Pheasant Branch Corridor Restoration and Improvements Master Plan

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Acronyms

AASHTO American Association of State Highway and Transportation Officials
ADA Americans with Disabilities Act
ADLP Acquisition and Development of Local Parks
BEHI Bank Erosion Hazard Index
EOR Emmons & Olivier Resources, Inc.
FAST Fixing America's Surface Transportation Act
FEMA Federal Emergency Management Agency
LiDAR Light Detection and Ranging
LWCF Land and Water Conservation Fund
NOAA National Oceanic and Atmospheric Administration
NPS Non-point Pollution Source
SRTS Safe Routes to School
TAP Transportation Alternative Program
UR Urban Rivers
WIDNR Wisconsin Department of Natural Resources
WisDOT Wisconsin Department of Transportation

Acknowledgments

The Pheasant Branch Corridor Restoration and Improvements Master Plan was prepared by Cardno, Inc. along with KL Engineering and Jensen Ecology. This plan and planning process was data driven with long hours spent collecting and analyzing as much information about this project area as possible. Middleton residents and members of the general public completed online surveys and attended public input meetings to help guide this process and information gained from these interactions proved to be invaluable in the development of this plan.

Our project team would like to extend a special thank you to:

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City of Middleton Common Council: https://www.cityofmiddleton.us/Directory.aspx?did=4

City of Middleton Conservation Lands Committee: https://www.cityofmiddleton.us/227/Conservancy-Lands-Committee

City of Middleton Parks and Recreations Commission: https://www.cityofmiddleton.us/221/Park-Recreation-Forestry-Commission

City of Middleton Water Resources Management Commission: https://www.cityofmiddleton.us/212/Water-Resources-Management-Commission

Friends of Pheasant Branch: https://pheasantbranch.org/

Executive Summary

Pheasant Branch has historically had problems with streambank erosion and suspended sediment driven by land-use changes within its watershed. Increased flood peaks and water volumes have degraded streambanks throughout the reach over time. On August 20, 2018, over 11 inches of rain fell in less than 24 hours in the Middleton and Cross Plains area. At the peak of the storm, rain was falling at a rate of 2 to 4 inches per hour according to National Weather Service data. The resulting flooding caused widespread damage throughout Pheasant Branch and the public trails system located within the City of Middleton.

This plan identifies restoration goals and objectives for improvements within the Pheasant Branch Corridor from the confluence pond located west of Deming Way to the crossing at Century Avenue. Recommendations contained within this plan were developed using information acquired from site investigations performed by the project team, previously prepared documents by the City of Middleton and associates[1], and input from citizens through public meetings and online polls. It contains an overview of previous work completed within the Pheasant Branch Corridor prior to the 2018 flood event, a damage assessment of impacts from the 2018 flood event, and a summary of public meetings and public polls used to gain community input on the project area. This plan also contains an overview of possible stream restoration alternatives, pedestrian stream crossing and path restoration alternatives as well as corridor wide vegetation alternatives and potential grant funding options to help fund restoration efforts within the Pheasant Branch Corridor. Project cost estimates contained within this Master Plan will be refined as detailed designs for the restoration projects described are completed.

Goals and Objectives

Goal #1: Protect the Pheasant Branch Corridor from future stormwater damage

Objective: Minimize streambank erosion and repair eroded streambanks

Objective: Improve stormwater flood flow capacity through the corridor

Objective: Provide additional freeboard before water reaches the lowest point on stream crossing structures found within the corridor

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[1]Pheasant Branch 2018 Flood Damage Assessment and Five Year Plan. Cardno. https://www.cityofmiddleton.us/DocumentCenter/View/6167/Pheasant-Branch-2018-Flood-Damage-Assessment-and-Five-Year-Plan

2018-2023 Conservancy Lands Plan, City of Middleton. Adaptive Restoration. https://www.cityofmiddleton.us/DocumentCenter/View/5556/Conservancy-Lands-Plan-2018-2023-Final

Reimaging the Unimaginable. The August 2018 Pheasant Branch Flooding in Middleton, WI. Department of Planning and Landscape Architecture, University of Wisconsin–Madison https://www.cityofmiddleton.us/DocumentCenter/View/6372/Reimagining-the-Unimaginable-DPLA-2019

Goal #2: Provide multi-modal transportation and recreation opportunities through the Pheasant Branch Corridor

Objective: Maintain pedestrian and bicycle passage through the corridor while reducing conflict between user groups

Objective: Provide safe access across Pheasant Branch

Goal #3: Improve ecological biodiversity throughout the Pheasant Branch Corridor

Objective: Reduce streambank erosion and provide in-stream habitat diversity

Objective: Establish adaptive management zones within the corridor and promote native vegetation diversity

Objective: Establish continued stewardship of the corridor

Streambank Restoration

Comparison of elevation data sets from 2017 (pre-flood) and 2018 (post-flood) yield an approximate sediment loss from the channel and streambanks throughout the Pheasant Branch Corridor during the August 2018 flood event of 55,000 to 60,000 cubic yards. In 2018 Cardno assessed damage to Pheasant Branch following the August 2018 flood event and found approximately 10,187 linear feet of streambanks showing signs of Extreme, Very High or High streambank erosion. Executive Summary Table #1 below details the breakout of these areas for each stream section.

Executive Summary Table 1: Streambank Erosion Risk Assessment for the Left and Right Bank of the Pheasant Branch Corridor

Project Area	Extreme Streambank Erosion (ft)	Very High Streambank Erosion (ft)	High Streambank Erosion (ft)	Total Linear Feet (ft)
Confluence Pond to Parmenter Street Pheasant Branch Streambank Restoration Project (Construction)	264	197	1,520	1,981
Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Construction)	625	453	3,892	4,970
Park Street to Century Avenue Pheasant Branch Streambank Restoration Project (Construction)	444	503	2,289	3,236

Total cost estimates for design and construction to repair these sections are shown in Executive Summary Table 2 below. Costs for streambank restoration completed in 2019 directly downstream of the Park Street Bridge are not included in this table.

Executive Summary Table 2: High Priority Areas for Streambank Restoration

Year	Project	Total Linear Feet of Restoration	Total Cost Estimate	Anticipated Project Completion
2020	Confluence Pond to Parmenter Street Pheasant Branch Streambank Restoration Project (Construction)	1,981	$ 225,000	2021
2020	Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Construction)	4,970	$ 521,000	2021
2020	Park Street to Century Avenue Pheasant Branch Streambank Restoration Project (Construction)	3,236	$ 401,000	2021
	Total	10,187	$1,147,000	2021

Bridges

The five main bridges (numbered 1-6 from West to East) within the Pheasant Branch Corridor as existing should not be re-used as they are undersized as far as length and do not maintain a minimum of at least 8 feet of freeboard from the stream bottom before water reaches the lowest point on the bridge. The pan footings show significant signs of wear, and there are other potential structural concerns based on the damage sustained during the August 2018 flood event. The side path bridge (Bridge #3) is not designed for access for bicyclist or standard pedestrian loading. Replacing bridges at these six locations to be able to pass flood flows below low chord during future extreme flood events is not possible in this project area as modeling results from EOR's Flood Modeling and Mapping of Pheasant Branch show most of the corridor is under water during 100-yr and 500-yr flood events.

Yet, lengthening all six of these bridges would increase the height to low chord and help increase the bridges capacity to pass smaller flood flows. Placing bridges downstream rather than upstream of concrete vehicle crossings is also advisable to provide grade control on the upstream side to keep channel slopes through the bridge higher and avoid adverse slope conditions as seen at Bridge #2. Slight modifications to the location of Bridge #2 and Bridge #5 would situate them upstream rather than downstream of the vehicle crossings and avoid the adverse conditions discussed above. Executive Summary Table 3 details costs and additional recommended lengths for each of the six bridge locations.

Executive Summary Table 3: Recommended Bridge Length and Estimated Cost

Structure	Length	Estimated Weight	Cost
Bridge #1	85 feet	45,000 pounds	$199,000
Bridge #2	88 feet	47,000 pounds	$205,500
Bridge #3 (side path)	70 feet	32,000 pounds	$156,000
Bridge #4	85 feet	45,000 pounds	$199,000
Bridge #5	78 feet	42,000 pounds	$195,000
Bridge #6	84 feet	45,000 pounds	$199,000

Costs include the structure itself, the substructure, shipping/delivery and installation. Based on the challenging access for the site, all bridges were assumed to be constructed in two sections and welded on-site. The preferred and recommended bridge type for replacement is a weathered Steel Pratt Truss bridge that incorporates a more natural aesthetic with the weathered steel and also utilizes some timber components as well.

Type: Pre-fabricated weathered Steel Pratt Truss style
Clear width: 14’
Loading: 90 pounds per square foot, 20,000 vehicle design load
Decking: IPE timber decking with second being asphalt if need based on specific maintenance operations
Railing: 48” tall, weather steel with timber rub-rail/ hand rail

Substructure: Pile bent piers with concrete cap, or pile- supported abutments based on soil investigations

Trail Enhancements

Three Options (A, B and C) are presented with a total construction cost of $2,023,844, $1,825,958, and $1,777,110 respectively. Options B and C offer suggested path re-alignment that would eliminate the need for two of the existing bridges at a cost savings of $394,000.

The following summarizes our recommendations for the path:

- Apply the 12’ wide asphalt pathway wherever practical to allow for mainline width to have the greatest separation of users
- Realign the pathway to remove the two easternmost bridges (Bridge #5 and Bridge #6 $394,000 cost savings)
- Additional grading or vegetation removal should be considered where practical to reduce blind corners and pinch points
- Incorporate stone side paths where practical, with special focus on:
  - areas where existing asphalt pathway will be abandoned
  - specialty areas for environmental observation (e.g. birding, new ecosystems, etc.)
  - trail alignment areas with blind corners or pinch points
- Utilize traditional asphalt vs. the porous asphalt previously utilized. This recommendation is based on lower initial material and installation costs, lower maintenance costs, and longer useful life.

Final design for the pathway will work in conjunction with the overall stream realignment and required grading recommendations for the floodplain and stormwater improvements. Public feedback showed concerns with conflicts between bicyclists and pedestrians, so increasing separation (through wider paths or stone side paths) where possible is encouraged. Estimated pathway costs do not include the streambank stabilization nor the vegetation restoration/ ecological modifications within the corridor.

Path realignment currently shows two locations to be considered. The westernmost realignment incorporates significant grading and cost. If the proposed grading does not equate to significant benefits for alleviating flood concerns, we would suggest eliminating that specific realignment and focusing instead on slightly modifying the path and removing adjacent vegetation to minimize the blind corners in that section of the trail.

Vegetation Restoration

Ecological restoration zones are proposed for areas within the Pheasant Branch Corridor. While these zones exist on a continuum and will overlap with each other, there are some distinct differences between them. Some of the work need for these restoration enhancements may be performed along with or in addition to recommended stream and trail enhancements.

Executive Summary Table 4: Vegetation Management Cost Estimates

Project Task	Cost
Initial Woody Invasive Clearing	$100,000-$160,000
Selective Re-Seeding/Planting	$30,000 - $40,000
Annual Stewardship	$50,000 - $70,000

Costs/Timeline

In total, $1,319,613 in grant funding has currently been awarded to restore damage sustained during the August 2018 flood event in the Pheasant Branch Corridor. The funds can be used to help off-set project costs for streambank stabilization measures described above, trail repairs and enhancements, as well as bridge replacement costs. The Executive Summary Table 5 below lays out a potential timeline for project completion.

Executive Summary Table 5: Potential Timeline and Cost Estimates

Project Task	Project Area Description/Details	Start Date	Completion Date	Cost Estimate
Engineering Request for Proposals Pheasant Branch Corridor Stream Restoration	Design to mitigate approximately 10,187 linear feet of eroded streambank	3/1/2020	4/1/2020	
Design and Permitting Pheasant Branch Corridor Stream Restoration	Design to mitigate approximately 10,187 linear feet of eroded streambank	4/1/2020	12/31/2020	$150,000
Construction Pheasant Branch Corridor Stream Restoration	Construction of streambank mitigation design of approximately 10,187 linear feet of eroded streambank	1/1/2021	9/1/2021	$997,000
Engineering Request for Proposals Pheasant Branch Corridor Trail and Bridge Project	Option A-C, with Option B and C including removal of two easternmost bridges	11/1/2020	12/1/2020	
Design and Permitting Pheasant Branch Corridor Trail and Bridge Project	Option A-C, with Option B and C including removal of two easternmost bridges	1/1/2021	8/1/2021	$200,000
Construction Pheasant Branch Corridor Trail and Bridge Project	Construction of the selected Option	8/1/2021	10/31/2021	$1,777,000 to $2,024,000
Vegetation Management	Beginning following stream restoration in 2021	Ongoing	Ongoing	$65,000

Before the August 2018 catastrophic flood event, this Pheasant Branch Corridor offered a unique opportunity for area residents and visitors to Middleton to enjoy native riparian plants and animals within an urban setting. We recommend that future restoration efforts not only seek to repair damage sustained during the August 2018 flood, but to use this flood event as an opportunity to create additional recreational opportunities through bridge and trail enhancement as well as enhance biological diversity throughout this urban riparian area moving forward.

History of Projects in Pheasant Branch Corridor

Since 1975, stormwater detention ponds, gabions, sheet-piling, vane deflectors, and grade control structures have been installed to control channel erosion within Pheasant Branch. These stormwater management practices have been effective in mitigating the effects of increased urbanization within the watershed.[2] Yet, increases in annual precipitation and flood peak flows in the watershed have led to areas of significant bank erosion within Pheasant Branch over time.

Since 2007, the City of Middleton has been working with the Wisconsin Department of Natural Resources (WIDNR) and the Federal Emergency Management Agency (FEMA) to repair severely eroded slopes within the Pheasant Branch Corridor and update the public trail system. These efforts included multiple construction projects, utilizing WIDNR Urban Non-Point Source Stormwater Construction grants, WIDNR Clean Water Fund grants, and FEMA grants to stabilize approximately 5,000 linear feet of eroded slopes and streambanks from 2007 to 2017 (Table 1).

Table 1: Recent History of Pheasant Branch Corridor Projects, 2007-2017

Year	Project	Total Cost	Grant Funded	City Funded	Grant Agency
2007	Pheasant Branch Slope Stabilization (Park Street to Century Avenue)	$47,000	$31,500	$15,500	FEMA & WIDNR NPS
2008	Pheasant Run Slope Stabilization (between Park Street and Century Avenue)	$27,700	$13,850	$13,850	WIDNR Clean Water
2009	Gabion Removal and Slope Stabilization (between Park Street and Century Avenue)	$28,500	$25,700	$2,800	FEMA
2009	Rootwad Slope Stabilization (between Park St and Century Avenue)	$19,000	NA	$19,000	NA
2010	Park Street to Century Avenue Streambank Stabilization & Habitat Enhancement Project	$149,354	$74,677	$74,677	WIDNR Clean Water
2012	Park Street to Parmenter Street Streambank Stabilization	$154,100	$77,050	$77,050	WIDNR NPS
2015	Kromrey Middleton School Stream Realignment	$109,000	NA	$109,000	NA
2017	Pheasant Branch Streambank Restoration North of Century Avenue	$220,812	$110,406	$110,406	WIDNR NPS

[2] Gebert, W.A., Rose, W.J., and Garn, H.S., 2012. Evaluation of the effects of Middleton's stormwater-management activities on streamflow and water-quality characteristics of Pheasant Branch, Dane County, Wisconsin 1975-2008: U.S. Geological Survey Scientific Investigations Report 2012-5014, 27 p.

Eight of these projects were completed along the mainstem of Pheasant Branch from Parmenter Street to the area north of Century Avenue within the City of Middleton (Figure 1).

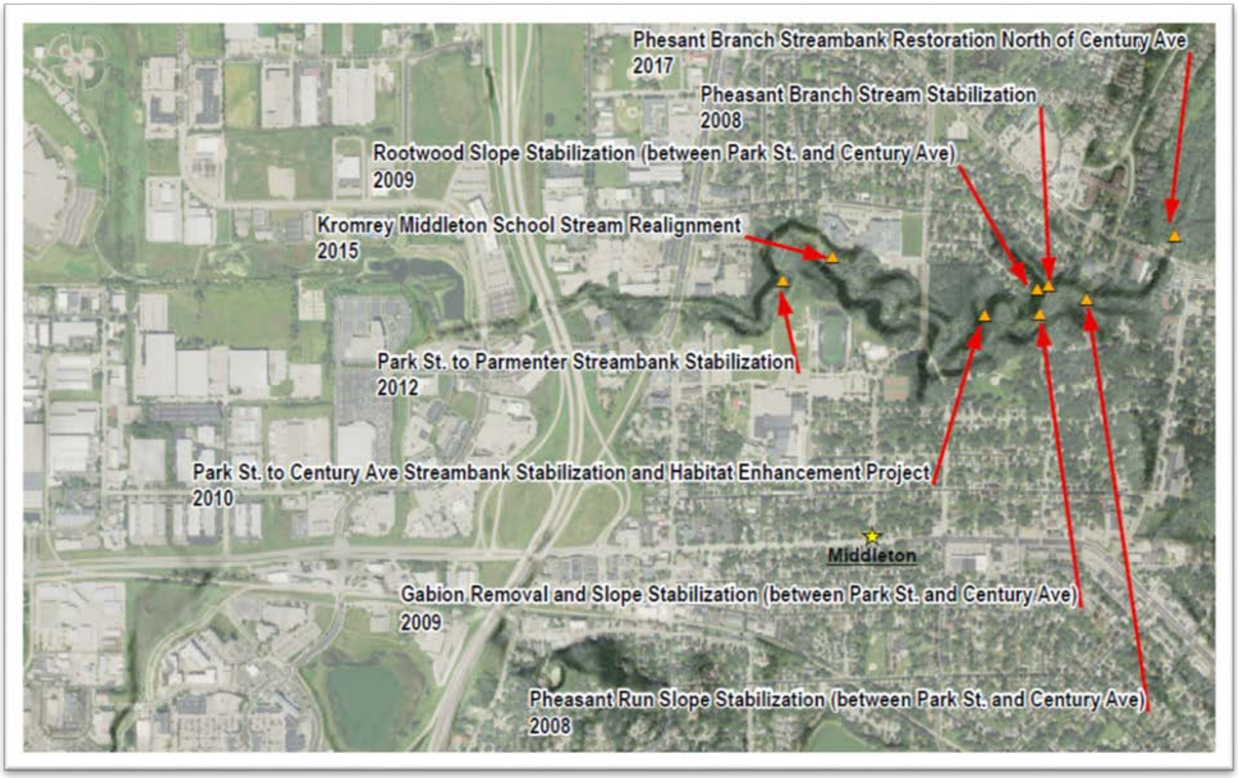

Figure 1: Channel erosion construction project locations within mainstem of Pheasant Branch from 2007-2017.

2007-2010 Pheasant Branch Stabilization Projects between Park Street and Century Avenue

From 2007 to 2010, the City of Middleton performed approximately 2,000 linear feet of streambank and slope stabilization using ecologically-sensitive techniques including rootwad composites to protect the toe of the slopes and create additional deep pool and under-bank habitat. Slope grading was also performed on these slopes to bring them to a more stable angle and once completed the entire project areas were seeded with a mixture of native forbs and grasses. The dense growth and deep root systems of the native vegetation help to hold bank materials in place while allowing water to infiltrate through the soil instead of flowing overland to the stream (Figure 2).

Figure 2: Photo of eroded slope adjacent to Pheasant Branch between Park Street and Century Avenue in 2005 (left) and same slope after construction taken in 2009 (right).

2012 Park Street to Parmenter Street Streambank Stabilization Project

In 2012, the City of Middleton stabilized nearly 1,500 linear feet of streambanks and slopes between Park Street and Parmenter Street within the Pheasant Branch Corridor using ecologically-sensitive techniques to mitigate erosion. To reduce the sediment load in the creek, stream energy dissipation structures and integrated bank treatments, including rootwad and toewood composites, cross-vanes, and single arm vanes were installed. These methods stabilized the banks while providing improved habitat for the insects, amphibians, reptiles, and fish found within the creek and riparian corridor (Figure 3).

Figure 3: Photo of eroded slope adjacent to Pheasant Branch between Park Street and Parmenter Street in 2010 (left) and same slope after construction taken in 2014 (right).

2015 Kromrey Middleton School Stream Realignment

The Pheasant Branch Kromrey Middle School Stream Relocation Project relocated approximately 500 linear feet of stream channel away from steep eroding slopes and streambanks by creating a new channel using ecologically-sensitive techniques to mitigate erosion. Relocation of this section of stream also increased flood flow capacity at the site allowing flood flows to rise up out of the bankfull channel and spread out over a newly created floodplain, dissipating energy, and offering increased protection at the toe of the steep slope above which a new addition to the Kromrey Middle School was built. As part of the project, an additional 0.04 acres of backwater oxbow wetland was created (Figure 4).

Figure 4: Photo of collapsing streambank adjacent to Pheasant Branch near site of Kromrey Middle School addition 2013 (left) and same section of stream after construction taken in 2016 (right).

Public Trail System Enhancements

In 2009 the City of Middleton performed the Pheasant Branch Corridor Trail project. This project made updates and modifications to the existing trail including paving the corridor trail system with porous asphalt from Parmenter Street to Century Avenue (Figure 5). Additional improvements included installation of three 60-foot, arched bridges between Park Street and Century Avenue (Figure 6). The total cost of this project was $305,389 of which approximately $167,970 was covered by a Wisconsin Department of Transportation (WisDOT) grant. Installation of the three bridges in 2009 combined with two existing 60-foot arched bridges installed in 2007 between Parmenter Street and Park Street made a total of five bridges on stream crossings within the corridor (an additional sixth, 65-foot bridge, was added in 2016).

Figure 5: Photo of Pheasant Branch porous asphalt trail between Parmenter and Park Street (taken 2013).

Figure 6: Photo of pedestrian bridge in Pheasant Branch Corridor between Park Street and Century Ave (taken 2013).

Vegetation Management

Efforts to control invasive species have been ongoing throughout the Pheasant Branch Corridor with City of Middleton staff as well as hired consultants working on removing invasive shrubs such as honeysuckle (*Lonicera spp.*), buckthorn (*Rhamnus cathartic)*, as well as invasive plant species such as garlic mustard (*Alliaria petiolate*). The City of Middleton has also taken advantage of donated services from residents over the years such as organizing volunteer groups to go out and pull garlic mustard, or utilizing volunteers for tree planting such as the Big City Mountaineers tree planting in 2014 (Figure 7).

Figure 7: Tree planting locations performed by Big City Mountaineers volunteer group along with donated time by Cardno personal in 2014.

August 2018 Flood Damage Assessment

On August 20, 2018, over 11 inches of rain fell in less than 24 hours in the Middleton and Cross Plains area. At the peak of the storm, rain was falling at a rate of 2 to 4 inches per hour according to National Weather Service data. Estimated peak flows from this storm event were over 3,000 cubic feet per second (cfs), or nearly three to four times higher than any flows recorded in this watershed over the last 43 years (Figure 8). The resulting flooding caused widespread damage throughout Pheasant Branch and the public trails system located within the Pheasant Branch Corridor.

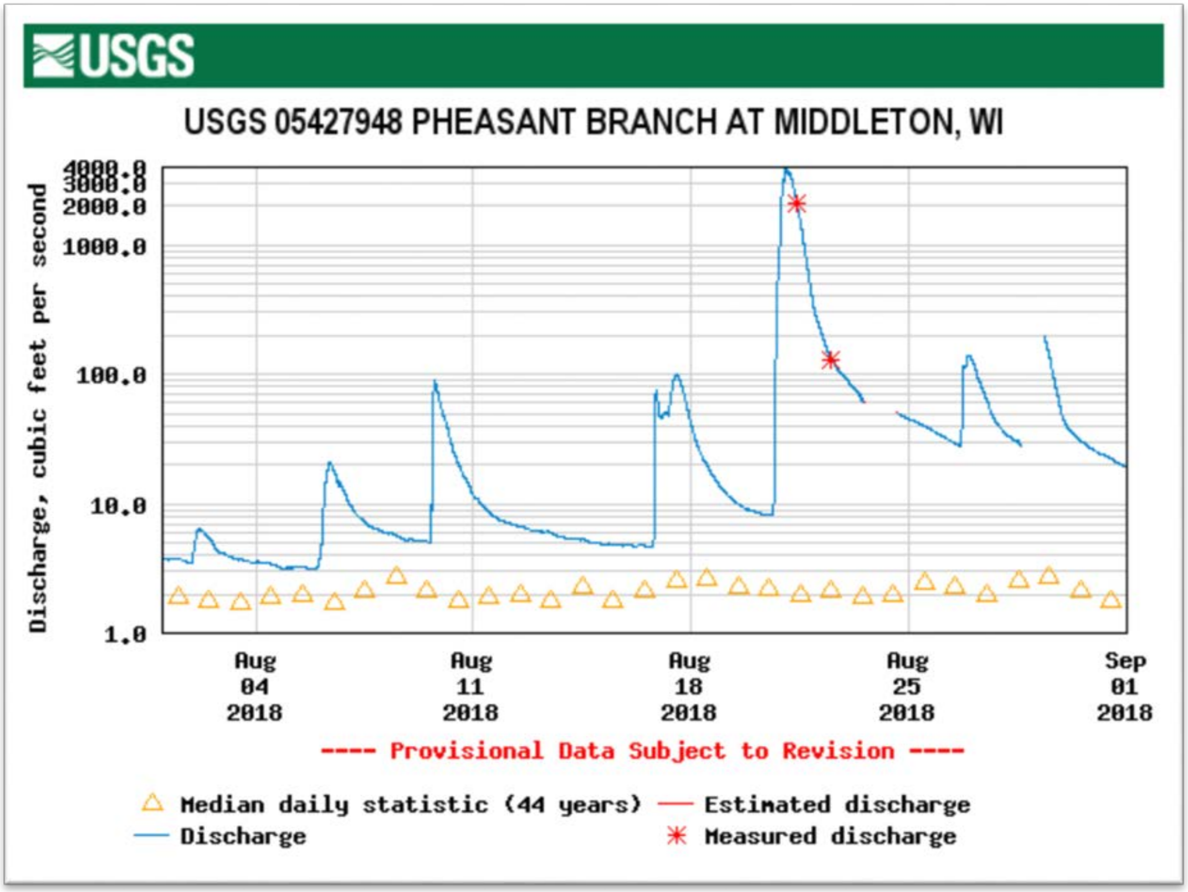

Figure 8: Flood discharge for August 20, 2018 flood event at Pheasant Branch stream gauge in Middleton.

Pheasant Branch Streambank Erosion Assessment

Cardno performed a complete streambank erosion assessment of both the left and right bank for the north fork, south fork and mainstem of Pheasant Branch. Streambank erosion assessments were preformed using the Bank Erosion Hazard Index (BEHI) model developed by Dr. David Rosgen[3]. The BEHI model evaluates the susceptibility of a streambank to erosion for multiple erosional processes. Individual BEHI variables are recorded through visual assessments and physical measurements to determine the combined risk for specific streambank sections to future streambank erosion (Figure 9).

Figure 9: BEHI model streambank erosion risk assessment for mainstem of Pheasant Branch between Park Street and Century Avenue

A complete set of the BEHI model streambank erosion risk assessment for the left and right bank of the Pheasant Branch Corridor can be found in Appendix A.

[3] Rosgen, David. WARSSS - Watershed Assessment of River Stability and Sediment Supply

Mainstem Pheasant Branch Damage Assessment (Between the Confluence Pond and Parmenter Street)

Some areas of the mainstem of Pheasant Branch between the confluence pond and Parmenter Street did experience various degrees of bank erosion following the August 2018 flood event. Streambank assessments within this area determined that approximately 1,520 linear feet of streambanks showed High bank erosion rates with an additional 197 linear feet exhibiting Very High and 264 linear feet of Extreme streambank erosion (Figure 10).

Figure 10: Extreme streambank erosion as a result of August 2018 flood event near Deming Way viewing downstream (1/15/19).

Mainstem Pheasant Branch Damage Assessment (Between the Parmenter Street and Park Street)

The mainstem of Pheasant Branch between Parmenter Street and Park Street experienced significant damage following the August 2018 flood event. All three pedestrian bridges that cross the channel between Parmenter Street and Park Street were damaged (Figure 11).

Figure 11: Photo of damaged bridge near Parmenter Street following August 2018 flood viewing downstream (8/25/18).

Extensive damage also occurred at the Donna Drive sedimentation pond where flood waters overtopped the pond, eroding the pond bank, causing a complete failure of the pond and stream embankment (Figure 12).

Figure 12: Photo of Donna Dr. sedimentation pond failure following August 2018 flood event (8/25/18).

Much of the damage to the existing bridges and streambanks in this section was caused by debris jams consisting of mainly shallow rooted tree species that collapsed into the stream during the August 2018 food event. Streambank assessments performed through this reach identified approximately 3,892 linear feet of streambanks showing evidence of High bank erosion with 453 linear feet of Very High and 625 linear feet of Extreme streambank erosion. Much of the pedestrian trail system adjacent to Pheasant Branch was also damaged during the August 2018 flood event. These areas will also need to be repaired along with restoration of streambanks and the stream channel in this section of Pheasant Branch (Figure 13).

Figure 13: Photo of pedestrian trail damage between Parmenter Street and Park Street following August 2018 flood event (8/25/18).

Mainstem Pheasant Branch Damage Assessment (Between Park Street and Century Avenue)

The mainstem of Pheasant Branch between Park Street and Century Avenue experienced significant damage during the August 2018 flood event including damage to each of the three pedestrian bridges located in this section of stream (Figure 14).

Figure 14: Photo of damaged pedestrian bridge between Park Street and Century Avenue following August 2018 flood event (8/25/18).

The public trail system within this section was also damaged and well as multiple areas of significant streambank erosion. Streambank erosion assessments within this reach found that approximately 2,289 linear feet of streambank showed evidence of High bank erosion with 503 linear feet of Very High and 444 linear feet showing evidence of Extreme streambank erosion. Much of the damage to bridges and streambanks in this section was caused by debris dams comprised of shallow rooted trees that collapsed into the channel during the August 2018 flood event. Extreme streambank erosion also occurred directly downstream of the Park Street crossing as flood flows we concentrated through the culverts running beneath the roadway (Figure 15).

Figure 15: Photo of extreme streambank erosion directly downstream of Park Street as a result of August 2018 flood event (10/11/18).

LiDAR Erosion Assessment of Pheasant Branch

As part of the August 2018 Flood Damage Assessment, Cardno sub-contracted Wisconsin Environmental Restorations, LLC to fly Pheasant Branch with a drone and record up-to-date LiDAR measurements of the channel. LiDAR information collected during these drone flights was then compared with 2017 LiDAR data acquired from Dane County to provide an assessment of streambank sediment lost during the August 2018 flood event (Figure 16).

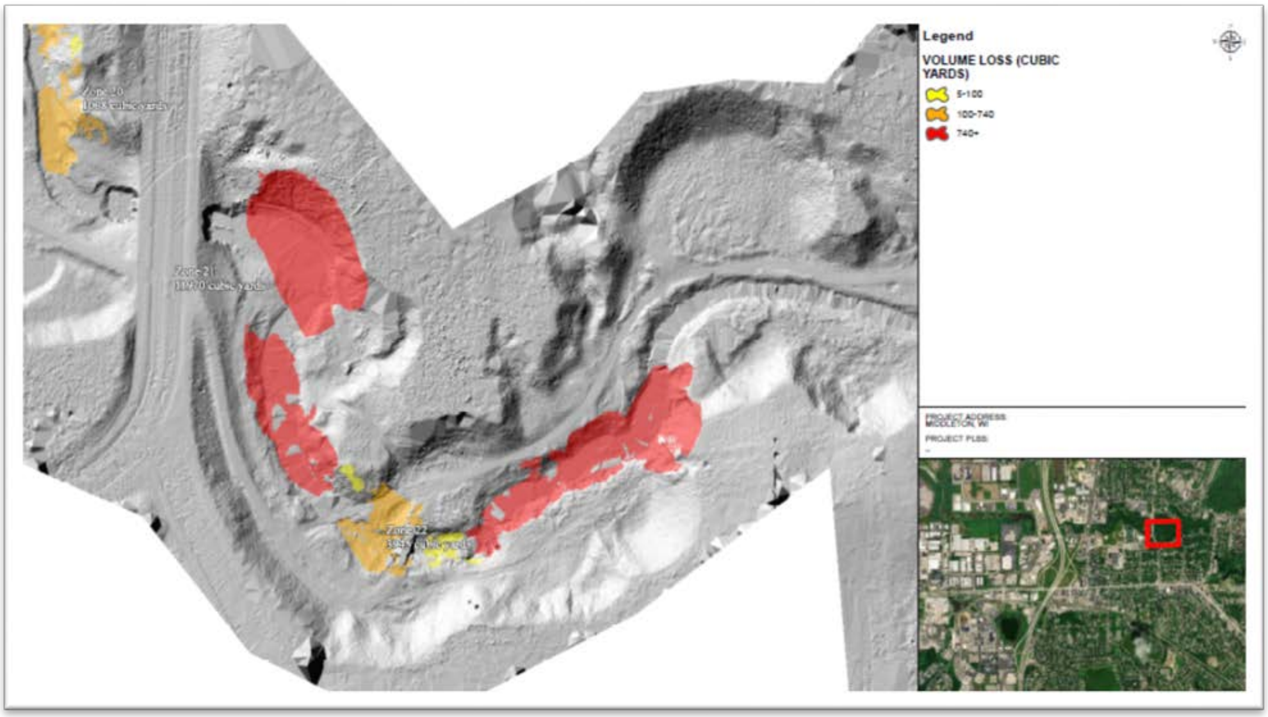

Figure 16: Example of comparison between 2017 and 2018 LiDAR data directly downstream of Park Street on the mainstem of Pheasant Branch.

Estimates of sediment loss throughout the Pheasant Branch Corridor total approximately 55,000 to 60,000 cubic yards of sediment lost from the channel and streambanks during the August 2018 flood event.

Pheasant Branch Corridor Planning Processes

Public Outreach

In order to procure public input for the Pheasant Branch master planning process two public input sessions were held at the Kromrey Middle School and two public surveys were put out by the City of Middleton using Polco, a civic participation technology platform. Location and dates for the public meetings and Polco surveys were advertised through the City's website and on social media. A comprehensive summary of the results from the public input meetings and Polco surveys can be found in Appendix B.

June 20, 2019 Public Input Meeting

The first public meeting was held on June 20, 2019. During the meeting an overview of the damage sustained during the August 20, 2018 storm event was given along with a description of the master planning process by the project team. A variety of topics were examined during this meeting and attendees were given the opportunity to discuss what they liked about the Pheasant Branch Corridor and what opportunities they saw for the corridor moving forward.

The graph below shows results for the question "How do you currently use the Pheasant Branch Corridor" (Figure 17).

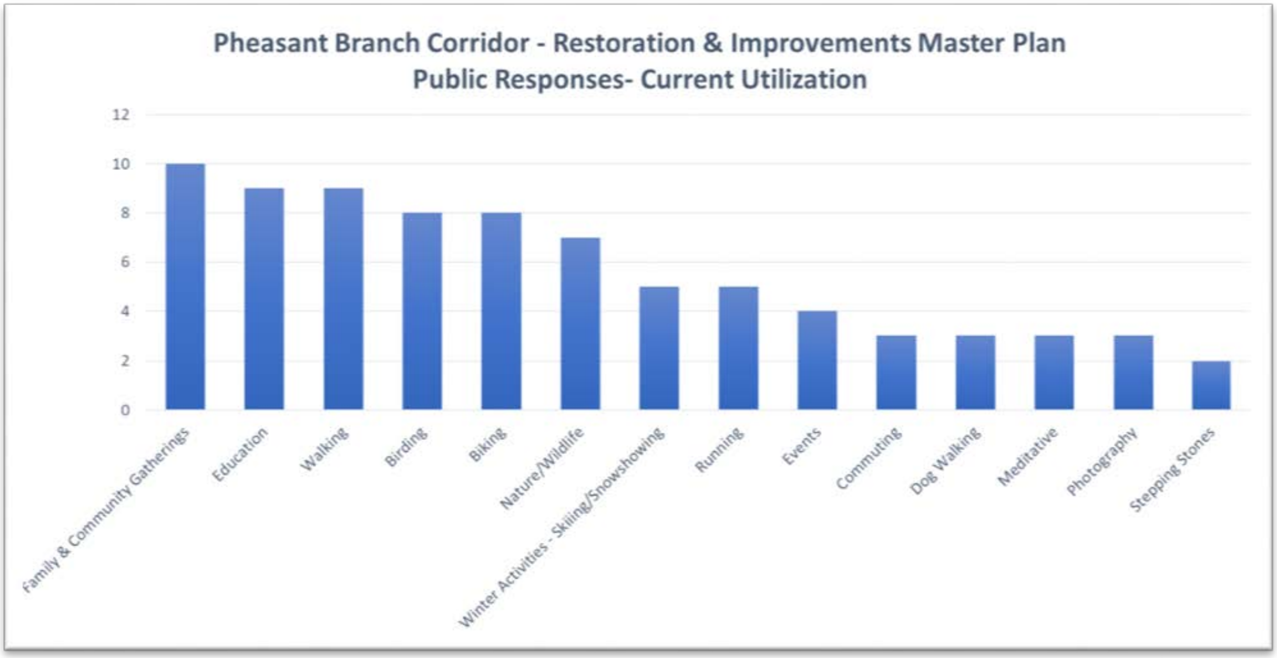

Figure 17: Summary of responses to how attendees used the Pheasant Branch Corridor during the June 20, 2019 public input meeting

The results from this question show that the corridor is well used for outdoor recreating and that nature and the natural setting of the corridor is important.

During this meeting attendees were also offered the opportunity to weigh in on any potential concerns they had with planned upcoming restoration efforts as well as any opportunities they saw restoration efforts could accomplish within the Pheasant Branch Corridor (Figures 18 & 19 below).

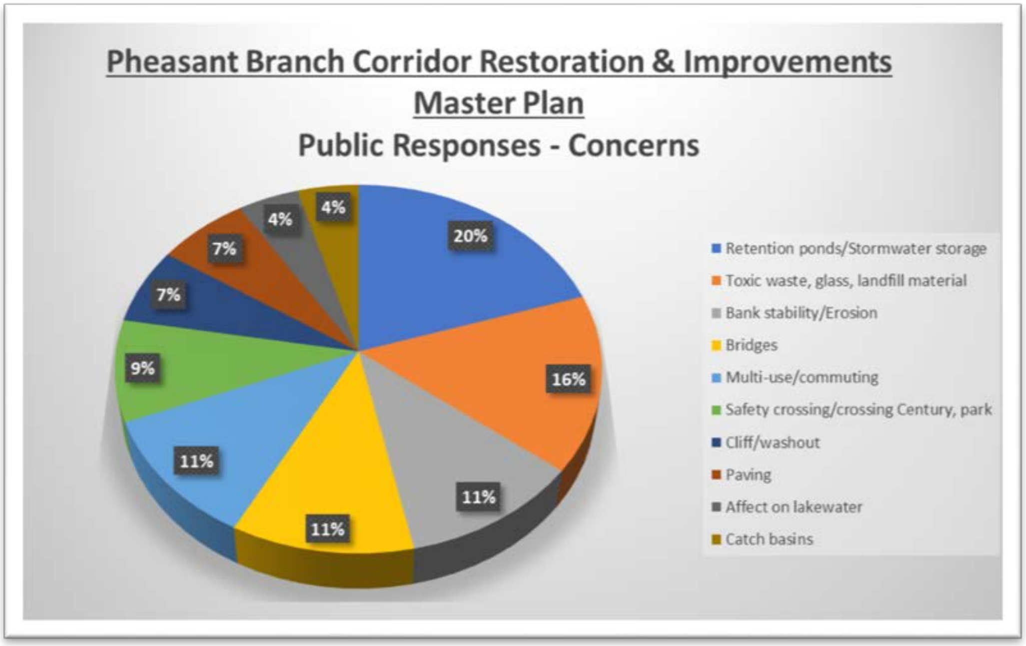

Figure 18: Summary of responses to concerns meeting attendees had with upcoming Pheasant Branch Corridor restoration efforts during the June 20, 2019 public input meeting

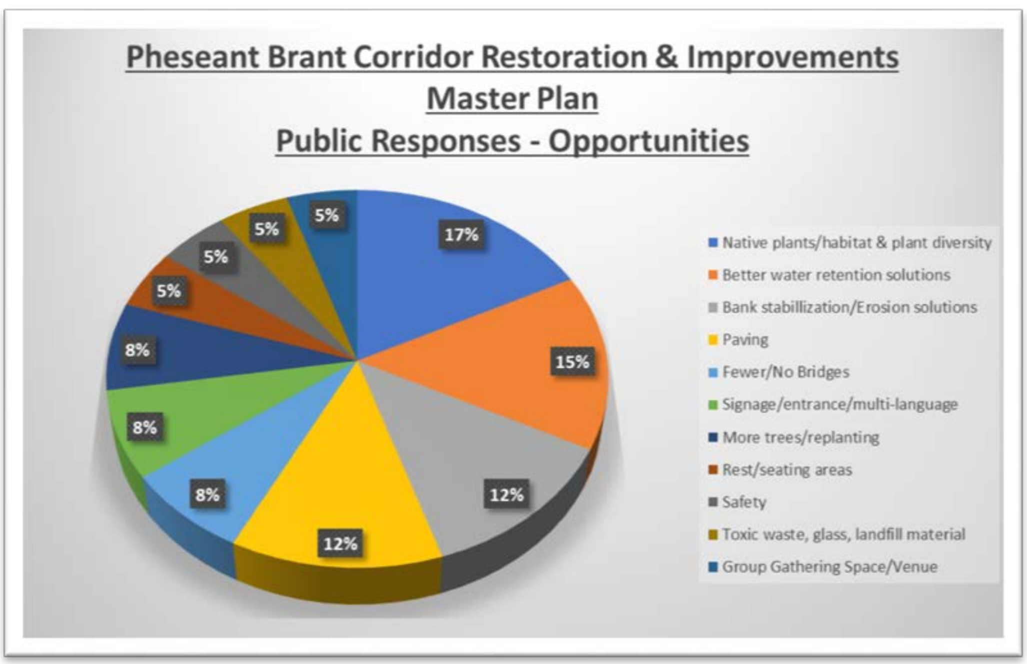

Figure 19: Summary of responses to opportunities meeting attendees saw for future Pheasant Branch Corridor restoration efforts during the June 20, 2019 public input meeting

A majority of the expressed concern by meeting attendees dealt with stormwater, bank erosion, damage to bridges and landfill materials found in the project area following the 2018 flood. These results coincided with attendees' responses viewing outdoor recreation and nature as the most important uses of the corridor as well as with responses to opportunities attendees saw including solutions to bank erosion along with better stormwater solutions and an emphasis on native plants and habitat diversity.

Public Survey #1

The first public survey was released by the City of Middleton on July 9, 2019 using Polco which included nine questions about the Pheasant Branch Corridor found below. Middleton has used Polco to release public surveys since 2017. For this survey 370 people responded and it was closed August 12, 2019.

Question #1: How often do you visit the Pheasant Branch Corridor?

Over 70% or 262 of the 370 respondents to this survey questions stated they use the Pheasant Branch Corridor daily (21%), at least twice a week (19%), or weekly (31%) showing the high usage rates by people in this area (Figure 20).

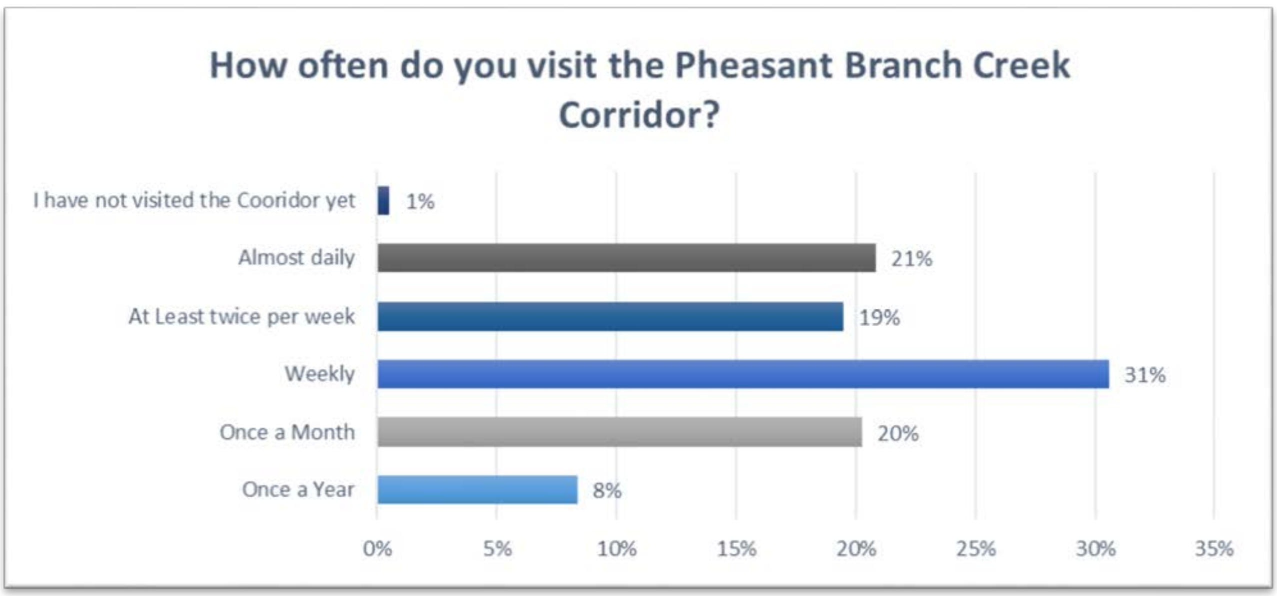

Figure 20: Summary of responses to Question #1 of the first public survey released 7/9/19

Question #2: Why do you visit the Corridor?

When asked why respondents visit the Corridor, 77% (285 respondents) indicated that they visit specifically to experience nature. This was followed by 68% indicating that exercise-walking was the second highest reason for Corridor visits. Exercise-biking was given as the third most reason of use of which 39% of respondent listed as their reason of visits. Other reported activities listed as reasons for Corridor visits consisted of Exercised-running (26%), Meditation/relations (15%), bird watching (14%), commuting to work (7%), commuting to school (2%), athletic event/race (2%), cross country skiing (2%), Exercise-snowshoeing (1%), outdoor classrooms (1%), and lastly, attending educational classes at 0% of reported reasons to visit (Figure 21).

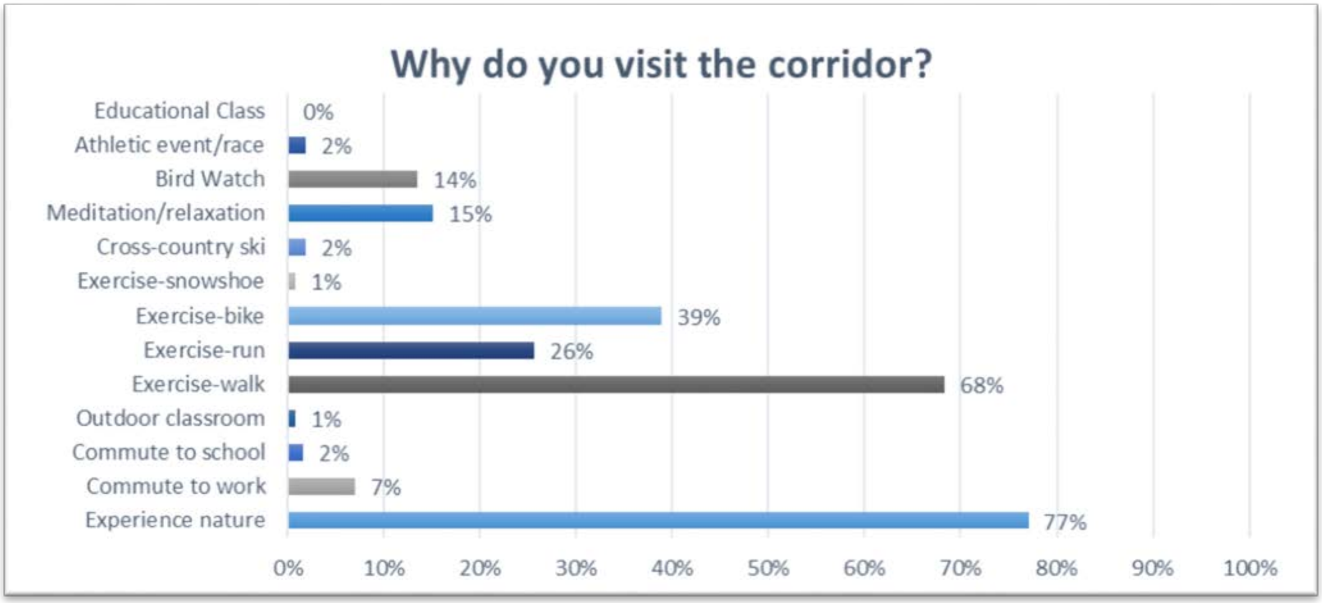

Figure 21: Summary of responses to Question #2 of the first public survey released 7/9/19

Question #3: How do you access the Creek Corridor?

Accessing the Corridor was widely completed by walking with 47% of surveyed Corridor visitors indicating this as their main mode of transport. Biking was the second most popular response at 27%. An additional 15% of respondents reported that driving to the corridor along was how they accessed the corridor while 2% responded that driving while either ride sharing or carpooling was their main way of access. Running (reported at 9%), was reported by 35 respondents and is supported by number of respondents indicating that forms of exercise were the main reasons for visiting the Corridor. Public transportation, while an option listed in the survey, was not reported by any of the respondents (Figure 22).

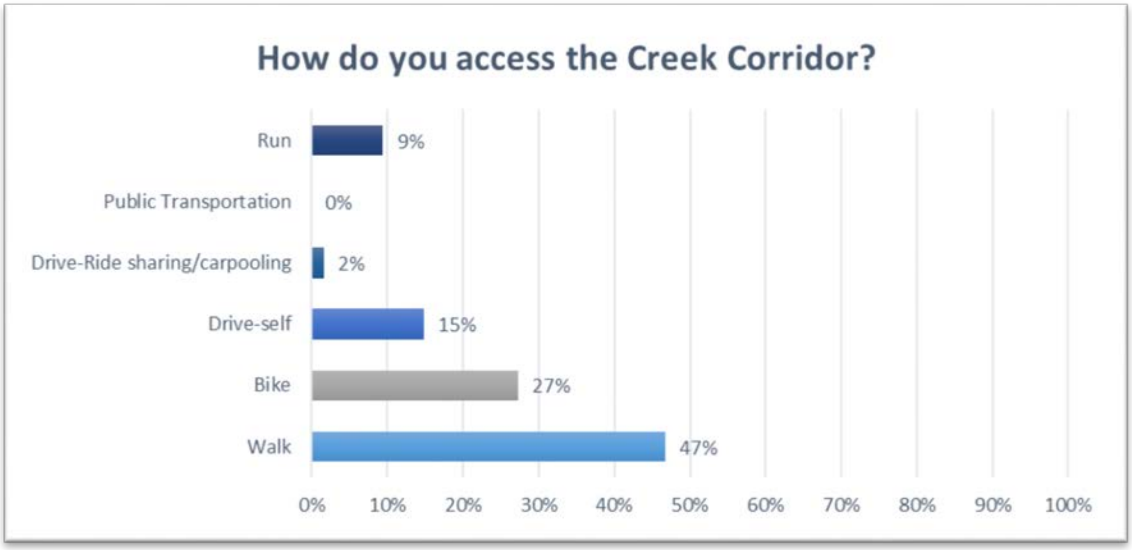

Figure 22: Summary of responses to Question #3 of the first public survey released 7/9/19

Question #4: What do you feel makes the Corridor a special place in Middleton?

Meeting attendees were asked “What do you feel makes the Corridor a special place in Middleton”. Six responses were recorded with the results as follows; trail – 44%, Pheasant Branch Creek – 35, animals/animal habitat – 10%, vegetation – 5%, topography – 5%. One (1%) respondent did indicate that they did not think the Corridor is important to Middleton (Figure 23).

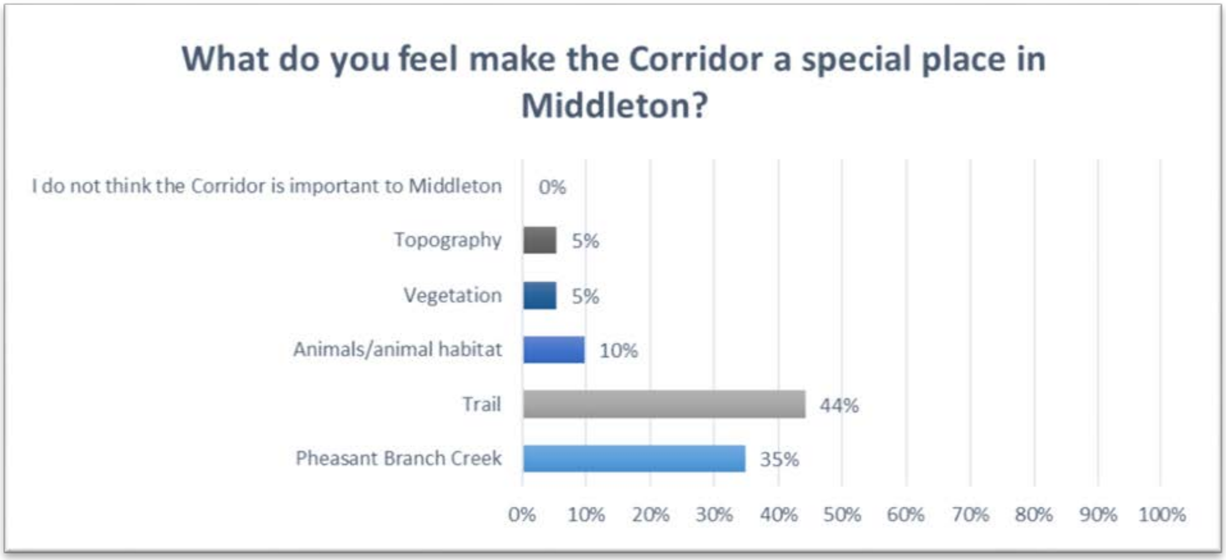

Figure 23: Summary of responses to Question #4 of the first public survey released 7/9/19

Question #5: How important is Creek Corridor access during the winter season?

Respondents did feel that the Creek Corridor access during the winter was important, with 67% combined indicating that they either felt access was Very Important (30%), or Somewhat Important (37%). 19% of respondents felt neutral to winter season access of the Creek Corridor. 5% of respondents also replied that they felt winter season access to the Creek Corridor was Not Important. Further, 9% of respondents did not visit the Creek Corridor during the winter months (Figure 24).

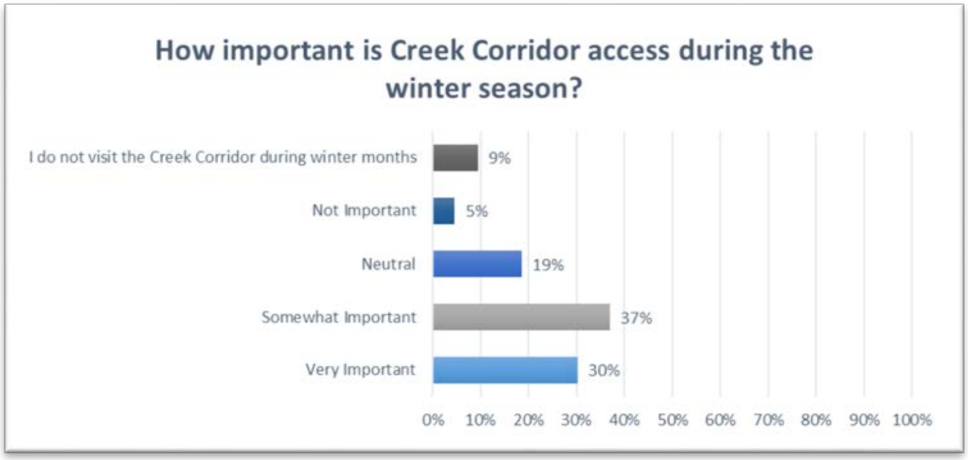

Figure 24: Summary of responses to Question #5 of the first public survey released 7/9/19

Question #6: Which benefit of the corridor is most important to you?

Those surveyed were asked to select one benefit of the Corridor they felt was most important to them. Access to Nature was a significant response with 45% of respondents selecting this option. Improved health and wellness was the second most selected option with 16% choosing this as most important. 13% responded that Bicycle Transportation was most important while 8% felt pedestrian transportation was most important. Stormwater management/water pollution reduction/flood mitigation was selected by 7%. 6% of respondents chose Animal/insect/pollinator habitat and 4% listed community identity as most important. These were followed by vegetation diversity and increased property value/generating economic development each being listed as most important by 1% of those surveyed (Figure 25).

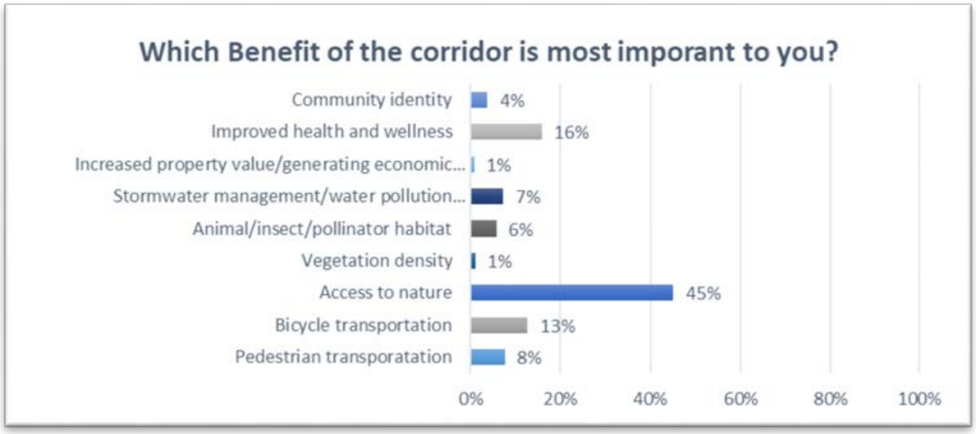

Figure 25: Summary of responses to Question #6 of the first public survey released 7/9/19

Question #7: What potential improvements do you consider priorities?

Respondents were asked to choose their top three priorities for potential improvement. Of those surveyed, the top three priorities ranked were stormwater management/flood control (73%), trail maintenance (52%), and streambank stabilization (46%). While not in the top 3, pedestrian bridge replacement (32%), water flow rate reduction during storm events (23%), and tree replacement (20%) were the next highest priorities ranked. The remaining improvement priorities consisted of restoring native grasslands (15%), Interpretive signs for geological history & vegetative systems (6%), bench replacement (4%), trail maps (3%), interpretive signs for cultural/local history (3%), bicycle parking (1%), and vehicular parking (1%) (Figure 26).

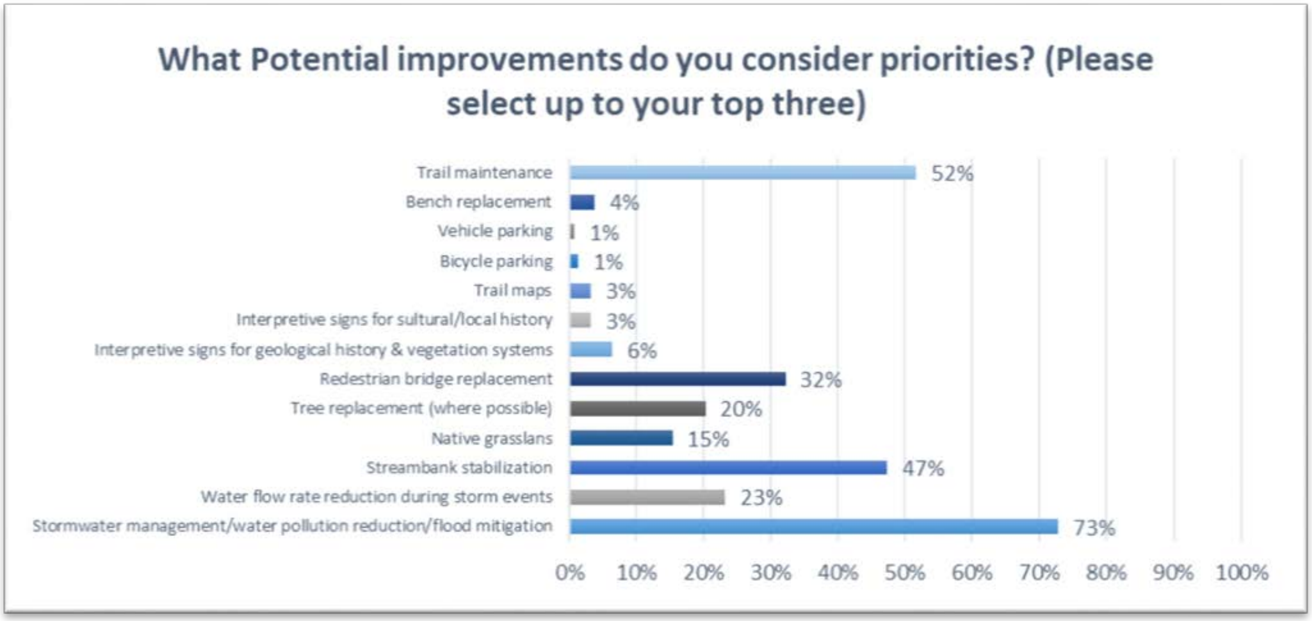

Figure 26: Summary of responses to Question #6 of the first public survey released 7/9/19

Question #8: What potential activity do you consider a priority?

When asked what potential activity was considered a priority respondents were fairly consistent based on the options given. It should be noted that the highest selected category was “I do not think activities are a priority” at 30%, and will be discussed in further detail in later sections. Bicycling (21%), Organized events for observing nature (15%), Safe routes to school (14%), and commuting to work/shopping/or community destinations (13%) all followed closely behind. Organized nature walks (6%), and organized running races (1%) were selected as the least potential activity considered a priority (Figure 27).

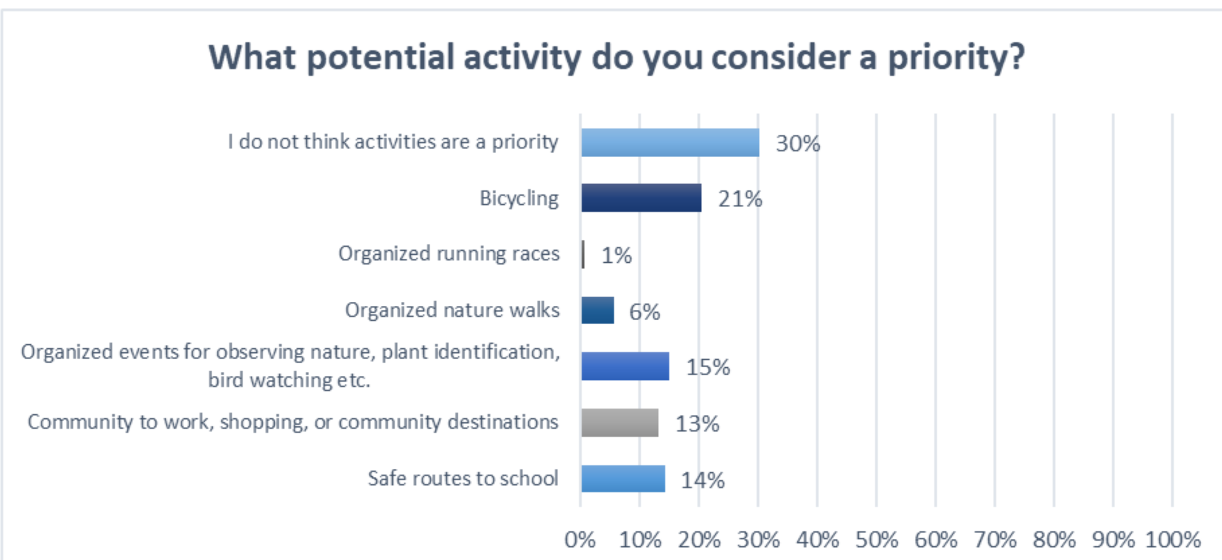

Figure 27: Summary of responses to Question #8 of the first public survey released 7/9/19

Question #9: Do you support the city borrowing funds to finance Corridor improvements?

The final question of the first public survey asked attendees if they supported the City borrowing funds for the potential improvements. Of those surveyed, 87% (322 respondents) were supportive of borrowing any necessary funds. The remaining 13% (48 respondents) did not support the idea of the City borrowing funds (Figure 28).

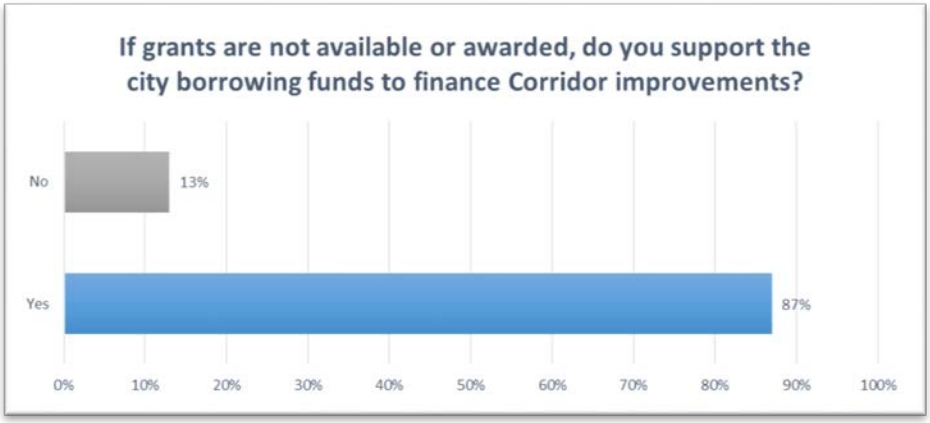

Figure 28: Summary of responses to Question #9 of the first public survey released 7/9/19

In general, the responses to the first public survey show that the Pheasant Branch Corridor is valued by local residents as well as other users from communities surrounding Middleton as an important place where citizens and families interact. Figure 29 below depicts the municipal ward residency of survey respondents as well as the number of respondents that came from each of these areas. Answers to survey questions and additional comments provided for each question also show respondents see the City of Middleton's response to the flooding in 2018 as an opportunity to replace what was lost and make improvements while keeping the corridor as natural as possible.

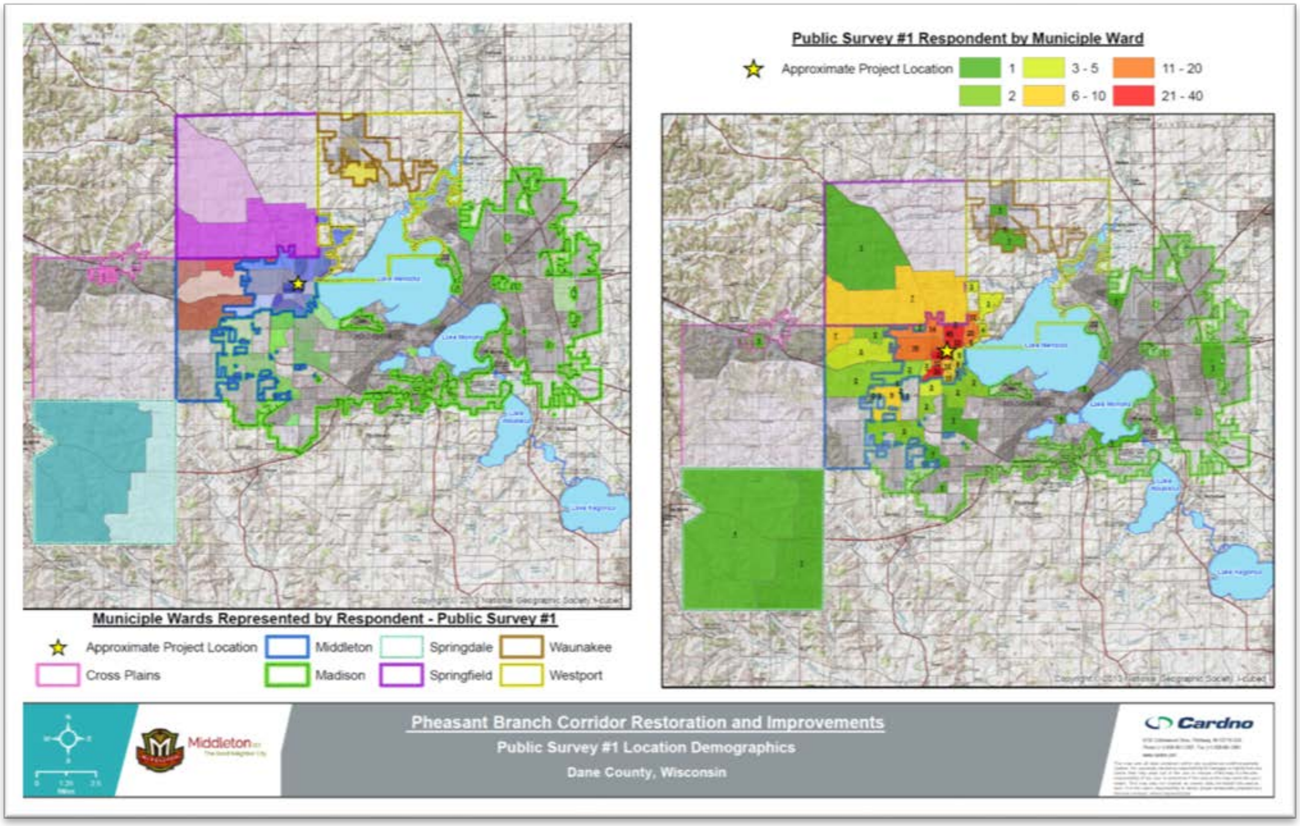

Figure 29: Maps depicting municipal ward residency and number of public survey respondents

Public Survey #2

The second public survey was released by the City of Middleton on August 22, 2019 using Polco and included two questions about the Pheasant Branch Corridor found below.

Question #1: Bridge Design Preference (109 Respondents)

Public Input was gathered relative to the bridge type. Examples were shown that then scored each type based on cost, maintenance, and constructability (Figure 30).

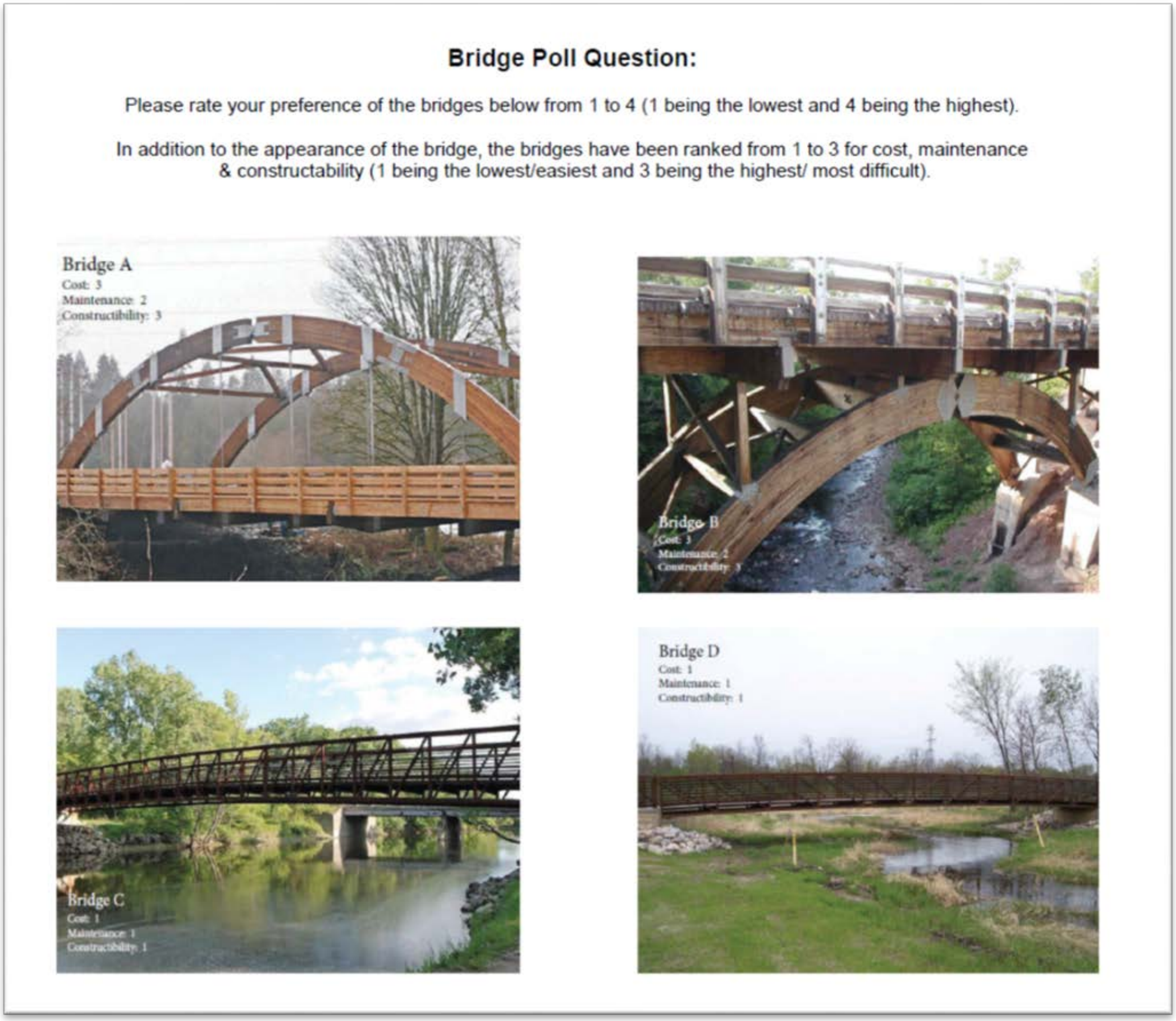

Figure 30: Bridge design preference poll photos

The highest scored example was a pre-fabricated bike/pedestrian bridge in a weathered Steel Pratt Truss style. (Both C & D were variations of this type).

Question #2: Streambank Stabilization Preference (118 Respondents)

For this question, survey respondents we given a choice between hard armoring streambanks with sheet-piling or gabion baskets, using stone rip rap to stabilize streambanks, or using more “soft-engineering” techniques that provide more habitat than the stabilization methods mentioned previously. These habitat friendly techniques included the use of toewood and native vegetation as a means of stabilization. A majority of the respondents chose using native vegetation as their preference for stabilizing streambanks. This preference was also shown during the second public input meeting where when given the same choices 16 out of 21 attendees chose native vegetation as the preferred streambank stabilization method (Figure 31).

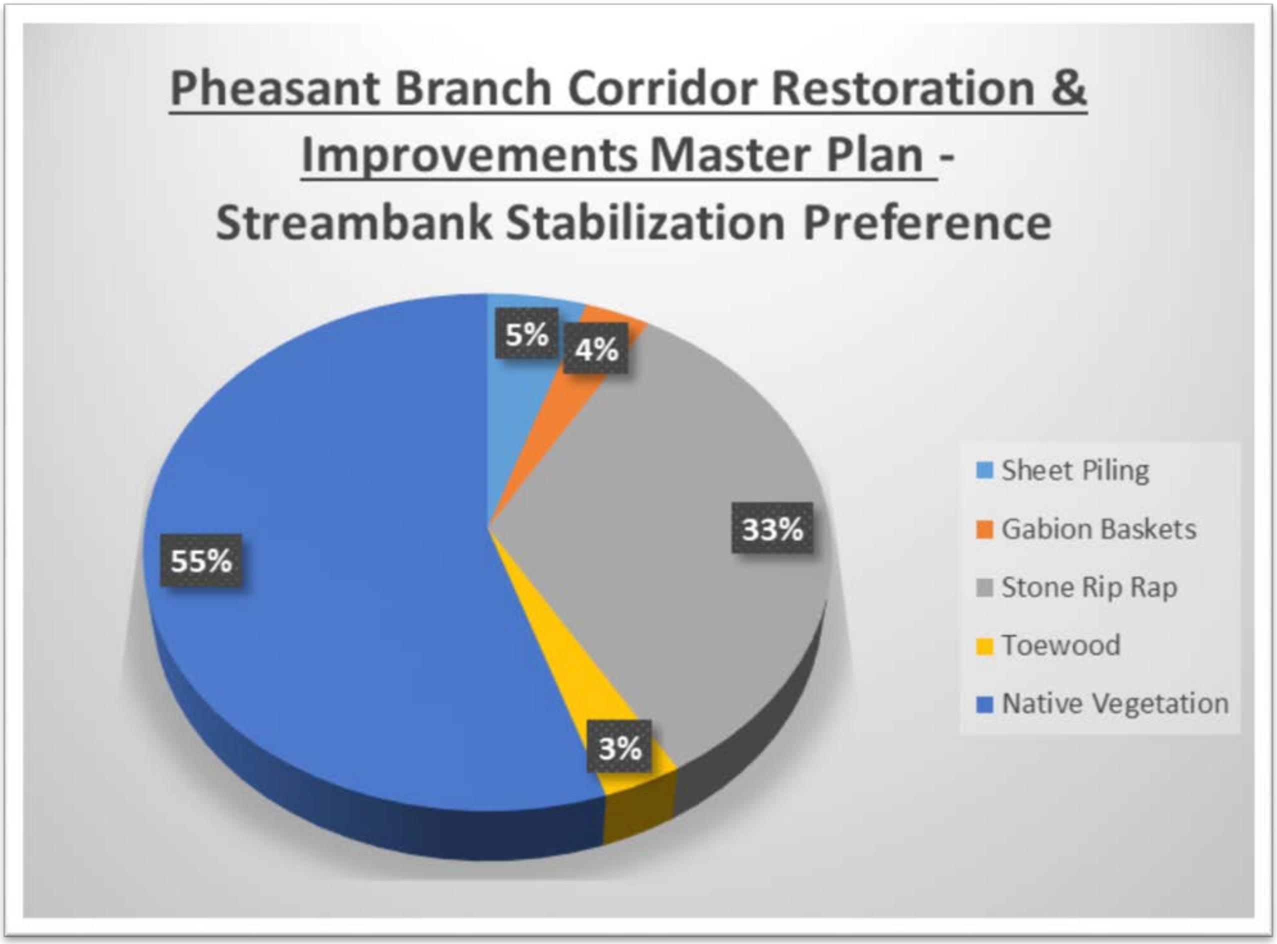

Figure 31: Public survey responses to streambank stabilization preference.

September 10, 2019 Public Input Meeting #2

The second public meeting was held on September 10, 2019. During the meeting an overview of responses to public polls was presented as well as potential bridge and trail enhancement options, streambank stabilization options, and potential vegetation management options for restoring the Pheasant Branch Corridor. Attendees were then asked a series of five questions about the materials presented to allow for public input on the options discussed prior to concluding the meeting (Figures 32 – 36).

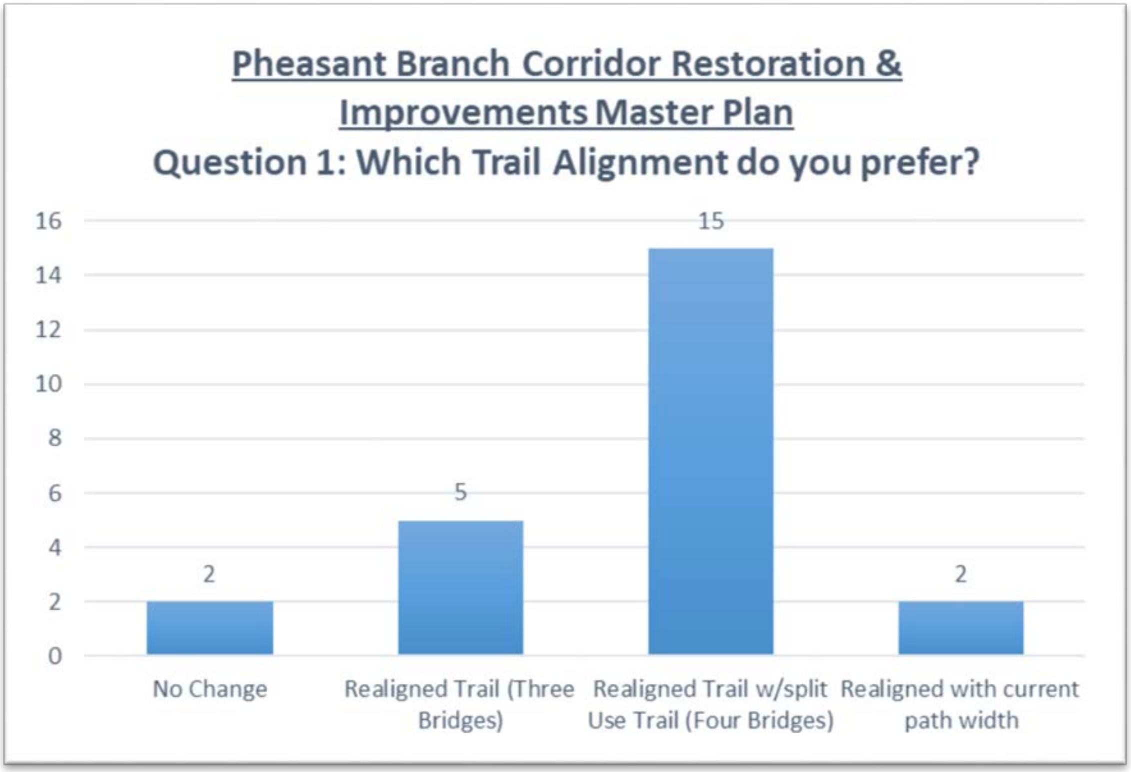

Figure 32: Public input meeting responses to trail alignment preference

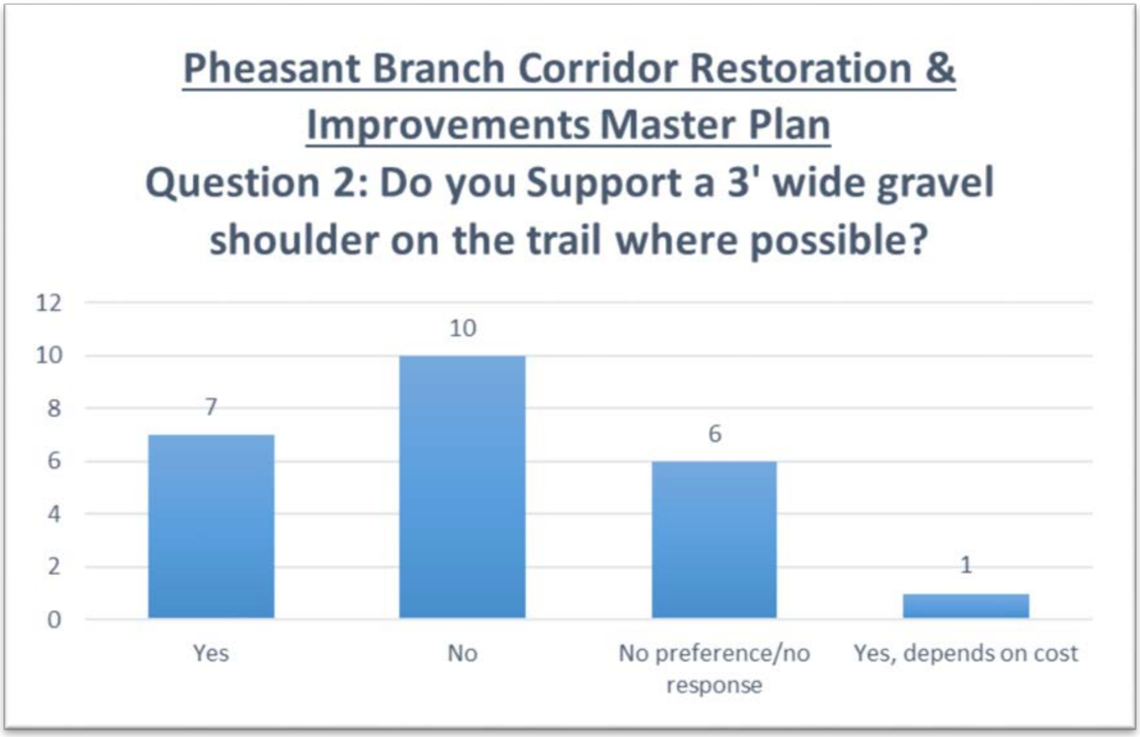

Figure 33: Support for three foot wide gravel shoulder during public input meeting

Figure 34: Support for using an ecological approach during public input meeting

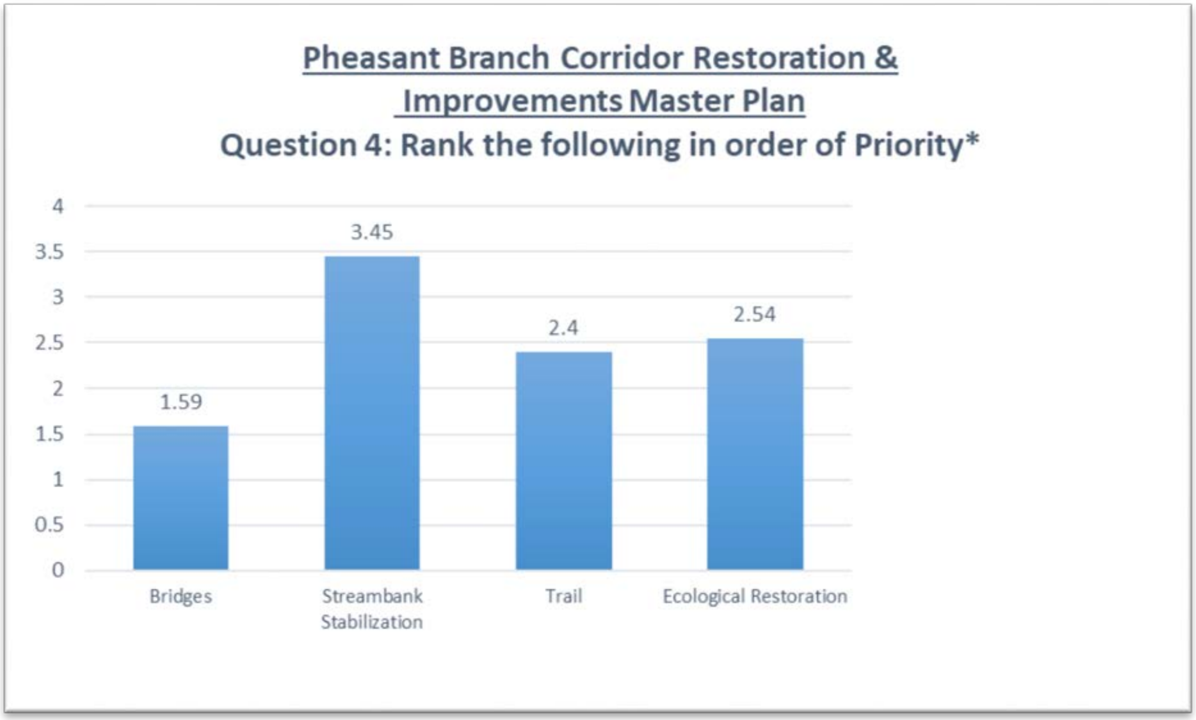

Figure 35: Prioritization of restoration efforts during public input meeting

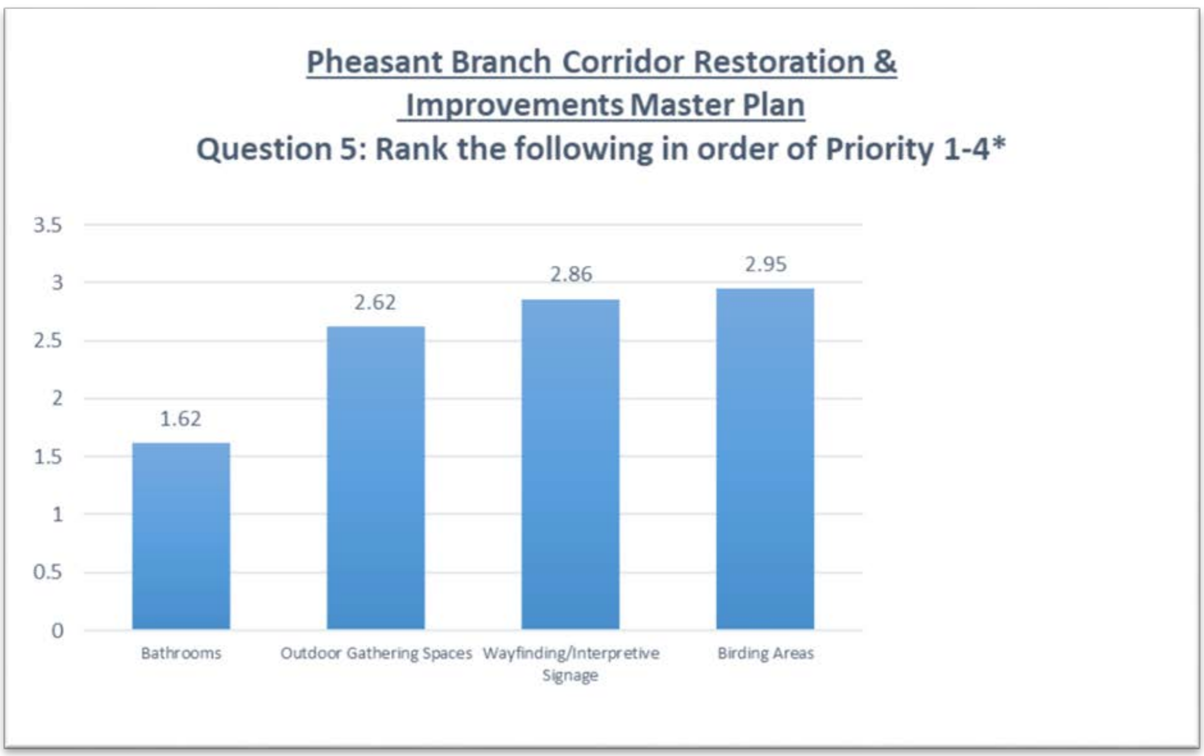

Figure 36: Prioritization of corridor amenities during public input meeting

Pheasant Branch Stream Crossings

There are currently a total of six bridges in the Pheasant Branch Corridor project area, with five of the six bridges (Bridge #1, 2, and 4-6) located on the main path and the one (Bridge #3) located on an off-shoot path towards the Kromrey Middle School (Figure 37).

Figure 37: Location and installation date for six bridges between Parmenter Street and Century Avenue

The five main bridges are 60-feet long and have timber superstructure, decking and railings. Their substructure is comprised of pans that rest on the existing embankment. Bridge #3 also sits on pans and is a combination of weathered steel and timber. During the flooding event in August of 2018, all six of the bridges were "lifted" and washed downstream to various degrees and damaged by flood debris impacts. Bridges were repaired with railing and decking replaced and they were then temporarily resituated to the greatest extent possible in the same area they originally were located.

Floodplain Modeling and Analysis of Pedestrian Bridges

Emmons & Olivier Resources, Inc. (EOR) completed a SWMM model of the Pheasant Branch watershed and an accompanying report for the City of Middleton. This model will be used to create updated floodplain maps that would be ready for a potential submittal to FEMA as well as be a functional tool that could be used in the future to analyze land use change, incorporate the City's storm sewer network, assess management alternatives, or test other scenarios. Using this model, EOR produced a technical memo describing flood characteristics at six recreational trail bridges in the Pheasant Branch Master Plan project area between Parmenter Street and Century Avenue. The complete memo along with associated data output can be found in Appendix C.

Methods

EOR contracted Professor Daniel Wright at UW-Madison to update National Oceanic and Atmospheric Administration (NOAA) Atlas 14 inundation-duration-frequency curves with the more recent heavy rainfall events from August of 2018 as well as from March of 2019 (964 cfs), observed in the watershed and adjusted the 100-yr, 24-hour design rainfall depth to match the U.S. Geological Survey (USGS) 100-yr flow estimate. This slightly-adjusted 100-yr rainfall depth from Dr. Wright's work is shown in Table 2.

Table 2: 24-hr design storm rainfall totals used in bridge analysis

Recurrence Interval	Rainfall	Peak Flow (cfs) at Parmenter Street
2	2.39"	556
5	3.36"	973
10	4.07"	1246
25	5.19"	1705
50	6.25"	2135
100	7.68"	2718

These rainfall depths were applied to the calibrated model to create the flows and analyze stream crossings in the project area for the 2-, 5-, 10-, 25-, 50-, and 100-yr rainfalls. Each bridge was reviewed to determine:

- The maximum water surface elevation at upstream face ("Max HGL")
- If there was flow out of the main channel ("Floodplain activated")
- If water was high enough to be obstructed by the lowest point on the bridge ("Water to low chord")
- If the bridge deck was overtopped ("Bridge deck overtop")
- Channel velocity maximum feet per second (ft/s)
- Floodplain velocity maximum feet per second (ft/s)

Results

Table 3 below displays the results of the modeling effort and compares the different existing bridges by indicating at which return interval a certain flow condition occurs as well as the maximum channel and floodplain velocities during the 100-yr storm event.

Table 3: Recurrence interval storms triggering flow conditions and maximum velocities for 100 yr. storm events at all six bridge locations

Condition	Bridge 1	Bridge 2	Bridge 3	Bridge 4	Bridge 5	Bridge 6
Floodplain activated	100-yr	2-yr	5-yr	50-yr	10-yr	50-yr
Water to low chord (bottom of beam)	50-yr	10-yr	10-yr	100-yr	25-yr	25-yr
Bridge deck overtop	NA	50-yr	25-yr	NA	100-yr	50-yr
Max channel velocity for 100 yr. event (fps)	4.85	2.61	5.49	7	8.58	9.06
Max floodplain velocity for 100 yr. event (fps)	0.43	1.78	3.16	5.04	5.61	4.18

<u>Bridge #1, 1st Pedestrian Bridge East of Parmenter Street (60')</u>

This 60-foot long arched bridge was installed in 2007 with a 12,000 pound design load. It has a 12-foot clear width between railings and the railing height is 54 inches. Bridge #1 has a substructure that sits on galvanized sill pans that rest on an incised channel. A vehicle crossing with a significant drop is located directly upstream of the bridge which creates a larger channel slope and capacity through bridge (Figure 38). Hydraulic modeling results show that the floodplain is not activated until the 100-year discharge. Water surface reaches the bottom of the beam (low chord) by the 50-year flood discharge, but the bridge deck does not overtop even during the 100-year flood discharge.

Figure 38: Upstream face of Bridge #1

Bridge #2, 2ND Pedestrian Bridge East of Parmenter Street (60')

Bridge #2 is a 60-foot long arched bridge installed in 2007 with a 12,000 pound design load. It has a 12-foot clear width between railings, a railing height of 54 inches, and has a substructure that sits on galvanized sill pans. It is located directly downstream of a tight bend in the stream and there is a vehicle crossing with a significant drop located directly downstream of the bridge (Figure 39). Bridge #2 has been placed in a section of channel with a low floodplain bench that activates by the 2-year discharge. The low chord of the bridge is reached by water at the 10-year discharge because the bridge is set fairly low on the streambanks and the downstream vehicle crossing is creating lower hydraulic channel capacity. The bridge deck is not overtopped until the 50-year discharge.

Figure 39: Upstream face of Bridge #2

Bridge #3, 3rd Pedestrian Bridge East of Parmenter Street (65')

This 65-foot long arched bridge was installed in 2016 and has a substructure that sits on galvanized sill pans. The design load is noted as 30 pounds per square foot (psf) and then 10,000 pounds at mid-span. It has a 6-foot clear width between railings and the railing height is 42 inches (Figure 40). Bridge #3 has been placed in a section of meandering channel with a low floodplain bench that activates by the 5-year discharge. Hydraulic modeling results show the water surface reaching the bottom of the beam (low chord) by the 10-year flood discharge, and the bridge deck is overtopped at the 25-year discharge.

Figure 40: Upstream face of Bridge #3

Bridge #4, 4th Pedestrian Bridge East of Parmenter Street (60')

Bridge #4 is a 60-foot long arched bridge installed in 2009 with a 12,000 pound design load. It has a 12-foot clear width between railings, a railing height of 54 inches, and has a substructure that sits on galvanized sill pans that rest on an incised channel (Figure 41). A vehicle crossing is located upstream of the bridge. Hydraulic modeling results show that the floodplain is activated and water reaches the low chord of the bridge by the 50-year discharge. The bridge deck is not overtopped by the 100-year flood discharge.

Figure 41: Upstream face of Bridge #4

Bridge #5, 5th Pedestrian Bridge East of Parmenter Street (60')

This 60-foot long arched bridge was installed in 2009 with a 12,000 pound design load. It has a 12-foot clear width between railings and the railing height is 54 inches. Bridge #5 has a substructure that sits on galvanized sill pans (Figure 42). Bridge #5 has been placed in a section of channel with a wide floodplain bench that activates by the 10-year discharge. The low chord of the bridge is not reached by water until the 25-year discharge and the bridge deck is not overtopped until the 100-year flood discharge. This section of channel also experiences high flow velocities during the 100-year discharge. A vehicle crossing is located directly downstream of the bridge and a stormwater outflow is located directly upstream. Hydraulic modeling results show the bridge deck is overtopped at the 100-year discharge.

Figure 42: Upstream face of Bridge #5

Bridge #6, 6th Pedestrian Bridge East of Parmenter Street (60')

Bridge #6 is a 60-foot long arched bridge installed in 2009 with a 12,000 pound design load. It has a 12-foot clear width between railings, a railing height of 54 inches, and has a substructure that sits on galvanized sill pans (Figure 43). Bridge #6 has been placed in a narrow section of channel, low on the banks. A vehicle crossing is located directly upstream of the bridge. Hydraulic modeling results show the water surface reaches the bottom of the beam (low chord) at the 25-year flood discharge, the floodplain is activated by the 50-year, and the bridge deck is also overtopped by the 50-year flood discharge which means the bridge deck is overtopped before stream flows reach the floodplain. This bridge section also experiences the largest velocities of any of the six bridge locations during the 100-year flood discharge.

Figure 43: Upstream face of Bridge #6

Bridge Modeling Discussion

Many factors affect the hydraulics at each bridge including bank height, local channel slope and floodplain geometry. Bridge #2, #3, #4 and #5 have floodplain areas that are set back from the edge of the main channel and are lower than the bridge's low chord. As a result water levels reach floodplains areas before the low chord of the bridge is reached. It does not appear that there was grading associated with bridge placement in these locations that would focus flow through the channel.

Bridge #2 and #3 appear to be the most flood-prone with floodplain areas reached by the 2-yr and 5-yr flood flows. The low chord of each bridge obstructs flow during the 10-yr flow. While, bridges #1 and #4 appear to have the least flood risk and are the only bridges that do not overtop during the 100 year flow.

All bridges but Bridge #3 (trail spur to middle school) have concrete vehicle crossings with baffle blocks/steps either directly upstream or downstream of the bridge and vehicle crossings and crossing configuration can have important effects. For example, Bridge #1 has both a weir and a vehicle crossing with a steep drop upstream of the bridge, resulting in higher channel slope and hydraulic capacity underneath the bridge and lower flood risk to the bridge. Conversely, Bridge #2 has a vehicle crossing downstream of the bridge, and scour between the bridge and the vehicle crossing has resulted in adverse local channel slope and lower channel hydraulic capacity underneath the bridge. As a result, the bridge low chord is impacted at the 10-yr event despite having a very well connected adjacent floodplain (connected at the 2-yr).

Replacing bridges at these six locations to be able to pass flood flows below low chord during future extreme flood events is not possible in this project area as modeling results from EOR's Flood Modeling and Mapping of Pheasant Branch show most of the corridor is under water during 100-yr and 500-yr flood events (Figure 44).

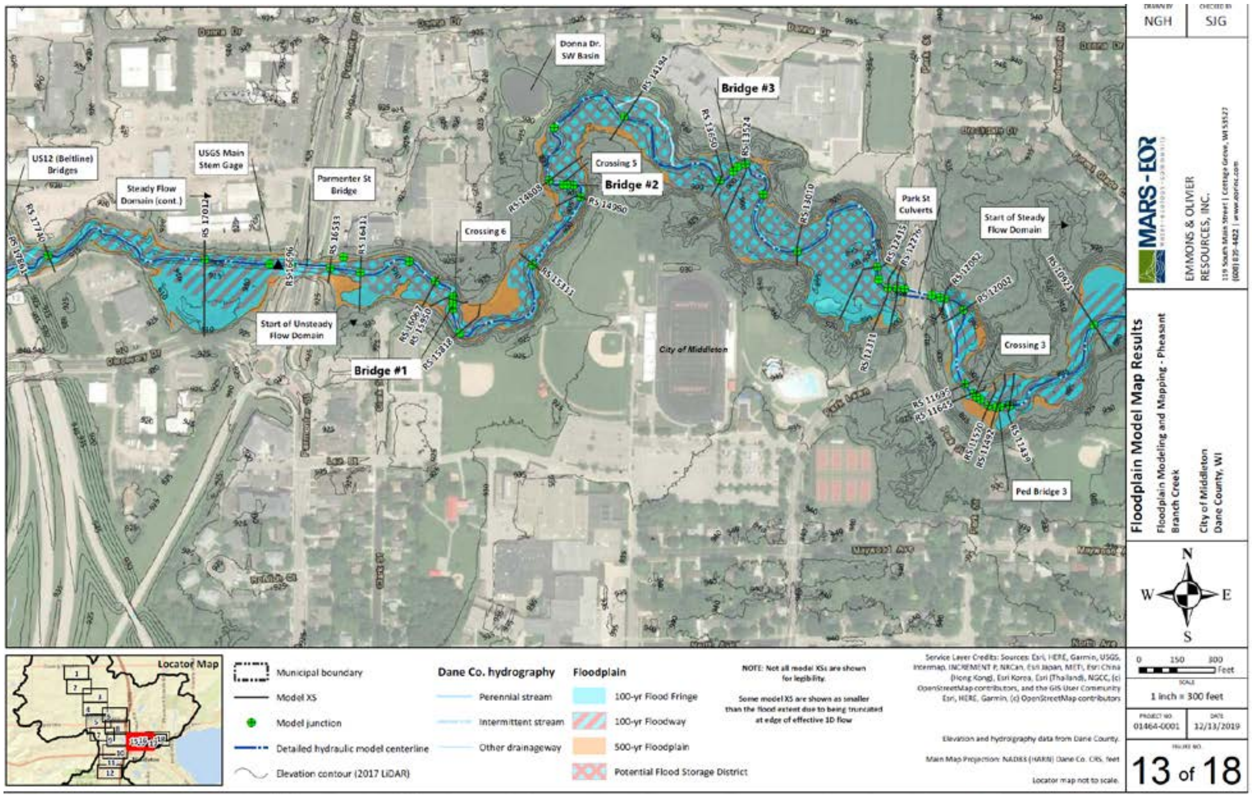

Figure 44: Flooding extent of 100-yr and 500-yr modeled flood flows between Parmenter Street and Park Street (modified bridge numbering from original EOR report[4])

Yet, lengthening all six of these bridges would increase the height to low chord and help increase the bridges capacity to pass smaller flood flows. Grading around each bridge location could be done to focus flow through the bridge up to the floodplain elevation. Floodplain grading could also be performed to allow access to floodplains below the low chord of each bridge site so flows could access floodplain areas before damaging the bottom beam of the bridge.

Placing bridges downstream rather than upstream of concrete vehicle crossings is advisable to provide grade control on the upstream side and keep channel slopes through the bridge higher avoiding adverse slope conditions as seen at Bridge #2. Slight modifications to the location of Bridge #2 and Bridge #5 would situate them downstream of the vehicle crossings.

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[4] Floodplain Modeling and Mapping – Pheasant Branch Final Report prepared by EOR for City of Middleton, 2019.

Design Considerations

The five main bridges as existing should not be re-used as they are undersized as far as length, do not maintain a minimum of at least 8 feet of freeboard, the pan footings show significant signs of wear, and there are other potential structural concerns based on the damage sustained during the August 2018 flood event. The side path bridge is not designed for access for bicyclist or standard pedestrian loading.

Based on the surroundings, a more natural aesthetic was developed for public input. As noted above, in addition to the aesthetic, the top concept presented to the public included reference to maintenance needs/longevity, overall cost, and constructability specific to this site. Although extremely unobtrusive with the material aesthetic, an all-timber bridge does not rate as well with the longevity and durability.

The preferred and recommended bridge type is a weathered Steel Pratt Truss bridge (Figure 45). This then incorporates a more natural aesthetic with the weathered steel and also utilizes some timber components as well. Comparatively, this is the most cost-efficient option and rates high in overall longevity and maintenance. In reference to the actual installation on-site, costs have been developed that assume bridges are fabricated in two pieces vs. a single piece to minimize site disturbance.

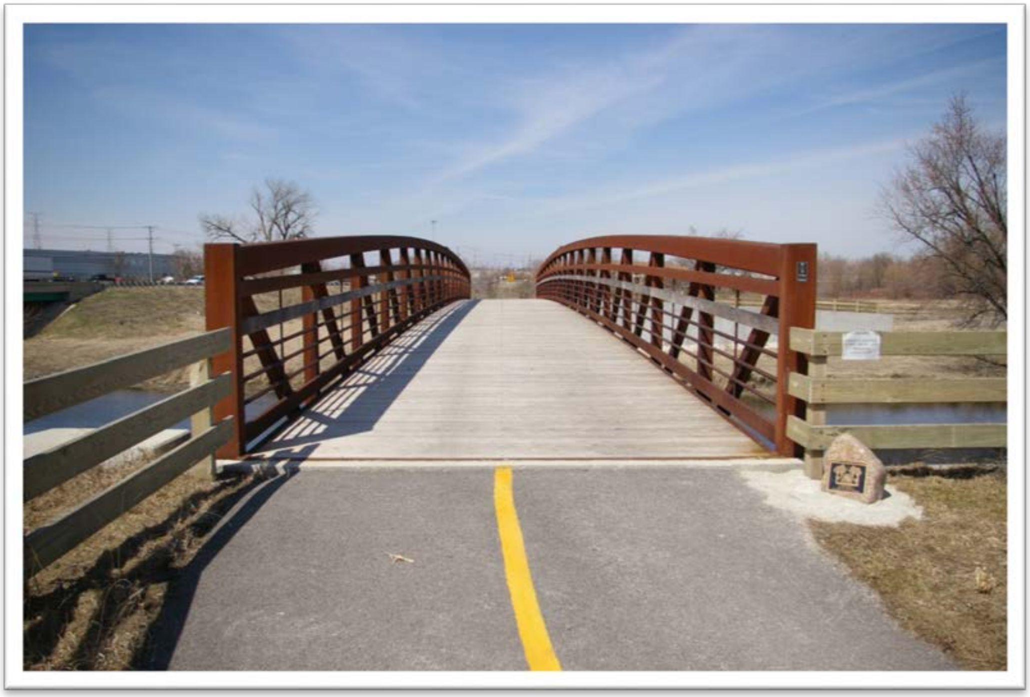

Figure 45: Example Steel Pratt Truss bridge

Width

Minimum clear width on a shared use path for a bridge with significant use is 12' wide. This is based on allowing a 1' "shoulder" from the adjacent 10' wide pathway. The preferred width is 14'. Based on public input on maximizing space between bicyclist and pedestrians, **we are recommending that all bridges on the main spine are designed with a 14' clear width.** In addition to the added separation between users, it also allows for greater flexibility with maintenance vehicles. **We would also suggest that the side path bridge be widened to at least 8' clear width to all for the minimum bi-directional shared use trail width.**

Loading

Typical loading for bicycle and pedestrian bridges take into account the pedestrian live load as well as any maintenance vehicles as well. The standard bike/pedestrian loading is 90 pounds per square foot (psf). Bicycle/pedestrian bridges designs typically include 10,000 (H5) or 20,000 pounds (H10) for vehicles. WisDOT BOS standard is to use H10 for pedestrian bridges wider than 10 feet—BUT typically on local projects that are not on the highway system, if the municipal need is 10,000 pounds, then that is allowed. The bridge is designed for the worst case loading from the vehicle or 90 psf pedestrian load, whichever is more restrictive.

Due to the potential for larger forestry and utility trucks, we are recommending a vehicle load of 20,000 pounds. At times, a smaller 10,000 pound vehicle load is specified on bike/pedestrian bridges, however, but based on the anticipated use and the relatively small cost difference (typically less than 5 % of bridge cost), we are recommending the heavier loading. Detail design will include requesting information on all vehicles that you plan to take over it and if not standard, specific measurements on their axles, gross weight, etc. This then will play into the overall structure design. We recommend that all bridges are designed to 90 psf for pedestrian loading and the mainline bridges incorporate the 20,000 pound vehicular load. Further discussions with the City based on the need for maintenance vehicles would then determine the recommended loading for vehicles on the side path bridge.

Railings

Per American Association of State Highway and Transportation Officials (AASHTO), WIDNR, and WisDOT design standards, railing heights on bicycle/pedestrian bridges range from a minimum 42" and maximum standard as 54". The standard sizes that are designed on bridges typically include 42", 48" and 54" high Figure 46.

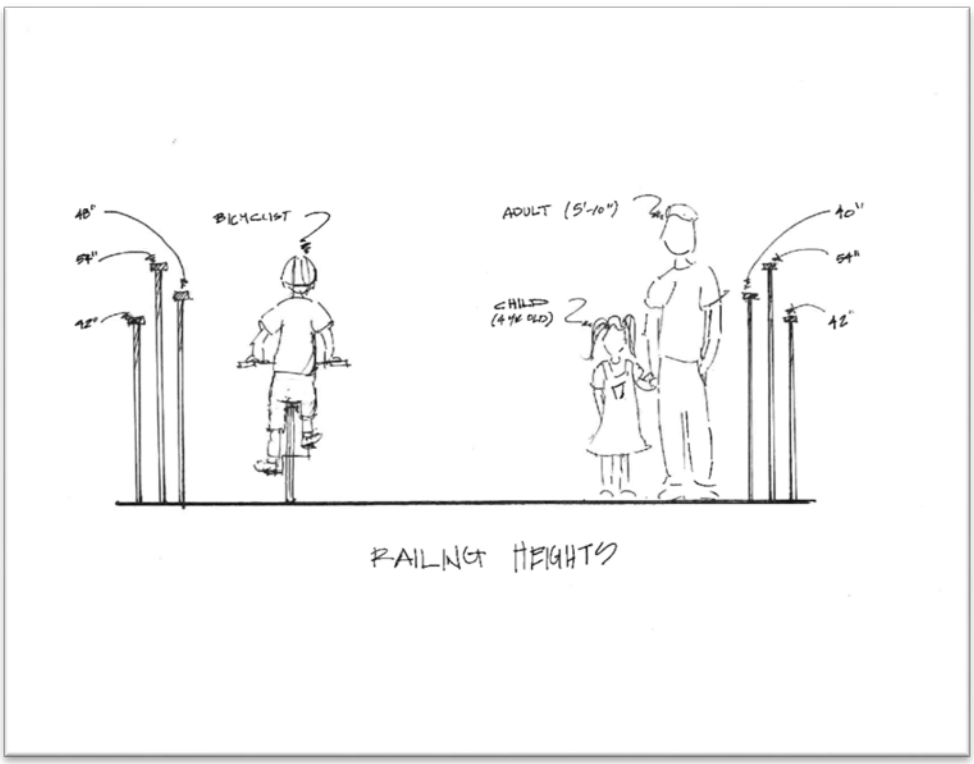

Figure 46: Example bridge railing height

The 54” height typically has the negative elements that the taller height causes difficulties with view shed and posture for viewing (for both adults and youth). The 42” allows for better view sheds, but the comfort level for safety of bicyclists is sometimes diminished. Based on these considerations, we recommend that all railing is designed to a 48” height with rub-rail to serve secondarily as a handrail (Figure 47).

Figure 47: Example bridge railing style

The current bridges had a picket style configuration. In order to reduce material costs, add flood capacity and ease of pedestrian use, we’d recommend that the Pratt Truss incorporate vertical and diagonal weathered steel members along with the horizontal rails and then a timber rub-rail/ handrail is added.

Material

With longevity and maintenance a concern within the corridor, timber railings also are not as desirable (warping & vandalism). We recommend utilizing the weather steel for the majority of the railing and then supplementing with a timber rub-rail to serve secondarily as a handrail.

Substructure

The existing bridges are currently supported by a "Pan" system substructure. In this section, we'll detail the typical options for substructure of bicycle/pedestrian bridges (Figure 48).

Figure 48: Example Bridge Pan style substructure. Pans are located at each of the posts on the snow

A galvanized base pan is a pad partially embedded into suitable native soil. The Pan System "floats" (partially imbedded) on top of the existing surface and in bridge situations has an additional anchor in place for added stability. The superstructure of the bridge then "sits" on these pans.

Pros:

- Least expensive material cost
- Quick and easy installation
- Can be installed with light equipment

Cons:

- Proprietary product with no standardized engineering
- Does not withstand strong water flows (will move horizontally and vertically)
- Because it "floats" on top of the existing ground, is subject to vertical freeze/thaw movements
- Potential high maintenance needs based on regular lifting and settling from spring/winter thaw/ freeze
- Not recommended for heavier loading

Concrete spread footing

Spread footings are generally used where the soil can sustain reasonable pressures without excessive settlement. Additionally, these are also typically used where there is no worry of scour nor soil erodibility and there are not sensitive environments surrounding them as they typically require the greatest disturbance area (Figure 49).

Figure 49: Example bridge concrete footing abutment substructure

Pros:

- Medium material cost
- If in the correct soils, very effective structurally
- Can be installed with light to medium equipment

Cons:

- Given the amount of sand in the area after the flood, would require significant scour protection from future flood events
- Greater wetland fill based on size of footings
- More challenging construction access

Pile supported

Pile foundations utilize driven piling to support a reinforced concrete abutment. This creates a solid base for construction, with no anticipated movement related to freeze/thaw or loads. This deep foundation type is typically resistant to scour issues from flooding events (Figure 50).

Figure 50: Example bridge bent pile pier substructure

Pros:

- Most applicable based on the assumed soils
- Resistant to vertical and horizontal forces
- Minimizes footprint for wetland impacts
- Minimizes footprint for hydraulic impact

Cons:

- Higher cost
- Heavy equipment required for installation
- Loud construction noise during installation

Helical piles are similar to bent piles, but are “screwed” into the ground instead of “hammered”. They are typically used where there is not much of the pile that is exposed above ground and in cases where there is not strong running water. Whereas they could be applicable for boardwalk situations in the corridor, we would not recommend being used at the steam locations based on water flow.

Understanding that geotechnical investigations, final bridge design elements, and hydraulics will be critical to actual design, we would typically recommend the use of pile supported abutments for this site.

Decking Material

Multiple materials were considered for the decking material as noted below:

Concrete:

Pros:

- Formed directly on the superstructure (joists and headers) of the bridge.
- The material is durable and snow removal can be accomplished with a blade.

Cons:

- The 2nd most expensive material cost.
- The most intensive for installation time and effort.
- Difficulty with the installation based on the tight environment (leading to higher installation costs).
- Application of salt as a de-icing product would "pit" the concrete and thereby reduce its integrity.
- Weight of the concrete will then require a more extensive substructure--increasing cost.
- Replacement of any failed areas in the future would be challenging.

Asphalt (wear course):

Pros:

- Typically used in old railroad bridge conversions.
- Installed at the same time as the path- allowing for no joints for potential vertical separation.
- The material is durable and snow removal can be accomplished with a blade.
- Medium cost.
- Vandalism can be addressed with asphalt sealing.

Cons:

- The asphalt itself needs to be installed on a structural timber deck. The asphalt is purely the wear course, so you are in essence paying for a "double" deck.
- Replacement of any failed areas in the future would be challenging.
- Less "natural" aesthetic.

Composite Decking (wear course):

Pros:

- Replacement of failed areas can be easily accomplished.
- Available in natural colors and finishes.
- Works well in heavily timbered areas where leaf litter is a concern for slip potential
- Long-lasting.

Cons:

- Most expensive material and installation cost.
- The composite decking itself has very little structural capacity, so it needs to be installed on a structural timber deck. The composite decking is purely the wear course, so you are in essence paying for a "double" deck.
- Snow removal will not allow for a blade and use of a brush is still being evaluated. Snow removal with a blower attachment is typically what is being used.

Timber Decking:

Pros:

- Least expensive of all options
- A variety of species available that are long-lasting (hardwood or treated)
- Very "natural" aesthetic
- Replacement of failed areas can be easily accomplished

Cons:

- Snow removal will not allow for a blade and use of a brush is still being evaluated. Snow removal with a blower attachment is typically what is being used. Alternately, some municipalities install a "conveyor-belt" like material on the deck to protect it in the winter time and allow for additional traction and plowing activities.
- In heavily timbered areas, regular blowing of leaves is recommended to avoid slip concerns.

Recommendations

Based on all considerations, we would recommend a hardwood decking (IPE). If maintenance operations would not support utilizing other snow removal besides a blade, then the secondary recommendation would be to have an asphalt wear course.

The following summarizes our recommendations for the bridges:

Type:	Pre-fabricated weathered Steel Pratt Truss style
Clear width:	14'
Loading:	90 psf, 20,000 vehicle design load
Decking:	IPE timber decking (with second being asphalt if need based on specific maintenance operations)
Railing:	48" tall, weather steel with timber rub-rail/ hand rail
Substructure:	Pile bent piers with concrete cap (or pile-supported abutments based on soil investigations)

For the side path bridge, we would recommend the same design requirements above expecting potential variance on the vehicle loading and clear width based on the City's desired users bike, pedestrian, maintenance vehicles. Final design will be based on the structure requirements itself (structure type, width, loading, etc.), what the hydraulics will support, wetland delineations, streambank improvement/ alignments, and the findings of the geotechnical report. The intent of the improved structures will be to minimize backwater elevation and provide additional freeboard, by raising the elevation of the low chords of the brides and increasing the span of the bridges. It is also important to note that for the best hydraulic condition, the bridges will need to fully span the creek, without vertical piles/structures impeding flow within the channel.

Cost Estimates

Cost estimates for each bridge are specific to final design with geotechnical results and potential stream realignments which may modify the overall length and piling depth/height. It is assumed that all bridges will be removed and replaced with new bridges. The length of the mainline bridges was increased based on the assumption that a minimum of 8' of freeboard was desired. This height than was extrapolated to the topography which then increased the bridge length. The higher elevation then will reduce the impacts of flooding in the future. Detailed estimates are included within each trail alignment alternate located in Appendix D and also summarized in Table 4 below.

Table 4: Recommended Bridge Length and Estimated Cost

Structure	Length	Estimated Weight	Cost
Bridge #1	85 feet	45,000 pounds	$199,000
Bridge #2	88 feet	47,000 pounds	$205,500
Bridge #3 (side path)	70 feet	32,000 pounds	$156,000
Bridge #4	85 feet	45,000 pounds	$199,000
Bridge #5	78 feet	42,000 pounds	$195,000
Bridge #6	84 feet	45,000 pounds	$199,000

Costs include the structure itself, the substructure, shipping/delivery and installation. Based on the challenging access for the site, all bridges were assumed to be constructed in two sections and welded on-site.

Pheasant Branch Trail System

The current alignment of the trail is dependent on the existing topography and the stream alignment. The trail is currently 10' wide porous asphaltic pavement with 2-3' stone shoulders that are largely grown in with vegetation (Figure 51).

Figure 51: Photo of existing trail within Pheasant Branch Corridor

The floods of 2018 did significant damage to the pathway with bank undercutting, sediment deposits, and with some parts of the path itself being removed. Additionally, the heavy machinery required for clean-up also caused some damage to the pathway in many areas. The pathway has been patched where possible to allow for the public some access, but it was patched on a temporary basis. The pathway as existing poses many safety concerns with trip hazards, uneven & inconsistent surfaces, and inconsistent widths. The existing trail location along with the location of 2019 planned repairs are shown in Figure 52.

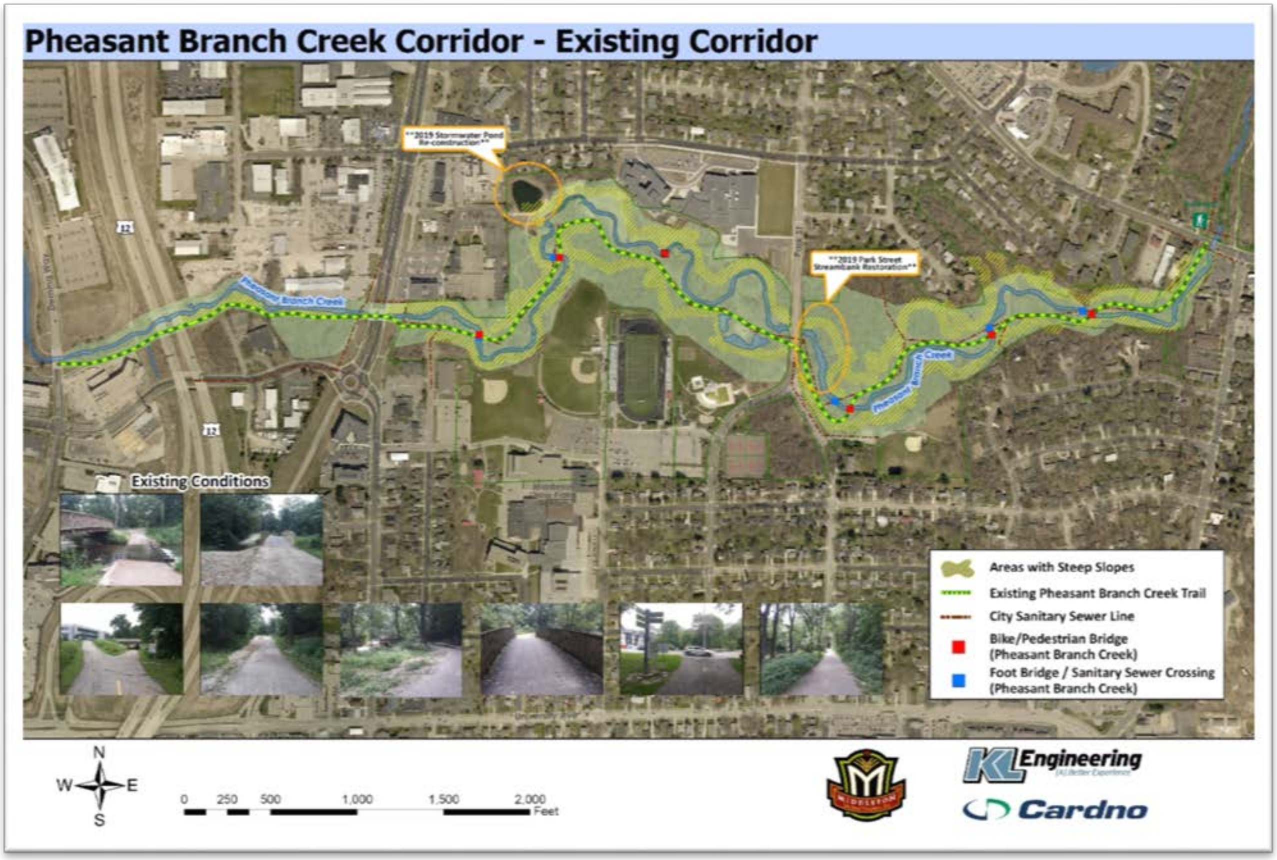

Figure 52: Map of existing trail location and 2019 planned projects within Pheasant Branch Corridor

Trail Alternatives

Three pathway alignments were presented to the public for consideration. Summarization of these options are further delineated within each alternative below. A detailed cost estimate for all three options can be found in Appendix D.

Option A: Existing Alignment and Trail Cross Section

This alternative was to replace the path in the same alignment that it currently exists. In this alternative, the pathway itself would be approximately 5,620 feet long and would have 5 bridges on the mainline and the side path bridge would also remain. The path would remain as a 10' wide asphaltic surface and a 3' stone shoulder would remain on one side to allow for runners and the other shoulder would be turf Figure 53).

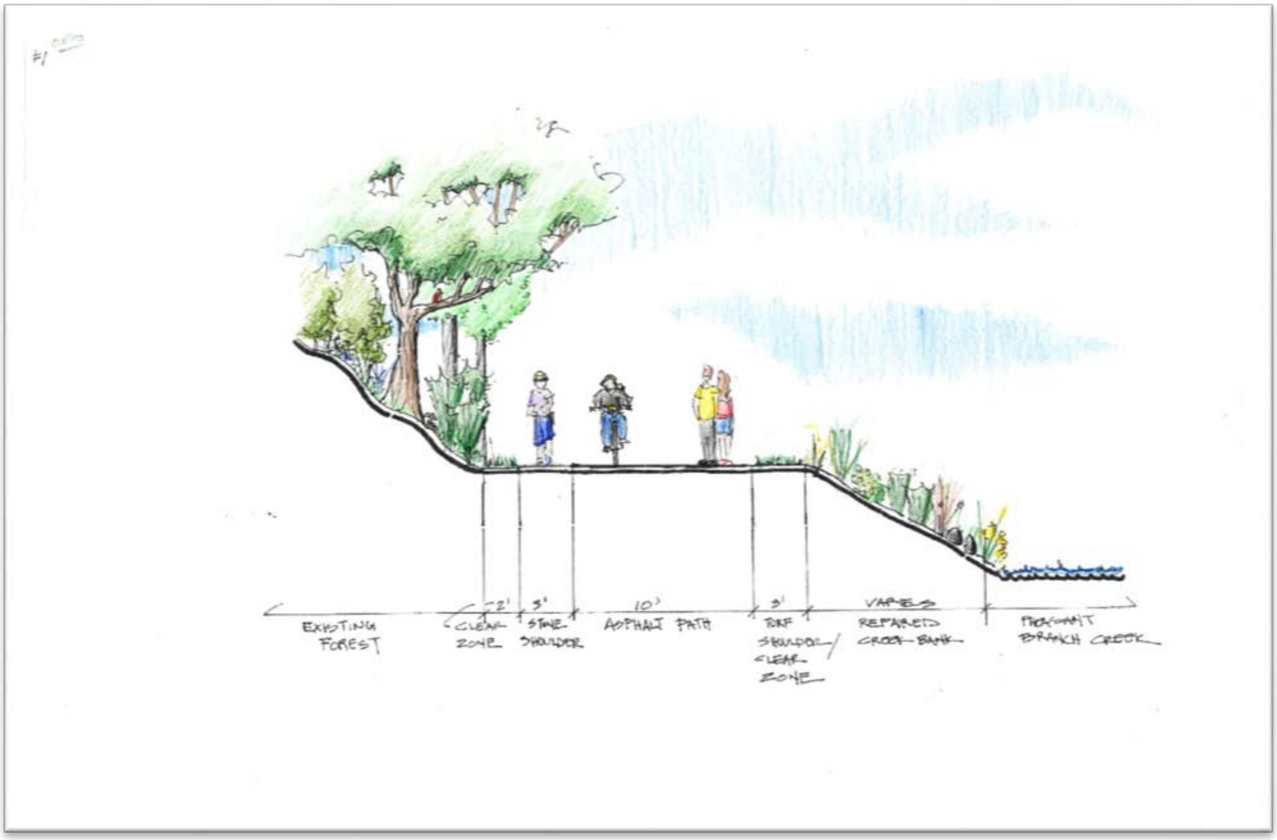

Figure 53: Existing trail cross section schematic

Estimated construction cost for this option is $2,023,842. This includes a 25% construction contingency based on the conceptual nature of the design and then 8% added cost for construction oversight (Figure 54).

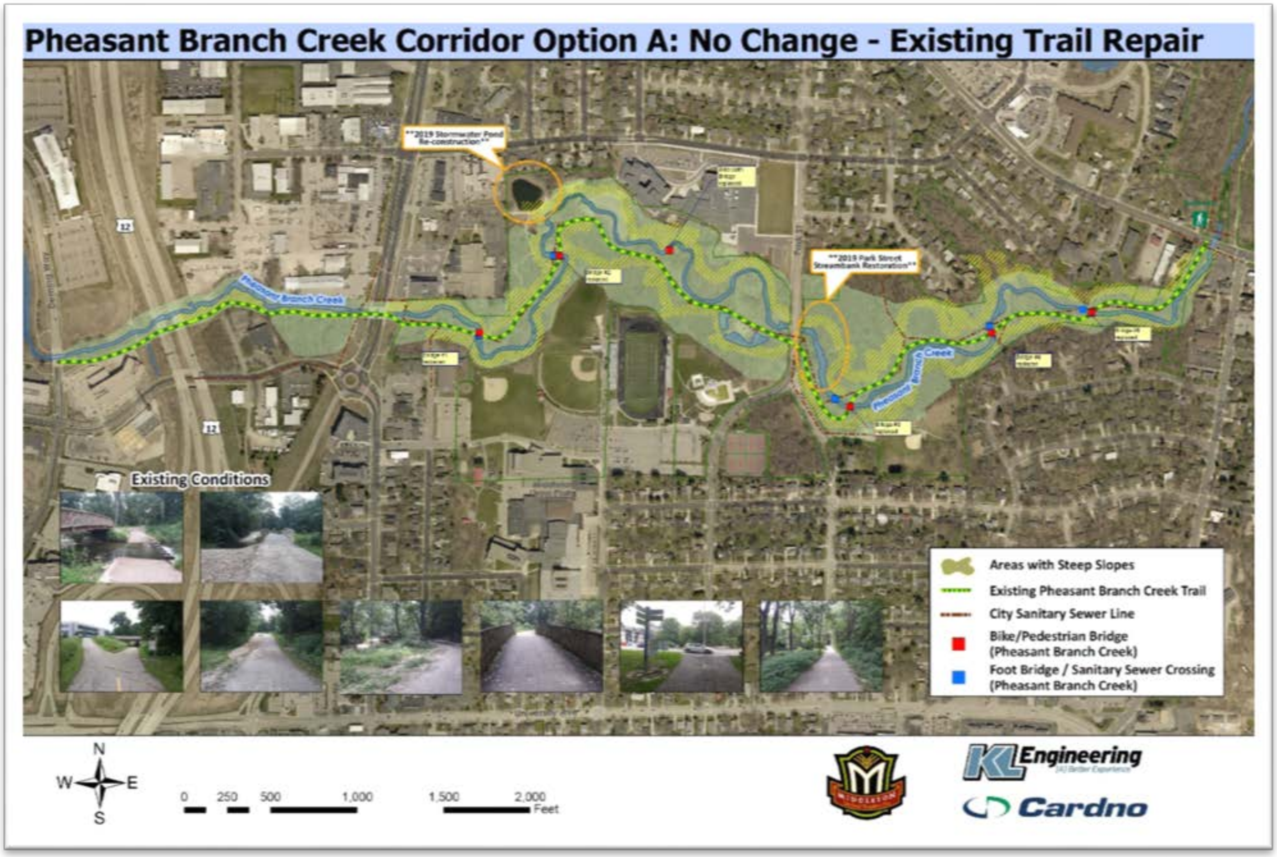

Figure 54: Project location Map of Option A: No Change with Existing Trail Repair

Pros:

- Simplest redesign
- Stone shoulder allows for softer surface for runners

Cons:

- Does not address potential floodplain & stormwater infiltration improvements with path realignment pairing with:
  - Stream realignment
  - Grading
- Most costly with all six bridges & longest trail length
- Does not improve bicycle & pedestrian conflicts at
  - Pinch points
  - Blind corners
- Stone shoulder adds additional maintenance costs/needs
- Stone shoulder causes concern with some mainline trail users with path stone causing issues for wheeled users such as rollerbladers, strollers, small children on bikes, etc.

Option B: Pathway Realigned and Widened Cross Section

This alternative re-aligns the path in two areas. The pathway itself would be approximately 5,765 feet long and would have 3 bridges on the mainline, and the side path bridge being realigned. The path would expand to a 12' wide asphaltic surface with turf shoulders (Figure 55).

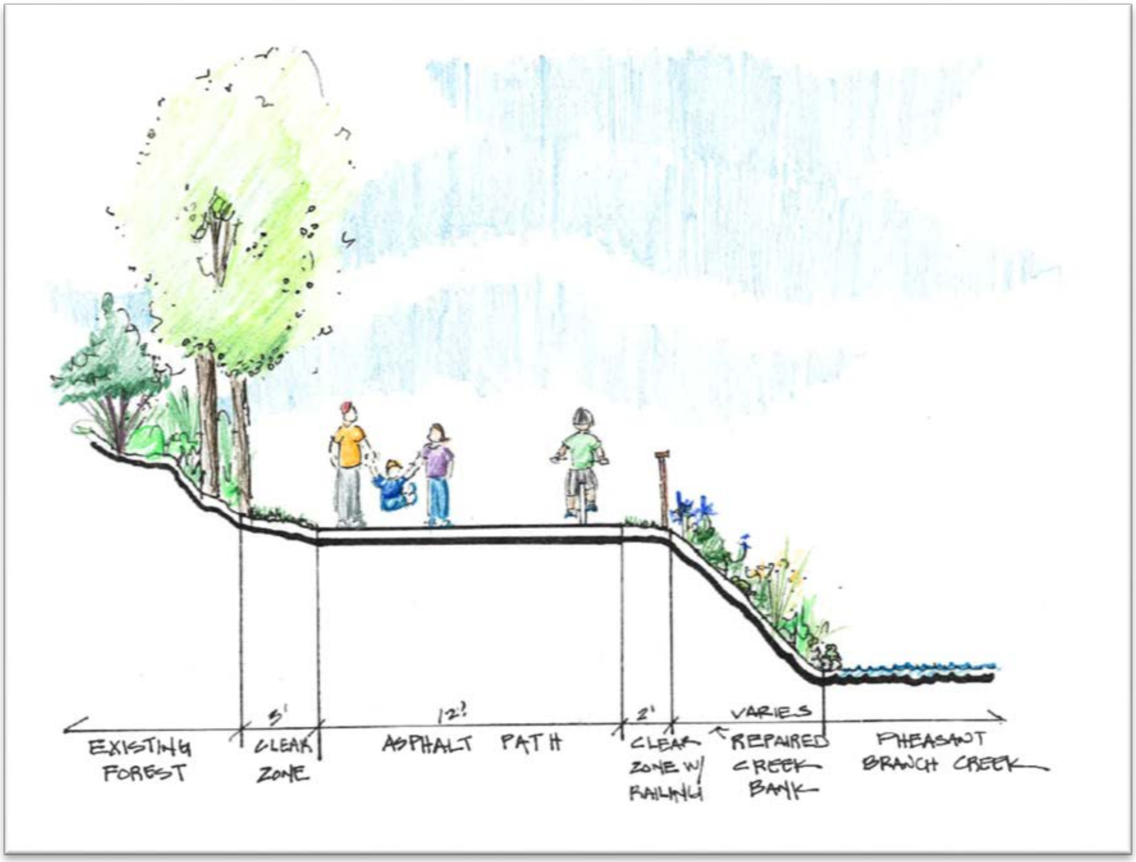

Figure 55: Widened trail cross section schematic

Pros:

- Eliminates two mainline bridges (Bridge #5 and Bridge #6 cost savings of $396,000)
- Less potential for bridge maintenance costs and impingement of floodplain due to removal of two bridges
- Offers opportunities to improve floodplain capacity & stormwater infiltration
- Improves visibility for users by reducing blind corners and pinch points at both realignment locations
- Reduces overall trail length with the realignment at the westernmost location

Cons:

- Stream realignment will be required (dependent on DNR approval to relocate channel)
- Westernmost realignment will require extensive costs based on required grading to make Americans with Disabilities Act (ADA) compliant (estimated cost: $72,000)

Estimated construction cost for this option is $1,777,110. This includes a 25% construction contingency based on the conceptual nature of the design and then 8% added cost for construction oversight. If the westernmost realignment were removed, this would save $72,000 in estimated construction costs (Figure 56).

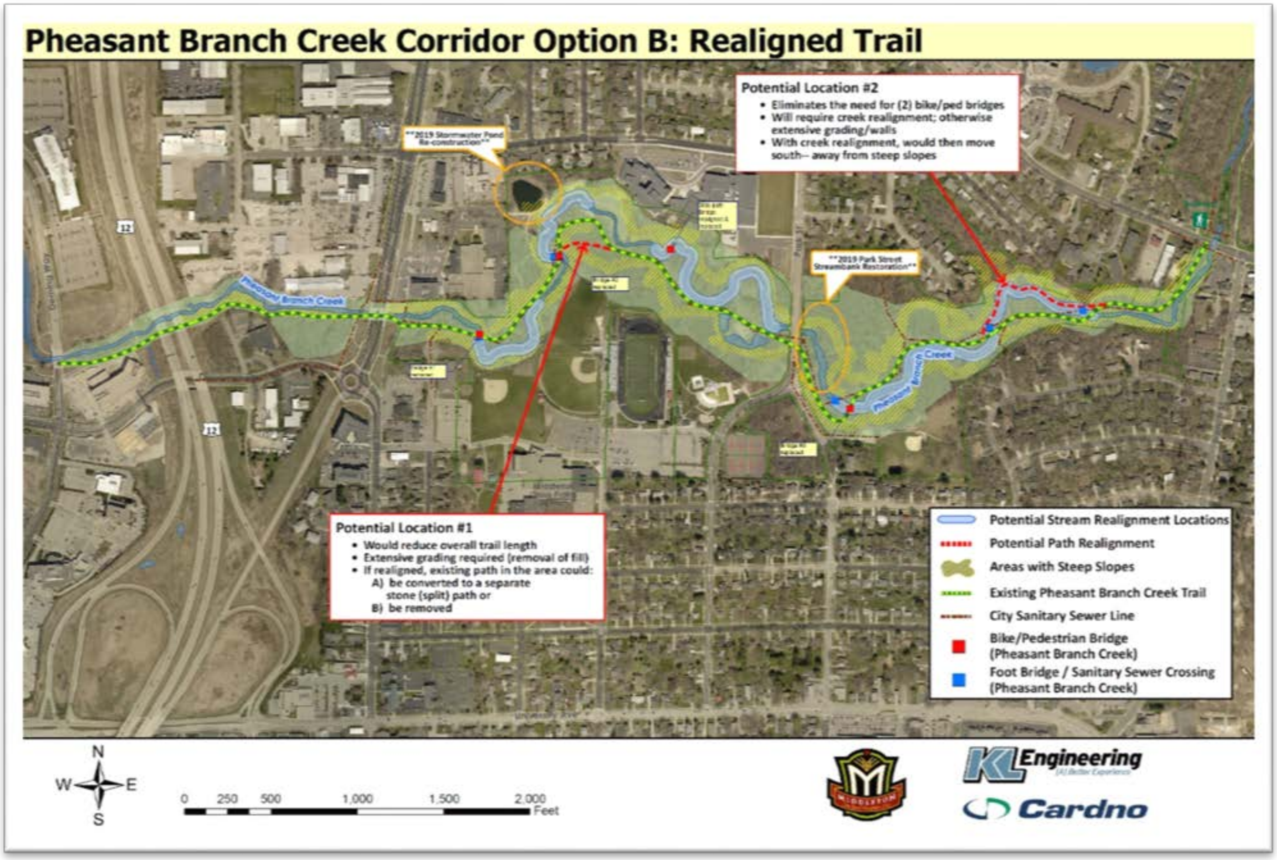

Figure 56: Project Location Map of Option B: Realigned Trail

Option B would require a slight stream realignment to move the existing channel away from steep valley walls which would be dependent on DNR approval to relocate channel. Moving the channel in this location could be completed while adding additional flood flow capacity and floodplain benches similar to the work completed in the Pheasant Branch Corridor in 2015 where the main channel was moved away from steep valley walls above which a new addition to the Kromrey middle school was built. The two bridges could still be eliminated in this option without channel relocation, yet significant additional expense would need to be added to the project to perform extensive grading and wall building on the north side of the channel.

Option C: Pathway Realigned with Split-Use Side Paths

This alternative re-aligns the path in two areas. The pathway itself would be approximately 5,765 feet long and would have 3 bridges on the mainline, and the side path bridge being realigned. The path would remain as a 10' wide asphaltic surface 10' wide and have turf shoulders. There would also be 5' stone side paths in key areas with this alternative in addition to the mainline asphalt pathway (Figure 57).

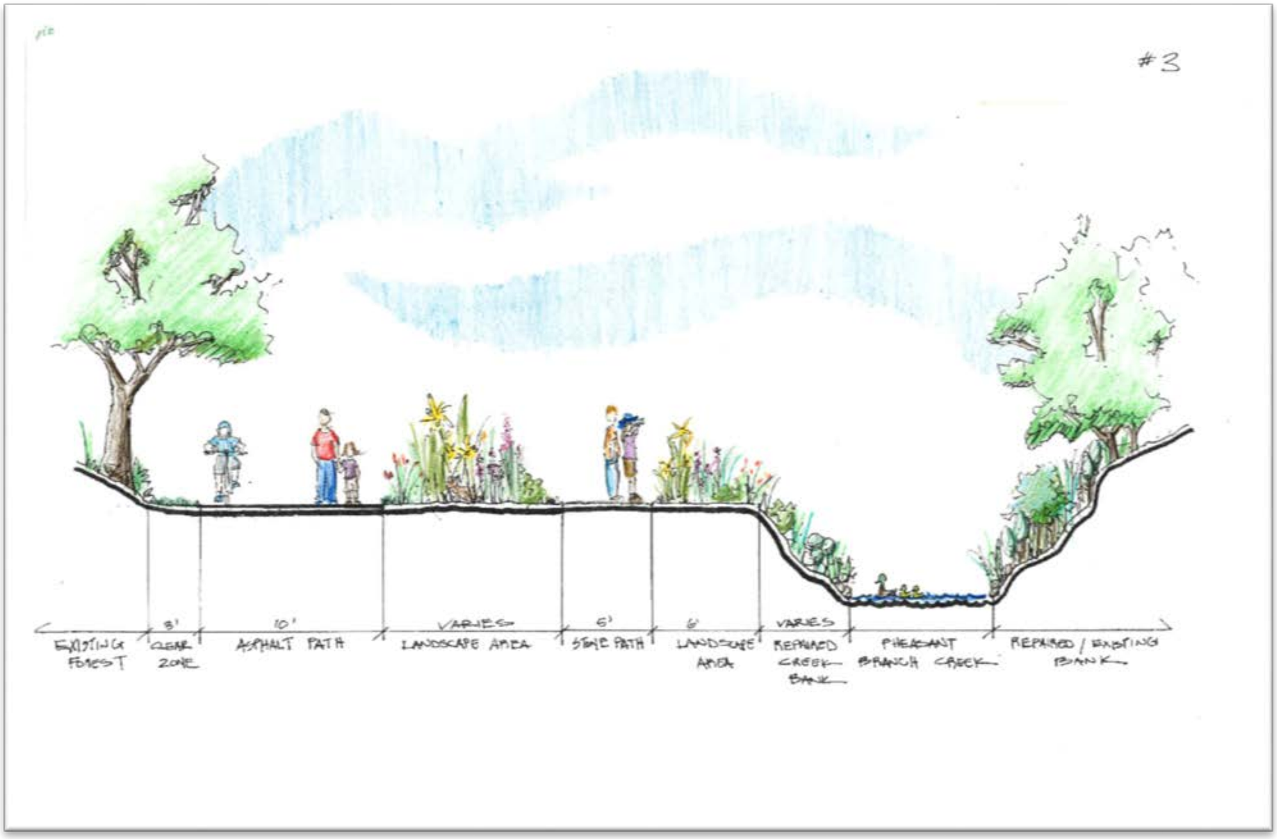

Figure 57: Split-use path option

Pros:

- Eliminates two mainline bridges (Bridge #5 and Bridge #6 cost savings of $396,000)
- Less potential for bridge maintenance costs and impingement of floodplain due to removal of two bridges
- Offers opportunities to improve floodplain capacity & stormwater infiltration
- Improves visibility for users by reducing blind corners and pinch points at both realignment locations
- Stone side paths offer the following:
    - Allow for additional separation of users
    - Allow users to rest/pause within the environment
- Stone side path locations would be considered where:
    - Existing blind curves on main path
    - Corridor improvements are already removing vegetation for flood storage
    - Corridor improvements that realign the existing paved path
    - Stream realignment occurs

Cons:

- Stream realignment will be required (dependent on DNR approval to relocate channel)
- Westernmost realignment will require extensive costs based on required grading to make ADA compliant.

Estimated construction cost for this option are $1,825,958. This includes a 25% construction contingency based on the conceptual nature of the design and then 8% added cost for construction oversight. If the westernmost realignment were removed, this would save $72,000 in estimated construction costs (Figure 58).

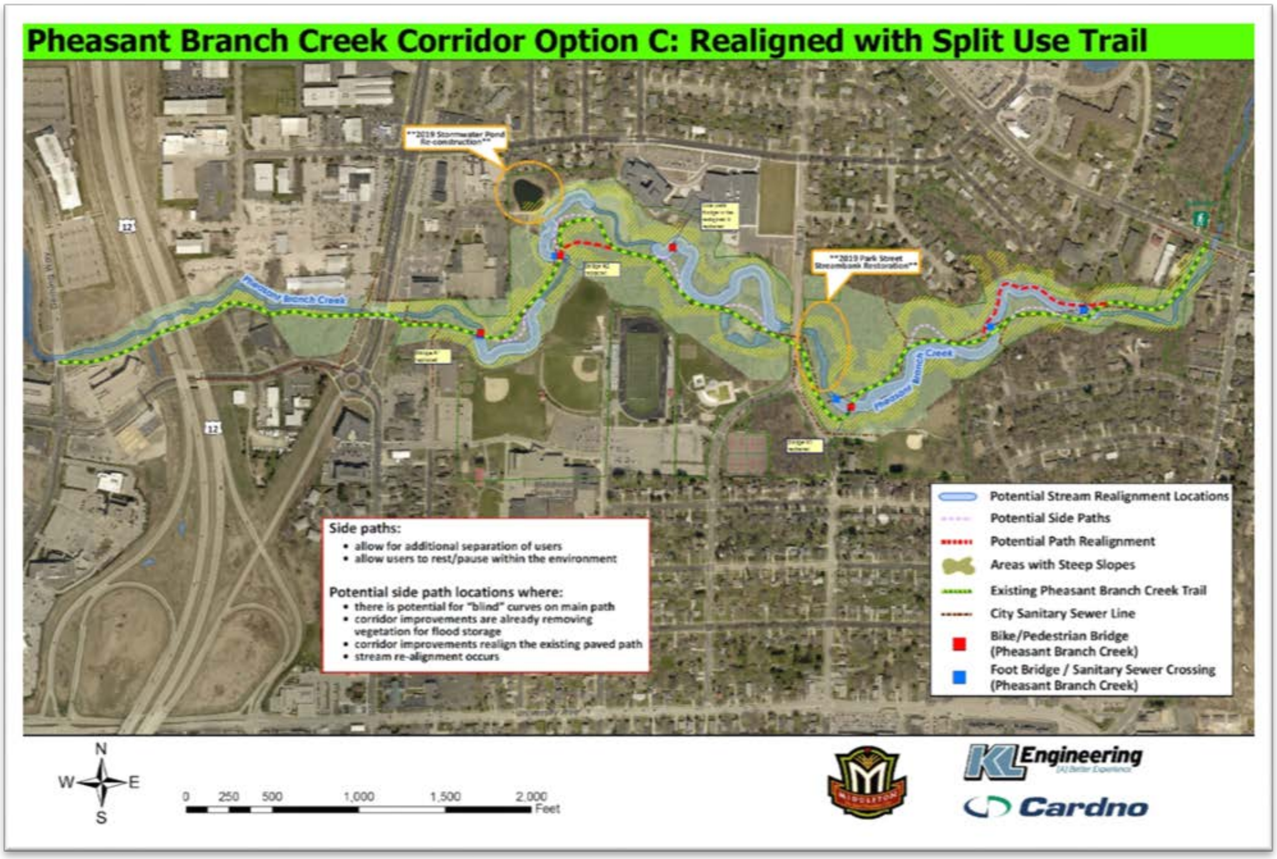

Figure 58: Project Location Map of Option C: Realignment with Split-Use Trail

Option C would require a slight stream realignment to move the existing channel away from steep valley walls which would be dependent on DNR approval to relocate channel. Moving the channel in this location could be completed while adding additional flood flow capacity and floodplain benches similar to the work completed in the Pheasant Branch Corridor in 2015 where the main channel was moved away from steep valley walls above which a new addition to the Kromrey middle school was built. The two bridges could still be eliminated in this option without channel relocation, yet significant additional expense would need to be added to the project to perform extensive grading and wall building on the north side of the channel.

Recommendations

The following summarizes our recommendations for the path:

- Apply the 12' wide asphalt pathway wherever practical to allow for mainline width to have the greatest separation of users
- Realign the pathway to remove the two easternmost bridges (Bridge #5 and Bridge #6 $394,000 cost savings)
- Additional grading or vegetation removal should be considered where practical to reduce blind corners and pinch points
- Incorporate stone side paths where practical, with special focus on:
    - areas where existing asphalt pathway will be abandoned
    - specialty areas for environmental observation (e.g. birding, new ecosystems, etc.)
    - trail alignment areas with blind corners or pinch points
- Utilize traditional asphalt vs. the porous asphalt previously utilized. This recommendation is based on lower initial material and installation costs, lower maintenance costs, and longer useful life.

Final design for the pathway will work in conjunction with the overall stream realignment and required grading recommendations for the floodplain and stormwater improvements. Public feedback showed concerns with conflicts between bicyclists and pedestrians, so increasing separation (through wider paths or stone side paths) where possible is encouraged. Estimated pathway costs do not include the streambank stabilization nor the vegetation restoration/ ecological modifications within the corridor.

Path realignment currently shows two locations to be considered. The westernmost realignment incorporates significant grading and cost. If the proposed grading does not equate to significant benefits for alleviating flood concerns, we would suggest eliminating that specific realignment and focusing instead on slightly modifying the path and removing adjacent vegetation to minimize the blind corners in that section of the trail.

Pheasant Branch Stream Restoration

Pheasant Branch has historically had problems with streambank erosion and suspended sediment driven by land-use changes within its watershed. Increased flood peaks and water volumes have degraded streambanks throughout the reach over time. Problems with streambank erosion in Pheasant Branch ultimately lead to problems in Pheasant Branch Marsh as well as within Lake Mendota. Sediment from bank erosion is also deposited within the channel reducing the channel's capacity to carry flow and efficiently transport sediment. Flooding from the storm event August 20, 2018 exacerbated erosion within the Pheasant Branch Corridor as detailed in the *August 2018 Flood Damage Assessment* section above.

Table 5 below shows a breakdown of the linear feet of Extreme, Very High and High streambank erosion assessed by Cardno in 2018 for three sections of the Pheasant Branch Corridor.

Table 5: Streambank Erosion Risk Assessment for the Left and Right Bank of the Pheasant Branch Corridor

Project Area	Extreme Streambank Erosion (ft)	Very High Streambank Erosion (ft)	High Streambank Erosion (ft)	Total Linear Feet (ft)
Confluence Pond to Parmenter Street Pheasant Branch Streambank Restoration Project (Construction)	264	197	1,520	1,981
Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Construction)	625	453	3,892	4,970
Park Street to Century Avenue Pheasant Branch Streambank Restoration Project (Construction)	444	503	2,289	3,236

Restoration of the streambanks in the Pheasant Branch Corridor will focus on these areas as they pose a high risk to public and private property. Areas identified for restoration are shown in Figures (59, 60 and 61).

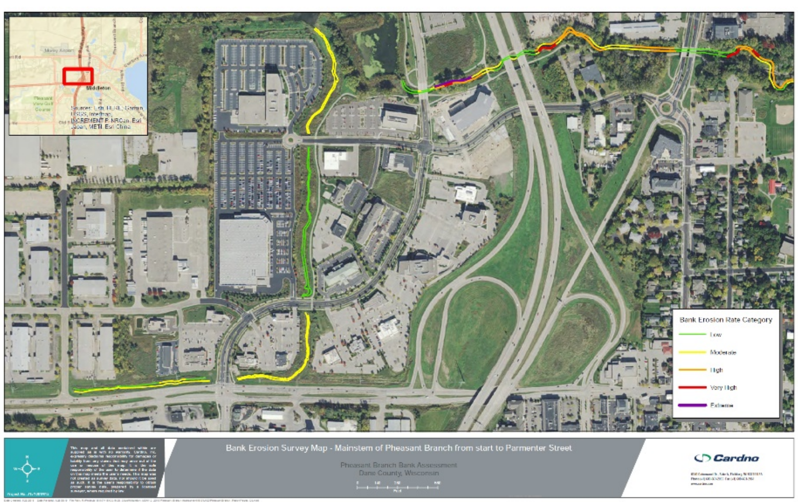

Figure 59: Location of streambank restoration areas identified between the confluence Pond and Parmenter Street

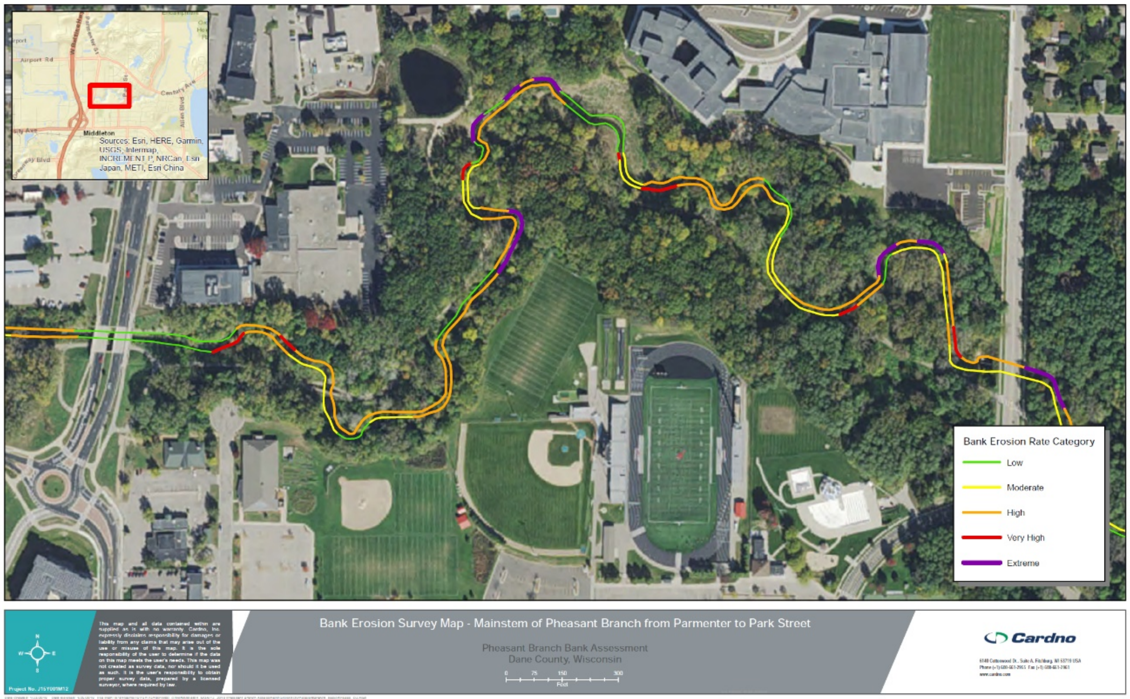

Figure 60: Location of streambank restoration areas identified between Parmenter Street and Park Street

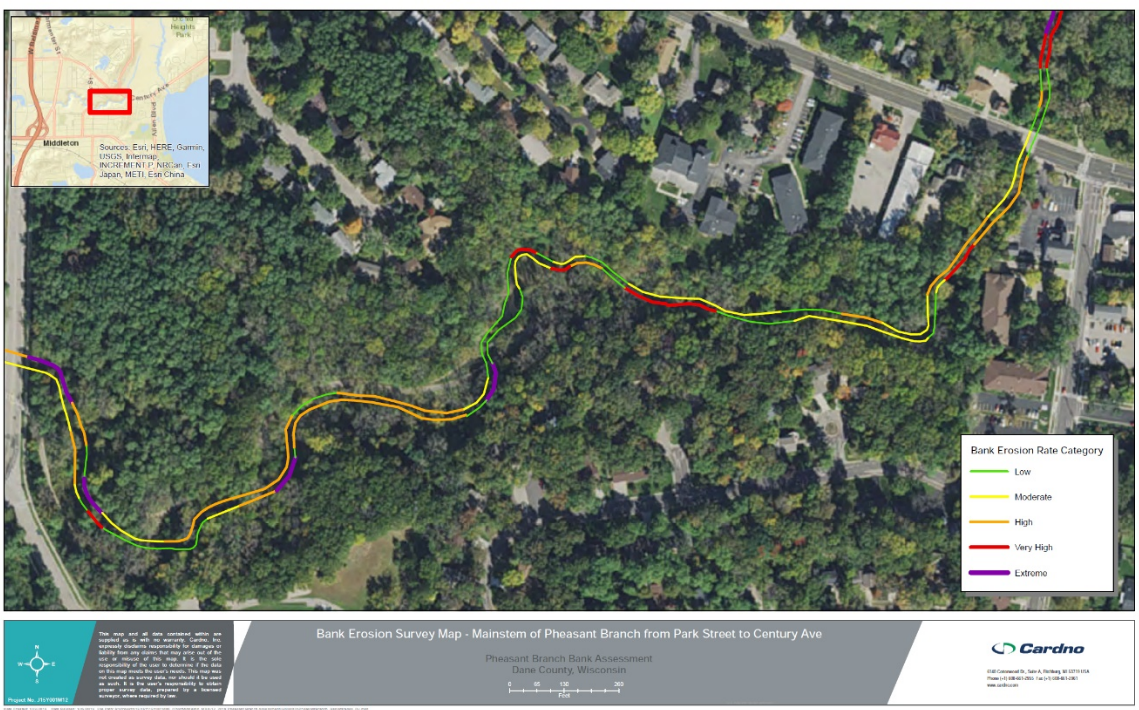

Figure 61: Location of streambank restoration areas identified between Park Street and Century Avenue

Damaged and Shallow Rooted Trees Adjacent to Pheasant Branch

Much of the damage to bridges, infrastructure and streambanks caused by the August 2018 flood event was caused by or exacerbated by shallow rooted tree species such as box elder (*Acer negundo*) that collapsed into the channel during flooding. These early successional or pioneering tree species have shallow root systems that do a poor job of stabilizing streambanks. They do, however, provide shade to streambanks preventing other more beneficial plant species from establishing or occurring. Many remaining box elder and other shallow rooted tree species that didn't collapse into the stream during the August 2018 flood event have been severely undermined and have the potential for causing damage in the future. Future restoration efforts in the Pheasant Branch Corridor should take into consideration removing all the down and damaged trees adjacent to the streambank to prevent damage in future flooding events. Trees removed during restoration activities can be stockpiled and re-used to stabilize banks and provide additional in-stream habitat throughout the Pheasant Branch Corridor.

Streambank Stabilization Alternatives

Areas of active streambank erosion throughout the Pheasant Branch Corridor vary in size, extent of active erosion, and in applicable treatments. In many cases, eroded slopes and streambanks could be repaired through the use of integrated bank treatments including rootwads composites and/or toewood (Figure 62).

Figure 62: Underwater photo take of installed rootwad composite (8/20/12)

Rootwad Composites and Toewood

Rootwad composite revetments and toewood are installed consisting of a combination of rootwads, (the intact lower trunk and root mass of mature trees), branches and stone. These structures provide a biological streambank stabilization alternative that aids in dissipating energy and near-bank stress from stream flows, increasing channel roughness while avoiding accelerating flows downstream of where they are installed. They also promote scour in the near-bank area providing pool habitat which is currently lacking in the Pheasant Branch system due to the legacy of bank sediments found within the channel. Small spaces found within the rootwads and wood installed provide cover for small fish, as well as reptiles and small mammals found in the riparian habitat (Figure 63).

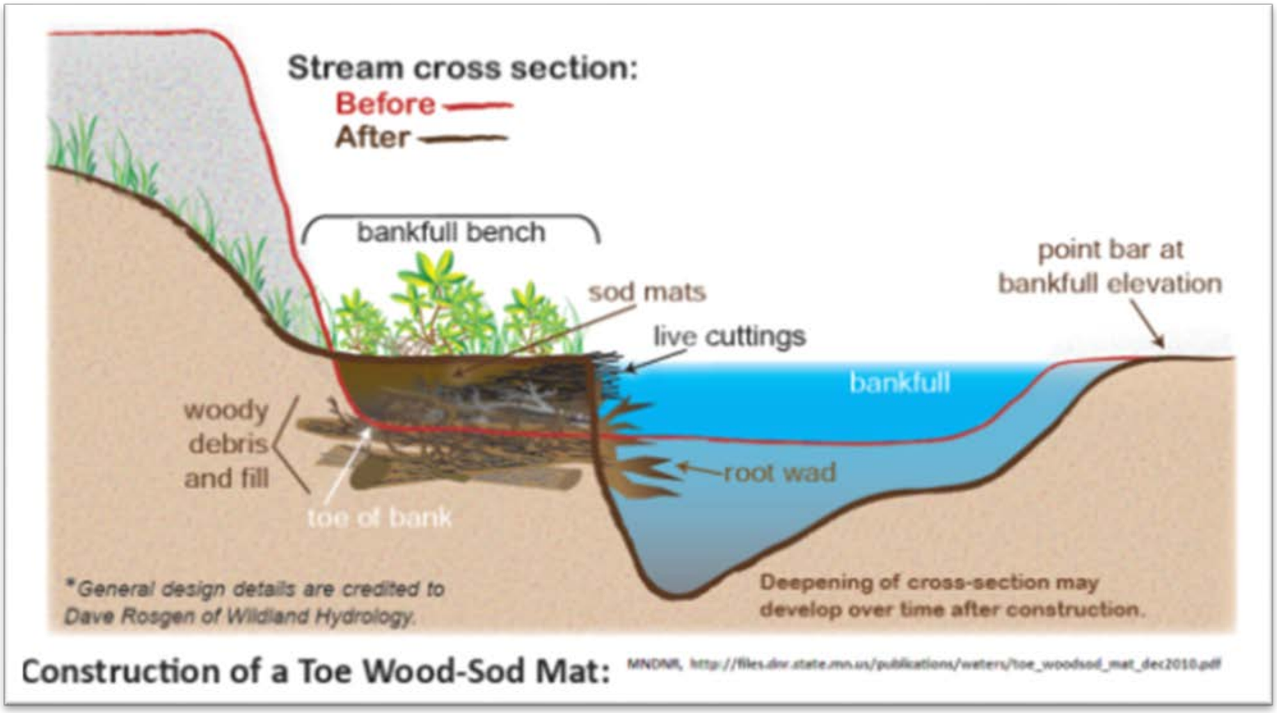

Figure 63: Example cross section of toewood design

These structures also create a diversity of micro-flow conditions, due to their non-uniformity, which can enhance aquatic invertebrate diversity allowing benthic organisms to select specific positions within the geometry of the local flow conditions. The habitat benefits associated with these structures will help address degraded habitat which is an additional impairment listed for the watershed.

Cross vane and flow deflection structures

Cross vane grade controls and flow redirection structures such as single arm vanes and J-Hooks can be used to deflect stream flow away from the streambank toward the center of the channel mitigating bank erosion at sites within the project areas. Flow deflection structures (including single arm vanes, cross-vanes and J-Hooks) have been utilized under various channel conditions for over 30 years throughout most regions of the U.S. There is a large volume of technical information regarding field applications and hydraulic research related to these structures. Once installed, these structures induce deposition in near-bank areas while accelerating flows back toward the center of the channel creating scour pools essentially transforming areas of erosion into areas of deposition, further protecting the toe of the streambank. Trees procured during restoration activities could also be incorporated into the flow redirections structures in order to create addition in-stream and under-bank habitat while providing grade control (Figure 64).

Figure 64: Example of rootwad log vane J-Hook combination installed by Cardno on the Knife River in 2016 near Two Harbors, MN

Floodplain Access and Flood Flow Capacity

The rainfall event on August 20, 2018 (into the morning of August 21) was one of, if not the largest rainfall events ever recorded in the State of Wisconsin over a 24 hour period. There were, however, some areas within the Pheasant Branch Corridor that made it through this flood event with very little bank erosion and/or damage to steep slopes. One of the areas that made it through the August 2018 flood event with little damage was approximately 500 linear feet of relocated channel near the Kromrey Middle School constructed in 2015. Relocation of this section of stream between Parmenter Street and Park Street increased flood flow capacity at the site allowing flood flows to rise up out of the bankfull channel and spread out over a newly created floodplain area to dissipate stream energy while offering increased protection at the toe of the steep slope above which a new addition to the Kromrey Middle School was built (Figure 65).

Figure 65: Photo of relocated section of Pheasant Branch in 2017 (left) and same section of stream less than a week after flooding taken on 8/25/18 (right).

Moving forward floodplain access should be considered during all restoration efforts within the Pheasant Branch Corridor. Erosion from the August 2018 flood event moved thousands of cubic yards of streambank materials through the Pheasant Branch system. This additional flood flow capacity should be utilized in future restoration designs moving forward. Wherever possible, bankfull benches and floodplain access should be created to allow flood flows to rise out of the channel and onto benches and floodplain areas dissipating stream energy while also keeping an efficient low flow and bankfull channel to help move legacy flood sediments efficiently through the system. There may also be areas within the Pheasant Branch Corridor were the stream channel can be realigned away from existing steep slopes to provide additional floodplain access, yet these areas need to be chosen carefully due to current sanitary sewer lines and other infrastructure that is located near the existing channel in many locations.

Native Vegetation

The use of the engineering techniques described above are recommend for use during restoration of damaged areas in the Pheasant Branch Corridor as opposed to some of the more traditional “hard armoring” techniques such as sheet-piling and gabion baskets. These “hard armoring” techniques can accelerate local flows causing erosion issues downstream of where they are installed and offer little to no available stream habitat once installed (Figure 66).

Figure 66: Photo of failed gabion baskets between Park Street and Century Ave taken in 2008 (left) and directly downstream of Century Ave taken in 2018 (right).

There may be certain areas with the Pheasant Branch Corridor that require additional protection measures (such as where infrastructure or private property are at risk due to bank failure). Installation of sheet-pilling may be warranted in these specific areas, yet we recommend that this “hard armouring” be buried within the slope so a more natural look as well as additional streambank habitat can still be installed in these areas.

Yet, establishing native vegetation on restored slopes and streambanks is recommended for restoration designs in the Pheasant Branch Corridor moving forward. Once established, the deep dense roots of native grasses and forbs act to increase bank stability and trap bank sediments in place. Another benefit to using natives is once established, only minimal management is needed. Maintenance on newly restored areas to limit encroachment of invasive species as well as early successional tree species is recommend for all restored areas for at least three years following construction activities.

Cost Estimates

Table 6 below details the total cost to repair recommended streambanks identified as showing evidence of High, Very High or Extreme streambank erosion caused by the August 2018 flood event. Costs for streambank restoration completed in 2019 directly downstream of the Park Street Bridge are not included in this table. Projects listed within the mainstem of Pheasant Branch are listed in order from upstream to downstream.

Table 6: High Priority Areas for Streambank Restoration

Year	Project	Total Linear Feet of Restoration	Total Cost Estimate	Anticipated Project Completion
2020	Confluence Pond to Parmenter Street Pheasant Branch Streambank Restoration Project (Construction)	1,981	$ 225,000	2021
2020	Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Construction)	4,970	$ 521,000	2021
2020	Park Street to Century Avenue Pheasant Branch Streambank Restoration Project (Construction)	3,236	$ 401,000	2021
	Total	10,187	$1,147,000	2021

Restoration of these areas could be performed in one large project or broken into three projects, yet we recommend starting from upstream and working downstream if broken up.

Future Project Consideration within the Pheasant Branch Corridor

A drop structure and two large culverts at the stream crossing underneath Park Street currently act as a barrier to upstream migration of fish in the mainstem of Pheasant Branch. Retro-fitting with fish passage structures to aid fish passage over and through the current barrier or replacement of the current crossing with a bridge would eliminate this barrier (Figure 67). Replacement with a bridge would also increase flood flow capacity through this crossing which would need to be accounted for in designs. The existing drop structure also currently provides grade control at this location. Installation of grade control structures that still provide fish passage would also be necessary if the current structure was removed to mitigate destabilizing channel adjustments.

Figure 67: Photo of Park Street fish barrier

Pheasant Branch Corridor Vegetation

Existing Site Conditions

Restoration of the corridor vegetation is important to the overall ecological health of the area and can aid in erosion control and stormwater capture and control. While there are some high-quality areas of native vegetation within the corridor, most of it is degraded and invasive in composition. Many areas are dominated by invasive trees and shrubs such as black locust, buckthorn and honeysuckle. There are also numerous invasive herbaceous species such as garlic mustard and dame's rocket. These species are shading out the understory and preventing native herbaceous growth. Removal and control of these invasive species can help simulate the native herbaceous growth and allow for some native tree and shrub regeneration. With its more fibrous root systems, this native herbaceous growth can help stabilize the slopes while also providing pollinator habitat.

Removal of the over story invasive trees will also change the character of the corridor. Examples of this more open community type can be seen in areas where many trees have been lost from the flood. While these areas seem devastated from the loss of cover, this opening of the canopy will allow much more light to reach the ground and encourage the establishment of a much more diverse assemblage of plant communities such as savanna, prairie, emergent wetlands, and ephemeral wetlands. Once established, these communities will become much better habitat, more diverse, lower maintenance, self-sustaining, and more resilient. A diverse ecosystem is more resilient to disease, predation, changing climatic conditions and other disturbances.

Ecological Restoration Summary

The descriptions below break out the various proposed ecological restoration zones within the corridor. While these zones exist on a continuum and will overlap with each other, there are some distinct differences between them (Figure 68).

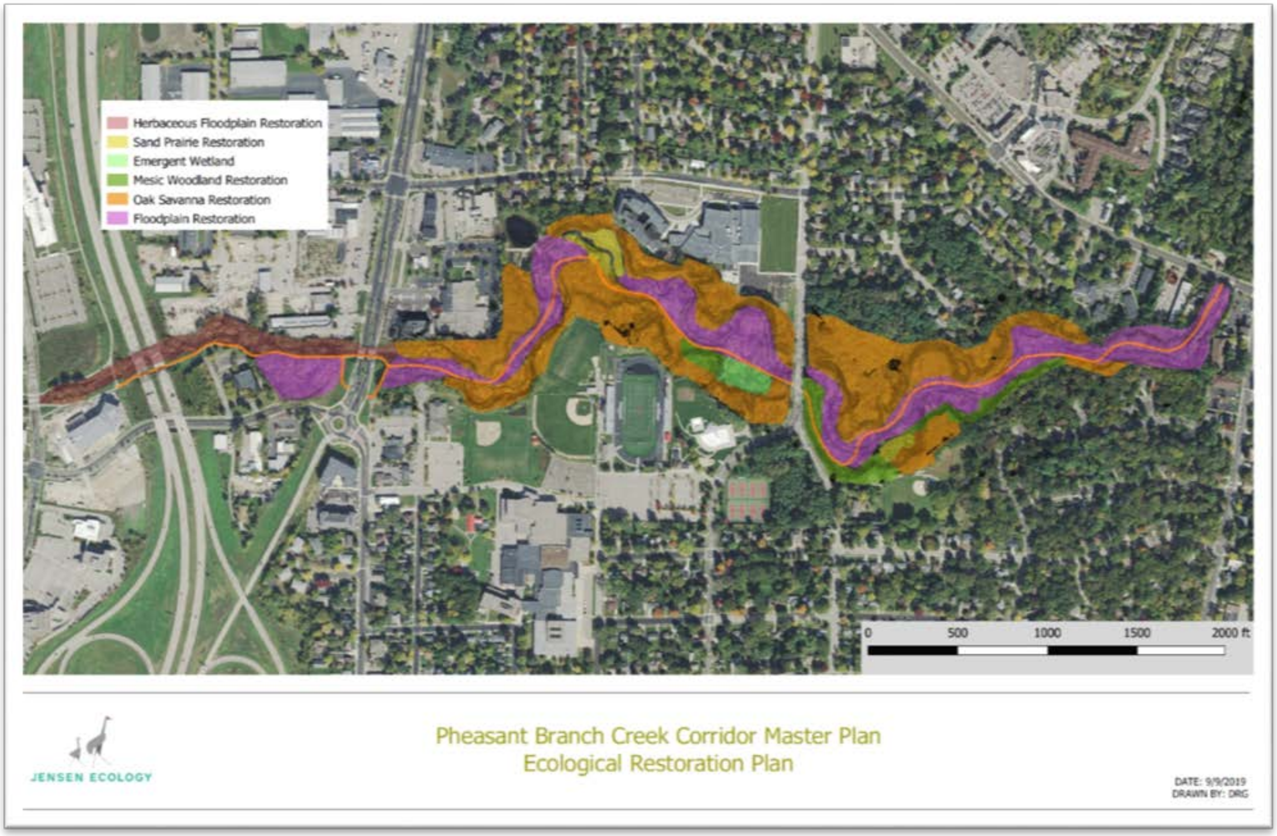

Figure 68: Ecological Restoration Summary Map

Herbaceous Floodplain Restoration

The herbaceous floodplain restoration is confined to the reach of the corridor from Deming Way to Parmenter. This reach is more open and surrounded by development and major roads. It is somewhat channelized with very steep banks and is currently dominated by invasive herbaceous plants such as reed canary grass and shallow rooted trees such as willow, box elder and silver maple (Figure 69).

Figure 69: Vegetation typical of the section between Deming Way and Parmenter Street. This channelized section is dominated by invasive herbaceous plants and shallow rooted trees such as silver maple and box elder.

Restoration of this area would ideally begin with re-grading the slopes to a more stable gradient with floodplain benches, then re-vegetating with a diverse herbaceous plant mix. The area closest to the water would be a wetland and floodplain mix and would transition to drier prairie species as you move upslope.

Sand Prairie Restoration

The sand prairie restoration is proposed for areas that received large deposits of sand from the 2018 flood. In some areas, several feet of sand were deposited on the existing vegetation (Figure 70).

Figure 70: Areas of significant sand deposition by the 2018 flood. Rather than remove the sand, these are excellent opportunities for restoration of sand prairie and other sand-dependent ecosystems within the corridor.

Rather than remove the sand, these are excellent opportunities for restoration of sand prairie and other sand-dependent ecosystems within the corridor. Because clearing is proposed and these areas will rarely be inundated, it is appropriate to propose a sand prairie restoration here. Restoration would consist of clearing the invasive vegetation and re-seeding with sand prairie and sand-dependent species (Figure 71).

Figure 71: Restored sand prairie two growing seasons after seeding. Site was a former pine plantation that was cleared and re-seeded.

Emergent Wetland

The emergent wetland is proposed for the one existing emergent wetland in the corridor and would also be planned for any wetlands or oxbows that may be created during channel re-construction (Figure 72).

Figure 72: Restored emergent wetland with large populations of arrowhead, water plantain, iris and other species at a native plant nursery in Illinois

This restoration would include removal and control of invasive species and re-introduction of native wetland species (Figure 73).

Figure 73: Hibiscus growing in an emergent wetland on a slough on the Upper Mississippi River.

Removal of shallow rooted trees near the stream in the corridor would provide more opportunities for a diverse wetland. These wetlands would provide beneficial habitat, aid in stormwater capture and storage, and help control runoff.

Mesic Woodland Restoration

The mesic woodland restoration would be proposed for north-facing, shadier areas that would harbor more shade-tolerant woodland species. When doing the site survey, a number of remnant species were noted, such as maiden hair fern and alternate-leaved dogwood (Figure 74). Clearing and managing of invasive species would be the main restoration action required here. With adaptive management of invasive species, we would hope to stimulate the native species already present.

Figure 74: Alternate-leaved dogwood growing in the corridor, getting overtaken by invasive shrubs.

Clearing and managing of invasive species would be the main restoration action required here. With adaptive management of invasive species, we would hope to stimulate the native species already present (Figure 75).

Figure 75: Photo of invasive shrubs within the Pheasant Branch Corridor

Oak Savanna Restoration

The oak savanna is the largest area of proposed restoration within the corridor. Most of the upland areas within the corridor could be restored to oak savanna (Figure 76).

Figure 76: Restored oak savanna two years after woody clearing and seeding. Area will be managed with prescribed fire and invasive control. Note the herbaceous cover and diversity

There are many canopy oak trees with large infestations of invasive trees and shrubs underneath them. There is very little sunlight reaching the ground in these areas, preventing oak regeneration and lowering overall diversity. This also exacerbates erosion as there is very little groundcover at all underneath the canopy.

Restoration would entail clearing invasive trees and shrubs to allow sunlight to reach the ground to stimulate the herbaceous understory and oak regeneration. Herbaceous invasive species such as garlic mustard and dame's rocket will also need to be controlled as part of this restoration area. Re-seeding would also be proposed to increase herbaceous diversity. These areas could be managed by prescribed fire to control woody invasive species and stimulate native herbaceous cover (Figure 77).

Figure 77: Overgrown knoll with large over story oaks that would be an ideal candidate for oak savanna restoration in the Pheasant Branch Corridor.

Floodplain Restoration

The floodplain restoration refers to the wooded areas directly abutting the creek within the existing floodplain. These areas experienced severe erosion and tree loss during the 2018 flood. This area is currently dominated by large canopy trees such as black walnut, cottonwood and silver maple along with invasive trees like black locust (Figure 78).

Figure 78: Native herbaceous floodplain vegetation thriving where some sunlight can reach the ground. Further clearing along with re-seeding and other restoration would stimulate regeneration of native herbs

Clearing trees (especially invasive species such as black locust) will be necessary to aid in stormwater conveyance but will also provide an opportunity to restore the native herbaceous community, shrub layer and stimulate oak regeneration. Herbaceous invasive species such as garlic mustard and dame's rocket will also need to be controlled as part of this restoration area (Figure 79).

Figure 79: Example of a compromised tree that will eventually fall into the stream and potentially become hazardous debris during a flood event. Clearing some trees from the corridor will reduce the damage caused by debris in high flows

Management Recommendations

Successful restoration of the site will depend upon ongoing stewardship and maintenance of the site. This site, like many other restoration sites, is very dynamic. Because of this, we suggest applying the adaptive restoration approach to restoration and management efforts. Adaptive restoration entails adapting management to the changing climactic and other conditions on-site. This includes monitoring the results of restoration methods. If certain methods are not working, Managers will adapt them accordingly. Adaptive restoration is crucial to the long-term management of the Pheasant Branch Corridor.

Ongoing stewardship will include several different elements. Mechanical and chemical control of invasive woody and herbaceous species will be ongoing. We will need to stay diligent on managing invasive species already present on-site and be on the lookout for other potential invaders. Invasive species control requires constant vigilance as new species often appear when managing sites long-term. However, the amount of time required to manage the invasive species will decrease with time as their populations decline. Prescribed burning is another critical management tool for prairies, savannas, and oak woodlands.

Oak savanna and prairie ecosystems are very fire-dependent as their open habitat historically was often maintained by fire. Re-introducing fire onto the landscape is an effective tool to manage these community types. Besides managing the woody species, prescribed fire can also aid the re-establishment of native herbaceous species, as they too respond vigorously following fire. Prescribed fire would be a useful tool in the restoration and ongoing management of the overgrown oak savanna areas and the proposed sand prairies. Great care must be taken before beginning a prescribed fire program to ensure the fire is executed safely, efficiently and in accordance with local regulations.

Stewardship activities should be performed or supervised by qualified professionals trained in the appropriate methods and familiar with the natural systems in which the work is being done.

Cost Estimates

Restoring vegetative communities and maintenance following restoration work will be essential to the long-term success of the projects. Table 7 below contains cost estimates for restoring vegetation and maintenance including clearing of invasive brush and small trees. Initial seeding in areas such as the sand prairie and oak savanna may need to be followed up by re-seeding depending on many site factors including initial growth, invasive species encroachment, etc. Some difficult areas may also need to be planted with plugs or larger plans if seeding fails. Costs in Table 7 assume some re-seeding and/or planting will be needed. More detailed cost estimates can be made following stream restoration and trail restoration work, especially in terms of any additional clearing needed following these activities.

Table 7: Vegetation Management Cost Estimates

Project Task	Cost
Initial Woody Invasive Clearing	$100,000 - $160,000
Selective Re-Seeding/Planting	$30,000 - $40,000
Annual Stewardship	$50,000 - $70,000

Prescribed fire could be used on an annual basis as part of the annual stewardship in the Pheasant Branch Corridor, yet not all areas of the corridor will need to be burned every year and some may not be managed with fire at all.

Grants

In order to aid the City of Middleton in funding the restoration approaches discussed above the following grant funding sources have been awarded.

Awarded Grants

Dane County Parks Grant

The City of Middleton has been notified that they will be receiving **$900,000** to aid in funding project costs in the Pheasant Branch Corridor. The funds can be used to help off-set project costs for streambank stabilization measures described above, trail repairs and enhancements, as well as bridge replacement costs.

Wisconsin Department of Natural Resources Non-point Pollution Source Grants

Following the August 20, 2018 flood, Cardno applied for and received WIDNR Non-point Pollution Source (NPS) Grants for areas previously repaired using NPS grant funds within the project area (Table 8).

Table 8: WIDNR Urban Non-Point Source Stormwater Construction Grant Request for Pheasant Branch Corridor

Project Area	Total Requested from WIDNR	Total Cost Estimate
Pre-Flood - Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Design and Construction)	$124,000	$248,375
Parmenter Street to Park Street Pheasant Branch Streambank Restoration Project (Design and Construction)	$ 148,588	$ 297,175
Park Street to Century Avenue Pheasant Branch Streambank Restoration Project (Design and Construction)	$ 147,025	$ 294,050
Total	**$ 419,613**	**$839,600**

In total, $1,319,613 has been awarded to restore damage sustained during the August 2018 flood event in the Pheasant Branch Corridor.

Additional Potential Grant Funding Sources

Wisconsin Department of Transportation (WisDOT)

Programs:

Transportation Alternative Program (TAP) which includes Safe Routes to School (SRTS) as a separate subcategory. Transportation Enhancement and Bicycles & Pedestrian Facilities Program grants were combined into the overall TAP category.

Summary:

The TAP is a legislative program that was authorized in Fixing America's Surface Transportation Act (or "FAST Act"), the federal transportation act that was signed into law on December 4, 2015. With certain exceptions, projects that met eligibility criteria for the Safe Routes to School Program, Transportation Enhancements, and/or the Bicycle & Pedestrian Facilities Program are eligible TAP projects. Facility development can include both development of new facilities as well as modifications of existing facilities. Bicycle facilities must be transportation-oriented (not solely for recreational purposes), can be located within or outside of the highway right-of-way and could include riding or walking surfaces and related amenities. Eligible projects under the safety category include non-construction safety-related activities, such as safety and educational activities. Projects must be accessible to the general public or targeted to a broad segment of the general public

Safe Routes to School is that subprogram where WisDOT administers Wisconsin's portion of the national SRTS program. Under the Wisconsin SRTS Program, approximately $3.5 million his available annually. The grants can be used to identify and reduce barriers and hazards to children walking or bicycling to school.

Timeframes:

- [1]Grant applications are typically released in October of odd years (2019)
- Grant applications are due end of January of the following year (2020)
- [1]Grant awardees notified in Summer of the following year (2020)
- [1]Paperwork processing to allow for project authorization/ project to begin late fall of the notification year
- [2]WisDOT Design process = 1 to 2.5 years
- Project must start construction within 4 years of commencement date (date award letter was sent)

[1]timeframes listed above are typical, but have been known to vary greatly by anywhere from 3- 6 months

[2]WisDOT design process timing is dependent on complexity of project

Pros:

- 80% federal match / 20% local
- Relatively easy grant application
- Easy and quick reimbursement process (can request multiple)
- Grant awards range from $25,000 - $1,000,000

Cons:

- Intensive paperwork associated with federal requirement and oversight = increased design costs
- Stricter design guidelines = higher construction costs
- Community is charged for WisDOT oversight costs
- Strong statewide competition for grants
- New facilities are ranked higher than existing
- Utilitarian needs vs. recreational are ranked higher
- Reimbursement program (spend $ then get reimbursed) vs. grant straight distribution of $ ahead of time

Wisconsin Department of Natural Resources Stewardship Fund

Programs:

Land and Water Conservation Fund (LWCF) and Recreational Trails Program (RTP)

Summary:

The LWCF and Recreational Trails Program (RTP) federal grant programs are administered by WIDNR in conjunction with the stewardship local assistance grants. These programs fund projects that provide outdoor recreation opportunities for the public.

The federal LWCF grant program was enacted by the U.S. Congress in 1965 to develop high-quality outdoor recreation opportunities for the public. LWCF grants provide 50% cost-share to state, tribal, and local governments. Since its inception, more than 1800 projects have been completed in Wisconsin with more than $81M in federal LWCF funds. LWCF grants support land acquisition and facility development (i.e. construction) projects. Projects which provide or enhance water-based activity (such as canoeing, fishing, etc.) and supports multiple uses are highly ranked in this program.

The RTP provides funds through the transfer of federal gas excise taxes paid on fuel used on off-highway vehicles. These funds are used to develop and maintain recreational trails and trail-related facilities for both motorized and non-motorized recreational trail uses. Recreational Trails Program funds may only be used on trails which have been identified in or which further a specific goal of a local, county or state trail plan included or referenced in a statewide comprehensive outdoor recreation plan required by the Federal LWCF Program. Thirty percent of the funds must be used on motorized trail uses, 30 percent on non-motorized trail uses and 40 percent on diversified (multiple) trail uses. The grant cap is ordinarily $45,000 per grant per fiscal year but every third year the grant cap will be increased to $200,000 for two-thirds of the available funding and the remaining one-third will retain the $45,000 grant cap. Non-motorized trail uses include hiking, bicycling, in-line skating, and equestrian use. Project eligibility includes the following:

- maintenance and restoration of existing trails (ranks higher than new)
- development and rehabilitation of trailside and trailhead facilities and trail linkages
- construction of new trails

Key Criteria (both programs):

- Provide public access to outdoor recreation
- Relationship to the Statewide Comprehensive Outdoor Recreation Plan
- Regional or statewide in nature
- Serves the greatest populations
- Involves intergovernmental cooperation or donations
- Supports multiple uses
- Nature-based
- Related or near water facilities
- Improvements to allow for universal accessibility

Timeframes:

- Grant applications released = Fall Year 1
- Grant applications due = May Year 2 (following the release of the applications the previous fall)
- Grant awardees notified = Fall Year 2
- Project authorization = Late Winter/Spring Year 3

Pros:

- 50% federal match / 50% local
- Design must meet ADA and WIDNR standards, but no additional reporting other than standard local permits, etc.
- Grant awards range from $45,000 - $200,000

Cons:

- Intensive grant application process
- Slower reimbursement timeframe (3 months to 1 year)
- VERY Strong statewide competition for grants (typically get three times the amount of applicants than awards)

Other:

- Community must have a current Comprehensive Outdoor Recreation Plan in order to be eligible
- Require a local resolution in support of the grant application & commitment to resources if awarded the grant
- If you have active stewardship grants not closed, this counts against your point total

Wisconsin Department of Natural Resources Knowles-Nelson Stewardship local assistance grant programs

- Aids for the Acquisition and Development of Local Parks (ADLP)
- Urban Rivers (UR) grants

Summary:

The ADLP program helps communities and organizations acquire land for public nature-based outdoor recreation and improve community recreation areas. Funds are allocated on a regional basis, proportional to population. Projects compete against other projects from their region. Funds are allocated on a regional basis, proportional to population. Projects compete against other projects from their region.

The UR program helps restore and preserve the character of urban river corridors through the acquisition and development of land adjacent to rivers. Projects compete statewide. No applicant can receive more than 20% of the UR funds allocated in any fiscal year.

Funding Priorities:

For both:

- Support a local CORP
- Support multiple uses
- Support local/regional plans
- Have other priority characteristics specified in statute/code
- Provide accessible recreation opportunities

For ADLP:

- Are of regional/statewide significance
- Result in a first-of-a-kind facility for the applicant
- Involve two or more governmental agencies

For UR:

- Restore river corridors following dam removal
- Support redevelopment of brownfields
- Acquire land with unique natural or aesthetic values
- Acquire land that connects with previous land acquisitions
- Provide outdoor recreation opportunities for diverse urban populations
- Provide new or expanded access to urban waterways

Timeframes:

- Grant applications released = Fall Year 1
- Grant applications due = May Year 2 (following the release of the applications the previous fall)
- Grant awardees notified = Fall Year 2
- Project authorization = Late Winter/Spring Year 3

Pros:

- 50% federal match / 50% local
- Design must meet ADA and WIDNR standards, but no additional reporting other than standard local permits, etc.
- Allow for up to 50% of grant amount to be requested upfront
- Grant awards range from $45,000 - $200,000

Cons:

- Intensive grant application process
- Slower reimbursement timeframe (3 months to 1 year)
- VERY Strong statewide competition for ADLP grants. UR are more regional, so potentially more available.

Other:

- Community must have a current Comprehensive Outdoor Recreation Plan in order to be eligible
- Require a local resolution in support of the grant application & commitment to resources if awarded the grant
- If you have active stewardship grants not closed, this counts against your point total

Please Respect the Environment

ABOUT CARDNO

Cardno is an ASX-200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage, and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD]. For additional information, visit www.cardno.com.

Cardno ZERO HARM EVERY JOB. EVERY DAY.

At Cardno, our primary concern is to develop and maintain safe and healthy conditions for anyone involved at our project worksites. We require full compliance with our Health and Safety Policy Manual and established work procedures and expect the same protocol from our subcontractors. We are committed to achieving our Zero Harm goal by continually improving our safety systems, education, and vigilance at the workplace and in the field. Safety is a Cardno core value and through strong leadership and active employee participation, we seek to implement and reinforce these leading actions on every job, every day.