memo

Project Name |	Riparian Shading Feasibility Projects (10B, 11, 12 & 13)	**Date** |	6/6/2018
To / Contact info |	BCWD Board of Managers		
Cc / Contact info |	Karen Kill, District Administrator Camilla Correll, District Engineer		
From / Contact info |	Kevin Biehn & Mike Majeski		
Regarding |	Project Cost & Benefit Analysis		

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BACKGROUND

This memo characterizes the following four potential capital improvement projects that have been previously identified by the District, most recently vetted via the District's *Riparian Shading Study (2018)*. The intent of this effort is to further advance the planning of these projects so that the District can make more informed decisions on project prioritization and is in better position to receive project funding if so inclined. These four projects are identified in the following table and in Figure 1.

Unique ID*	Type of Project	Location/Length
10B	Shading along stream	1,100 Linear Feet adjacent to Millbrook Development
11	Shading along stream	1,300 Linear Feet on City of Stillwater/Millbrook Development
12	Stream enhancement, stabilization & shading	450 Linear Feet Upstream of Hwy 96/ Costa Property
13	Restoring a previously straightened segment of the creek with an emphasis on shading	1,045 Linear Feet on Costa Property

* ID references the proposed thermal improvement projects from the TMDL Implementation Plan (Figure 1).

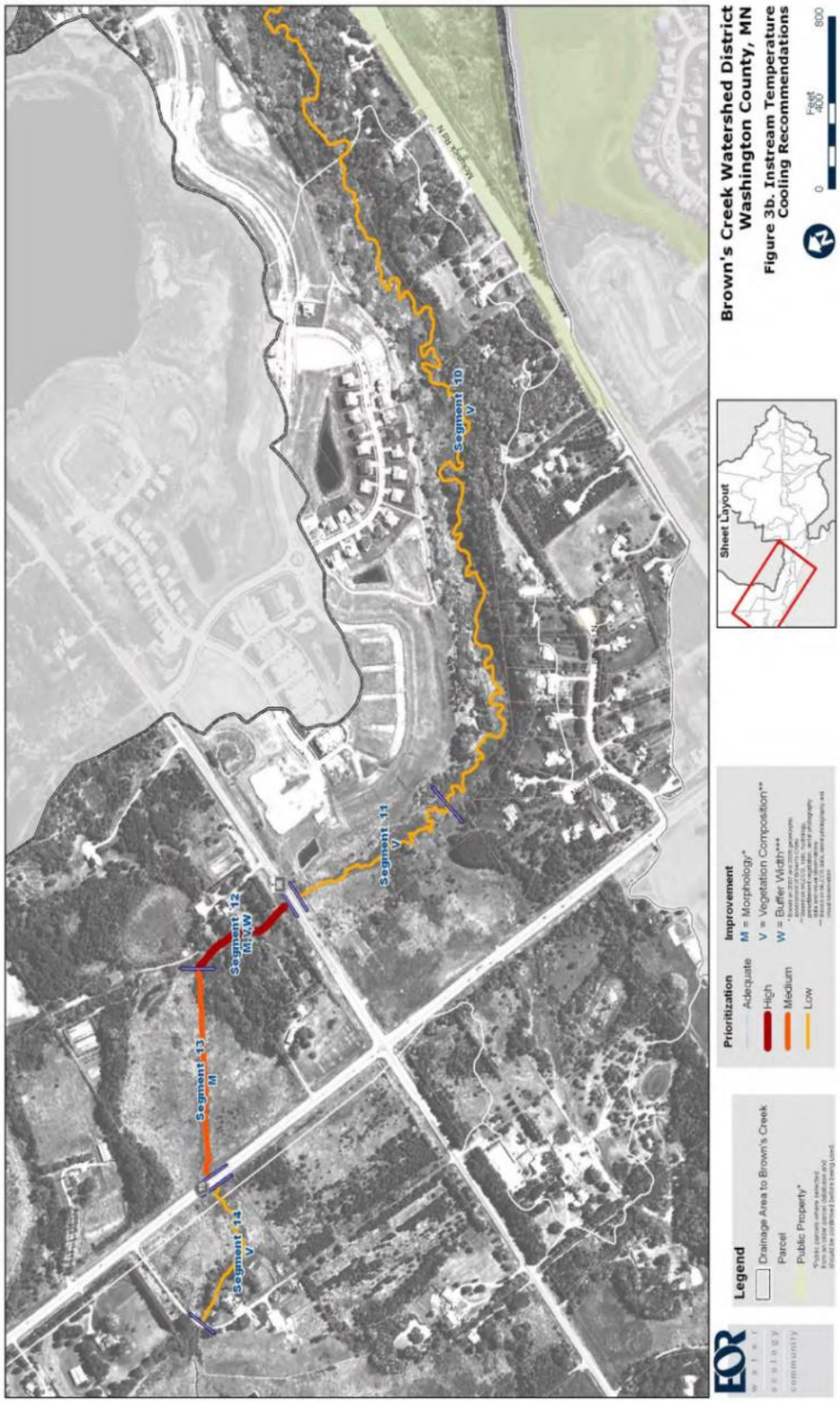

Figure 1. Project location map excerpted from page 41 of the BCWD TMDL Implementation plan

INDIVIDUAL PROJECT ASSESSMENTS & CONCEPT DESIGNS

Site 10B

Site Assessment
Site 10B is located immediately south of the Millbrook development and encompasses the segment of Brown's Creek that flows through an existing shrub wetland where beaver dams have historically occurred. This reach was assessed on May 15, 2018 and only one remnant beaver dam was identified. The dam was not fully intact and no longer supports the beaver pond that occurred immediately upstream of the dam. The creek is now contained entirely within the banks of the channel. Based on aerial imagery (Figure 2 & Figure 3), the beaver dam was built sometime between April 2011 and March 2012 and failed sometime before October 2014. During the period of beaver activity, approximately 575 linear feet of the creek upstream of the dam was inundated as the beaver pond flooded over the banks of the channel. This resulted in the localized die-off of speckled alder and other shrubs that were growing adjacent to the creek. The die-off of woody vegetation along the flooded wetland has resulted in increased solar energy inputs within the creek.

Following the dam failure, the water levels receded in the beaver pond, and subsequently two meander cutoffs occurred within the previously flooded channel (Figure 4). The meander cutoffs were likely the result of the dam failure. The creek banks in this reach are comprised of peat, silt, and muck that were likely softened by the prolonged inundation of the beaver pond. Once the beaver dam failed, the stream was able to preferentially flow over the meanders, in part due to channel aggradation that occurred upstream of the dam. The preferential flow over the meanders resulted in the eventual cutoff of the two meanders. Approximately 148 linear feet of stream length was lost following the two meander cutoffs.

The existing instream habitat features of site 10B include a typical riffle/pool sequence with soft substrates along the inside bends of the meanders and coarse sands and small gravels within the riffles. Woody debris is common throughout the reach and is comprised primarily of the trunks and branches of alder and willow that have fallen into the creek. Leaf packs are also common in areas where woody debris has accumulated within the channel. The leaf packs provide refuge and food for a variety of aquatic macroinvertebrates. The meander cutoffs, which are now oxbow wetlands, provide habitat for amphibians and reptiles and contain suitable substrates (muck and peat) for obligate wetland hydrophytes such as sedges and bulrushes to colonize. Prior to the beaver dam, seven discernable meander cutoffs were found within this reach. Following the dam failure, there are now nine meander cutoffs within the reach. In regards to a coldwater fishery, the primary limiting habitat feature within this reach is the lack of deep pool habitat. Most pools are less than 2 feet deep at baseflow stage.

Concept Design
The proposed concept design for site 10B includes the planting of herbaceous plugs and wetland adapted trees and shrubs such as tamarack, silver maple, speckled alder, and red-osier dogwood within the previously flooded wetland area to increase the amount of shade over the creek during the growing season. A list of plants suitable for planting within the riparian corridor (copied from the Riparian Shading Study) is summarized in Appendix A. Strategic placement of shrubs and trees as recommended in the Riparian Shading Study is proposed to allow for maximum shade over the stream while maintaining dense herbaceous vegetation along the creek banks. As shown in Figure 5, the placement of trees is to occur along the south side of the creek and spread out to maximize shading in areas where the existing tree canopy is limited. In general, the shrubs will be placed closer to the stream and the trees set further back to prevent shading out of herbaceous species

growing along the stream banks, thereby limiting bank erosion and subsequent channel widening commonly observed along streams with dense wooded corridors. All shrubs and trees planted would require browse protection from deer and beaver. The herbaceous plants listed in Appendix A include those species that grow tall and have broad leaves to maximize shading of the creek. These species are proposed to be planted in strategic locations along the stream banks within the "herb. enhancement" polygon as shown in Figure 5. Planting herbaceous species along both sides of the creek was considered, but intensive, long-term management of the existing reed canary grass meadow along the creek would be required to ensure the establishment of the native herbaceous plants. This management effort may not be feasible considering the constraints of the HOA parcel and adjacent private parcels. The proposed planting of herbaceous species in groups at specific locations along the south and west sides of the creek would only require management of small pockets of reed canary grass. The placement of native species in groups would increase the chance of establishment as a whole, and the plants would better withstand the encroachment of reed canary in the long-term. This concept design would require the management of small pockets of reed canary grass in specific locations where the herbaceous plants are proposed. Management of reed canary grass will require multiple treatments of herbicide and/ or prescribed burns prior to planting the native species.

The aforementioned meander cutoffs are part of the natural geomorphic process of an "E" channel and the recent stream changes in this reach were caused primarily from beaver activity. As stated above, these cutoffs provide habitat for a variety of flora and fauna and do not pose significant thermal or sediment impacts to the creek. Reconnecting the cut off meanders via the use of heavy machinery was considered, but based on professional judgement the cost and risk of failure (breaching of meander) outweighs any minor benefits of increased sinuosity and floodplain connectivity. Therefore, construction activities related to reconnecting the recently cut off meanders are not being proposed.

Figure 2. Brown's Creek on May 18, 2010 before the beaver dam was constructed (beaver dam location added for reference)

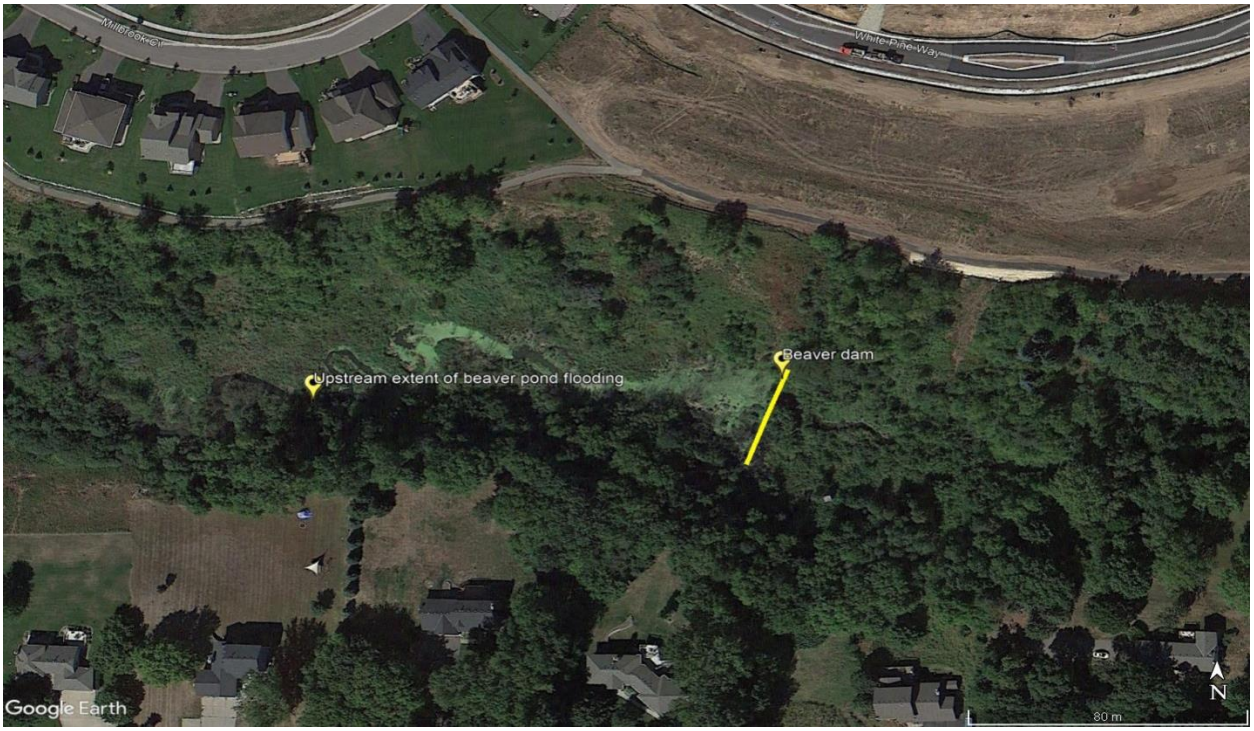

Figure 3. Brown's Creek on September 15, 2013 showing the extent of the beaver pond (pale lime green color along the creek alignment indicates ponded water and colony of duckweed and possible algae floating on the surface)

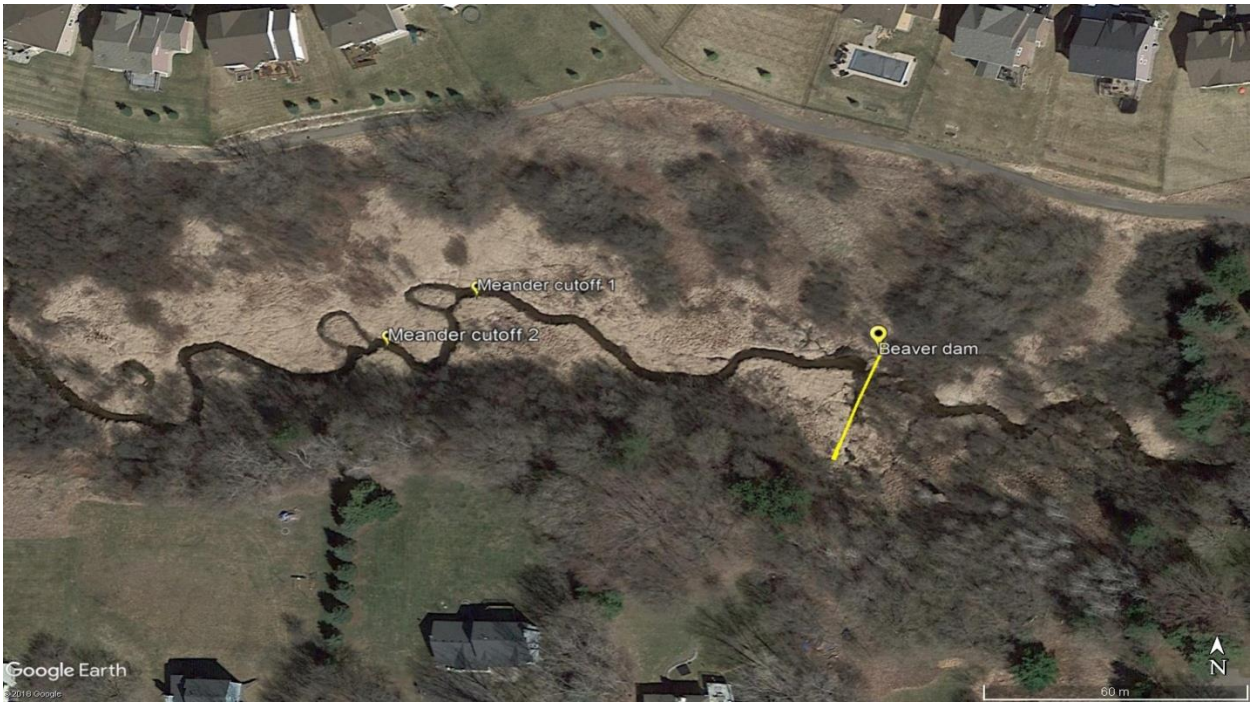

Figure 4. Brown's Creek on April 5, 2017 showing the locations of the meander cutoffs following the beaver dam failure.

Three-year maintenance will include routine irrigation of all planted materials and replacement of species that do not become established. Long-term maintenance of the site may also include occasional prescribed burns, invasive species management, and upkeep or replacement of shrub and tree browse protection devices. Biannual beaver dam inspections and beaver trapping may be warranted to ensure the plant survival within the project area.

The estimated costs for project administration, legal overview, engineering, implementation, and three-year operations & maintenance for this concept design are outlined in Table 1.

Permit Considerations

Permit submittals that will be required for the project include a joint permit application through MNDNR (MPARS) and the United States Army Corps of Engineers. Project disturbance from tree, shrub, and herbaceous plug plantings should be less than 400 square feet within the wetland areas. If wetland impacts from the proposed project are determined to be less than 400 square feet, the project will likely not require a permit; however, the project will still need to be reviewed by regulatory agencies for approval.

Access & Accessibility

The project is intended to be limited to the parcel owned by the Millbrook Home Owners Association (HOA). The Millbrook HOA has been a willing participant in previous District projects and is open to this project in principle. Construction access permission will need to be obtained from the HOA. The proposed construction access is shown in Figure 6. Construction limits for this project will occur within the immediate stream corridor, confined to the pink-shaded "herb. enhancement" polygon as shown in Figure 5. In addition, an easement along the project reach will need to be obtained from the property owner to conduct long-term site monitoring and maintenance of the project. The easement will need to encompass the construction limits of the project site as described above.

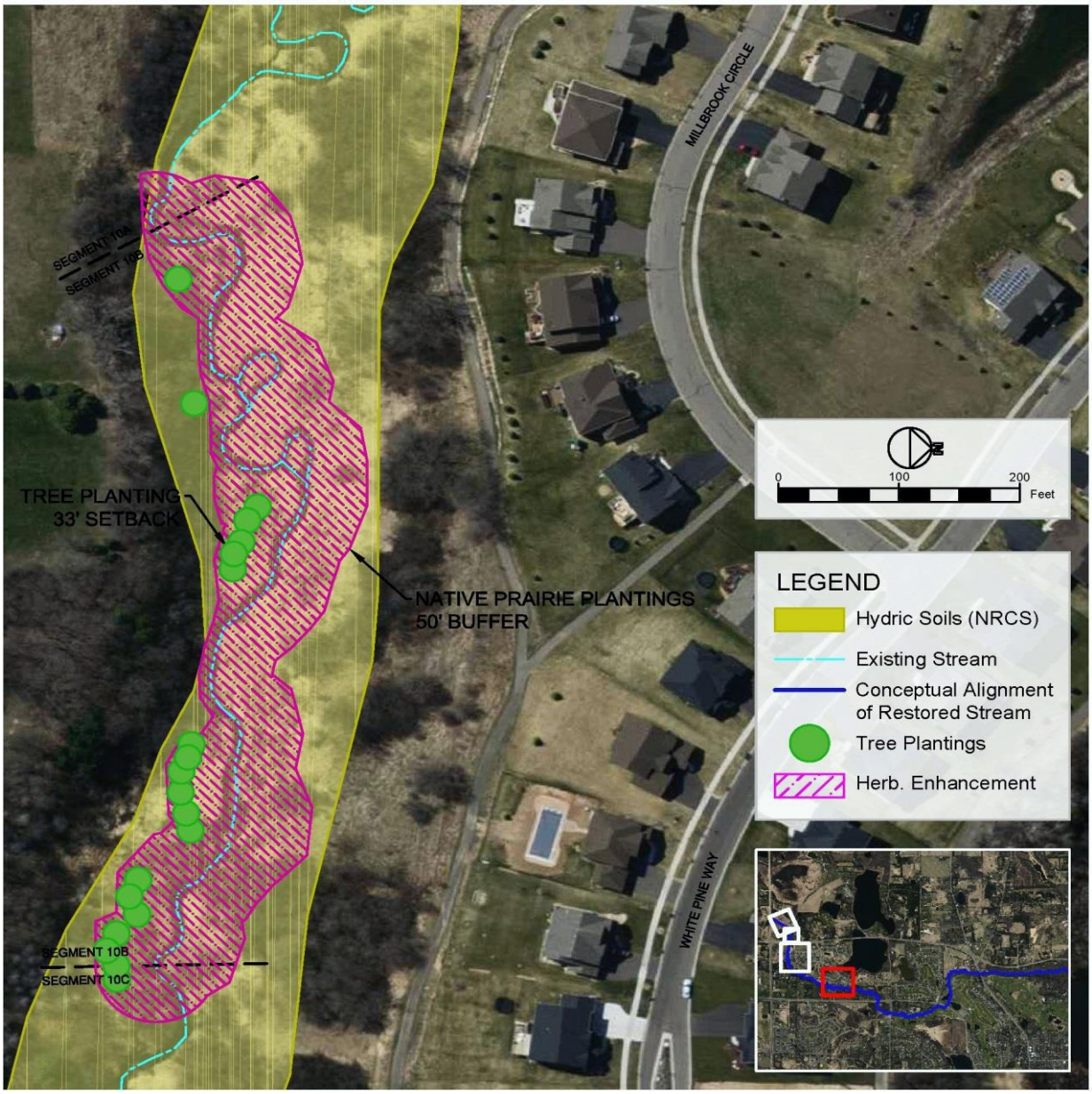

Figure 5. Concept design from Figure 59 of the Riparian Shading Study

Figure 6. Proposed construction access for Site 10B

Estimated Cost
All foreseeable costs for implementing this project have been estimated utilizing current industry unit and percentage of construction costs (Table **1**). Cost estimation is based on the following implementation scenarios:

- Pricing is based on the utilization of private contractors. The project would likely be less expensive if an entity such as the Minnesota & Iowa Conservation Corps was utilized to complete all or a portion of the project.
- The project has been estimated as a stand-alone project. Based on probable economy of scales the project would likely have a lower cost if completed concurrently with an additional project(s).

Table 1. Site 10B Estimated Project Costs

ENGINEER'S OPINION OF PROBABLE PROJECT COST

Site 10B

Item No.	Construction Item	Estimated Quantity	Units	Unit Price	Total Price	Noted Assumptions
1	1" DIA. BARE ROOT TREE WITH WEED MAT AND BROWSE PROTECTION	20	EA	$ 120.00	$ 2,400.00	
2	18" HEIGHT BARE ROOT SHRUB WITH WEED MAT AND BROWSE PROTECTION	40	EA	$ 58.00	$ 2,320.00	
3	SITE PREPARATION FOR PERENNIAL PLANTING	1	LS	$ 2,500.00	$ 2,500.00	
4	1 GALLON POT NATIVE PERENNIAL WITH WEED MAT	800	EA	$ 11.00	$ 8,800.00	
5	BIANNUAL MAINTENANCE	3	YR	$ 2,750.00	$ 8,250.00	[1]
				CONSTRUCTION SUBTOTAL	$ 24,270.00	
				CONSTRUCTION PLUS CONTINGENCY (20%)	**$ 29,124.00**	

Item No.	Implementation Task	Estimated Quantity	Units	Ave Hourly Rate	Total Price	Noted Assumptions
1	PLANNING AND ENGINEERING	10	HR	$ 142.00	$ 1,420.00	
2	PERMITTING AND APPROVALS	5	HR	$ 135.00	$ 675.00	[2]
3	BIDDING AND CONSTRUCTION ADMIN	75	HR	$ 131.00	$ 9,825.00	[3]
				PROFESSIONAL FEES TOTAL	**$ 11,920.00**	
				PROFESSIONAL FEES PLUS CONTINGENCY (20%)	**$ 14,304.00**	
				TOTAL ESTIMATED PROJECT COST	**$ 43,428.00**	

[1] Maintenance obligations after the 3-year period are not accounted for herein
[2] No permit fees are assumed nor included
[3] Includes oversight of 3-year maintenance period

Site 11

Site Assessment
Site 11 is located immediately west of the Millbrook development and encompasses the reach of Brown's Creek from Highway 96 to the upstream segment of Site 10A. This site contains an exemplary reference reach for an "E" channel within the central region of the Brown's Creek

corridor. This reach has a high sinuosity and low width to depth ratio, resulting in a well-defined riffle/pool sequence with well-vegetated, stable, undercut stream banks that provide excellent overhead cover and refugia for fish and macroinvertebrates. The overhanging vegetation along the stream banks occurs throughout the entire reach. Riffles are comprised of coarse sand and small gravels, and the pools contain primarily silt, fine sand, and small gravels. In contrast to Site 10B, this reach contains very little woody debris due to the lack of woody cover near the stream. Much of the immediate stream corridor is comprised of sedges, reed canary grass, and other herbaceous plants with alder and willow occurring to the west of the sedge meadow. Curly-leaf pondweed is prevalent within the stream and has caused localized sediment accumulations in pools and has exacerbated the embeddedness of some riffles. Although the stream has higher gradient through this reach, the density of curly-leaf pondweed prevents fine sediments from flushing out of some riffles and runs, resulting in a "soft" stream bottom that has limited habitat for macroinvertebrates that require coarse substrates.

Concept Design

The proposed concept design for Site 11 includes the planting of herbaceous plugs and wetland adapted trees and shrubs such as tamarack, silver maple, speckled alder, and red-osier dogwood within the sedge meadow to increase the amount of shade over the creek during the growing season. Other plant species that may be planted within the project site are listed in Appendix A. Strategic placement of shrubs and trees as recommended in the Riparian Shading Study is proposed to allow for maximum shade over the stream while maintaining dense herbaceous vegetation along the creek banks. As shown in Figure 7, the placement of trees is to occur primarily along the southeast and southwest aspects of adjacent meanders to maximize shading in areas where the creek flows in a general west-to-east or east-to-west direction. Shrubs will be planted closer to the stream and the trees set further back to prevent shading out of herbaceous species growing along the stream banks, thereby limiting bank erosion and subsequent channel widening commonly observed along streams with dense wooded corridors. All shrubs and trees planted would require browse protection from deer and beaver.

The herbaceous plants listed in Appendix A include those species that grow tall and have broad leaves to maximize shading of the creek. These species are proposed to be planted in strategic locations along the stream banks within the "herb. enhancement" polygon as shown in (Figure 7). Similar to the concept design for Site 10B, planting herbaceous species along both sides of the creek was considered, but intensive, long-term management of the existing reed canary grass meadow along the edge of the creek would be required to ensure the establishment of the native herbaceous plants. The proposed planting of herbaceous species in groups at specific locations along the southeast and southwest aspects of adjacent meanders would only require management of small pockets of reed canary grass. The placement of native species in groups would increase the chance of establishment as a whole, and the plants would better withstand the encroachment of reed canary in the long-term. This concept design would require the management of small pockets of reed canary grass in specific locations where the herbaceous plants are proposed. Management of reed canary grass will require multiple treatments of herbicide and/ or prescribed burns prior to planting the native species.

Three-year maintenance will include routine irrigation of all planted materials and replacement of species that do not become established. Long-term maintenance of the site may also include occasional prescribed burns, invasive species management, and upkeep or replacement of shrub and tree browse protection devices.

The estimated costs for project administration, legal overview, engineering, implementation, and three-year operations & maintenance for this concept design are outlined in Table 2.

Permit Considerations
Permits that will be required for the project include a joint permit application through MNDNR (MPARS) and the United States Army Corps of Engineers. Project disturbance from tree, shrub, and herbaceous plug plantings should be less than 400 square feet within the wetland areas. If wetland impacts from the proposed project are determined to be less than 400 square feet, the project will likely not require a permit; however, the project will still need to be reviewed by regulatory agencies for approval.

Access & Accessibility
The western half of the project area is owned by the City of Stillwater and the eastern half is owned by the Millbrook Home Owners Association (HOA). Both owners have previously been supportive of District projects within this vicinity and are support of this project in principle.

The proposed construction access is shown in Figure 8. Construction limits for this project will occur within the immediate stream corridor, confined to the pink-shaded "herb. enhancement" polygon as shown in Figure 7. In addition, an easement along the project reach will need to be obtained from the property owner(s) to conduct long-term site monitoring and maintenance of the project. The easement will need to encompass the construction limits of the project site as described above.

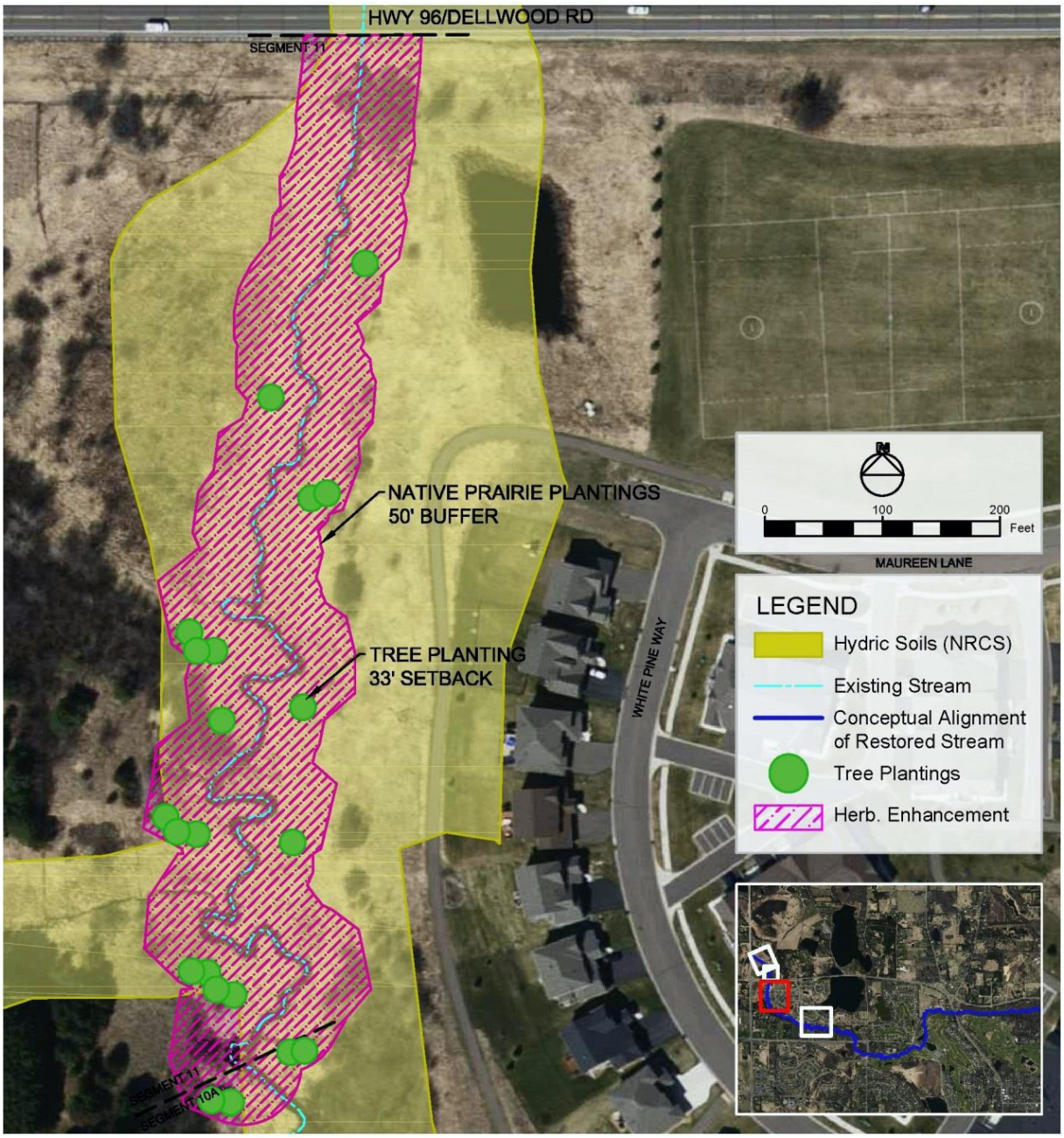

Figure 7. Concept design from Figure 58 of the Riparian Shading Study

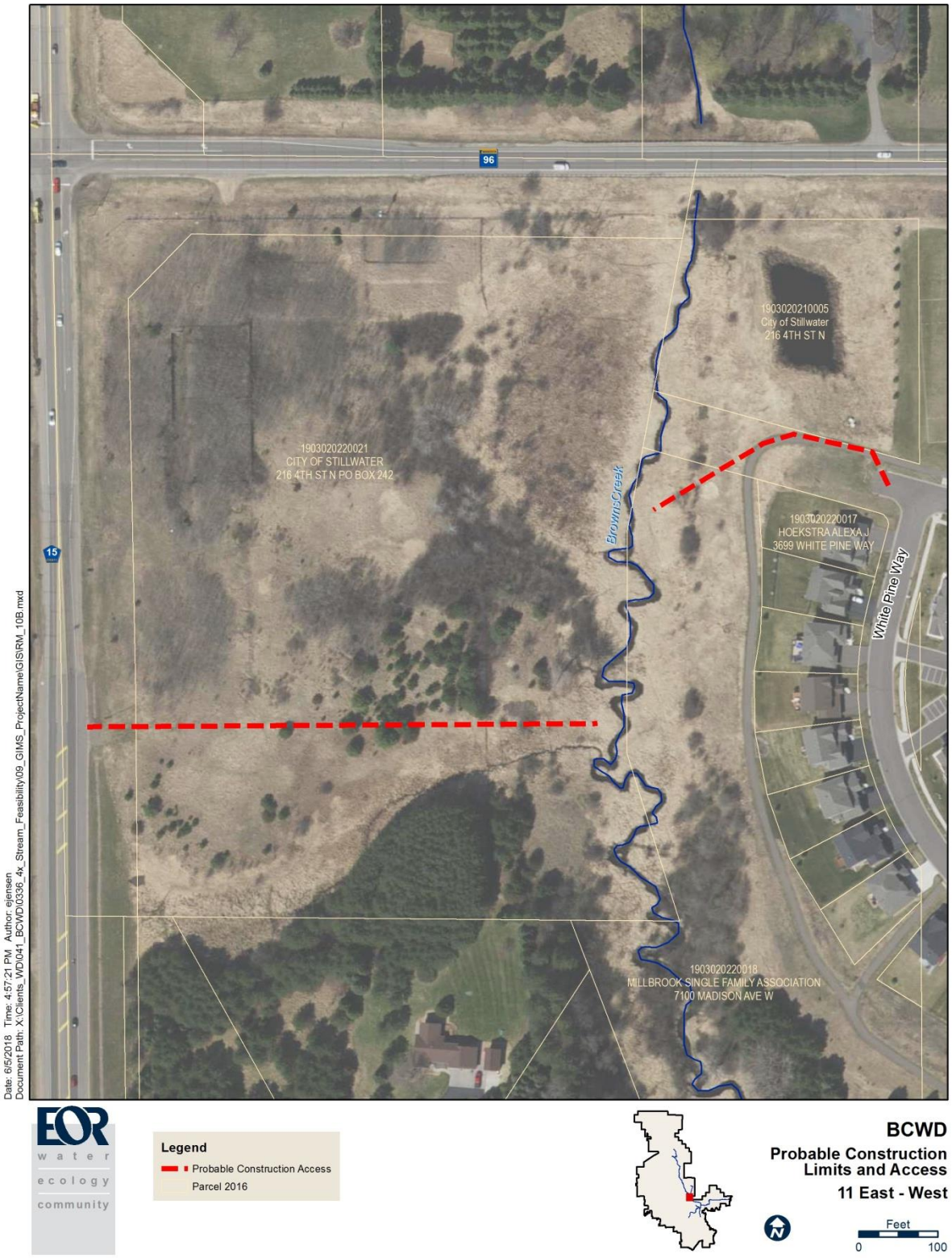

Figure 8. Proposed construction access for Site 11

Estimated Cost
All foreseeable costs for implementing this project have been estimated utilizing current industry unit and percentage of construction costs (Table **2**). Cost estimation is based on the following implementation scenarios:

- Pricing is based on the utilization of private contractors. The project would likely be less expensive if an entity such as the Minnesota & Iowa Conservation Corps was utilized to complete all or a portion of the project.
- The project has been estimated as a stand-alone project. Based on probable economy of scales the project would likely have a lower cost if completed concurrently with an additional project(s).

Table 2. Site 11 Estimated Project Costs

ENGINEER'S OPINION OF PROBABLE PROJECT COST
Site 11

Item No.	Construction Item	Estimated Quantity	Units	Unit Price	Total Price	Noted Assumptions
1	1" DIA. BARE ROOT TREE WITH WEED MAT AND BROWSE PROTECTION	21	EA	$ 120.00	$ 2,520.00	
2	18" HEIGHT BARE ROOT SHRUB WITH WEED MAT AND BROWSE PROTECTION	42	EA	$ 58.00	$ 2,436.00	
3	SITE PREPARATION FOR PERENNIAL PLANTING	1	LS	$ 2,500.00	$ 2,500.00	
4	1 GALLON POT NATIVE PERENNIAL WITH WEED MAT	800	EA	$ 11.00	$ 8,800.00	
5	BIANNUAL MAINTENANCE	3	YR	$ 2,750.00	$ 8,250.00	[1]
				CONSTRUCTION SUBTOTAL	$ 24,506.00	
				CONSTRUCTION PLUS CONTINGENCY (20%)	**$ 29,407.20**	

Item No.	Implementation Task	Estimated Quantity	Units	Ave Hourly Rate	Total Price	Noted Assumptions
1	PLANNING AND ENGINEERING	10	HR	$ 142.00	$ 1,420.00	
2	PERMITTING AND APPROVALS	5	HR	$ 135.00	$ 675.00	[2]
3	BIDDING AND CONSTRUCTION ADMIN	75	HR	$ 131.00	$ 9,825.00	[3]
				PROFESSIONAL FEES TOTAL	**$ 11,920.00**	
				PROFESSIONAL FEES PLUS CONTINGENCY (20%)	**$ 14,304.00**	
				TOTAL ESTIMATED PROJECT COST	**$ 43,711.20**	

[1] Maintenance obligations after the 3-year period are not accounted for herein
[2] No permit fees are assumed nor included
[3] Includes oversight of 3-year maintenance period

Site 12

Site Assessment
Site 12 is located on the Costa property between Site 13 and Highway 96. This reach of Brown's Creek runs through a residential yard with limited near-stream buffers. The creek has been

armored with fieldstone boulders on both sides of the creek. Landscape fabric, crushed rock, and ornamental plants also occur along the downstream portion of the segment. The area outside of the creek banks consists of mowed turf lawn. The armored banks are stable and show little evidence of erosion; however, the boulders, landscape fabric, and crushed rock are likely contributing to instream thermal impacts as these landscape features occur in open canopy areas where direct solar energy can reach the ground surface. This reach has low sinuosity and a moderate width to depth ratio, with few well-defined riffles and pools. The boulder-armored banks and limited overhanging herbaceous vegetation is likely contributing to the moderate width to depth ratios observed in this reach by preventing the natural catchment and accumulation of sediments along the edges of the creek. During higher stream flows, sediments likely flush through the channel with the boulders preventing the natural buildup of sediments along the edges of the creek. Without the buildup of sediments, the creek is unable to naturally narrow itself through catchment of sediments and subsequent colonization by herbaceous plants. The wider channel also reduces instream flow velocities, thereby limiting the amount of bed scour and subsequent development of pools and riffles.

Overhanging vegetation and undercut banks are mostly absent throughout the reach, particularly along the east side of the creek. The lack of overhanging vegetation and undercut banks negatively influence the quality and diversity of macroinvertebrates within the reach. This site also contains very little woody debris due to the lack of woody cover near the stream and manicured nature of the stream corridor. The primary approach to reducing instream temperatures and improving habitat in this reach is to plant native herbaceous plants along the creek banks to increase the amount of overhanging vegetation and provide additional shading and habitat for instream fish and macroinvertebrates.

Concept Design

The proposed concept design for Site 12 includes the planting of herbaceous species along the edges of the creek and increasing the buffer width in areas where a naturally vegetated creek buffer has been removed. In addition, the strategic placement of one or two trees within the riparian corridor is proposed to provide shade in areas where shading from the existing tree canopy is limited. The higher elevations of the riparian corridor within this reach allow for a greater diversity of trees species to be considered for the project including bur oak, white oak, sugar maple, basswood, river birch, silver maple, or peachleaf willow. Herbaceous plants proposed along the edge of the stream may include various native grasses and forbs as listed in Appendix A. The proposed buffer enhancement areas are shown in Figure 9 and encompass an approximate 13 foot wide buffer along both sides of the creek (identified as the pink-shaded herb. enhancement polygon in the figure). The proposed buffer expansion would require the removal of existing landscape features within the 13 foot wide buffer such as sod, landscape fabric, crushed rock, and relocation of lawn edging material. The estimated costs for project administration, legal overview, engineering, implementation, and three-year operations & maintenance for this concept design are outlined in Table 3.

Three-year maintenance will include routine irrigation of all planted materials and replacement of species that do not become established. Long-term maintenance of the site may also include invasive species management and replacement of species that do not become established.

Permit Considerations

Permits that may be required for the project include a joint permit application through MNDNR (MPARS) and the United States Army Corps of Engineers. Project disturbance from the removal of the existing landscape features as described above would likely exceed the 400 square foot

threshold within the riparian corridor, thereby triggering the need for permit submittals and review.

Access & Accessibility

Construction access permission will need to be obtained from the property owner. The proposed construction access is shown in Figure 10. Construction limits for this project will occur within the immediate stream corridor, confined to the pink-shaded "herb. enhancement" polygon as shown in Figure 9. In addition, an easement along the project reach will need to be obtained from the property owner to conduct long-term site monitoring and maintenance of the project. The easement will need to encompass the construction limits of the project site as described above.

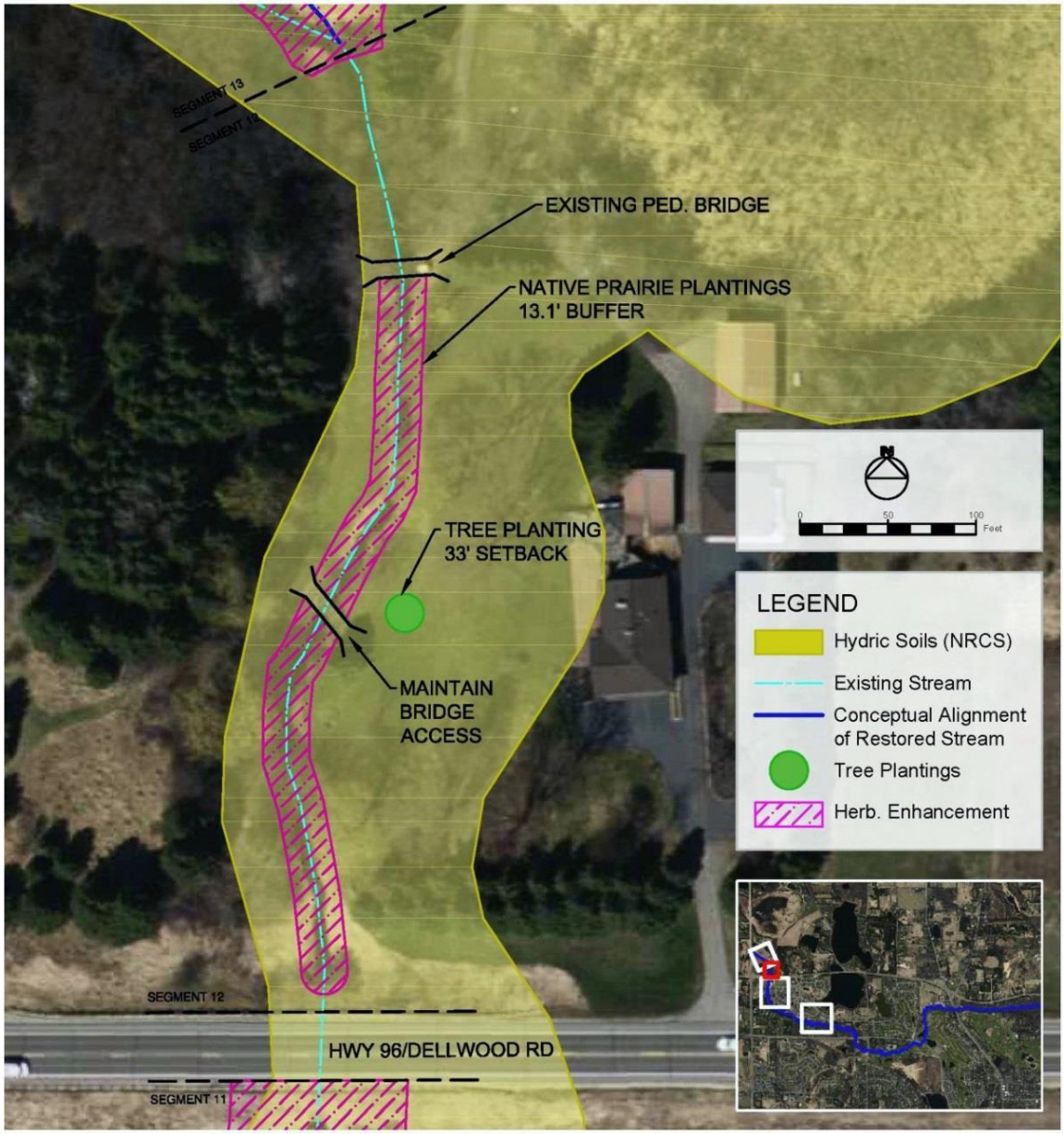

Figure 9. Concept design from Figure 57 of the Riparian Shading Study

Figure 10. Proposed construction access for Site 12

Estimated Cost

All foreseeable costs for implementing this project have been estimated utilizing current industry unit and percentage of construction costs (Table **3**). Cost estimation is based on the following implementation scenarios:

- Pricing is based on the utilization of private contractors. The project would likely be less expensive if an entity such as the Minnesota & Iowa Conservation Corps was utilized to complete all or a portion of the project.
- The project has been estimated as a stand-alone project. Based on probable economy of scales the project would likely have a lower cost if completed concurrently with an additional project(s).

Table 3. Site 12 Estimated Project Costs

ENGINEER'S OPINION OF PROBABLE PROJECT COST

Site 12

Item No.	Construction Item	Estimated Quantity	Units	Unit Price	Total Price	Noted Assumptions
1	1.5" DIA. B&B TREE WITH WEED MAT AND BROWSE PROTECTION	5	EA	$ 210.00	$ 1,050.00	
2	18" HEIGHT POTTED SHRUB WITH WEED MAT AND BROWSE PROTECTION	20	EA	$ 58.00	$ 1,160.00	
3	SITE PREPARATION FOR PERENNIAL PLANTING	1	LS	$ 5,000.00	$ 5,000.00	
4	4" POT NATIVE PERENNIAL WITH MULCH	350	EA	$ 7.00	$ 2,450.00	
5	BIANNUAL MAINTENANCE	3	YR	$ 2,750.00	$ 8,250.00	[1]
				CONSTRUCTION SUBTOTAL	$ 17,910.00	
				CONSTRUCTION PLUS CONTINGENCY (20%)	**$ 21,492.00**	

Item No.	Implementation Task	Estimated Quantity	Units	Ave Hourly Rate	Total Price	Noted Assumptions
1	PLANNING AND ENGINEERING	45	HR	$ 142.00	$ 6,390.00	
2	PERMITTING AND APPROVALS	10	HR	$ 135.00	$ 1,350.00	[2]
3	BIDDING AND CONSTRUCTION ADMIN	95	HR	$ 131.00	$ 12,445.00	[3]
				PROFESSIONAL FEES TOTAL	**$ 20,185.00**	
				PROFESSIONAL FEES PLUS CONTINGENCY (20%)	**$ 24,222.00**	
				TOTAL ESTIMATED PROJECT COST	**$ 45,714.00**	

[1] Maintenance obligations after the 3-year period are not accounted for herein
[2] No permit fees are assumed nor included
[3] Includes oversight of 3-year maintenance period

Site 13

Site Assessment

Site 13 is located along the Costa wetland between Manning Avenue and the upstream terminus of Site 12. This reach of Brown's Creek has been ditched historically, resulting in low stream sinuosity and poor riffle/pool development. Based on historic aerial imagery, the stream has been ditched since at least 1938 (Figure 11). Although the creek has an accessible floodplain throughout the

reach, the creek has been contained within the alignment of the ditch and has only slightly migrated over the past 80 years. Stream bank migration has likely been mitigated by a combination of dense native riparian vegetation stabilizing the creek banks and low stream gradient. Instream habitat is limited to overhanging vegetation and occasional woody debris jams in areas where alder shrubs have fallen into the creek. Channel substrates are comprised of silt and fine sand with coarse sand occurring in areas with increased flow velocities. This reach contains no riffle habitat and few deep pools. The deepest pool occurs immediately downstream of the snowmobile bridge crossing where a tight bend occurs. This bridge does not appear to be negatively impacting the stability of the creek, but does shade out riparian vegetation directly underneath the bridge. The vast majority of the reach is comprised of a low gradient run that is currently influenced by the presence of an old beaver dam located near the downstream end of the reach (Figure 12). The elevation of the beaver dam has resulted in aggradation of sediments within the channel, as evidenced by muck and fine sand deposited within the stream within the middle and lower reaches of the segment.

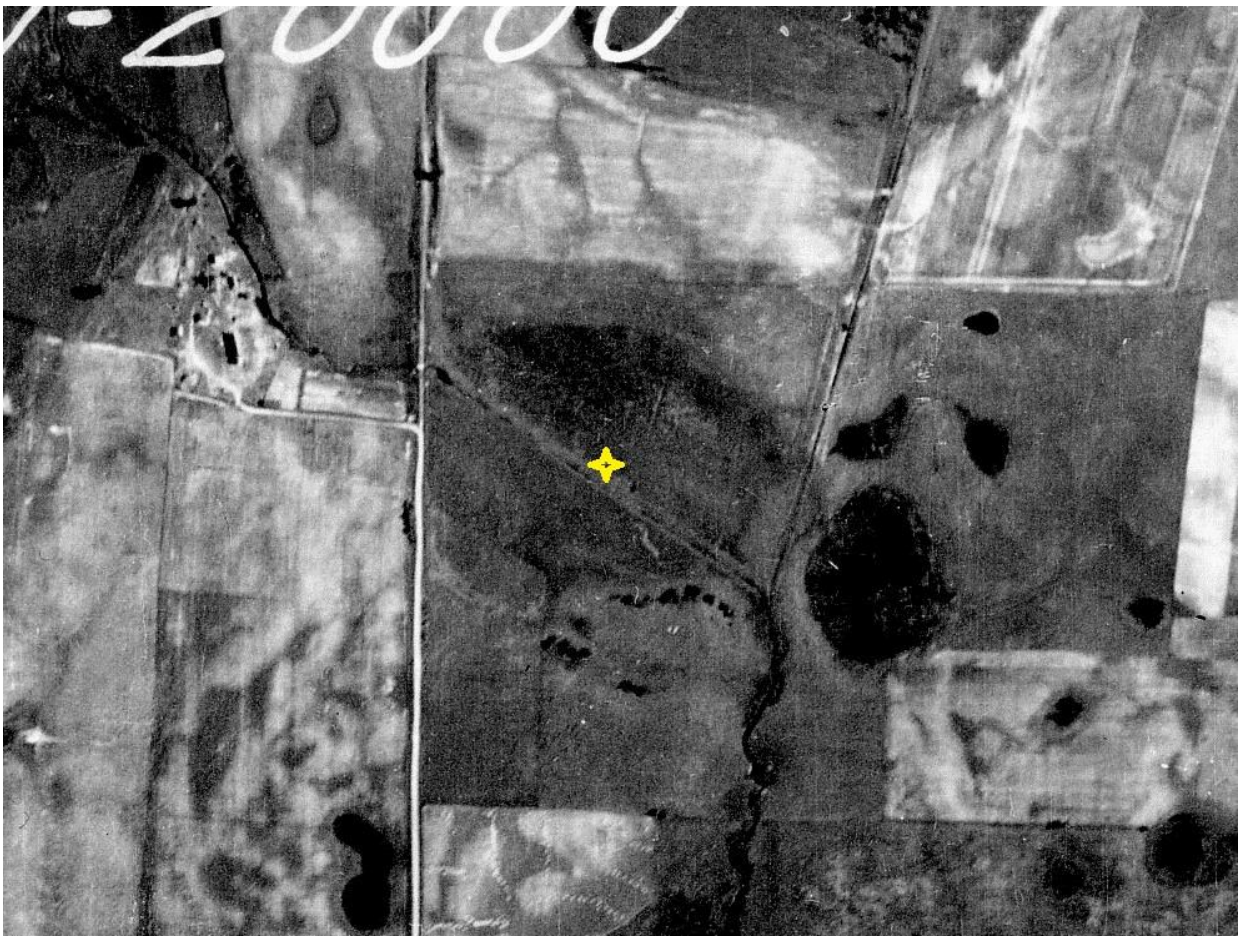

Figure 11. Historic aerial image of Site 13 taken on July 28, 1938 (the yellow star is the center of the Costa wetland)

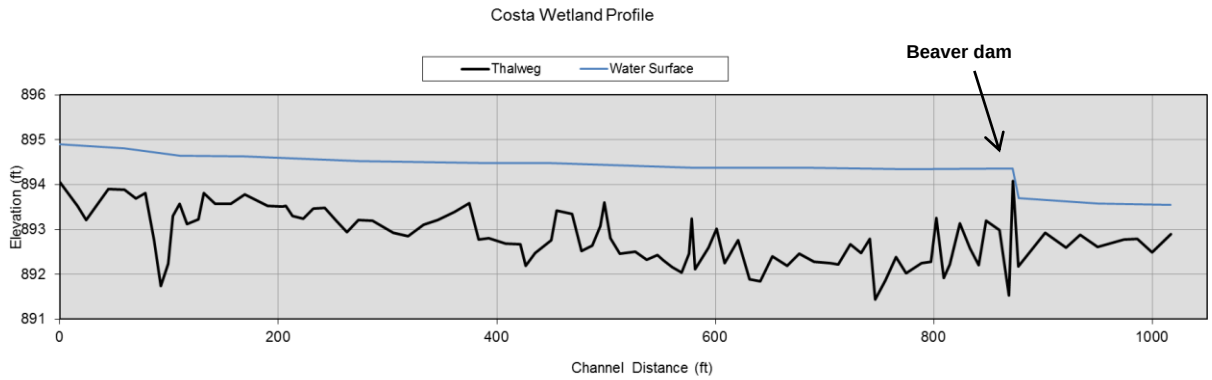

Figure 12. Site 13 profile from geomorphic survey conducted on May 15, 2018

Concept Design

The proposed concept design for Site 13 includes the construction of a sinuous stream channel through the Costa wetland to re-create a stable "E" channel similar to the reference reach described in Site 11 (Figure 13). The creation of a sinuous stream course will enable the natural development of pools and riffles and increase bed scour. This bed scour will create a deeper and narrower channel that will reduce direct solar energy inputs to the stream. In addition to the creation of a sinuous stream course, the design includes the planting of herbaceous plugs and wetland adapted trees and shrubs such as tamarack, dogwood, and willows within the existing sedge meadow to provide shade over the creek during the growing season (Figure 13). Project construction would consist of excavating a narrow channel similar in cross section to the reference reach in Site 11 through the existing sedge meadow and subsequent placement of excavated material within the existing ditch after the channel plugs are removed. The sequence of channel creation and ditch fill would be timed such that the old ditch would be filled immediately after the new channel is brought online to limit the duration of stockpiled soil within the wetland. The second phase of the project would involve the planting of trees, shrubs, and herbaceous plugs in strategic locations as shown in Figure 13. The placement of trees and shrubs is proposed along the southern and western areas along the proposed stream course. In general, the shrubs will be placed closer to the stream and the trees set further back to prevent shading out of herbaceous species growing along the stream banks, thereby limiting bank erosion and subsequent channel widening commonly observed along streams with dense wooded corridors. The herbaceous plants listed in Appendix A include those species that grow tall and have broad leaves to maximize shading of the creek. These species are proposed to be planted along the stream banks within the "herb. enhancement" polygon as shown in Figure 13. All shrubs and trees planted would require browse protection from deer and beaver.

Three-year maintenance will include routine irrigation (if needed) of all planted materials and replacement of species that do not become established. Monitoring and management for invasive species will need to be conducted during the growing season and may include hand pulling of individual plants or spot treatments with an herbicide approved for aquatic use. Long-term maintenance of the site may also include occasional prescribed burns, invasive species management, and upkeep or replacement of shrub and tree browse protection devices.

The estimated costs for project administration, legal overview, engineering, implementation, and three-year operations & maintenance for this concept design are outlined in Table 4.

Permit Considerations
Site 13 is classified as a designated trout stream. Any stream impacts within a designated trout stream that are greater than 400 linear feet will require permits including a joint permit application through MNDNR (MPARS) and the United States Army Corps of Engineers. Based on MN Statue 4410.43, the project may also trigger the need for an Environmental Assessment Worksheet (EAW). The following is the threshold test as described in the statute:

"*Subp. 26. Stream Diversion. For a diversion, realignment, or channelization of any designated trout stream, or affecting greater than 500 feet of natural watercourse with a total drainage area of ten or more square miles unless exempted by part 4410.4600, subpart 14, item E, or 17, the local government unit shall be the RGU.*"

The proposed project meets all the criteria for an EAW as described above; therefore, project will likely require an EAW.

Assuming permits can be obtained for this project, construction access will need to be secured with the landowner(s). Potential construction access points include Manning Avenue (Option A), or from the private driveway on Lyle Burtzlaff's property (Option B, Figure 14). The benefit of Option A is immediate creek access off Manning Avenue, but this access point would require traffic control and may result in wetland impacts from construction of a temporary rock construction entrance and/or staging area adjacent to Manning Avenue. Option B would likely not require traffic control, but permission from the landowner would be needed to use the driveway. Construction limits for this project would occur within the immediate stream corridor, confined to the pink-shaded "herb. enhancement" polygon as shown in Figure 13. In addition, an easement along the project reach will need to be obtained from the landowner to conduct long-term site monitoring and maintenance of the project.

Access & Accessibility
The timing of construction of the new stream channel would likely have to occur during frozen ground conditions due to the nature of the soft organic soils in the wetland. The use of large wooded platforms (skids) will likely be needed to prevent heavy machinery from breaking through the frost and becoming stuck. The benefit of working from these skids would be reduced impacts to the existing soils and dormant wetland vegetation during project construction.

Estimated Cost
All foreseeable costs for implementing this project have been estimated utilizing current industry unit and percentage of construction costs (Table **4**). Cost estimation is based on the following implementation scenarios:

- Pricing is based on the utilization of private contractors. The project would likely be less expensive if an entity such as the Minnesota & Iowa Conservation Corps was utilized to complete all or a portion of the project.
- The project has been estimated as a stand-alone project. Based on probable economy of scales the project would likely have a lower cost if completed concurrently with an additional project(s).

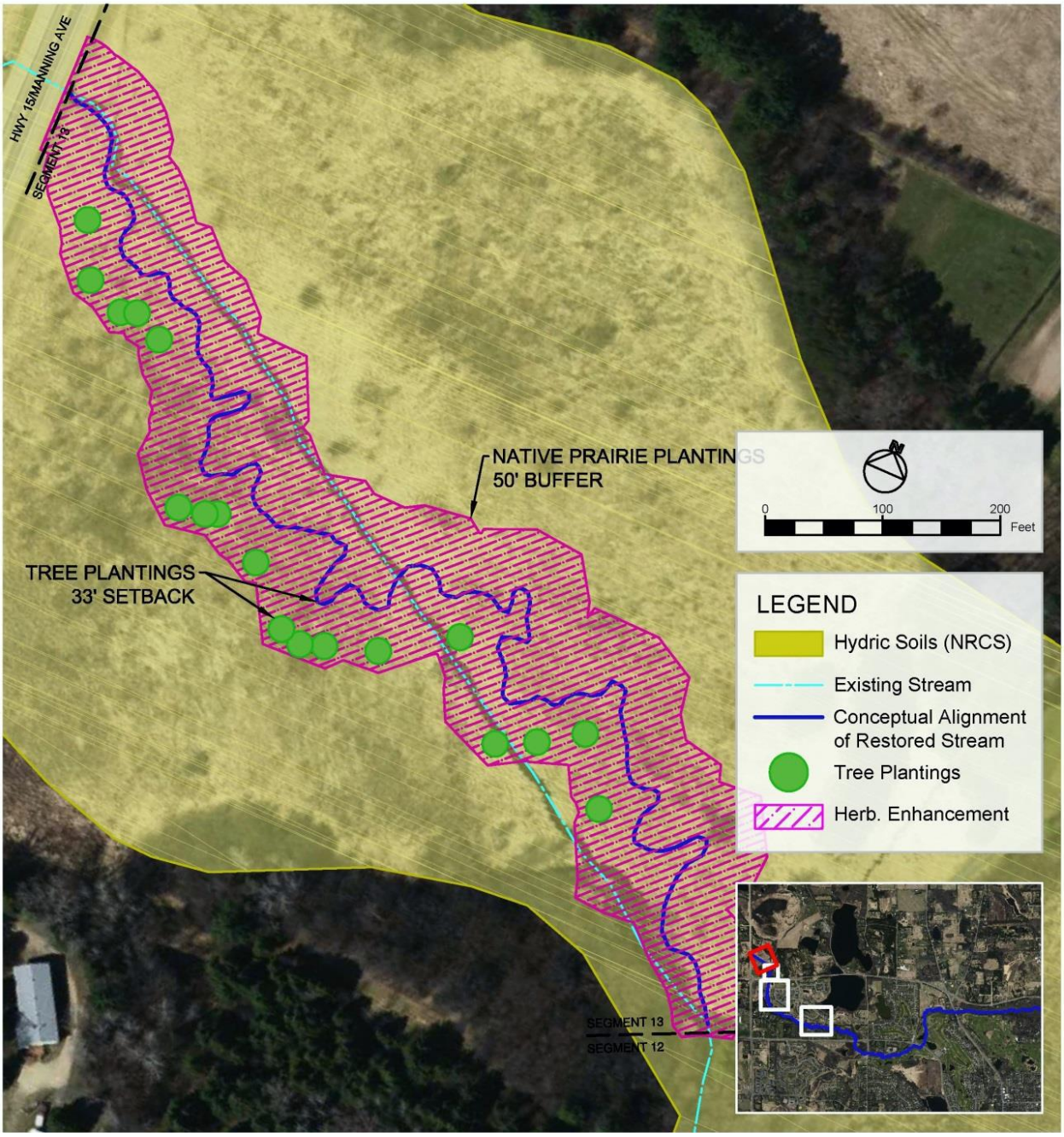

Figure 13. Concept design from Figure 56 of the Riparian Shading Study

Figure 14. Proposed construction access locations for Site 13 (two options)

Table 4. Site 13 Estimated Project Costs

ENGINEER'S OPINION OF PROBABLE PROJECT COST

Site 13

Item No.	Construction Item	Estimated Quantity	Units	Unit Price	Total Price	Noted Assumptions
1	MOBILIZATION & TRAFFIC CONTROL	1	LS	$ 8,000.00	$ 8,000.00	
2	SITE CLEARING & GRUBBING	1	LS	$ 2,000.00	$ 2,000.00	
3	EROSION & SEDIMENT CONTROL	1	LS	$ 5,000.00	$ 5,000.00	
4	COMMON EXCAVATION	100	CY	$ 8.00	$ 800.00	
5	ONSITE EMBANKMENT	600	CY	$ 3.50	$ 2,100.00	
6	OFFSITE EMBANKMENT	400	CY	$ 9.50	$ 3,800.00	
7	HAND-PLACED RIPRAP - CLASS 2 RIVER ROCK / GRAVEL	15	CY	$ 110.00	$ 1,650.00	
8	EROSION CONTROL BLANKET (DeKoWe® 700 OR APPROVED EQUAL)	150	SY	$ 6.50	$ 975.00	
9	EROSION CONTROL BLANKET (C125 BN OR APPROVED EQUAL)	1750	SY	$ 4.50	$ 7,875.00	
10	ROOTWAD	25	EA	$ 625.00	$ 15,625.00	
11	HYDROSEEDING & SEED	1	LS	$ 5,000.00	$ 5,000.00	
17	1" DIA. POTTED TREE WITH WEED MAT AND BROWSE PROTECTION	18	EA	$ 145.00	$ 2,610.00	
18	18" HEIGHT POTTED SHRUB WITH WEED MAT AND BROWSE PROTECTION	36	EA	$ 55.00	$ 1,980.00	
19	4" POT NATIVE PERENNIAL	1200	EA	$ 7.00	$ 8,400.00	
20	3-YR MAINTENANCE	3	YR	$ 3,000.00	$ 9,000.00	[1]

CONSTRUCTION SUBTOTAL	$ 82,315.00
CONSTRUCTION PLUS CONTINGENCY (20%)	**$ 98,778.00**

Item	Implementation Task	Estimated	Units	Ave Hourly	Total Price	Noted
1	PLANNING AND ENGINEERING	350	HR	$ 142.00	$ 49,700.00	[1]
2	PERMITTING AND APPROVALS	100	HR	$ 135.00	$ 13,500.00	[2]
3	BIDDING AND CONSTRUCTION ADMIN	180	HR	$ 131.00	$ 23,580.00	[3]

PROFESSIONAL FEES TOTAL	**$ 86,780.00**
PROFESSIONAL FEES PLUS CONTINGENCY (20%)	**$ 104,136.00**
TOTAL ESTIMATED PROJECT COST	**$ 202,914.00**

[1] Maintenance obligations after the 3-year period are not accounted for herein
[2] Includes geomorphic assessment
[3] Includes preparation of EAW
[4] Includes oversight of 3-year maintenance period

CUMULATIVE PROJECT BENEFITS

Based on the thermal modeling results of the Riparian Shading Study, the cumulative benefits of implementing all four proposed projects is a reduction in monthly mean stream temperatures ranging from 0.2-0.6 degrees Celsius (from June-August) from Manning Avenue to the confluence with the St. Croix River. Historic stream temperature data collected upstream of the Brown's Creek gorge has been measured within the thermal stress threshold for brown trout during summer months. A reduction in stream temperatures from implementation of the four projects could lower stream temperatures just below the thermal stress threshold for trout, thereby allowing for potential population expansion, natural reproduction, and increased survival of trout upstream of the gorge. In addition, the cumulative benefits of the four projects combined also augment the cooling benefits of other projects recently implemented in the watershed, such as the Brown's Creek rock crib. Additional benefits of woody and grassy buffers as summarized in Table 18 of the Riparian Shading Study are shown in Table 5.

Table 5. Benefits of woody and grassy buffers copied from Table 18 of the Riparian Shading Study

Benefit	Woody	Grassy
Support aquatic fauna (fish and macroinvertebrates)	◔	◕
Reduce suspended sediment in the stream by:		
(1) Stabilizing stream bank (channel morphology)	◔	◕
(2) Stabilizing upland areas	◑	◑
(3) Filtering sediment from runoff before it reaches stream	●	●
Improve microclimate conditions as a means to reduce stream temperature	◔	●
Raise or maintain groundwater levels in order to increase or sustain groundwater contributions to the stream.	○	○
Improve carbon cycling and dissolved oxygen levels.	◑	◑
Reduce phosphorus in the stream by:		
(1) Controlling TSS (see above)	◔	◕
(2) Filtering dissolved phosphorus from runoff	◑	●
(3) Nutrient uptake in hyporheic zone	◔	●
Adapt to climate change	n/a	n/a
Maintain vegetated buffer (i.e. maintenance requirements)	◑	◑

○ no benefits are provided under any condition

◔ ◑ ◕ partial benefits are provided (to varying extents of 25, 50, and 75%), sometimes under different conditions

● full benefits are provided under all conditions

n/a – unclear differentiation of benefits in literature

Habitat Benefits

Habitat benefits from implementation of the four projects would be increased pollinator and foraging habitat (flowers and berries), bird nesting habitat, and the quantity and quality of overhanging bank vegetation. The most significant overall increase in terrestrial and aquatic habitat would occur in Site 13 with the creation of a sinuous stream channel. As described in the site assessment for Site 13, this reach contains no riffles and few deep pools. The construction of a sinuous stream channel would allow for the natural development of numerous riffles and pools that subsequently would provide riffle and pool habitat for a variety of aquatic fauna, especially macroinvertebrates and fish. As Brown's Creek is impaired for lack of coldwater assemblage and biota this benefit is critical.

Specific Project Benefits
Data collected during the Riparian Shading Study were used to calculate existing and future creek shade percentages for each project site (Table 6). In general, the planting of shrubs and herbaceous species will provide increased shade in the short term (1-5+ years) with trees providing additional shade over the long term. The future shade percentages shown in the table are based on maturation of all planted herbaceous plants, shrubs, and trees as proposed in each concept design described above. The future shading percentages also include thermal benefits from reducing stream widths at all project sites (decreasing width to depth ratios).

Table 6. Existing & future shade percentages of each project site calculated from the Riparian Shading Study.

Project Site	Existing Shade Percentage	Potential Future Shade Percentage
10B	56%	84%
11	49%	80%
12	75%	83%
13	44%	82%

Summary of Estimated Project Cost
All foreseeable costs for implementing these projects have been estimated utilizing current industry unit and percentage of construction costs (Table 3). Cost estimation is based on the following implementation scenarios:

- Pricing is based on the utilization of private contractors. The project would likely be less expensive if an entity such as the Minnesota & Iowa Conservation Corps was utilized to complete all or a portion of the project.
- The project has been estimated as a stand-alone project. Based on probable economy of scales the project would likely have a lower cost if completed concurrently with an additional project(s).

Table 7. Summary of Engineer's Opinion of Probable Project Cost – Cumulative Project Summary

Site	Engineering & Implementation Cost (Includes a 20% Contingency)	
10B	$	43,400
11	$	43,700
12	$	45,700
13	$	202,900
	$	335,800

PRIORITY RANKINGS & RECOMMENDATIONS

The following priority rankings are based on a combination of cost/ benefit analysis for each proposed project and other variables including a

Priority Rankings

1. **Site 13**: While this potential project has a probable cost that exceeds the other three projects combined it has the greatest projected increase in future shade, thermal refugia and would result in significant habitat improvements for aquatic biota and therefore is the ranked the highest out of the four projects.

2. **Site 11**: Has second greatest projected increase in future shade and comparatively low project implementation cost. Over 50% of construction inputs would occur on City of Stillwater property and remaining inputs would occur within the Millbrook HOA.

3. **Site 10B**: Has significant projected increase in future shade and comparatively low project implementation cost. All construction inputs would occur within the Millbrook HOA.

4. **Site 12**: Comparatively high implementation cost per linear foot of stream improvement and minimal increase in future shade projection. Probable challenging landowner approvals and agreements.

Recommendations
Site 13 - Continue to pursue voluntary participation with private landowner as approval is not currently in place. Consider coordinating a tour of the District's Oak Glen Stream Buffer Project and consulting with Matt Kocian of the Rice Creek Watershed District who was in a very similar situation on a restoration of Hardwood Creek. Educate property owners on the values of the project and the reality that implementation would not hinder or devalue development opportunity.

Sites 10B & 11 - Pursue funding to implement both projects concurrently

Site 12 – Active pursuit of project is not recommended at this time.

Appendix A

Plants Suitable for Planting in Brown's Creek Riparian Corridor (copy of Table 25 from the Riparian Shading Study)

TREE			
Common Name	**Scientific Name**	**Wetland Status**	**Mature Height / Form**
Silver Maple	*Acer saccharinum*	FACW	30-32m / large canopy
River birch	*Betula nigra*	FACW	20m / slender to round crown
Tamarack	*Larix laricina*	FACW	20m / tapered crown
Bur Oak	*Quercus macrocarpa*	FAC	30m / broad crown
Peachleaf Willow	*Salix amygdaloides*	FACW	10-15m
Black Willow	*Salix nigra*	OBL	15-25m / broad crown
SHRUB			
Common Name	**Scientific Name**	**Wetland Status**	**Mature Height**
Speckled alder	*Alnus incana*	FACW	3-7.5m
Buttonbush	*Cephalanthus occidentalis*	OBL	1.25-4.5m
Silky dogwood	*Cornus amomum*	FACW	1.75-3.5m
Red-osier dogwood	*Cornus sericea*	FACW	1-2.5m
Swamp Rose	*Rosa palustris*	OBL	1.5-2.5m
Slender Willow	*Salix petiolaris*	OBL	2-3.5m
Nannyberry	*Viburnum lentago*	FAC	3-7.5m
GRASS			
Common Name	**Scientific Name**	**Wetland Status**	**Mature Height**
Big Bluestem	*Andropogon gerardii*	FAC	60-210cm
Rattlesnake Manna Grass	*Glyceria canadensis*	OBL	60-150cm
American managrass	*Glyceria grandis*	OBL	90-150cm
Prairie cord grass	*Spartina pectinata*	FACW	90-240cm
FORB			
Common Name	**Scientific Name**	**Wetland Status**	**Mature Height**
Turtlehead	*Chelone glabra*	OBL	60-120cm
Common boneset	*Eupatorium perfoliatum*	OBL	60-120cm
Spotted Joe-pye Weed	*Eutrochium maculatum*	OBL	60-300cm
Sawtooth sunflower	*Helianthus grosseserratus*	FACW	60-300cm
Cup Plant	*Silphium perfoliatum*	FACW	90-240cm
Blue vervain	*Verbena hastata*	FACW	30-180cm
Ironweed	*Vernonia fasciculate*	FACW	90-180cm