegetation on ravine erosion rates in Seven Mile Creek Park area and how they contribute to the Minnesota

River. In this study field data was collected that included: soil particle size, erodibility, bulk density, critical shear strength, and vegetation properties. The vegetation properties data collected included: root depth, species composition, and percent cover. Their results show that the material on top of the ravine sidewalls and the alluvial materials present near the ravine outlets are more erodible than the underlying surficial materials that are dense tills. The study also concluded that the role of vegetation in the erosion process tends to vary depending on where the vegetation is within a ravine. An example of this is that where there are large steep ravines sidewall erosion that has been eroded by undercutting and mass-wasting, vegetation has very little effect on the erosion processes. One of Lenhart et al. (2015) solutions is to have engineered wood jams that could potentially help reduce down-cutting and stabilize the stream bed. Based on Lenhart's paper, there was only a slight difference between eroding versus non-eroding ravines. The eroding ravines have a very high erosion rate, whereas the non-eroding, or less actively eroding ravines have a high erosion rate. What is not as clear, is comparing eroding ravines and non-eroding ravines in Seven Mile Creek Park and the surrounding area. Previous literature shows erosion rates and grain size to be an important factor to keep in mind when looking at ravine erosion (Lenhart et al. 2015).

I will also be defining non-eroding or not actively eroding ravines as ravines with vegetation covering it and based on the erosion rate as determined by Lenhart et al. Also eroding ravines are more actively eroding than my non-eroding or less actively eroding ravine. My specific research problems address the similarities and differences between eroding and non-eroding ravines. I compared and contrasted the grain size in ravines of the Seven Mile Creek watershed.

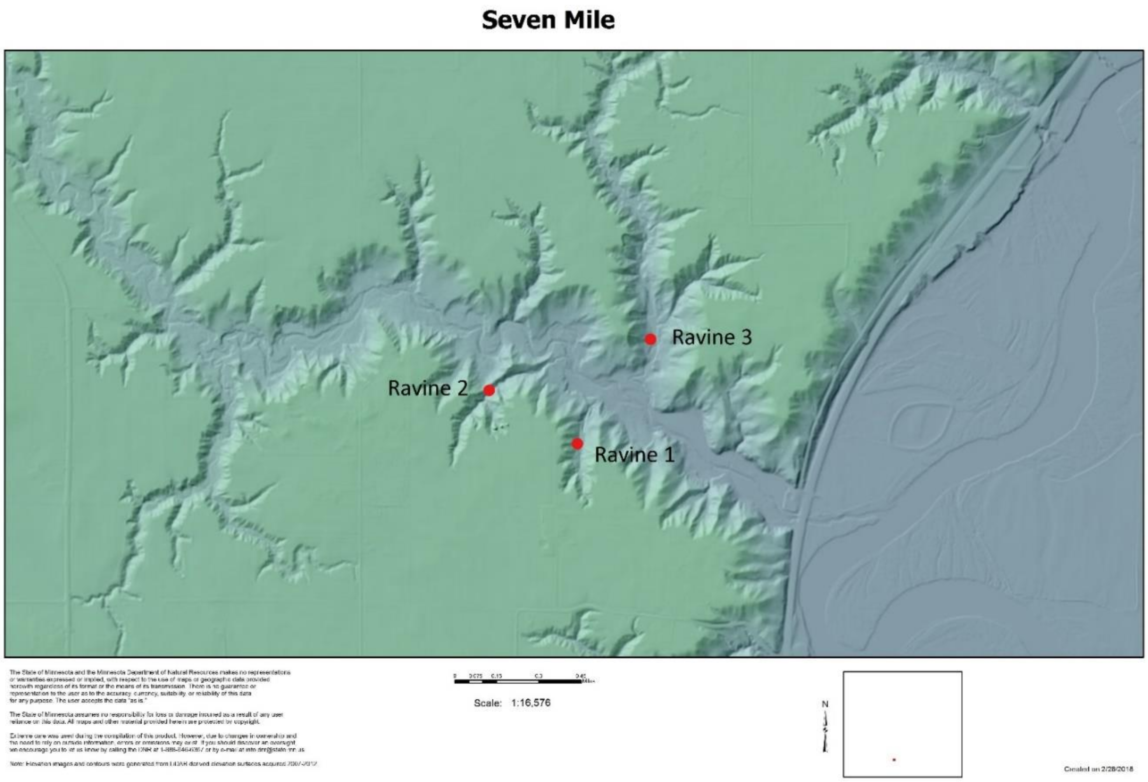

Figure 1: The three ravines in Seven Mile Creek Park where samples were taken. Ravines 1 and 2 are eroding ravines and Ravine 3 is a non-eroding ravine, according to Lenhart et al. (2015).

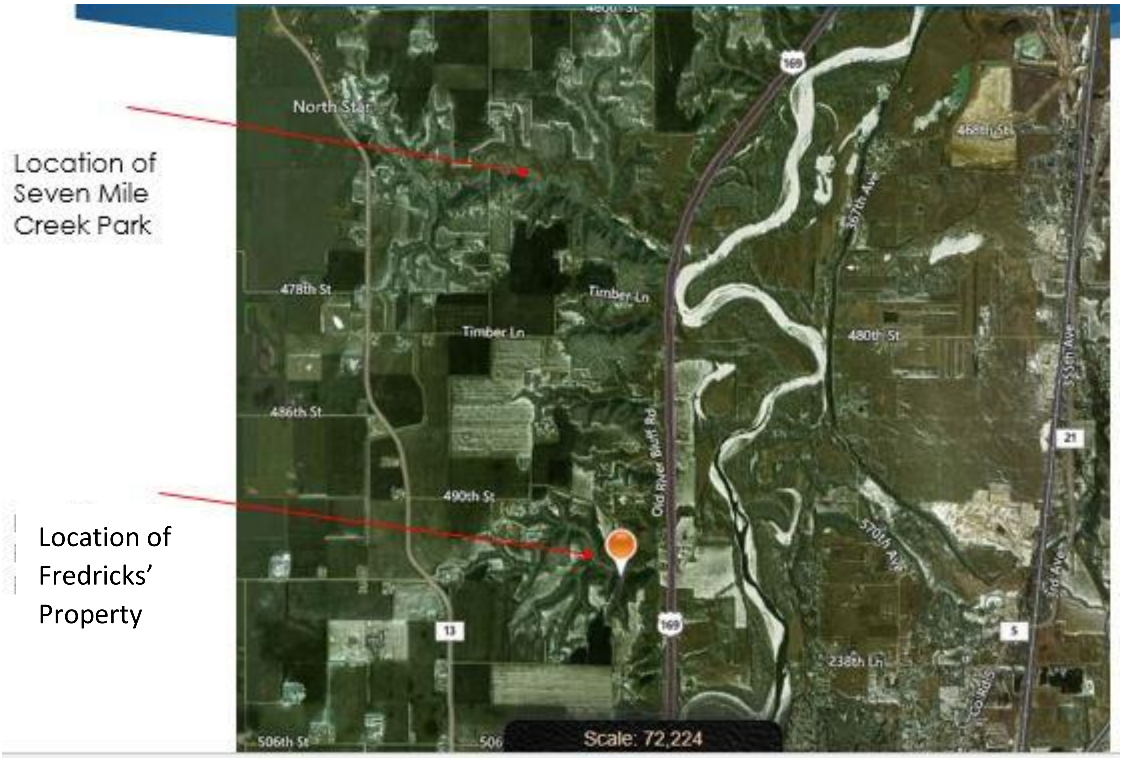

Figure 1.1: Location of the Fredricks' property, relative to Seven Mile Creek Park.

Geologic Setting

In the region of the present-day Minnesota River valley, the most recent glacial event was the retreat of the Wisconsin ice sheet. The glacier's meltwater was accumulated into Lake Agassiz. The Glacial Lake Agassiz existed around 30,000 to 10,000 years ago. The Minnesota River valley was then created by the Glacial River Warren, which was a result of the draining of Glacial Lake Agassiz. The Minnesota River Valley has a base level that has been lowered by over 70 feet. During the Holocene, the knickpoints of the river have propagated about 40 km up the tributaries, which leaves bluffs and ravines (Gran et al., 2015). A ravine is from stream cutting erosion. A ravine is a narrow steep-sided valley and is usually worn down by water flowing through it. Ravines are smaller than a valley but larger than a gully. Ravines can store sediment. Ravines tend to be locally important sources of sediment.

The sediment coming from the eroding ravine can then be transported down the ravine and into the Minnesota River eventually. The sediment is fine-grained sediment, much of the sediment is from till, some is proglacial lake sediment, and some is river derived. The definition used for this study of non-eroding ravines, is ravines with vegetation covering it. The vegetation will stay on the ravines when the ravine is not actively eroding. The overall surficial geology of south-central Minnesota is unconsolidated, fine grained material. The unconsolidated material can consist of layers of unsorted silt and clay or sand. My study area of Seven Mile Creek Park and the surrounding area is underlain by unconsolidated silt, clay, and sand. The sorted clay comes from proglacial lakes and the sand is coming from glacial rivers. The glacier deposited the unsorted sediment. Figure 1.2 shows the Minnesota River and the different tributaries that were carved out.

Figure 1.2: Showing the Minnesota River and its tributaries, created by Glacial River Warren.

Methods

Samples were collected from five ravines. Samples were taken from three different ravines in Seven Mile Creek Park from two different ravines on the Fredricks' property. Samples were taken close to the head of the ravine (as close as I could get), a sample near the middle of the ravine's length, and near the ravine mouth. Nine samples were collected from the two eroding ravines in Seven Mile Creek Park, four samples were taken from the one non-eroding ravine in Seven Mile, and four samples came from the two ravines on the Fredricks' property. In total 17 samples were collected and replicate samples were analyzed using the particle size analyzer (PSA), for a total of 57 analyses (not including test runs done on certain samples). The samples were taken from the sides of the ravines. The samples taken come from the undisturbed material from the ravine walls. Most samples were taken about a meter or so down from the top of the side of the ravine. A few of the samples came from the floor of the ravine. The question then is the rate of ravine erosion linked to the size of the sediment that the water has to pick up to move it.

Each sample was analyzed for grain size. First, a 0.05g-0.01g subsample of each field-collected sample was acquired and put into 50mL centrifuge tube. Then 5mL of HMP solution was added into the tube. Samples were put on a mechanical shaker for 24 hours, to disaggregate, the clay particles, so that the mud particles would be counted separately. The samples were then put through the PSA and analyzed following the manual for the PSA. The PSA, analysis provides raw and cumulative grain counts. Grain size data was analyzed, the analysis of grain sizes comes from different hypotheses tested to figure out if there is a correlation between grain size and the erosion of eroding ravines versus non-eroding ravines. The grain size was compared in eroding versus non-eroding ravines in Seven Mile Creek and Fredricks'. The Fredricks' ravines were also compared to the eroding ravines in Seven Mile Creek Park. Grain size was compared in the eroding ravines in Seven Mile Creek Park, looking at the specific place where in the ravine each sample came from; the head of the ravine, the middle, and near the mouth of the ravine.

Results

Ravines 1, 2, 4, and 5 are eroding ravines. These ravines are actively eroding because there have been different studies showing how they are highly actively eroding. Ravine 3 from Seven Mile Creek Park is a non-eroding ravine. I will be reporting data on the average grain sizes, average skewness, and average kurtosis for each ravine.

Ravine	Samples	Field Description	Pictures from Ravines
1	**Sample 11**: SM Ravine 1 coarser layer above clay/sand layer **Sample 12**: SM 1 knickpoint **Sample 13**: SM Ravine 1 Layer below clay layer near channel bottom **Sample 14**: SM Ravine 1 clay/sand layer	A lot of clay material. Sides look mostly poorly sorted, with a few rocks embedded here and there. The material on the ground or previous channel bed has some well rounded sediment and larger rocks that have moved down. The cutting leaves a clay material that looks very smooth, almost like rock. Substantial rains over the last five days before samples were taken. The channel is incised 1.05 meters down from ground level. First ravine after foot bridge. This is an eroding ravine.	 Figure 2: Close up of the clay material in Ravine 1.  Figure 4: Sample 12 was taken on the left side  Figure 3: Another close up of the clay/sand material on the side of Ravine 1.  Figure 5: Closer up image of same ravine as Figure 4

2	**Sample 1**: Above Rock Ledge (not taken on the floor of the ravine, but a little farther up on the side of the ravine). **Sample 3**: 2ft below rock ledge Ravine 2 (not directly below rock ledge, but to the right of the rock ledge where the ravine side is). **Sample 4**: Clay material 2 bottom **Sample 5**: First sample clay material Ravine 2 **Sample 8**: Ravine 3 above rock ledge 1	This is an eroding ravine. Third ravine after foot bridge. Material is clay and sand, sandy clay. The second sample from bottom of ravine. Same material, about 0.5 meter below first sample. A third sample came from two feet below the rock ledge, on the side of the ravine. A fourth sample came from above the rock ledge. Both samples three and four are silty with maybe a little clay.	 Figure 6: Close up of where Sample 5 was taken  Figure 7: Close up of where Sample 4 was taken.  Figure 8: The rock ledge, samples were taken above and below the rock ledge. See samples 1, 3, and 8.  Figure 9: Zoomed out view of where Sample 5 was taken.

3	**Sample 2**: Non-eroding ravine **Sample 15**: Non-eroding ravine #1 closest to river **Sample 16**: Non-eroding ravine #2 general middle of ravine **Sample 17**: Non-eroding ravine #3 farther up the ravine, furthest from ravine	The first sample from this ravine came from closest to river. All the samples consisted of till or soil material. It was well sorted throughout. On the very outside of the side of the ravine, there were bigger rocks. The ravine was pretty uniform throughout, samples were taken towards the river, the general middle, and farther up from the middle.	 Figure 10: Till or soil material as seen in the sample from the non-eroding Ravine 3 in Seven Mile Creek Park.

4	**Sample 6**: Fredricks' Ravine closer to ravine top 1 **Sample 7**: Fredricks' ravine material before slumping 2 **Sample 9**: Fredricks' ravine clay material	The middle of the ravine is where I got one of the samples. The clay material looks like it has layers, tilted sideways. There is water running through this ravine on September 5th, 2017. The clay is fine sediment. It almost looks like a sandstone. The second sample has clay material, with the clay layer at least 10-12 feet up on the side of the ravine. The third sample came from a little downstream of the second sample.	 Figure 11: Clay material, like in Sample 9.
5	**Sample 10**: Fredricks' east ravine stop 3	Branch of ravine that goes up east side of Frederick's property. Till and colluvium about 1.5 meters from ground level. What counts as ravine wall material or is this sample too high above where the water would be flowing. This one might not count as an erosional ravine because of this.	 Figure 12: View from towards the top of the ravine.

Table 1: Table showing the five ravines and what material they are composed of.

Ravine 1: Seven Mile

Tables for Average Grain Size, Skewness, and Kurtosis in Ravine 1 Samples

	Sample 11	Sample 12	Sample 13	Sample 14
Run 1	91.91	173.6	154.3	204.6
Run 2	226.6	171.2	138.5	236.7
Run 3		136.6	150.1	220.4
Average	159.3	160.5	147.6	220.6
Standard Deviation	95.24	20.70	8.18	16.05

Table 1.1: Mean grain sizes for samples from Ravine 1. Grain size is in µm. The value missing was when the machine quit after run 2.

	Sample 11	Sample 12	Sample 13	Sample 14
Run 1	0.66	0.38	0.59	0.01
Run 2	0.37	0.44	0.65	0.07
Run 3		0.63	0.72	0.16
Average	0.37	0.48	0.65	0.08

Table 2: The skewness for each sample was taken from Ravine 1.

	Sample 11	Sample 12	Sample 13	Sample 14
Run 1	0.94	0.74	0.88	0.82
Run 2	0.89	0.74	1	0.85
Run 3		0.95	1.07	0.85
Average	0.92	0.81	0.98	0.84

Table 3: The kurtosis for each sample was taken from Ravine 1.

Table 1 shows the mean grain size for each of the three replicate samples and their averages. Table 2 shows the skewness of grain size of those particular samples for Ravine 1 (R1-SampleNumber). Sample 14 skewness at 0.08 is closest to a normal univariate distribution. Samples R1-11, R1-12, and R1-13 have slightly higher skewness, and are skewed positively, only slightly toward coarser grain sizes. Table 3 shows the Kurtosis values, where kurtosis is how much the data has a peak, how sharp or flat the distribution is, so a kurtosis number of zero is a normal distribution curve. Table 3 shows values closer to one than to zero so Ravine 1 on average is farther away from a normal distribution.

Ravine 2: Seven Mile

Tables for Average Grain Size, Skewness, and Kurtosis in Ravine 2 Samples

	Sample 3	Sample 4	Sample 5	Sample 8
Run 1	130.8	196.9	169.1	161.8
Run 2	133.0	233.1	166.5	139.0
Run 3	159.7	220.6	156.8	134.6
Average	141.2	216.9	164.1	145.1
Standard Deviation	16.09	18.39	6.483	14.60

Table 4: Mean grain size for samples from Ravine 2. Grain size is in µm.

	Sample 3	Sample 4	Sample 5	Sample 8
Run 1	0.45	0.24	0.4	0.44
Run 2	0.61	0.13	0.34	0.51
Run 3	0.43	0.11	0.39	0.59
Average	0.50	0.16	0.38	0.51

Table 5: The skewness for each sample was taken from Ravine 2.

	Sample 3	Sample 4	Sample 5	Sample 8
Run 1	0.85	0.84	0.83	0.81
Run 2	1.12	0.91	0.85	0.86
Run 3	0.84	0.93	0.81	1.02
Average	0.94	0.89	0.83	0.90

Table 6: The kurtosis for each sample was taken from Ravine 2.

Table 4 shows the grain size of the replicate samples and then the average grain size. Table 5 shows that the skewness of grain size of Ravine 2 is farther away from a normal distribution of zero values. Sample R2-4 in Table 5 is closest to a zero value, with a value of 0.38, so it is still not a normal distribution. Table 6 shows that all the kurtosis values are far from a normal distribution, with the average of Ravine 2 being 0.89, whereas a normal distribution would be closer to zero.

Ravine 3: Seven Mile

Tables for Average Grain Size, Skewness, and Kurtosis in Ravine 3 Samples

	Sample 2	Sample 15	Sample 16	Sample 17
Run 1	132.1	131.3	146.9	169.1
Run 2	148.6	105.2	151.9	152.7
Run 3	107.9	112.0	140.3	134.0
Average	129.5	116.2	146.4	151.9
Standard Deviation	20.47	13.54	5.818	17.56

Table 7: Mean grain size for samples from Ravine 3. Grain size is in µm.

	Sample 2	Sample 15	Sample 16	Sample 17
Run 1	0.48	0.59	0.57	0.39
Run 2	0.32	0.54	0.46	0.44
Run 3	0.55	0.72	0.56	0.60
Average	0.45	0.62	0.53	0.48

Table 8: The skewness for each sample from Ravine 3.

	Sample 2	Sample 15	Sample 16	Sample 17
Run 1	0.9	0.88	0.85	0.80
Run 2	0.82	0.92	0.82	0.80
Run 3	0.86	1.38	0.91	0.94
Average	0.86	1.06	0.86	0.85

Table 9: The kurtosis for each sample from Ravine 3.

Table 7 shows the grain size of the three replicate samples and then the average grain size. Table 8 shows the skewness of the three runs of grain sizes from Ravine 3. The skewness for Ravine 3 is still farther away from a normal distribution. The closest average value to zero for a normal distribution is Sample R3-2 with 0.45. Table 9 shows that Ravine 3 is skewed farther from a normal distribution curve, where the highest kurtosis value is from Sample R3-15, with a value of 1.06.

Ravines 4 and 5: Fredericks

Tables for Average Grain Size, Skewness, and Kurtosis in Ravine 4 and 5 Samples

	Sample 6	Sample 7	Sample 9	Sample 10
Run 1	143.6	142.8	120.9	120.8
Run 2	170.0	133.8	95.26	125.6
Run 3	163.7	172.0	85.10	103.3
Average	159.1	149.5	100.4	116.6
Standard Deviation	13.79	19.97	18.45	11.74

Table 10: Mean grain size for samples from Ravines 4 and 5. Grain size is in µm.

	Sample 6	Sample 7	Sample 9	Sample 10
Run 1	0.52	0.55	0.74	0.67
Run 2	0.46	0.57	0.68	0.01
Run 3	0.40	0.26	0.60	0.67

Average	0.46	0.46	0.67	0.45

Table 11: The skewness for each sample was taken from Ravine 4 and 5.

	Sample 6	Sample 7	Sample 9	Sample 10
Run 1	0.84	0.89	1.33	1.17
Run 2	0.89	0.87	1.75	1.12
Run 3	0.84	0.79	2.39	1.31
Average	0.86	0.85	1.82	1.20

Table 12: The kurtosis for each sample was taken from Ravine 4 and 5.

Table 10 shows the grain sizes and then the average grain sizes for Ravine 4 and 5. Table 11 shows the average skewness of the three runs grain sizes averaged for Ravines 4 and 5. These values are also fine skewed away from a normal distribution curve, with the closest value to zero as Sample R5-10 with a value of 0.45. Table 12 shows the amount of kurtosis, with the highest amount of skewness from Sample R4-9 at 1.82. The values from Table 12 for Ravines 4 and 5 shows the kurtosis as higher values than zero, so it is becoming larger and more positive.

Discussion

Comparing Ravines 1, 2, and 3

Samples 11 with a skewness of 0.37, Sample R1-12 with a skewness of 0.48, and Sample R1-13 with a skewness of 0.65 are all strongly fine-skewed. Sample 14 is nearly symmetrical with its skewness at 0.08. Sample R1-14 could be different because it has a larger grain size than the other samples in this ravine. The skewness of the samples suggests that Ravine 1 is lopsided towards fine grain sizes. This suggests that even if there were coarser grains in it, the average was more fine grained.

Sample R2-3 has a skewness of 0.50, Sample R2-5 has a skewness of 0.38, and Sample R2- 8 has a skewness of 0.51 have a strongly fined skewness. Sample R2-4 has a skewness of 0.16 and is fine skewed based on the three runs average skewness. The skewness of the samples suggests that Ravine 2 has an average skewness towards fine grained. Ravine 2 is composed mostly of clays and silty clays. So this would make sense since a lot of those samples were fine grained clays and silty clays.

Sample R3-2 has a skewness of 0.45, Sample R3-15 has a skewness of 0.62, Sample R3-16 has a skewness of 0.53, and Sample R3-17 has a skewness of 0.48 and all have a strongly fine-skewed. The skewness of the samples suggests that Ravine 3 has an average skewness towards more fine grained.

Comparing Ravine 4 and 5

Sample R4-6 has a skewness of 0.46, Sample R4-7 has a skewness of 0.46, Sample R4-9 has a skewness of 0.67, and Sample R5-10 has a skewness of 0.45 and all have a strongly fine-skewed. The skewness of the samples suggests that Ravines 4 and 5 have an average skewness towards more fine grained. Ravines 4 and 5 are discussed together because both came from the Fredrick's property ravines and only one sample came from Ravine 5 so they are discussed together.

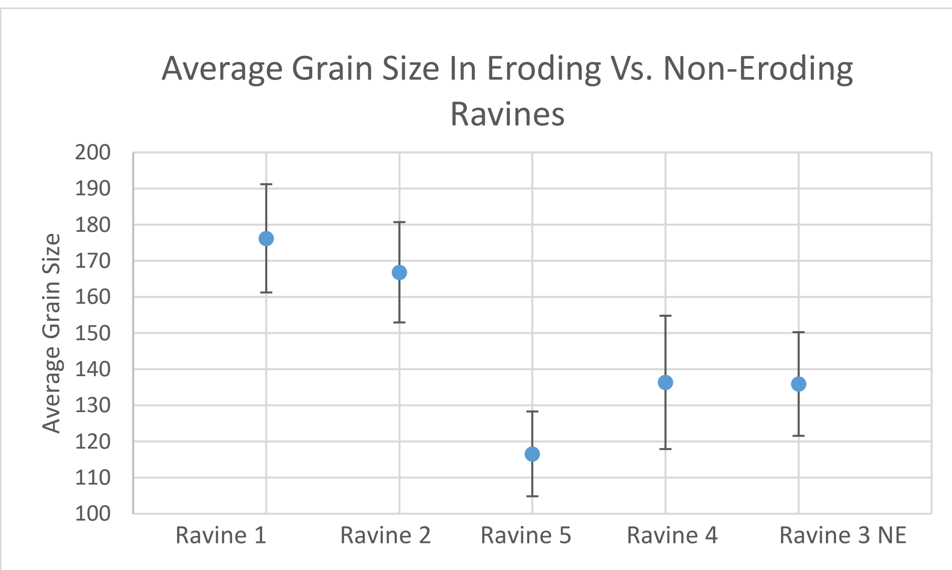

Figure 14: Average grain size for each ravine site. Ravines 1, 2, 4, and 5 are eroding ravines while Ravine 3 in non-eroding. The error bars represent the standard deviation for each ravine site.

Eroding (Ravines 1 and 2) have coarser grain sizes than the non-eroding ravine (Ravine 3) in Seven Mile Creek Park (Figure 14). The error bars were determined using the average standard deviation of each of the samples standard deviations. The Fredricks' ravines (Ravines 4 and 5) are more similar in grain size to Ravine 3 (non-eroding ravine) in Seven Mile Creek Park. The kurtosis number suggest that is it poorly sorted till being that the kurtosis numbers are positive.

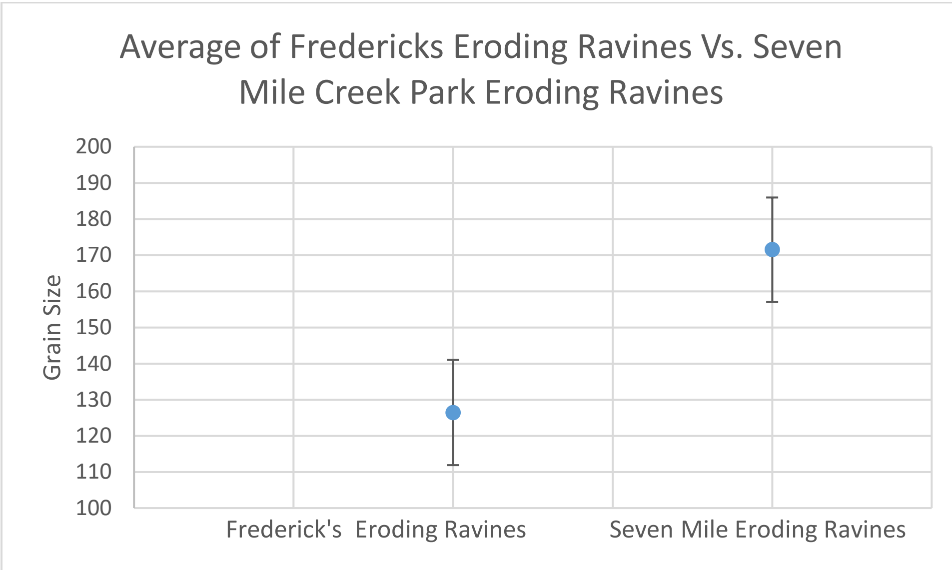

Figure 15: The average grain size of Fredericks eroding ravines (Ravines 4&5) versus Seven Mile Creek Park (Ravines 1&2) average grain size of eroding ravines.

Ravines 4 and 5 were included in the Fredericks' eroding ravines average. Eroding ravines 1 and 2 from Seven Mile Creek were combined using their previous average to get the new average for the two ravines (Figure 15). The error bars of standard deviation from the Fredericks' eroding ravines versus Seven Mile Creek Park ravines barely do not intersect one another in grain size average. All the ravines tend to be skewed towards fine grain, but often have a bimodal grain size distribution.

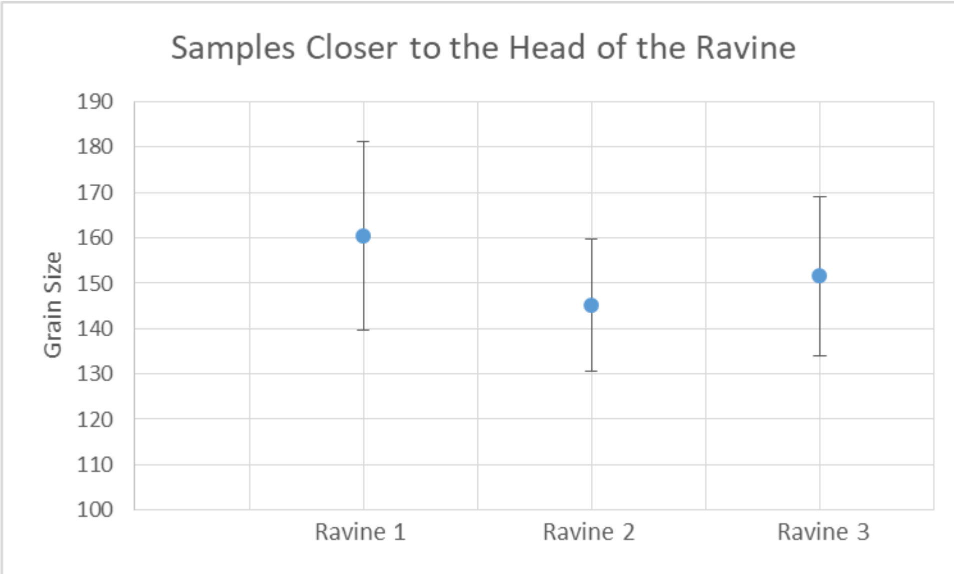

Figure 16: Sample from each ravine that were taken closer to the head of the ravine in Seven Mile Creek Park.

The three ravines in Seven Mile Creek Park show that the grain sizes are very similar when taken closer to the head of the ravines (Figure 16)..

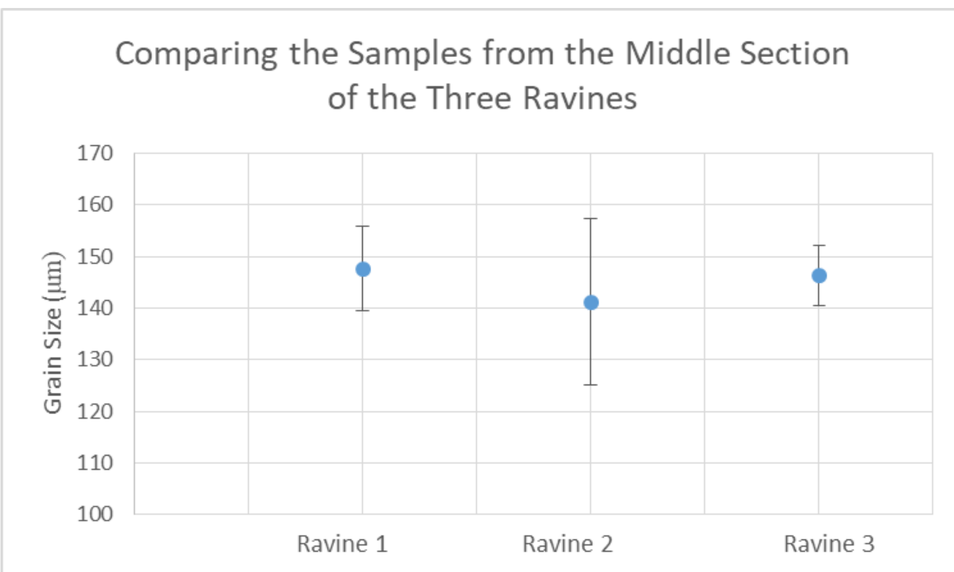

Figure 17: Samples from each ravine that were taken from closer to the middle section of each ravine in Seven Mile Creek Park.

The three ravines from Seven Mile Creek Park show that there is a very similar grain size for each of the ravines in the middle section of the ravine (Figure 17).

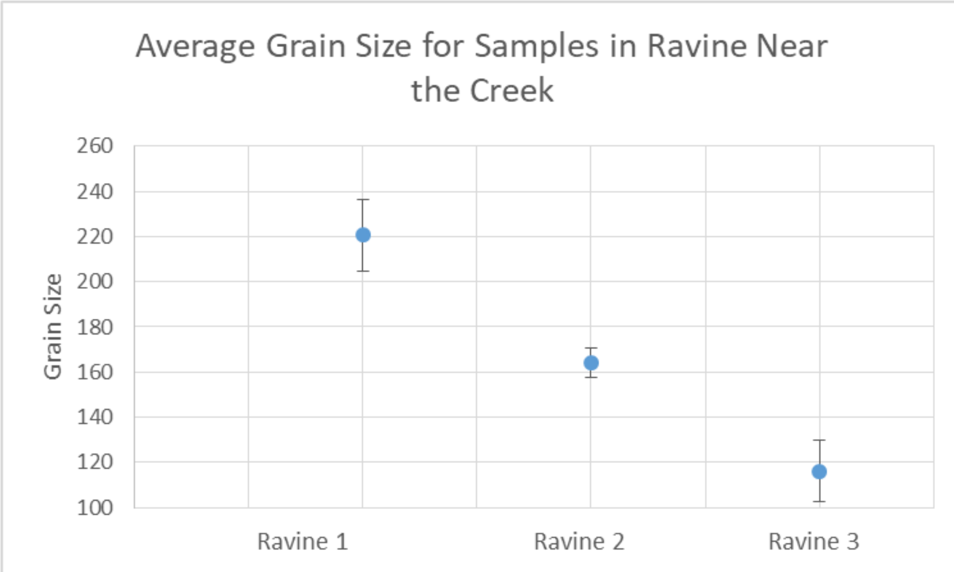

Figure 18: Samples from each ravine were taken near the mouth of each ravine in Seven Mile Creek Park.

The three ravines from Seven Mile Creek Park show a difference in grain size when taken from near the creek where Ravines 1 and 2 are more coarser grained than Ravine 3 (Figure 18).

Many of the samples have a grain size distribution that are bimodal, which would account for some of the samples having fine and coarse grains.

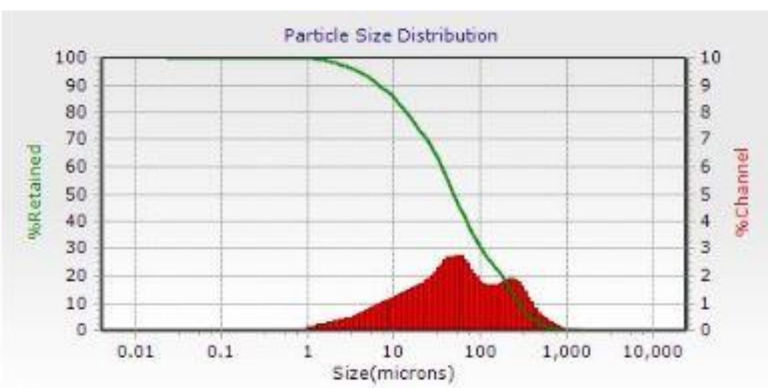

Figure 19: Shows the grain size distribution for a sample in Ravine 3.

All the ravines are either strongly fine-skewed or fine-skewed, with one sample being nearly symmetrical with its skewness. The results show that there is not a significant difference between eroding and non-eroding ravines. There was however a significant difference between the Fredricks' ravines and Seven Mile Creek Park eroding ravines. The Fredricks' Ravines look more like the non-eroding ravine at Seven Mile Creek. The different area from Seven Mile Creek Park are the Fredricks' ravines, so they are still in the same watershed but in a different location.

A similar grain size was found for the non-eroding ravine in Seven Mile Creek Park and the Fredricks' ravines. One of the samples from the Fredericks' ravine contained a similar looking till material to the non-eroding ravine in Seven Mile Creek Park. This result concludes that there may be a similarity between similar till material, but a slight difference in grain size from each clay material in different areas. The till may look similar in appearance from the different areas but the clay fraction in them is different.

The skewness of the grain size of each ravine suggests that the samples contained more than one grain size, with usually one peak on the finer grained size and then one peak towards the coarser grain sizes. This distribution in grain sizes is also seen from a lot of the samples being bimodal graphs. Lenhart et al. (2015) also described the two eroding ravines in Seven Mile Creek Park to have a very high erosion rate. Whereas the non-eroding ravine in Seven Mile Creek Park has a high erosion rate. The implications for the Minnesota River include more sediment being added to the river because the ravines have high erosion rates which will then negatively impact the water clarity and the ecosystem of the Minnesota River.

Conclusion

The grain size is not a concluding factor when looking for differences in ravines and their erosion rates. Further analysis of the high erosion rates and implications to the Minnesota River could include flow in a ravine, the vegetation cover, and the moisture content in ravine. Grain size is not a concluding factor when looking for differences between eroding and non-eroding ravines. The prediction would be that coarser grain sizes in a ravine would mean slower erosion rates. From my data there was not a significant difference in grain size between eroding versus non-eroding ravines in Seven Mile Creek Park, which would suggest that there is not a correlation between grain sizes and if the ravine is actively eroding. This conclusion could change with more data and more ravines tested. More samples to provide for grain size data and erosion rates would be needed to further analyze if grain size is a key factor in eroding versus non-eroding ravines.

References

Balogh, S. J., Meyer, M. L., and Johnson, D. K., 1997, Mercury and Suspended Sediment Loadings in the Lower Minnesota River: Environmental Science and Technology, v. 31p. 198-202.

Belmont, P., Gran, K., Jennings, C. E., Wittkop, C., and Day, S. S., 2011, Holocene landscape evolution and erosional processes in the Le Sueur River, central Minnesota: GSA Field Guide, v. 24, p. 439-455.

Belmont, P., Gran, K. B., Schottler, S. P., Wilcock, P. R., Day, S. S., Jennings, C., Lauer, J. W., Viparelli, E., Willenbring, J. K., Engstrom, D. R., and Parker, G., 2011b, Large Shift in Source of Fine Sediment in the Upper Mississippi River: Environmental Science and Technology.

Bevis, M., 2015, Sediment budgets indicate Pleistocene base level fall drives erosion in Minnesota's greater Blue Earth River basin.

Gran, K. B., Belmont, P., Day, S. S., Finnegan, N., Jennings, C., Lauer, J. W., and Wilcock, P. R., 2011, Landscape evolution in south-central Minnesota and the role of geomorphic history on modern erosional processes: GSA Today, v. 21, no. 9, p. 7-9.

Gran, K. B., Finnegan, N., Johnson, A. L., Belmont, P., Wittkop, C., and Rittenour, T., 2013, Landscape evolution, valley excavation, and terrace development following abrupt postglacial base-level fall: Geological Society of America Bulletin, v. 125, p. 1851-1864.

Gunderson, L., Finley, R., Bourne, H., and Lofton, D., 2015, Sediment Reduction Strategy for the Minnesota River Basin and South Metro
Mississippi River, Minnesota Pollution Control Agency, p. 1-67.

Kessler, A. C., Gupta, S. C., Doliver, H. A. S., and Thoma, D. P., 2012, Lidar quantification ofbank erosion in Blue Earth County, Minnesota: Journal of Environmental Quality, v. 41, no. 1, p. 197-207.

Kessler, A. C., Gupta, S. C., and Brown, M. K., 2013, Assessment of river bank erosion in southern Minnesota rivers post-European settlement: Geomorphology, v. 201, p. 312-322.

Lenhart, C. F., Brooks, K. N., Heneley, D., and Magner, J. A., 2009, Spatial and temporal variation in suspended sediment, organic matter, and turbidity in a Minnesota prairie river: implications for TMDLs, Volume 165: Springer Science and Business Media, Envion Monit Assess, p. 435-447.

Lenhart, C. F., Titov, M. L., Ulrich, J. S., Nieber, J. L., and Suppes, B. J., 2013, The Role of Hydrologic Alteration and Riparian Vegetation Dynamics in Channel Evolution along the Lower Minnesota River: American Society of Agricultural and Biological Engineers: v. 56, p. 549-561.

Mulla, D. J., and Sekely, A. C., 2009, Historical trends affecting accumulation of sediment and phosphorus in Lake Pepin, upper Mississippi River, USA, Journal of Paleolimnology, v. 41, p. 589-602.

Thoma, D. P., Gupta, S. C., and Bauer, M. E., 2001, Quantifying River Bank Erosion with Scanning Laser Altimetry, International Archives of Photogrammetry and Remote Sensing, v. XXXIV-3/W4, p. 169-174.

Tran, A., 2015, Analysis of Potential Ravine and Bluff Stabilization Sites within the Blue Earth and Le Sueur River Basins: Lake Pepin Legacy Alliance, p. 1-240.

Westra, J. V., Easter, W., and Olson, K. D., 2002, Targeting Nonpoint Source Pollution Control: Phosphorus in the Minnesota River Basin: Journal of the American Water Resources Association, v. 38, p. 493-505.

"Turbidity, Total Suspended Solids & Water Clarity." *Environmental Measurement Systems*, www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/.