technical memo

Project Name |	South Fork Nine Mile Creek Bank Stabilization	**Date** |	11/19/2021
To / Contact info |	Randy Anhorn, District Administrator		
Cc / Contact info |	NMCWD Board of Managers		
From / Contact info |	Mike Majeski & Dan Mossing		
Regarding |	Baseline Stream Assessment		

BACKGROUND

EOR was contracted by the Nine Mile Creek Watershed District (NMCWD) to conduct a stream assessment and identify bank erosion and other areas of concern along 3.3 miles of the South Fork Nine Mile Creek in Minnetonka, Eden Prairie, Edina, and Bloomington (see highlighted reaches in Figure 1). One of the primary goals for this project is to address the biotic impairments (fish and benthic macroinvertebrates) identified by the Minnesota Pollution Control Agency (MPCA) for South Fork Nine Mile Creek, which is impaired from Lake Smentana to Normandale Lake (Figure 2). A common stressor for biotic impairments is excess sediment; therefore, a project that provides a stable stream channel would directly benefit the biotic community of Nine Mile Creek and downstream aquatic resources. The overarching goal of this project is to provide a stable creek channel and restore eroding banks to reduce internal sediment and nutrient loading within the creek. Preliminary assessments conducted for this project identified several geomorphic issues along the creek including excessive lateral bank migration and subsequent bank erosion, channel incision, and floodplain abandonment.

The following summarizes the methodology and results of the stream assessment, including site maps, individual stream reach descriptions, Pfankuch Stream Stability Index scores, identification of priority bank stabilization sites, hydrologic model review, and high-level construction cost estimates for potential project sites. A separate deliverable as part of this project includes an ArcGIS working map that delineates the location of each stream reach assessed, Pfankuch scores, and locations of key infrastructure such as road crossings, culverts, and buildings.

The South Fork of Nine Mile Creek upstream of East Bush Lake Road has a drainage area of 17.4 square miles and is comprised of urban and suburban development, wetlands, lakes, and woodlands. The combination of these land uses result in both flashy and attenuated stormwater flow that impacts both the flow rate and erosion processes that exist within the channel. Surface water is the primary source of flow within the creek, but some groundwater discharge is present. This is an important aspect of the stream and will need to be considered when contemplating proposed designs (i.e., designs that address both bank erosion and water quality impairments).

METHODOLOGY & FLOOD MODELING

The Pfankuch Stream Stability Index is a stream channel assessment tool that provides an initial evaluation of the overall condition of wadeable streams and includes bank condition, floodplain accessibility, riparian vegetation, bank and channel substrates, and the stage of channel evolution. Three main categories are assessed with this tool including the upper banks, lower banks, and stream bottom. The tool assesses

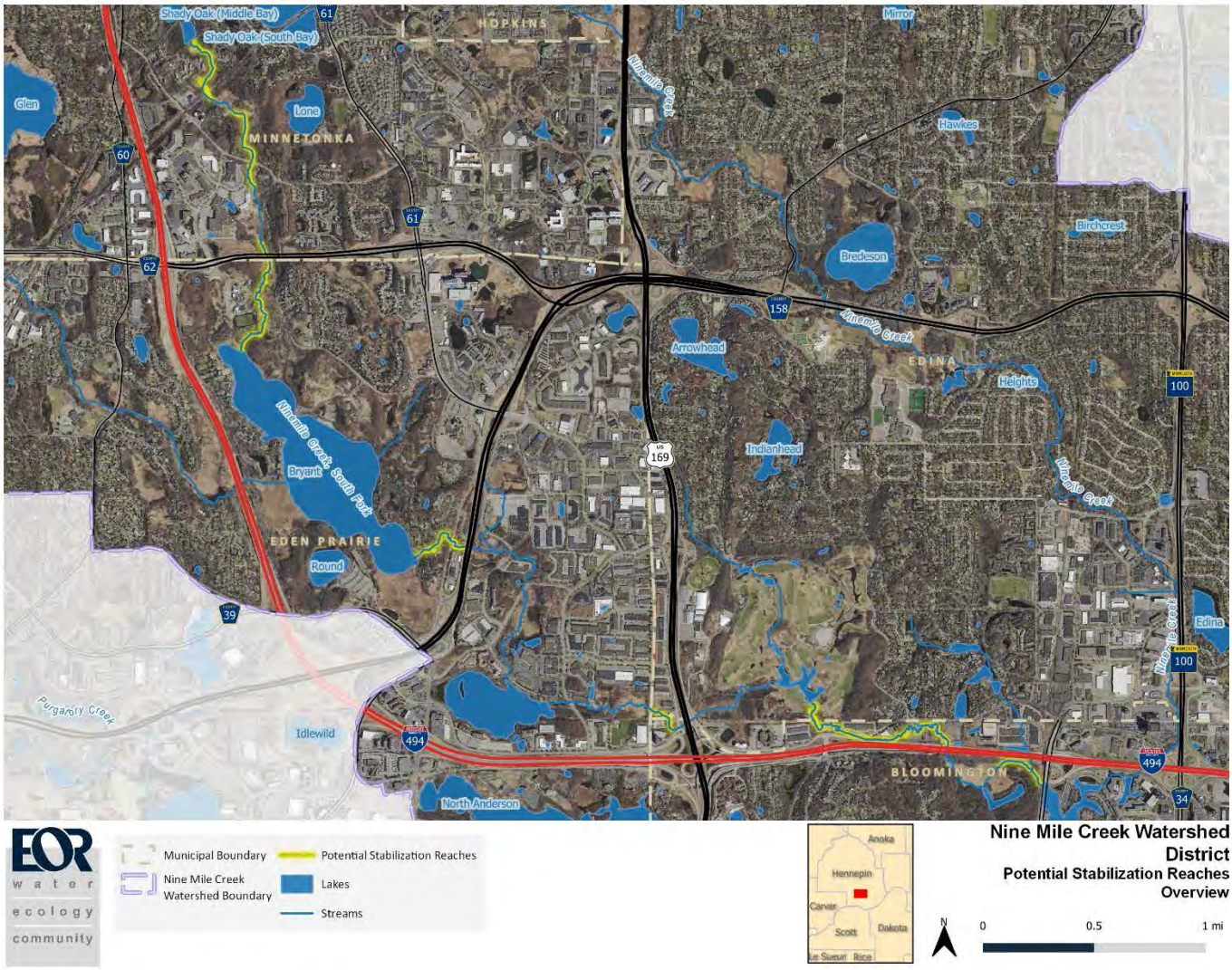


Figure 1. Project Overview Map

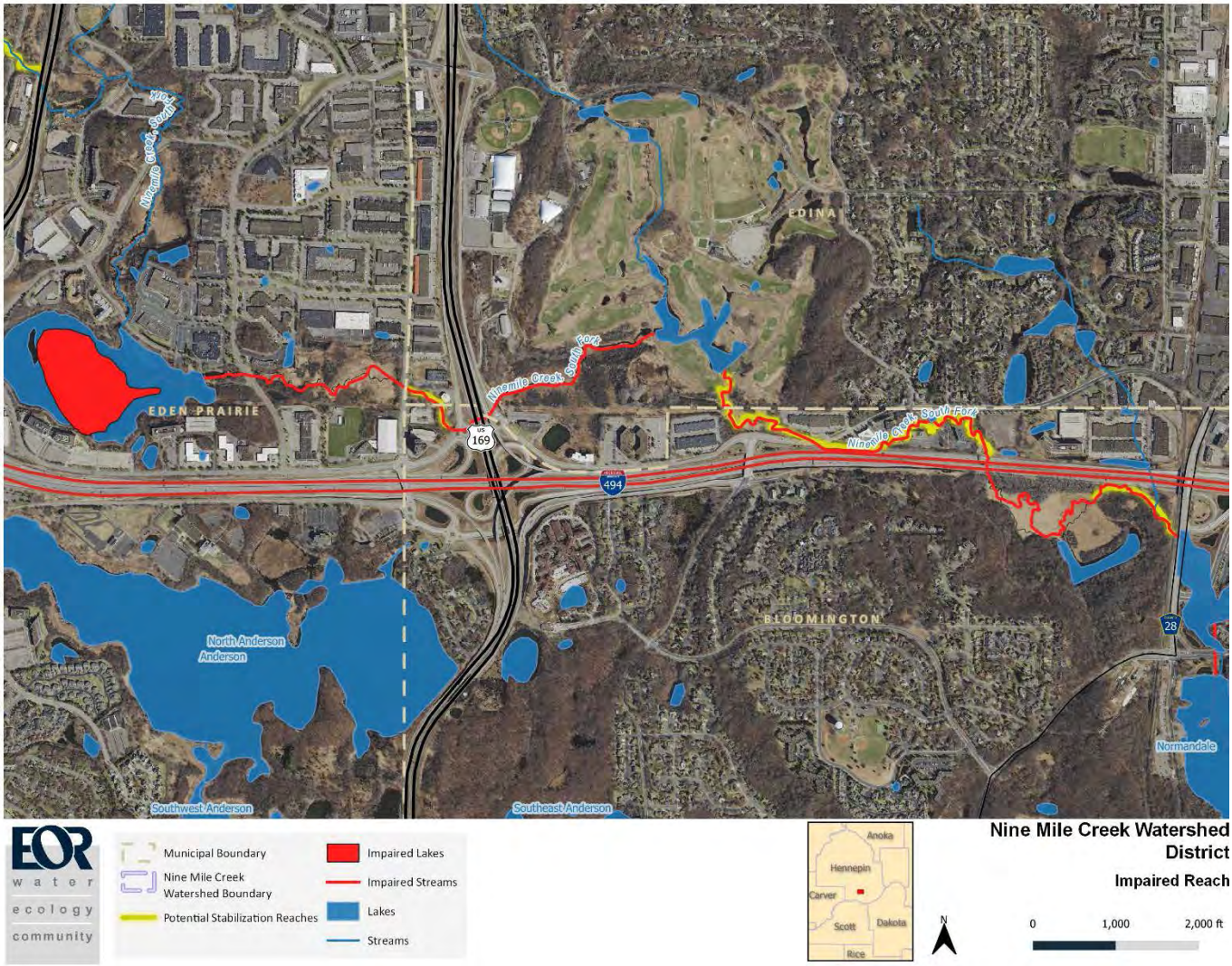


Figure 2. MPCA Impaired Waters Along South Fork Nine Mile Creek

visually apparent physical features within a designated reach of a stream corridor and assigns a numeric score based on each parameter evaluated. Total scores are tallied to determine the overall channel condition, with a scoring range from 14 to 147, with 14 signifying a stable and functional stream and 147 indicating a severely degraded stream. Due to its qualitative nature, the tool may not detect all causes of resource concerns, especially if such causes are a result of land use changes in other parts of the watershed.

To support the Pfankuch Stream Stability Index assessment, notes and photographs were taken in conjunction with GPS data points to document specific areas of bank erosion and infrastructure that could be impacted by continued channel migration and bank erosion.

To supplement the stream channel assessment, the NMCWD XPSWMM model was reviewed to understand the flow characteristics in the stream. The model contained 3,995 nodes and 4,949 links with a drainage area of approximately 16,977 acres. The model simulated runoff in the watershed using Horton infiltration and the SWMM runoff method. Peak flows for 2-year, 10-year, and 100-year 24-hour design storms were computed for Reach 8, upstream of Bryant Lake, and for Reach 19 at E Bush Lake Road (Table 1). The flow at Reach 8 is characterized by higher peak flows with a shorter duration while the flow at Reach 19 is characterized by significantly lower peak flows with a longer duration. The longer duration flows at Reach 19 are a result of the attenuation that occurs in the watershed as the water flows through a series of lakes and wetlands in the middle and lower portions of the creek.

Table 1. Predicted Peak Flows in South Fork Nine Mile Creek

Reach ID	Description	Peak Flow (cfs)		
		2-year 24-hour Design Storm (2.8 inches)	10-year 24-hour Design Storm (4.28 inches)	100-year 24-hour Design Storm (7.47 inches)
8	Upstream of Bryant Lake	292	506	1010
19	E. Bush Lake Road	109	170	269

RESULTS

The following is a summary of data collection and analyses completed for the project. Nineteen individual stream reaches were assessed from Minnetoga Lake/Jorissen Road to East Bush Lake Road (Figure 3). Stream reaches varied from stable "E" channels in the headwaters area upstream of Rowland Road to severely degraded "F" channels such as the reach between Creekridge Circle and I-494. Major stream issues identified in the degraded reaches included accelerated lateral bank migration, channel incision, floodplain abandonment, and poor riparian vegetation. Individual reach site descriptions can be found in Appendix A and reach photographs can be found in Appendix C.

Pfankuch Stream Stability Index Scores

Five channel conditions are computed from the Pfankuch Stream Stability Index based on the overall score of each reach assessed: Stable reaches have a score from 14-26, Fairly Stable reaches have a score from 27-44, Moderately Unstable reaches have a score from 45-79, Severely Unstable reaches have a score from 80-115, and Extremely Unstable reaches have a score from 116-147. Of the 19 reaches evaluated for this project, 4 reaches were Stable, 8 reaches were Fairly Stable, 4 reaches were Moderately Unstable, 3 reaches

were Severely Unstable, and 0 reaches were Extremely Unstable (Table 2, Table 3, Appendix D). Reach maps displaying the start and end points of each reach assessed and associated Pfankuch channel conditions are provided in Appendix B. In general, Stable reaches occurred in the headwaters area upstream of Rowland Road where stream gradient is low, riparian vegetation is dense, and limited stormwater inputs occur. As stream gradient and surface runoff increase in the system, the stream channel begins to degrade as reflected in the reaches downstream of Highway 62 and 78th Street. Stream channel degradation in these reaches is further exacerbated by poor soils composition (high sand content and/or stratified layers), poor streambank vegetation and surface protection, and high numbers of in-channel obstructions including down trees, log jams, and mid-channel bars that cause high sheer stress along the banks. Stormwater flow rates and sediment loading are attenuated in the larger lake and wetland systems along the creek corridor as reflected in the reaches that scored Fairly Stable downstream of Bryant Lake and the Braemar Golf Course ponds (Figure 3).

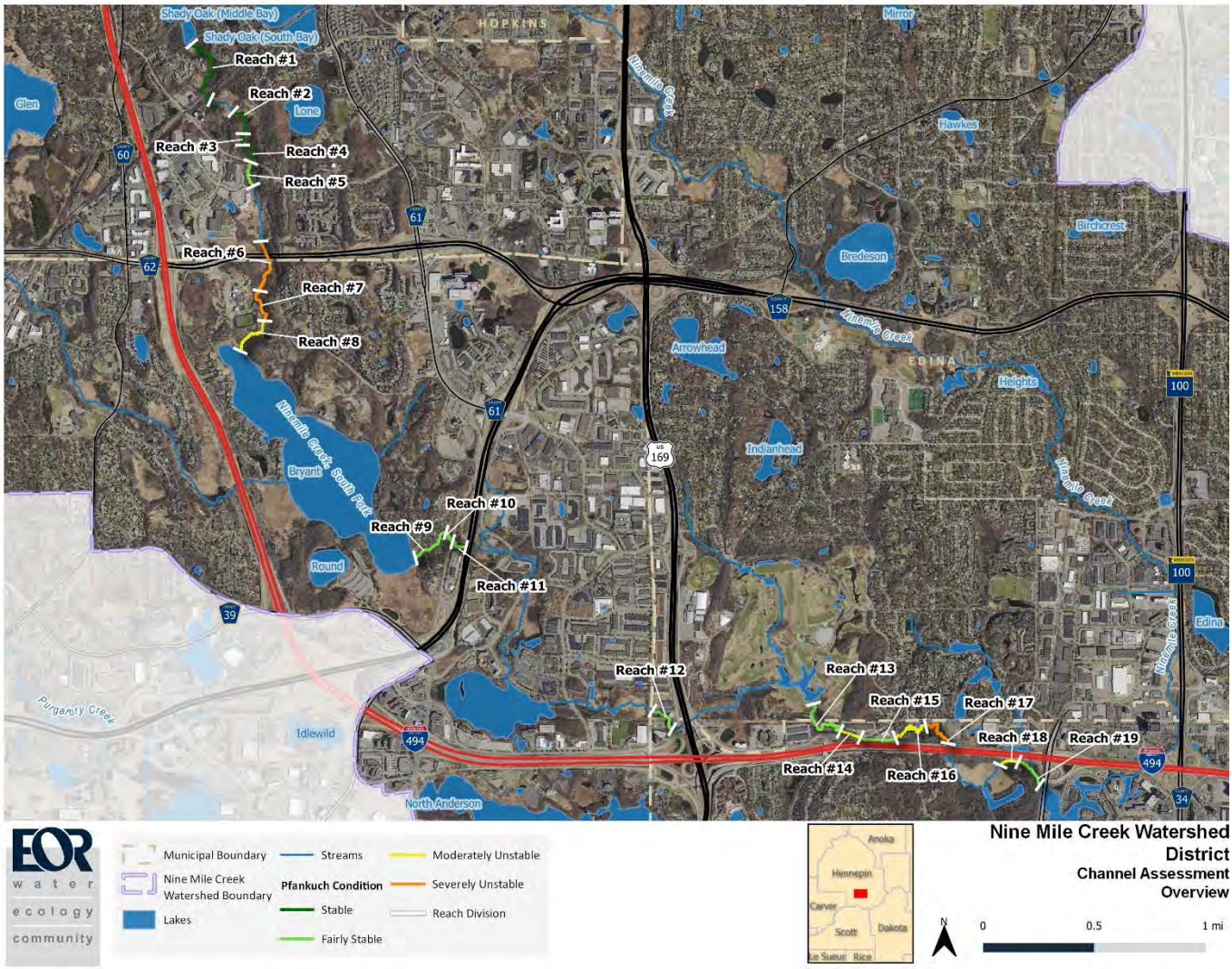


Figure 3. Stream Reaches Assessed along South Fork Nine Mile Creek

Table 2. Pfankuch Stream Stability Index Scores for 19 Reaches Assessed Along South Fork Nine Mile Creek

Reach #	Approximate Reach Length (ft.)	Stream Stability Index Score	Channel Condition
1	2018	22	Stable
2	769	18	Stable
3	277	23	Stable
4	550	15	Stable
5	609	40	Fairly Stable
6	1365	100	Severely Unstable
7	895	86	Severely Unstable
8	1134	54	Moderately Unstable
9	1169	44	Fairly Stable
10	290	40	Fairly Stable
11	455	44	Fairly Stable
12	730	42	Fairly Stable
13	1782	42	Fairly Stable
14	508	46	Moderately Unstable
15	873	44	Fairly Stable
16	1493	56	Moderately Unstable
17	1135	108	Severely Unstable
18	465	67	Moderately Unstable
19	784	30	Fairly Stable

Table 3. Pfankuch Channel Condition as a Percentage of Overall Length Assessed Along South Fork Nine Mile Creek

Channel Condition	Total Stream Length (ft.)	Overall Creek Length (%)
Stable	3614	21
Fairly Stable	6692	38
Moderately Unstable	3600	21
Severely Unstable	3395	20
Extremely Unstable	0	0

BANK STABILIZATION OPTIONS

Based on the results of the assessment and analysis of the data, several bank stabilization options were considered to address the degraded reaches along the creek. Bank stabilization options include the following bioengineering practices to reduce bank erosion while also restoring natural stream processes to improve sediment transport, maintain pool depths, and provide suitable substrates to improve the biotic impairments in the creek. These practices are also designed to provide stability and floodplain connectivity over a range of flows, including the three modeled peak flows shown in Table 1.

1. Toewood

The toewood practice utilizes natural materials (primarily large tree trunks, rootwads, and branches) to reconstruct a stable stream bank. Native soil, ideally sand and small gravel, is used as fill between the logs and branches with topsoil salvaged for use in a soil lift above the toewood structure. The rootwads and large tree trunks can be used to build-out (narrow) the stream bank, thereby reestablishing a stream bank formerly lost to erosion. Building out the stream bank will also improve sediment transport and establishment of deep pool habitat. Based on the existing size and number of trees within the project reaches, it appears there is ample woody material that could be harvested on-site for many of the bank erosion sites. Harvesting wood onsite offers a dual benefit for the project by reducing import of materials and providing selective thinning of the tree canopy to allow more sunlight to reach the ground surface, thereby allowing for the establishment of deep-rooted grasses and forbs to further stabilize the stream banks and increase the diversity of riparian vegetation.

2. Channel Narrowing with Woody Material and Boulder Toe

This practice incorporates bank grading along with rock and wood materials to stabilize the stream bank. Bank grading would be conducted to lower the stream banks and narrow the existing stream channel to improve sediment transport and improve pool depths. The existing stream banks would be lowered to the bankfull elevation with any excess soil used as fill along the stream bank. Field stone, rootwads, logs, and large branches harvested from the reach would be installed along the toe and face of the bankfull bench to provide stability of the bank and provide additional instream habitat. While this practice would require import of field stone, the amount of rock imported would be dependent on the amount of suitable woody material harvested onsite. This practice would require removal of trees along the entire length of the eroded bank to allow for bank grading and installation of materials.

3. Bank Stabilization with Woody Material and Grade Control

This practice incorporates a combination of bank grading, grade control, and placement of trees and logs to stabilize the stream bank. This approach incorporates grade control to increase and stabilize the bed elevation, thereby restoring slope and floodplain connectivity while reducing excavation inputs. The degree of bank grading will be based on the new bed elevation and established bankfull elevation. Logs, branches, and brush would be installed along the toe and face of the new bankfull bench to provide stability of the bank toe. As with the approaches above, this practice will require harvest of woody material that will allow for selective tree thinning and establishment of herbaceous riparian vegetation.

All three options presented would achieve the goals of stabilizing the stream banks, reducing sediment and nutrient loading, and improving instream fish and macroinvertebrate habitat. All three options would also

allow for narrowing of the stream channel to improve baseflow water depths, restore instream coarse substrates suitable for a variety of macroinvertebrates, and "build-out" away from key infrastructure while also increasing floodplain capacity along the creek corridor.

HIGH-LEVEL CONSTRUCTION COST ESTIMATES

EOR has reviewed recent contractor bid tabulations from similar projects that utilized the practices above to estimate high-level construction costs. In general, reaches with a Severely Unstable condition will require greater construction inputs, particularly soil excavation, compared to Moderately Unstable reaches. To simplify the development of high-level construction costs for this project, it is estimated Severely Unstable reaches will cost $120 per linear foot and Moderately Unstable reaches will cost $100 per linear foot. Primary factors that will impact the cost per linear foot include the amount of earthwork, tree harvest, and the proximity of construction to existing infrastructure such as grading near buildings/roads, harvesting trees near overhead utilities, or difficult site access.

Table 4 summarizes the reach lengths, proposed construction activities, and estimated construction costs for select reaches where channel degradation is most severe (Moderately Unstable and Severely Unstable reaches). The costs provided in the table represent only high-level estimates that would need to be refined using site-specific survey data and analysis. In addition, the cost estimates provided in Table 4 assume stabilization on a reach-by-reach basis; economy of scale would be realized if multiple reaches are implemented concurrently. Reach 14 and Reach 18 (both rated as Moderately Unstable) were excluded from the table since these reaches are confined to ditched sections of the creek adjacent to I-494 where there is very limited space to improve the creek. These reaches scored poorly in the upper bank category of the Pfankuch Stream Stability Index due to a disconnected floodplain; however, the lower banks in these reaches are relatively stable with only minor bank erosion observed. Therefore, the priority sites in Table 4 were based on the degree of observed bank erosion and active channel incision that is resulting in significant sediment and nutrient loading to the creek.

Table 4. High-Level Construction Cost Estimates for Select Reaches Along South Fork Nine Mile Creek.

Reach #	Pfankuch Channel Condition	Approximate Reach Length (ft.)	Proposed Bank Stabilization Options	Construction Cost	Engineering Cost*
6	Severely Unstable	1365	#1, #3	$163,800	(Implementation of all 5 Priority Reaches)
7	Severely Unstable	895	#1, #3	$107,400	
8	Moderately Unstable	1134	#1, #3	$113,400	
16	Moderately Unstable	1493	#1, #2	$149,300	
17	Severely Unstable	1135	#1, #2	$136,200	
TOTAL		**6,022**		**$670,100**	**$115,241**

*Refer to revised scope of services for breakdown of anticipated engineering tasks and hours

RECOMMENDATIONS

EOR has identified five potential bank stabilization project reaches along the South Fork Nine Mile Creek based on existing channel conditions and the degree of bank stability/ erosion (Table 4). It is recommended that the Severely Unstable reaches are prioritized for stabilization in the near future based on the severity of bank erosion in these reaches and the potential for impacts to existing infrastructure if erosion continues to advance. Although reaches 14 and 18 have a Moderately Unstable Pfankuch condition, overall bank erosion in these reaches is low compared to other sites. The greatest functional lift and benefit to the resource in terms of listed biotic impairments for the creek would be to prioritize the reaches that are contributing the greatest amount of sediment and nutrients to the system. Therefore, the reaches identified in Table 4 should be prioritized for restoration with consideration to improve reaches 14 and 18 at a later date. Reaches 6-8 are located upstream of the listed impairments for the creek but were included as a priority with reaches 16 and 17 due to excessive bank erosion and subsequent sediment loading to Bryant Lake.

Appendix A

Reach Descriptions

Reach 1

Reach 1 occurs from Jorrissen Road to the railroad crossing. The flow channel meanders through a shrub wetland complex comprised of a variety of native shrubs, grasses, and forbs but also contains invasive species including reed canary grass, narrowleaf cattail, glossy buckthorn, and common buckthorn. The channel banks are well vegetated and show little sign of erosion. The stream gradient is low with no perennial baseflow; some areas along the reach did not contain water. The stream channel is fully connected to the floodplain and contained dense herbaceous vegetation. Stream type: E, Pfankuch Condition: Stable.

Reach 2

Reach 2 begins downstream of the railroad crossing and extends to Lone Lake Park. The flow channel meanders through a wetland complex dominated by narrowleaf cattail and reed canary grass. The open canopy in this reach provides for dense herbaceous vegetation, resulting in channel banks that are well vegetated and show little sign of erosion. The stream gradient is low with no perennial baseflow; the channel downstream of the cattail marsh was dry during the assessment. Stream type: E, Pfankuch Condition: Stable.

Reach 3

Reach 3 occurs in Lone Lake Park upstream of the parking lot north of Rowland Road. The flow channel winds through a grassy meadow that contains dense herbaceous vegetation and a very stable channel that shows little sign of erosion. The stream gradient is low with no perennial baseflow; much of the channel was dry during the assessment. The floodplain becomes constricted in this reach but it is mostly connected to the floodplain during bankfull events. Stream type: E transitioning to a C, Pfankuch Condition: Stable.

Reach 4

Reach 4 occurs within a wetland meadow in Lone Lake Park and extends downstream to Rowland Road. The flow channel is much wider than the reaches upstream yet it is well connected to the floodplain. Herbaceous vegetation is dominated by reed canary grass which provides ample surface protection of the channel banks. As with the reaches upstream, the stream gradient is very low with no perennial baseflow; the stream channel was completely dry during the assessment. Stream type: C, Pfankuch Condition: Stable.

Reach 5

Reach 5 begins at Rowland Road and extends downstream approximately 600 feet. A large stormwater outfall is present at the upstream end of the reach and contributes a significant volume of runoff to the flow channel. Dense herbaceous vegetation within the reach provides good surface protection of the channel banks, though minor bank erosion does occur in the area downstream of the storm water outfall. The reach contains a low gradient channel that is well connected to the floodplain. A small groundwater spring occurs in the middle of the reach and provides a low volume of perennial baseflow. Stream type: C transitioning to E, Pfankuch Condition: Fairly Stable.

Note: The MPCA has a biological monitoring station located in this reach (03MN096) that was last sampled in 2005.

Reach 6

Reach 6 begins approximately 300 feet upstream of Highway 62 and extends downstream of Highway 62 approximately 800 feet. Channel downcutting (incision) begins in this reach and increases downstream.

Bank heights range from 1.5-3 feet with some banks over 6 feet in height, resulting in a floodplain that is mostly disconnected from the creek except during high flow events. A dense tree canopy occurs throughout the reach with invasive species (buckthorn) dominating the shrub layer. Dense shading has resulted in poor streambank vegetation with raw banks common throughout the corridor. Bank erosion is substantial in this reach, yet exposed gravel and cobble substrates occur within the stream. Perennial flow from groundwater supports a small assemblage of minnows and macroinvertebrates that were observed during the assessment. Stream type: C transitioning to F, Pfankuch Condition: Severely Unstable.

Reach 7

Reach 7 begins at the downstream terminus of Reach 6 and extends downstream to a paved walking path due west of Bryant Lake Dog Park. Similar to Reach 6, channel incision has resulted in bank heights that range from 1.5-4 feet, resulting in a floodplain that is mostly disconnected from the creek except during high flow events. A dense tree canopy occurs throughout the reach with buckthorn dominating the shrub layer. Dense shading has resulted in poor streambank vegetation with raw banks common along the corridor. Bank erosion is substantial in this reach, yet exposed gravel and cobble substrates occur within the stream, including numerous large fieldstone boulders scattered within the channel. Perennial flow from groundwater discharge supports a small assemblage of minnows and macroinvertebrates that were observed during the assessment. Pools are limited by sediment aggradation with depths that range from 0.8-1.25 feet. Stream type: F, Pfankuch Condition: Severely Unstable.

Reach 8

Reach 8 begins at the paved trail crossing due west of Bryant Lake Dog Park and extends downstream to the inlet to Bryant Lake. Reach 8 has a lower stream gradient compared to reaches 6-7 and is kept in check by the water elevation of Bryant Lake. The stream channel becomes narrower in areas with a reduced tree canopy, but bank erosion is still prevalent throughout the reach. A large sediment delta occurs at the inlet to Bryant Lake due to significant bank erosion that has occurred upstream. Stream substrates are predominantly sand with some gravel exposed in riffles and at channel constrictions. Pool depths are greatly diminished by the high sediment load and are on average less than one foot in depth. Stream type: F transitioning to a C, Pfankuch Condition: Moderately Unstable.

Reach 9

Reach 9 occurs from the outlet of Bryant Lake to an old channel crossing located approximately 275 feet upstream of Bryant Lake Drive. This reach has significantly less bank erosion compared to reaches 6-8, due in part to flow attenuation in Bryant Lake. The floodplain has been highly altered in this reach. The channel immediately downstream of Willow Creek Road is very wide (~20 feet) and shallow with no defined thalweg. Stream depths average less than 0.25 feet. The combination of very shallow stream depths and a very wide channel has resulted in poor channel substrates that are comprised of silt and sand. Conversely, a narrow stream channel occurs downstream of a private driveway crossing where the channel has been lined with fieldstone rock. Stream flow is concentrated within the rock channel which has resulted in greater stream depths and a defined thalweg. Stream type: DA transitioning to a C, Pfankuch Condition: Fairly Stable.

Reach 10

Reach 10 is a short section of the creek between the old channel crossing at the downstream terminus of Reach 9 and extends to Bryant Lake Drive. Reach 10 marks the end of the altered channel conditions documented in Reach 9. The tree canopy is reduced, resulting in well vegetated grassy stream banks. This reach contains a sinuous channel with a defined riffle-pool sequence. Although the channel is slightly incised, the floodplain is mostly connected to the stream due in part to three rock grade control structures that limit further channel incision. The channel is much narrower than Reach 9 and contains an increase in gravel substrates. Reach 10 marks the beginning of aquatic macrophyte growth within the creek and is

likely the result of seed dispersal from the existing macrophyte community in Bryant Lake. Species observed include curly-leaf pondweed, coontail, and floating-leaf pondweed. Stream type: E, Pfankuch Condition: Fairly Stable.

Reach 11

Reach 11 occurs from Bryant Lake Drive to Highway 212. A recent bank stabilization project has occurred in this reach that incorporated bank grading, boulder toe, and rock grade control structures. Stream gradient is low through the reach and is controlled by the rock grade control structures and the culvert elevation under Highway 212. Channel substrates include coarse gravel, sand, and silt with aquatic macrophytes occurring in areas where the tree canopy is open. Stream type: C, Pfankuch Condition: Fairly Stable.

Reach 12

Reach 12 occurs from Washington Avenue to Highway 169. Stream gradient is very low through this reach and is controlled by the Highway 169 culvert elevation. The channel banks are well vegetated where the tree canopy is reduced, but bank erosion was observed in a few areas. The stream channel is relatively flat and wide, resulting in sediment aggradation and poor substrate composition dominated by silt, sand, and dense aquatic macrophyte beds. Stream type: C, Pfankuch Condition: Fairly Stable.

Reach 13

Reach 13 occurs from the eastern Braemer Golf Course Pond to the east edge of the wetland meadow approximately 400 feet upstream of 78th Street. The stream channel in this reach flows through a wetland meadow dominated by reed canary grass. Channel substrates are comprised of silt and sand, resulting in poor riffle habitat. However, this reach contained the deepest pools of all the reaches assessed and are maintained by channel sinuosity, a narrow channel, and flow obstructions including down wood and brush. Pool depths ranged from 1.5-3 feet, with a few pools over three feet in depth. A low stream gradient and fine channel substrates support a variety of aquatic macrophytes including floating-leaf pondweed, lesser duckweed, watermeal, sago pondweed, curly-leaf pondweed, Canada waterweed, and coontail. In addition, a few native mussels were found including giant floater and pea clam. Stream type: E, Pfankuch Condition: Fairly Stable.

Reach 14

Reach 14 starts at the downstream terminus of Reach 13 and extends to 78th Street. The stream channel in this reach appears highly altered and ditched with a very narrow floodplain. The stream channel is wide and straight with substrates comprised of silt and sand. Riffle and pool features are diminished and affected by poor sediment transport and high composition of fine bed material. Pool depths range from 1-1.5 feet. Stream gradient is controlled by a rock grade control structure at the upstream end of the culvert under 78th Street. Minnows and giant floaters were observed in the reach along with dense macrophyte beds. Stream type: C, Pfankuch Condition: Moderately Unstable.

Reach 15

Reach 15 occurs from 78th Street and extends downstream approximately 700 feet. The stream channel in this reach has been ditched and runs parallel to I-494 with a floodplain that is almost non-existent. Stream bank vegetation is dominated by reed canary grass which provides ample surface protection. Although channel morphology is poor, little bank erosion was observed due in part to a low stream gradient, a wide channel, and densely vegetated stream banks. An increase in coarse substrates occurs in this reach, possibly derived from imported road base material from I-494. The open canopy along this reach allows for colonization of dense aquatic macrophyte beds comprised of floating-leaf pondweed, start duckweed, lesser duckweed, Canada waterweed, sago pondweed, and watermeal. Groundwater seepage was observed

along the north embankment along I-494. Stream type: C transitioning to F, Pfankuch Condition: Fairly Stable.

Reach 16

Reach 16 occurs from the downstream terminus of Reach 15 to Creek Ridge Drive. The stream channel courses through a dense forested corridor dominated by box elder, cottonwood, and common buckthorn. The dense tree and shrub canopy limits available sunlight, thereby reducing herbaceous ground cover. Lateral bank migration is exacerbated by a combination of high channel sinuosity, poor streambank vegetation, and numerous channel obstructions comprised of down trees, branches, and debris jams. Bank erosion has resulted in the formation of several mid-channel bars and side bars which has caused further bank erosion through deflection of high flow velocities into the adjacent stream banks. In areas with a reduced tree canopy, the stream channel is narrower with densely vegetated stream banks and limited bank erosion compared to the wooded areas. Pool depths in this reach range from 1-2 feet and provide habitat for a few species of fish including minnows and dace. In areas with an open tree canopy, some macrophyte growth was observed. Other aquatic species identified in the reach included pea clams and giant floaters. Stream type: C, Pfankuch Condition: Moderately Unstable.
Note: The MPCA has a biological monitoring station located in this reach (03MN059) that was last sampled in 2015.

Reach 17

Reach 17 is located between Creek Ridge Drive and I-494. Similar to Reach 16, the stream channel courses through a dense forested corridor dominated by box elder, cottonwood, and common buckthorn. Herbaceous ground cover is limited due to the dense tree and shrub canopy. Bank erosion and sediment issues abound in this reach and are the result of lateral bank migration that is exacerbated by a combination of high channel sinuosity, poor streambank vegetation, and numerous log jams and down trees. The stream channel has migrated near significant infrastructure including the road embankment of 78th Street and a commercial building; therefore, this reach is considered a top priority for a stabilization project. Bank heights range from 2-6 feet with a few banks over 15 feet in height. Pool depths in this reach range from 1-2 feet and provide habitat for a few species of fish including minnows and dace. Stream type: C transitioning to F, Pfankuch Condition: Severely Unstable.

Reach 18

Reach 18 begins at the east edge of the wetland complex south of I-494 and extends downstream approximately 460 feet. The stream channel in this reach occurs in a highly altered and ditched corridor with a very narrow floodplain. The stream channel is wide and straight with substrates comprised of silt and sand. Riffle and pool features are diminished and affected by poor sediment transport and high composition of fine bed material. Stream type: F, Pfankuch Condition: Moderately Unstable.

Reach 19

Reach 19 begins at the downstream terminus of Reach 18 and extends to East Bush Lake Road. The stream channel transitions into a wetland meadow dominated by reed canary grass and narrowleaf cattail. The stream channel is mostly connected to the floodplain and has limited bank erosion. Stream gradient in this reach is low with channel substrates comprised of silt and sand that support abundant macrophyte growth. Stream type: C, Pfankuch Condition: Fairly Stable.
Note: The MPCA has a biological monitoring station located in this reach (03MN097) that was last sampled in 2005.

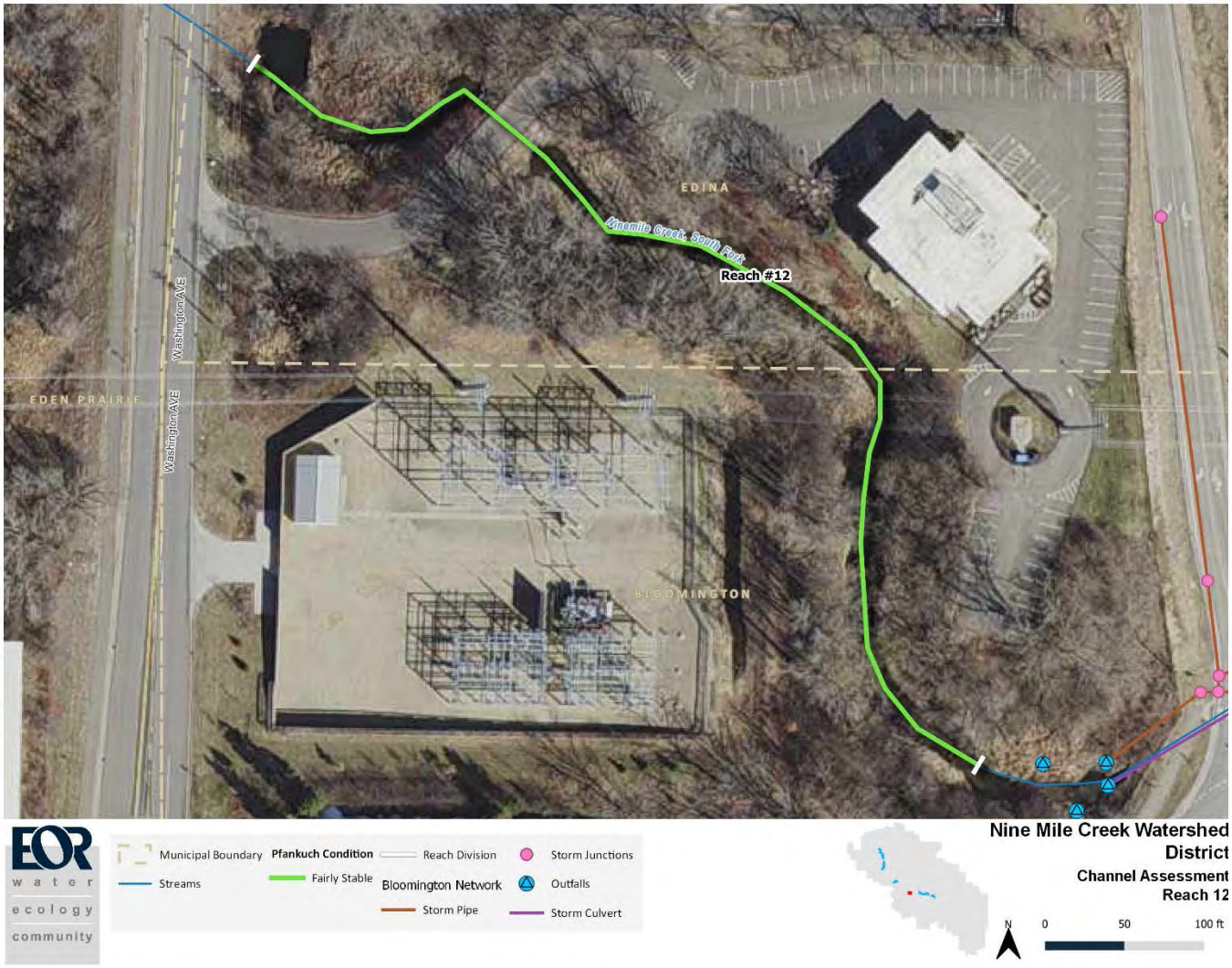
Appendix B

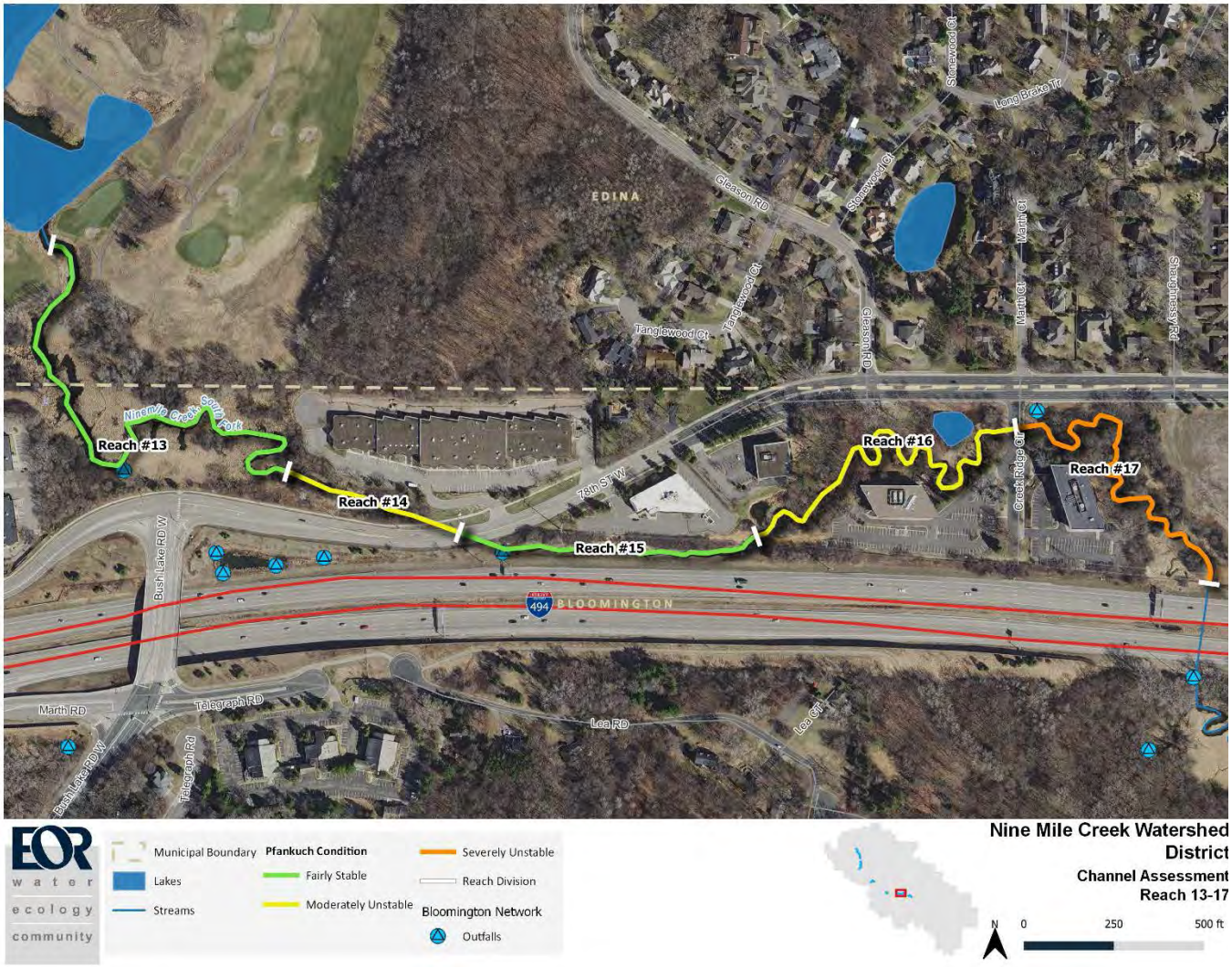
Reach Maps


Reach #3
Ninemile Creek, South Fork
Reach #4
Clearwater Dr
Roxland Rd
MINNETONKA
Clearwater Dr
Whitewater Dr
Reach #5
Whitewater Dr
Bren Rd
Bren Rd
Streams
Pfankuch Condition
Reach Division
Stable
Minnetonka Network
Fairly Stable
Storm Sewer
Outfalls
water
ecology
community
Nine Mile Creek Watershed District
Channel Assessment
Reach 4-5
N
0
100
200 ft


MINNETONKA
EDEN PRAIRIE
Reach #6
Reach #7
Reach #8
Bryant
Clearwater Dr
Chasewood Pkwy
Rowland Rd
Chasewood Dr
Morningside Ct
Morningside Dr
Thornhill Rd
Fallbrook Rd
Driftwood Rd
Orchard Hill
Fallbrook Rd
Boulder Bay Rd
Dunhill Rd
Beach Rd
62
494
Municipal Boundary
Lakes
Streams
Pfankuch Condition
Moderately Unstable
Severely Unstable
Reach Division
Eden Prairie Network
Storm Points
Outfalls
Storm Lines
Nine Mile Creek Watershed District
Channel Assessment
Reach 6-8
N
0
250
500 ft


Reach #10
Reach #11
Reach #9
EDEN PRAIRIE
Bryant Lake Dr
Willow Creek Rd
Bryant
Lakes
Streams
Pfankuch Condition
Fairly Stable
Reach Division
Eden Prairie Network
Storm Points
Outfalls
Storm Lines
Nine Mile Creek Watershed District
Channel Assessment
Reach 9-11
N
0
50
100 ft


EDINA
Nine Mile Creek, South Fork
Reach #12
Washington AVE
EDEN PRAIRIE
Washington AVE
BLOOMINGTON
Municipal Boundary
Streams
Pfankuch Condition
Fairly Stable
Reach Division
Bloomington Network
Storm Pipe
Storm Junctions
Outfalls
Storm Culvert
Nine Mile Creek Watershed District
Channel Assessment
Reach 12
N
0
50
100 ft

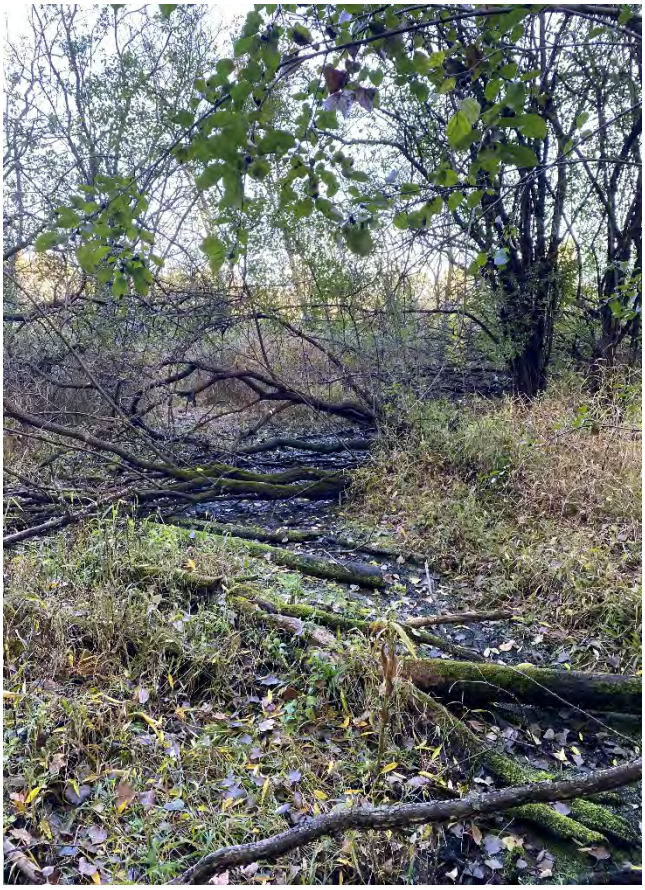

EDINA
BLOOMINGTON
494
Reach #13
Reach #14
Reach #15
Reach #16
Reach #17
Nine Mile Creek South Fork
Gleason RD
Tanglewood Ct
Stonewood Ct
Long Brake Trl
Marth Ct
Shangrilassy Rd
Creek Ridge Ct
75th St W
Bush Lake RD W
Marth RD
Telegraph RD
Telegraph Rd
Lea RD
Lea Crt
Municipal Boundary
Lakes
Streams
Pfankuch Condition
Fairly Stable
Moderately Unstable
Severely Unstable
Reach Division
Bloomington Network
Outfalls
Nine Mile Creek Watershed District
Channel Assessment
Reach 13-17
N
0
250
500 ft


Reach #18
Reach #19
BLOOMINGTON
Minnie Creek South Fork
494
Lakes
Streams
Pfankuch Condition
Fairly Stable
Moderately Unstable
Reach Division
Nine Mile Creek Watershed District
Channel Assessment
Reach 18-19
N
0
50
100 ft

Appendix C

Reach Photographs

Reach 1



Reach 2

Reach 3

Reach 4

Reach 5

Reach 6

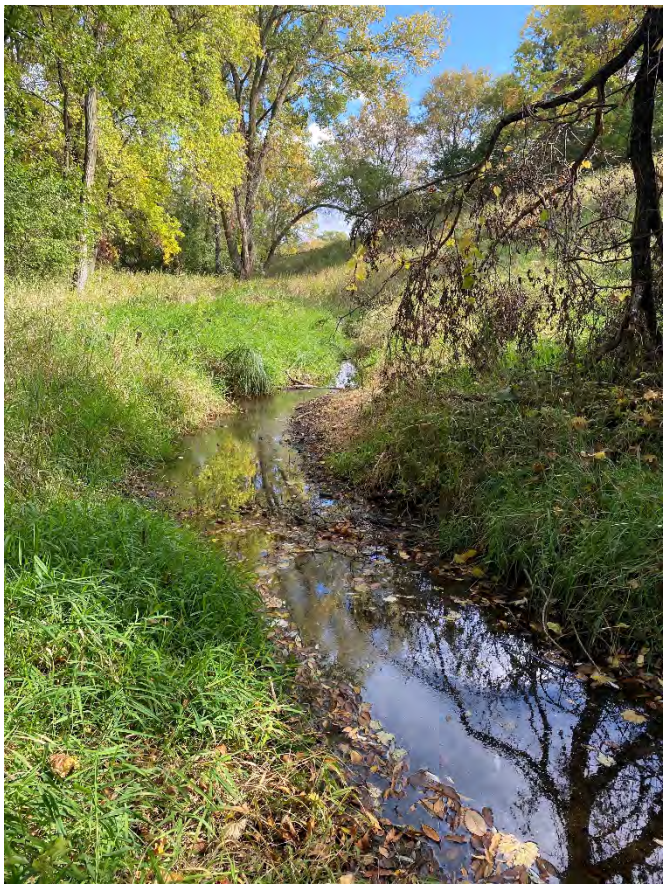
Reach 7

Reach 8

Reach 9

Reach 10

Reach 11



Reach 12

Reach 13

Reach 14

Reach 15

Reach 16

Reach 17

Reach 18

Reach 19

Appendix D

Pfankuch Stream Stability Index Data Summary

Reach #	1. Upper Banks				2. Lower Banks				3. Bottom			4. Stage of channel evolution	Score	
	Intermediate floodprone width	Degree of incision	Vegetative bank protection	Mass wasting or bank failure	Bank Materials/shear strength	Flow deflectors	Obstructions to flow/sediment traps	Cutting/scouring or gw seepage	Consolidation or particle packing (vertical)	Evidence of degradation/excess scouring	Evidence of aggradation/excess deposition	Stage observed	Stream Stability Index Total	Channel Condition
1	1	1	1	1	1	1	1	2	10	1	1	1	22	**Stable**
2	1	1	1	1	1	1	1	2	6	1	1	1	18	**Stable**
3	7	3	1	1	1	1	1	2	3	1	1	1	23	**Stable**
4	1	1	1	1	1	1	1	2	3	1	1	1	15	**Stable**
5	7	3	2	1	5	3	3	6	2	3	3	2	40	**Fairly Stable**
6	10	9	7	4	7	7	10	14	6	9	10	7	100	**Severely Unstable**
7	7	9	3	4	7	7	10	10	6	7	10	6	86	**Severely Unstable**
8	5	6	5	4	3	3	3	6	3	5	6	5	54	**Moderately Unstable**
9	5	3	5	1	3	3	3	2	3	3	10	3	44	**Fairly Stable**
10	5	9	1	1	1	3	6	2	3	3	3	3	40	**Fairly Stable**
11	7	6	3	2	3	1	3	4	3	3	6	3	44	**Fairly Stable**
12	5	3	1	1	3	3	3	4	3	3	10	3	42	**Fairly Stable**
13	3	6	1	1	3	3	3	4	6	3	6	3	42	**Fairly Stable**
14	7	6	3	2	3	3	3	4	3	3	6	3	46	**Moderately Unstable**
15	10	6	3	2	3	3	1	4	3	1	3	5	44	**Fairly Stable**
16	5	9	3	4	3	5	6	4	3	3	6	5	56	**Moderately Unstable**
17	3	12	7	11	7	9	14	14	3	7	10	11	108	**Severely Unstable**
18	10	12	10	2	3	5	3	6	6	1	6	3	67	**Moderately Unstable**
19	3	3	1	1	1	1	1	2	10	3	3	1	30	**Fairly Stable**