Design Report

RECREATION IMPROVEMENTS FOR THE VILLAGE OF AUGUSTA

"The Walkable Village - Where the Trails Meet"

ENGR 340
Team 15
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Executive Summary

The overarching goal of our project is to improve the recreation system in the Village of Augusta. This goal is the vision of the Augusta Village Council as outlined in various documents. There are many recreational facilities already used by residents and visitors to the village. Furthermore, there are currently unutilized lands that are resources for future recreational use. Several key objectives are integrated into a comprehensive long-range plan. Specific improvements are proposed including changes to current roads, trails, and other recreational facilities. Detailed designs of the Augusta Millrace Trout Stream, the Michigan Avenue Pedestrian Safety, and the Kalamazoo Riverfront Landing and Trail are described. Having been reviewed by the public for input, this recreation plan will be adopted by the village and submitted to the Michigan Department of Natural Resources for the purpose of obtaining recreational grant money, to help fund the proposed changes.

Project Areas

Our group organized the plethora of projects ideas into five distinct project areas. Each area is critical to meeting the objectives.

Michigan Avenue

Background

State route M-96 forms the main east-west street in the village, dividing the residential north from the commercial south. In the village's 66 ft wide right-of-way, 40 ft are paved. This is divided by painted lines into two standard 12 ft wide driving lanes (one in each direction), with an 8 ft wide shoulder on each side. The speed limit in this section is 35 mph. With most of the village's residential area to the north, restaurants and government buildings to the south, this road is necessarily a pedestrian crossing. The rise of the bridge limits visibility, and crossing this road on foot is dangerous.

Problem

Current pedestrian conditions are perceived as unsafe and discourage pedestrian traffic across and along Michigan Avenue.

Objectives

Improve pedestrian safety and comfort in traveling across or along Michigan Avenue, without decreasing the vehicle capacity of M-96 or reducing automobile access to the thoroughfare.

Criteria

Any design seeking to meet this objective must follow the following criteria. These follow the pattern for design criteria set earlier in this document and are outlined to be specific to this problem.

Objectives

All solutions must be effective at improving pedestrian safety.

Maintenance

Solutions to this problem will consider the impact of required maintenance. Some examples of maintenance to consider are landscaping requirements, sign replacement and maintenance frequency.

Constructability

Any construction plans will need to include viable detour routes and consider storm water drainage issues. Consideration must also be given to project phasing.

Safety

Solutions must consistently slow traffic on M-96 to a speed appropriate for the safety of pedestrians and traffic entering M-96. Solutions must provide a safe pedestrian crossing. Safety is based on visibility, traffic speed, and crossing length.

Appropriateness

The village would like this project to beautify its main road as a method for improving walkability. Any solution which diminishes the current aesthetics is clearly unacceptable.

Equity

Crosswalks should be accessible for foot, bicycle, rollerblade, and especially wheelchair traffic. Traffic calming techniques must allow current traffic patterns to remain minimally effected. Essentially, any improvements to village roads and walkways must encourage pedestrian traffic without significantly discouraging commuting, shopping, or shipping traffic.

Cost

This project and its future maintenance should be affordable for the village. At this time, the village has not determined a budget for this project, though it will be discussing options. Outside funding such as federal and state grants should be considered a benefit for the village and not a requirement for construction. This was recommended by Glen Avis, who recognizes that approval of village funding for projects requires the support of the residents for such projects. As external funding is useful, a brief summary of available grants is included in this document. For funding available for transportation and pedestrian improvements, please refer to the *Funding* section of this report.

Project Options

Vertical Displacement

Vertical displacement solutions raise portions of the roadway, which causes discomfort to casually speeding cars, and damage to excessively speeding cars. By varying the surface material from the pavement of the road, vertical displacements also improve crosswalk visibility. Three types of vertical displacements should be considered: speed bumps and speed humps, speed plateaus, and raised intersections.

Speed Bumps, Humps

Most people are familiar with speed bumps and speed humps, which run across the road between intersections. They are marked with paint or by varying the material of the formation from the material of the road.

Depending on their height, speed bumps can significantly decrease the speed of traffic. In many cases, cars are required to brake to speeds well below the posted limit. Speed bumps have a greater effect on larger vehicles, especially those transporting freight. Because of this failure of equity, the Village will not consider speed bumps as possible solutions regardless of how they meet the other required design criteria.

Speed Plateau

A speed plateau is formed by extending the length of a speed bump so that a car can have its entire wheelbase on a plateau before the front wheels return to the original road surface.

Speed plateaus can be constructed simply as poured-asphalt speed bumps with more material. But more often, the size of a speed plateau requires more attention to aesthetics.

Data displaying the effectiveness of speed plateaus is not conclusive and cannot be provided here. One may consider that they are a gentler form of speed bumps, which would have a lesser effect of decreasing speed but cost more in material and labor. It may be that they are more suited to this project, but more research will be necessary before they can be a recommended solution.

Raised Intersection

Placing a plateau at an intersection creates a raised intersection. This allows the plateau to affect speeds from multiple approaches at a critical location. This method is generally used at intersections which experience similar vehicle traffic flow rates in all directions and high volumes of pedestrian traffic. These constructs also employ aesthetic designs with material variation. Mosaic bricks, pavement, and cement can be used to clearly mark crosswalks. Brickwork produces the most appealing design, but is generally a more expensive option.

Because traffic volumes on roads intersecting M-96 within the village limits are not high enough to warrant a 4-way stop, it is unlikely that a raised intersection can be considered as an appropriate traffic calming technique for the village.

Horizontal Displacement Solutions

Most horizontal displacements force traffic from a straight line of travel. Vehicles must reduce speed in order to follow the movement of their lane. Other horizontal displacements “crowd” the drivers’ vision, encouraging them subtly to slow down. Some horizontal displacements serve two purposes: to slow traffic, and to decrease the pedestrian crossing distance. One such solution, commonly known as bulb-outs, were especially requested by the village, and will be given favor in the decision process. Bulb-outs are curb extensions at an intersection. They effectively slow traffic at a critical location, as well as decrease the crossing distance of previously existing pedestrian crosswalks.

Roundabouts

Roundabouts are used at intersections with similar flow in all directions where traffic would traditionally be stopped with a traffic light or four-way stop. Their primary purpose is to increase flow through the intersection and eliminate queue lengths and times. They also control the velocity at which traffic moves through the intersection. Roundabouts have a large circular island in the center of an intersection which forces all entering traffic to enter concentric circular lanes around the island. Traffic circles are similar, but use a smaller circular island in the intersection. This technique focuses on visually slowing drivers entering the intersection and does not create circular lanes to move traffic around the island.

A roundabout is not a feasible option for the village due to its size and cost. Also, none of the intersections in the village need to be controlled in all four directions. A traffic circle would be a better option for the village, although they are also generally intended to effect multiple directions. A carefully designed traffic circle would beautify the streetscape and effectively slow traffic. This in turn would increase local and regional accessibility as well as traffic and pedestrian safety. Costs for installing a traffic circle vary greatly, depending on size and material used. Also, much consideration must be given for large vehicles such as semi-trucks and fire engines.

Chicanes (Curb Extensions)

Curb extensions slow traffic by visually narrowing the road. They take many shapes and by placing them carefully, have varying effects on traffic. Alternating chicanes can force traffic to follow a serpentine route. Aligned extensions create “chokers,” or narrowed sections which can be placed near intersections for critical slowing. The cost range for chicanes is very large due to their versatility of design. The land gained by extending the curb is commonly used for beautification. Chicanes increase traffic and pedestrian safety by slowing traffic and decreasing crosswalk length. This option will be considered for the village.

Center Island Narrowing

Center islands can affect traffic by forcing a lane to dodge to the right. Placing a long center island along the entire width of a road creates a boulevard. Center islands slow traffic by forcing lateral movement and by visually closing the road. They also divide crosswalk lengths in half by allowing for a pedestrian safety island. Center islands will be not considered for the Village of Augusta. While islands can provide room for landscaping, stationary objects, such as trees, must be set back from

Signage and Pavement markings

Signage is very important for safety and traffic management. While designing the improvements for M-96, all current signage and pavement markings will be recorded. These will be checked against the current code and modified as necessary. When crosswalks are designated, specific signs and pavement markings will be used. While the primary objective will be to create a design that meets traffic codes, some consideration will be given for the effectiveness of the recommended signage as well as for the effect of the signs on the streetscape beautification.

Digital/Radar speed signs

Digital and radar combined speed signs consist of a traditional pole mounted speed limit sign with a computer box mounted below. The computer box contains a radar speed detector, a hard drive, and an LED screen. The sign records the speed of oncoming vehicles and is able to display that speed to drivers as they pass. These are considered effective with drivers who do not realize they are speeding because the posted speed is below the speed allowed by visibility and pavement conditions. The computer box is capable of recording data for extended periods of time, allowing for studies of the effectiveness of the sign and for studies of daily and seasonal traffic patterns. Many models of these signs include solar panels to decrease the maintenance required.

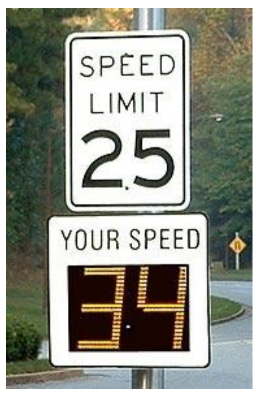

Figure 1: Digital Radar Speed Feedback Sign

Pedestrian Safety Flags

Pedestrian safety flags are a rising practice in much of the United States. Conclusive evidence proving their effectiveness or lack thereof has yet to be determined. They have low installation and maintenance costs; the US Department of Transportation reports that they typically cost less than $150 per unit at an intersection, and each flag can be replaced for around $1.50.

Design

Approach

To determine the appropriate solution which would meet the design criteria, a greater understanding of the pedestrian safety issue needed to be attained. The first step was to recognize critical pedestrian safety hazards. The first was pointed out by the Village, and a geometric examination supported their concern. The east pedestrian crossing at M-96 (Michigan Ave) and Webster Street is not only the most central crossing in the village, but also nearest the M-96 Bridge over Augusta Creek. The elevation of the bridge restricts pedestrian and driver visibility. As such, a safe crossing will be designed at this location and other designs will follow it as a model.

Calculations

Plan-profile data from a 1955 construction set provided the geometric data needed to calculate the available sight distance. AASHTO recommends calculating sight distance based on a vehicle being able to stop in time for an object when the vehicle's initial speed is equal to the design speed, generally 5 mph over the speed limit.

MDOT's Kalamazoo Traffic Management Center (TMC) did not approve of the sight distance as limited by the Augusta Creek M-96 Bridge, according to Michelle O'Neill. They are, at the time of this report, looking into possibilities for improving that curvature. This is difficult as the height of the bottom bridge beam is controlling the 100-year flood elevation. O'Neil reports that MDOT is seeking an allowance for the curvature of the bridge. Therefore, a conservative assumption is that the peak elevation of the bridge will remain the same. While lowering the bridge could improve sight distance, any such improvements should be viewed only as complement this design. Moreover, the designs herein may make MDOT's plan for an allowance may be easier to approve.

Primarily concerned with pedestrian safety, these calculations go beyond the traditional stopping sight distance. The first step is to consider a vehicle approaching a pedestrian in the east crosswalk of the Webster Street intersection: A westbound driver approaches the bridge with an eye height of 3.5 ft, looking at a person in the crosswalk. The pedestrian is approximated by a 2.0 ft object, as recommended by AASHTO. This 2.0 ft height should be used, as a conservative estimate of a child's height, with an adjustment factor for the low visibility of a pedestrian. It may also represent the taillights of a passenger car stopped for pedestrians.

The profile of the road is approximated with a parabolic vertical curve with constant grades on either side. According to the 1955 data, these grades are 2.1% on the east and 1.85% on the west. Using these slopes, the object height, the driver's eye height, and the elevation of the bridge and the crosswalk, we determined the furthest point from the crosswalk that a driver can see a pedestrian in the aforementioned crosswalk. An equation relating the slope of the line of sight to the eastern grade was determined. This required projecting the slope of the line of site to a location above where the vertical curve was no longer parabolic, but constant grade. Solving for the location at which the height between these lines was the 3.5 foot driver eye height yielded a distance of 380 ft from the crosswalk.

The required stopping sight distance (reaction distance plus stopping distance) for an approaching vehicle at the 35 mph speed limit was calculated and compared to the available distance. At 35 mph a driver travels 128.5 ft during PIEV (perception) time. In this case, that carries the vehicle over the bridge. On the west side of the bridge, the vehicle requires 125 ft to stop on the 1.85% downhill slope. With the 380 ft sight distance still available, a driver will have ample time to bring their vehicle to a stop, should they see a pedestrian in the crosswalk. Using a spreadsheet, stopping distance was generated for multiple speeds, which a) determines the critical speed at which drivers cannot stop in time, and b) creates a lookup table to use once speed data has been collected, as shown in Table 1: Vehicle Stopping Distance at Various Speeds

Table 1: Vehicle Stopping Distance at Various Speeds

					PIEV Time (s) =	2.5
					Available Sight Distance (ft) =	380.94
					AASHTO Braking (ft/s^2) =	11.2
Vehicle Speed	PIEV Dist (ft)	Resulting Available	Stopping Distance	Difference (ft)		
35	128.33	252.61	123.99058	128.62		
40	146.67	234.27	161.94688	72.33		Vehicle can stop before crosswalk
42	154.00	226.94	178.54644	48.39		
44	161.33	219.61	195.95573	23.65		
45	165.00	215.94	204.96402	10.98		
45.85	**168.13**	**212.81**	**212.81142**	**0.00**		Critical Speed at which Vehicle can just stop in time
48	176.00	204.94	233.20351	-28.26		
50	183.33	197.61	253.042	-55.44		Safety is Compromised
55	201.67	179.27	306.18083	-126.91		
58	212.67	168.27	340.49332	-172.22		

The Village officials believe that vehicles consistently travel in excess of the speed limit, diminishing pedestrian safety. Lacking the necessary vehicle speed data to support this claim at the current time, stopping distances were generated for multiple vehicle speeds in a spreadsheet. Using this data to determine the critical speed at which pedestrians were no longer safe provides a better understanding of the situation, as well as lookup tables for future speed studies. It was determined that vehicles travelling over 45 mph cannot stop before the pedestrian crossing. With the proper funding and equipment, a speed study should be conducted and compared to these tables. The wide roads make higher speeds comfortable, but the limited sight distance from the bridge limits that base free flow speed.

The previous calculations show that at the design speed, and for a factor well beyond it, pedestrians are safe as vehicles have enough distance to stop. Pedestrians have the right of way, and licensed drivers are assumed responsible for their safety. These laws reflect the fact that not all pedestrians can be held responsible for their own safety. Legally, this is a proper design. Although law protects people on paper, it will not protect a pedestrian in the situation when a driver is not paying adequate attention. A pedestrian standing on the southern curb of M-96 (Michigan Ave) at the crosswalk of Webster Street will look east and west, crossing the street when he or she will be out of the way of any approaching vehicles. Pedestrians are not comfortable crossing streets when they recognize that they will force a vehicle to slow down. With little protection in the event of an accident, pedestrians cannot step out on the faith that a driver will see them and stop in time. With this in mind, a mathematical determination of why pedestrians feel unsafe was undertaken.

Survey data from the Michigan Department of Transportation provides the crosswalk length. AASHTO recommends a pedestrian crossing speed of 4.0 ft per second for a pedestrian population where less than 20% are over 60 years of age. According to US Census Data from 2000, 12% of Augusta villagers were 65 and older. A pedestrian requires 11.25 seconds to cross the current crosswalk. In this time, a vehicle travelling only at the speed limit travels 580 feet, far greater than the available 380 ft sight distance. This discrepancy explains the pedestrians' discomfort: A person cannot cross the road with confidence that he or she will not be forcing an approaching vehicle to slow down. In fact, he or she may be in the middle of the first lane and then see an approaching vehicle that would be forced to stop because of his or her presence.

The next step was to generate spreadsheets to determine the necessary crossing lengths at various speeds and the resulting geometric change. This creates lookup tables to consult during the geometric redesigning process which will apply independent of the results of a speed study. An abridged version of the table is shown for a 35 mph approaching vehicle speed in Table 2: Crossing Length and Pedestrian Safety

Table 2: Crossing Length and Pedestrian Safety

	Pedestrian Speed (FT/S) =		4.00	
Available Sight Distance (ft) =			380.94	
	Vehicle Speed (mph) =		35.00	
Crossing Length (ft)	Ped Crossing Time (s)	Dist Traveled by Vehicle (ft)	Difference (ft)	Geometric Change (ft)
45	11.25	577.50	196.6	0
40	10	513.33	132.4	5
35	8.75	449.17	68.2	10
30	7.5	385.00	4.1	15
29.68	7.42	380.94	**0.00**	15.32
29	7.25	372.17	-8.8	16
25	6.25	320.83	-60.1	20
20	5	256.67	-124.3	25
15	3.75	192.50	-188.4	30

Decision

The decision to use bulb-outs at the intersection was based on a number of factors: the village's preference for such a design, the lower construction impact (can build on one side of the road at a time, unlike center islands), aesthetics, and the significant impact they have in decreasing pedestrian crossing lengths as well as vehicle speeds.

Designing bulb-outs requires consideration of a number of factors:

a) Available turning radius before and after design
b) Presence of on-street parking, preference for creation of parking
c) Crosswalk locations, sidewalk widths
d) Available shoulder width
e) Aesthetics, such as symmetry and surface area of pavement

The bulb-outs will be designed to minimize the pedestrian crossing length as much as possible while avoiding decreases the existing available turning radius, when possible. Pedestrian safety, while important, should not hinder the capacity of the road to deliver goods. Small radii prevent large trucks from safely navigating turns, which hinders pedestrian and vehicle safety as well as commerce.

Existing and proposed on-street parking affect bulb-outs in terms of their angle of approach. Significant tapering decreases the number of parking spaces, but some tapering is necessary for aesthetics. In some instances, approach tapering is necessary due to the lack of parking. To the fullest extent possible, tapering will be symmetrical along the centerline of the road. This is for aesthetic purposes only.

In the Village of Augusta, no parking will be created at this time. Between Chestnut and the Augusta Creek Bridge, the Village has agreed with MDOT not to create parking. Currently, the existing parking is sufficient; there are generally more spaces available than there are cars parked. However, if the Village increases their tourist draw, more parking could become necessary. As there will be ample shoulders between bulb-outs, that space could be turned into parking. Creating parking space is beyond the scope of this project.

According to the survey data provided by MDOT, M-96 (Augusta Drive) has 12 foot lanes, and varying 9-10 ft of shoulder throughout the village. In the new design with bulb-outs, the 12 foot lanes will remain. This meets the AASHTO minimum of 11 ft, and also follows the MDOT standard practice. The bulb-outs will occupy the shoulders at the intersections, but between the intersections, the full shoulder will remain. This is to minimize the cost and impact of construction as well as maintaining MDOT's preference for shoulders on state routes. In the future, extending the curb into the shoulders should be considered, especially if parking must be added. AASHTO recommends 8 foot wide parking spaces in urban areas, which means that the shoulders could be extended and the Village could gain 1-2 feet of green space or sidewalk along their main street. But our design must be prepared for acceptance by MDOT in the near future and will not reduce shoulder width in order to avoid bureaucratic resistance.

The bulb-outs will have 5 foot wide sidewalks on them, with ADA compliant ramps to the street level. The rest of the bulb-out will be filled with grass and/or foliage, for aesthetics. One bulb-out on the southwest corner of Webster and Michigan will remain paved, as the sidewalk there extends to the curb, and there isn't grass already. We recommend that the village install a bench in this area, or a similar aesthetic improvement.

Also included in the design is a bulb-out layout for M-96 and Chestnut St, which should be used as a typical design for 3 other intersections. This is part of a Three Phase Installation Plan.

Implementation

We are recommending that implementation of these traffic-calming, and pedestrian designs be considered in three phases:

1) Installation of a pilot Pedestrian Safety Flag System at Webster St and M-96 (Michigan Ave). This is a low cost, easily implemented solution which will allow the Village of Augusta to determine the effectiveness of the pedestrian flags and consider implementation of the system at other intersections.
2) Installation of the designed bulb-outs at Webster St. This is the most at-risk intersection, as shown earlier, as well as the most central to the Village.
3) Installation of bulb-outs at other intersections. Chestnut St and Water St should receive primary consideration. If the Village can afford 5 intersections, they should include Lincoln St and Church St. If only 4 will be installed, they should consider Cherry St. instead of Lincoln St and Church St.

Cost

The solution to this design was determined by many factors other than cost. Such constraints as geometric needs, bureaucratic processes, and general effectiveness limited the solution. Because this is the case, cost analysis is considered post-design, in order to give the Village a preliminary estimate of costs.

Pedestrian Safety Flags

This system costs $150 on average per unit, according to the FHWA. In the event that flags from the unit disappear, they cost $1.50 to replace. This low cost is one reason why this system has been so effectively implemented in many towns and cities.

Webster St and Michigan Ave Bulb-outs

Installation of bulb-outs at this intersection will cost $18,580.00 for materials and labor. With contractor, engineering, and contingency costs, this project will cost $33,330.00.

Typical Bulb-outs (Follow Chestnut St Design)

Installation of bulb-outs at other intersections will cost $44,140.00 per intersection.

Cost of Full Installation

With bulb-outs at Webster Street, Chestnut, Water Street, Lincoln Street and Church Street, this project will cost $254,000.00.

Additionally, this design will need to be examined and re-performed by a Professional Engineer who is licensed in the State of Michigan. The designs produced here can only be used by the Village to gain an understanding of what is available to them, and what they might expect from a professional engineering analysis.

Kalamazoo Riverfront

Background

The northeast quadrant of the Village of Augusta is dominated by swampy, low-lying land. The village holds much of the land in this area. The new Village wells are located on a rise above the floodplain, just off Augusta Drive. Jefferson Avenue, on the north of the flood plain, provides street access to the more remote parts of the tract.

The land is located within the 100 year flood plain of the Kalamazoo River, as delineated by the Federal Emergency Management Agency (FEMA), and is a registered Michigan State wetland, essentially prohibiting all forms of commercial development. Wetlands are protected by state as a valuable link in the ecological system. Not only are wetlands a unique and essential habitat, they play a vital role in filtering out contaminants and mitigating non-point source pollution. FEMA has determined that in order to protect against devastating flooding, the area's function of storing and conveying water must be maintained.

Problem

Valuable riverfront property is not being used to its full potential. There is no river access for canoers and kayakers within the village.

Objectives

Provide boat access to the Kalamazoo River for regional users. Allow the local public to recreate along the river bank.

Criteria

Objectives

The design solution must meet the objective listed above. It should provide access to Kalamazoo River for the whole region. This will require it shall meet all applicable ADA standards. Free parking would be preferable for local users. The site should be easily accessible by foot, and attractive to visit.

Cost

The designed solution must be cost effective in the short term, so it can be easily implemented, and the long term, so it can be sustained.

Maintenance

The designed solution must be reasonable for limited village resources to maintain. It must not cause erosion of the river banks. With simple steps all built structures must be able to withstand or escape damage caused by flooding.

Constructability

Constructability should be considered with any design solution. Potential limitations on available space, soil bearing capacity, and environmental standards associated with work in a wetland are all considerations. So much as possible improvements should be limited to lands already owned by the Village of Augusta or the State of Michigan.

Safety

Safety is a concern. Considerations include risk of crime due to isolated location, vandalism, and littering. Safe entry and exit to the site from M-96 by vehicle or foot should be considered. Determination of liabilities associated with public waterfront should also be made. Function under flood conditions should also be considered.

Appropriateness

Aesthetics and cultural appropriateness are major factors in determining how the project is received by the community. Improvements should be simple, but attractive. They should be visible, but not overbearing. Efforts should be made to keep existing trees and vegetation where possible. Facilities should be at a pedestrian scale, in keeping with the rest of the village.

Equity

Improvements should not compromise the silvicultural value of the land. Also, improvements should not impair the ecological function of the land to store and convey floodwaters, or filter out pollutants. All facilities must be ADA compliant, to accommodate all users. Pathways should comply with the nationally accepted guidelines for accessible trails, such as those of the North Country Trail. A boat launch should be able to accommodate a foreseeable variety of boats. Restrooms may need to be provided for users.

Project Options

River Trail

The Trail may be accessed from Michigan Avenue, Washington and Jefferson Street. Having multiple entrances would encourage use and improve accessibility by allowing through trips. An entrance from Michigan Avenue would be highly visible and accessible to the public. Access from the residential Washington and Jefferson Streets provide supervision of the trail entrance and improve safety. Also, connecting to these residential areas would encourage neighboring residents to utilize the trail. Key attractions along the trail route might include Old Augusta Creek, a lookout on the Kalamazoo River, and the old Oxbow.

Material options for the pathway include a wooden boardwalk, asphalt, permeable asphalt, concrete, permeable concrete, gravel, wood chips, or even earth. However, gravel, wood chips, and earth can be ruled out as they are not allowed under ADA codes (reference?). The use of these materials depends on a site specific design, considering the swampy conditions and routine flooding.

An optional trail along the river bank may include all of the following features: Exercise stations or mile markers for those using the trail for cardiovascular workouts; a series of signposts describing local flora and fauna, land forms, history, and so forth; clearings along the river bank with benches for resting, fishing, or bird watching.

Amenities

Other amenities may be desirable in this location. Outhouses or public restrooms may enhance the visibility and usability of this site. However, there may be major difficulties with placing these in a wetland and flood plain. If there proves to be sufficient use, a fish cleaning station may be desirable.

Landing location

There are two potential sites for the boat launch. The first is north of the M-96 bridge over the Kalamazoo River and the second is just south of that same bridge. The Village owns property along the edge of the river at both locations.

The village owns large reaches of the riverfront north of the M-96 Kalamazoo River Bridge. As a floodplain wetland however, this land difficult to develop. This location would pose some parking and construction access concerns. The slope here is also much steeper than its southern counterpart. This would translate into more grading and groundwork to reach ADA standards (necessary for all new projects in Augusta).

The riverfront immediately south of the Kalamazoo River Bridge was originally platted as a village street. While direct access from Michigan Avenue is not possible due to the elevation of the bridge approach, the riverfront can be accessed through the parking lot of Players Sports Bar and Grill overlooking the river. This location was chosen due to the more gradual slope as well as the potential for shared parking.

Parking

No parking would be the easiest option. This would limit use of the landing to boats already on the river. However, some users may occupy parking at adjacent businesses while they put in.

Parking on the site is virtually impossible due to site constraints, unless the boat launch is moved far to the north, away from the center of town.

Offsite parking means creating a parking lot at the nearest available village property; the ‘Triangle’, on the northwest corner of Augusta Drive and Michigan Avenue. This extra parking might serve additional purposes. Still, access to M-96 could prove unsafe.

Shared parking is a promising alternative. This would involve negotiating parking rights or right of way from adjacent businesses.

Boat Launch

Doing nothing is a viable option. It is the cheapest and easiest. Without a boat launch, the river banks will remain largely unused. Needs for water access may be met by an existing boat launch in the Fort Custer Recreation Area, which has a boat launch with a concrete ramp that can accommodate a wide range of craft, and is handicap accessible. It is , however, located a mile downstream and on the opposite shore from the village. To do nothing means that the village will still not be connected to the river.

A small earthen area adjacent to the river would allow access for a variety of purposes. However, this function of this area may not be clear to the public. Moreover, erosion may be a concern.

Installation of a floating dock would provide a visible means of access to the river. However, it would likely need to be removed for winter ice or spring floods.

A fixed dock or a solid river wall would provide a clear point of access to the river. However, a fixed structure needs to be durable, and account for varying water elevations. A unique approach used in Illinois uses 4 concrete steps. A conservative cost estimate based on similar projects would be no more than $25,000 (www.openlands.org).

A concrete boat ramp would be the most obvious and functional. It would allow even trailered boats access to the water. However, it would be costly (estimated $250,000), and construction may prove difficult due to site constraints. Safe access for trailers onto M-96 may not be possible. Also, it may prove redundant with the existing boat ramp in the Fort Custer Recreation Area.

An asphalt ramp with a landing at the bottom would be easily constructible and maintenance could be done by the village.

Table 3 Decision Matrix for Landing Type

	ADA Compliance	Construcability	MDEQ Compliance	Ease of Maintenance	Cost	
Do Nothing	0	10	10	10	10	***40***
Earthen Landing	0	9	10	9	9	***37***
Floating Dock	9	8	10	5	7	***39***
Fixed Dock	10	5	0	6	6	***27***
Concrete Ramp	10	6	10	7	4	***37***
Asphalt Ramp with Landing	10	7	10	8	6	***41***

In consideration of the options available, we recommend a signed, ADA compliant asphalt boat launch that can provide easy access for canoes and kayaks, to be located on the south side of the Kalamazoo River Bridge, with parking and access through Players Sports Bar and Grill as can be negotiated. The openness of the site will be easy for visitors to notice the boat launch, and deter vandalism and crime. Shared parking with Players Sports Bar will allow boaters who park in Augusta to make use of the existing parking lot, and the sight of the restaurant will welcome river travelers and encourage them to stop in Augusta. Ideally, Players Sports Bar will also be able to benefit from this new flow of visitors.

Figure 2 Proposed Landing Location

Boat Launch - Design Summary

It was determined that a motorized boat launch would be unnecessary and undesirable. A concrete boat ramp in the Fort Custer State Recreation Area provides adequate access for motorized boats that are transported by trailer. Furthermore, inviting motorized boats and the accompanying trailers could cause accidents while maneuvering in the parking lot or accessing M-96.

There are several options for the surface of the pathway and landing. Wood was eliminated because it would be slippery when wet. Grit strips placed on the wood for the necessary traction would need to be replaced frequently. Concrete would be more expensive both initially and to repair. Asphalt would be less expensive than concrete to implement and also easier to maintain.

The river level can change elevation significantly with the seasons. An elevation of 784' was chosen because that is the current elevation. At this elevation, the landing will not interfere with the flow of the river.

Storage for several boats will be available on the bank to the south of the landing, just past the railings. There is level ground there which boaters can pull up on. If boaters decide to go into town, they can easily leave their boats on the river bank or tied to the handrail supports.

As far as negotiations go, it is recommended that Players Sports Bar be contacted by the Village and some sort of agreement be made so that recreational enthusiasts can access the landing through the parking lot. It is recommended that the parking lot of Players Sports Bar be extended 33' east to accommodate recreational enthusiasts looking to use the boat launch.

This proposed location would require a ramp as it is more than 6' in length and there is a rise of more than 2.5'. A path width of 5' was chosen according to section 4.2.2 of the ADA guidelines. This is the minimum width required for two wheelchairs to pass side-by-side.

Section 4.8.4 of the ADA guidelines states that landings are to be provided at the top and bottom of each ramp and each run. According to section 4.8.2 of the ADA guidelines, a maximum rise of 30" (2.5') is allowed for every run. Since there is a 4' drop between the parking lot (Elev. 788') and the edge of water (Elev. 784'), a landing is required in the middle. The original slope between proposed landings was 8.7% and 8% for the west and east most runs respectively. Section 4.8.2 of the ADA code states that the least possible slope should be used for every ramp, with a maximum slope of 1:12 (8.3%). A slope of 1:20 (5%) is recommended for new designs. To reach the 1:20 slope required for ramps, the top landing of the boat launch will have to be at an elevation of 786'. The parking lot of Players Sports Bar does not extend all the way to the edge of their property, thus it is recommended that their parking lot be extended 33' east to accommodate increased parking due to boat launch users. This parking lot should have approximately 6% slope for drainage as well as to attain the 786' elevation on the eastern-most edge necessary for ADA compliance of the boat launch ramp.

Section 4.8.4 also states that landings required for ramps are to be at least as wide as the ramp leading to them. In addition, if there is a direction change involved, the landing is to be

5’ by 5’. Since the ramps are 5’ wide for wheelchair access, each landing is to be a 5’ by 5’ square.

Section 4.8.5 of the ADA guidelines states that handrails are required for every ramp with a rise greater than 6” or horizontal projection of 6’. The proposed ramps have both, therefore continuous handrails are to be put on both sides. The tops of these handrails are to be at a height of 34” (2.83’) in compliance with ADA standards.

Section 4.8.7 specifies that Edge protection is to be provided at the bottoms of ramps and landings with drop-offs. Along the riverside, a curb of 2” height is to be provided at the bottom of the ramps. If the space between the railing and the curb face is 9” or greater, there is no curb necessary. To maximize available maneuvering space, it is recommended that a 6” space between the western face of the curb and the centerline of the railing be provided. A space will be left open along the river’s edge for launching the watercraft. This space, as shown in drawing BL-1, will be free of guardrail and curb for easy access to the river.

Riverfront Trail - Design Summary

Trail Concept

The Riverfront Trail is a place where village residents can walk or run, or sit and rest. It allows them to enjoy the flora and fauna of the unique habitat of the floodplain wetland. Offer access to a little seen part of the village, it offers a new perspective on Augusta.

A series of educational signs placed along the route could greatly enhance this experience. These may such subjects as:

Geology and geography of the Kalamazoo River

History of the village and the trail site (Platted as part of the village, use as a pig farm)

Ecology of riparian wetlands and floodplains

Regulations protecting wetlands and floodplains

Story of trail construction

Unique flora and fauna along the trail

Achieving this goal will require understanding of many fields. Therefore, among the people working on the trail project there should be people who are knowledgeable about biology, aesthetics, engineering, construction, and education. Someone knowledgeable about the wetland environment would provide valuable insights when adjusting the trail layout to minimize impacts on the local habitat (Kusler).

Trail Layout

Because most of the pathway site is quite level, it is not necessary to do a complete topographic survey. However, a boundary survey should be conducted to identify the bounds of village owned land along the trail route. Property lines should be flagged at regular intervals so that field modifications to the trail route do not encroach on neighboring lands. The trail centerline should be no closer to the property line than 6 ft, to provide a safety tolerance from encroachment.

As detailed topographic data is not available for the trail site, the actual trail site should be modified from the included plans in order to take advantage of the natural terrain. Where possible, the trail should pass along higher ground to reduce seasonal inundation. In addition to this, the trail route should minimize impacts to the sylvan environment, seeking to preserve trees and ground vegetation.

Field modifications to the trail route should be marked by flagging at the edges of the trail route, and frequently enough for the curvature of the trail route to me visible. MDEQ permitting requires that this flagged trail route be photographed at 50 foot intervals; the photographs to be submitted with the permit application. (EZ path Guidelines)

The river trail should branch off of the sidewalk along the north side of Michigan Avenue, descending to the floodplain along the M-96 right of way. From there, the trail turns north along the platted McCalmy Street, across Old Augusta Creek, to the intersection of the undeveloped East Jackson Street. The trail should be distanced from the sensitive ecological environment that occurs along the river's edge. Thus, a buffer of 20-30 ft is to be maintained along the river to discourage travelers from leaving the trail and trampling the fragile river bank. Access to the river bank is provided by a spur trail to a platformed rest area. The intersection of the spur trail should be sufficiently vegetated to prevent shortcutting (NCT ch.3). The trail then turns and follows East Jackson Street westward, taking advantage of the high ground and clearing north of the well head. The well head area should be screened by brush to deter hikers from cutting through the restricted area. The trail then climbs to existing causeway that runs north through the Ransom Street right of way to the end of Washington Street.

Curves were designed using the conventional method for calculating turning radii. This assumes that bicycles and pedestrian turning behavior can be modeled the same way as an automobile's turn. Paths should allow a runner traveling at 10 mph to comfortably make any turn, but should discourage speeding cyclists from interfering with pedestrian traffic. Therefore, turns should have a radius of at least 9 feet but no more than 16 feet. This is especially critical at the entrance, where to deter unwanted uses. Bicycle use of the trail should be discouraged, as trail width is not suitable for combined pedestrian and bicycle traffic (FHWA).

Permitting

According to Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, this pathway project must receive a joint permit from Michigan Department of Environmental Quality (MDEQ) and the US Army Corp of Engineers (USACE) (Minor Permits). This form can be downloaded online (EZ Guidelines). A partially completed application is included with the project materials.

Projects qualifying for minor permits go through an expedited approval process, as they do not require a public notice, and there is less concern about the environmental impact (Sarkipato). In order to qualify for an EZ permit, a pathway in a wetland area may be no longer than 200 feet or wider than six feet. A boardwalk may not exceed 500 feet in length or six feet in width. Platforms are limited to 120 sqft in area. It may not be elevated more than 6 inches if it is located in the floodplain, where floodwaters are stored, or 4 inches in the floodway, which provides conveyance during floods. It must be open to allow water to flow beneath it (EZ Guidelines).

Due to the length of the trail, this project does not fall under the minor projects category. Therefore, it will require a fee of up to $2,000, and a public notice and decision period of up to 150 days. The public notice period gives concerned parties an opportunity to request a public hearing. A public hearing would likely add more time and effort to the approval process (Sarkipato). Natural Resources And Environmental Protection Act, Act 451, Section 324.30311 makes allowances for such projects, provided that the public benefit outweighs the cost and is not detrimental to 'aquatic resources' (Legislature). As is laid out in this report, both these requirements are fulfilled in this project and its design.

The approval process can be made easier if extra efforts are made to reduce adverse environmental impacts. One option is to create new wetland, but this is costly to implement. A more common tool for protecting wetlands is to create a conservation easement that forbids further development. Such an easement could be placed on village owned streets, lands, as well as private lands in the floodplain wetland following trail construction; however, the easement would prevent further trail development. Marginal improvements to the wetland could be made by increasing the length and frequency of boardwalk segments to allow the migration of small and fragile plants and animals. This would, of course, increase the total cost of the project (Sarkipato).

Even for non-minor permits, there are certain requirements for which the project should conform. Paths should not be elevated more than 6 inches if it is located in the floodplain or 4 inches in the floodway, as this would require a complicated flood impact study. The volume of fill should be limited to 300 cubic yards (8,100 cuft). Larger fill volumes require that a compensating cut be made to maintain the floodwater storage volume (Sarkipato). Due to the low lying nature of the floodplain, there are only small areas where this storage volume could be added, and would require significant impacts to the sylvan environment.

Pathway

Conventional widths for a path of this nature are 36-60 in wide with an additional 12-24 in additional side clearance and 8-10 ft vertical clearance (NCT ch.4). The paved trail should be 60 in wide to allow wheelchair access, in compliance with ADA code (4.3.4). It should not exceed a slope of 1:20 (5%), nor should it have a cross slope of greater than 1:50 (2%). The trail should include a resting area (with benches?) at least every 1200 feet, as is conventional for such trails (NCT ch.4).

Pathway materials should provide a coefficient of static friction of at least 0.6 in order to comply with ADA codes (4.5.1, A4.5.1). Pavement materials include…. Porous asphalt and concrete could be used to further reduce impacts on the wetland habitat and ensure a dry, slip-resistant walking surface. However, these pavement types are more costly to install and to maintain. The sylvan environment may further increase maintenance costs associated with cleaning tree debris off of the pavement.

Trail should be constructed of 2" asphalt over a suitable 6" aggregate base material. As necessary, loamy soil should be excavated to provide sufficient depth of base.

Boardwalk

Sections of the trail will need to be boardwalk in order to cross the open water at Old Augusta Creek and the Oxbow. Current plans estimate combine length of boardwalk to be about 50 ft. However, it more boardwalk may be incorporated into the project to cross especially low or muddy areas discovered during the initial trail layout. Increasing the length or frequency of boardwalk sections may be desirable to reduce impacts to the wetland habitat (see permitting).

The North Country Trail Association points out that canoe-able waters in some states may count as “navigable waterways.” This would mean that Old Augusta Creek and the Oxbow may require a bridge as high as 5 ft and require an engineer’s approval (ch.5). However, Old Augusta Creek or the Oxbow do not classify as navigable waterways in the State of Michigan, as they are narrower than 30 ft and carry no flow rate. Therefore they do not pass the “Floating Log Test” (Law Enforcement 6).

Although a 36 in wide (3 ft) deck would satisfy accessibility requirements, a 72 in wide (6 ft) deck width is more desirable. This is a common width for bridges along the North Country Trail, as the width of the bridge should not be an impediment to trail travel, accommodate any foreseeable increase in traffic, and because bridges places where hikers tend to delay. Furthermore, a wider trail decreases the need for railings by allowing greater space between pedestrian and the edge. Railings cost $15.61 /ft of boardwalk, $13.27 /ft (567%) more than the minimum required curb ($234 / ft). While the wider deck width increases the cost by at least $9.59 /ft, or $4,028, the elimination of railings will save $4,910. Building a 6 ft rather than a 4 ft wide deck reduces overall cost by eliminating the need for railings in many places, but increases the benefit by 50%.

Decking material may be any wood decking or dimensioned lumber. All wood used in construction should be pressure treated (NCT ch.5). Composite materials may be used for the decking, but would be more costly. For the purpose of projecting a cost, 1x4 pressure treated whitewood was used in the design. This is available at conventional contractor retail stores such as Home Depot.

The boardwalk is designed to support a uniform loading of 85 psf, which conforms to the industry standard for pedestrian bridges (REDD). The boardwalk deck must be at least 36 in wide to conform to ADA standards, but must have a passing area at least every 200 ft if it is narrower than 60 in (4.3.3, 4.3.4).

Boardwalk spans were designed in accordance with American Wood Council’s *LRFD Manual for Engineered Wood Construction*, with reference to International Codes Council’s *Design of Wood Structures* textbook. After working through a sample calculation by hand, the equations were programmed into a spreadsheet to determine the necessary beam size for a variety of span lengths. The spreadsheet then relates these beams sizes to a cost, determined by a table of lumber prices tabulated from the local Home Depot’s website. A plot of unit cost per span length can be found in Figure 3.

The board walk should be as high as possible, as elevating the board walk will help protect it from seasonal flooding; floodwaters rising above the beams and deck of the boardwalk will begin to lift the structure. Nevertheless, foundations should be designed to account for this buoyant force (Kusler), using either the friction of wooden piers or the weight of concrete pads to hold the boardwalk in place.

The soil in the riverfront area is classified as Glendora Sandy Loam, which is approximately 85% sand, 5% silt, 5% clay, and 5% organic matter. It has a specific gravity of about 1.6, or a weight of about 100 lb per cuft. It falls under the Unified Soil Classification (USC) of SC-

SM, and can also be classified as an AASHTO type A-4 soil. This information can be accessed via the National Resource Conservation Service's Web Soil Survey (NCRS WSS). However, this resource cannot give any information about the bearing capacity of the soil, which is necessary for foundation design. Moreover, it is important to field verify this information, as it may be highly variable throughout the area or may change with soil depth. Because the limited soil data demands expert testing and the design of pier foundations can be complex, the design of the foundation should be accomplished by a knowledgeable geotechnical engineer.

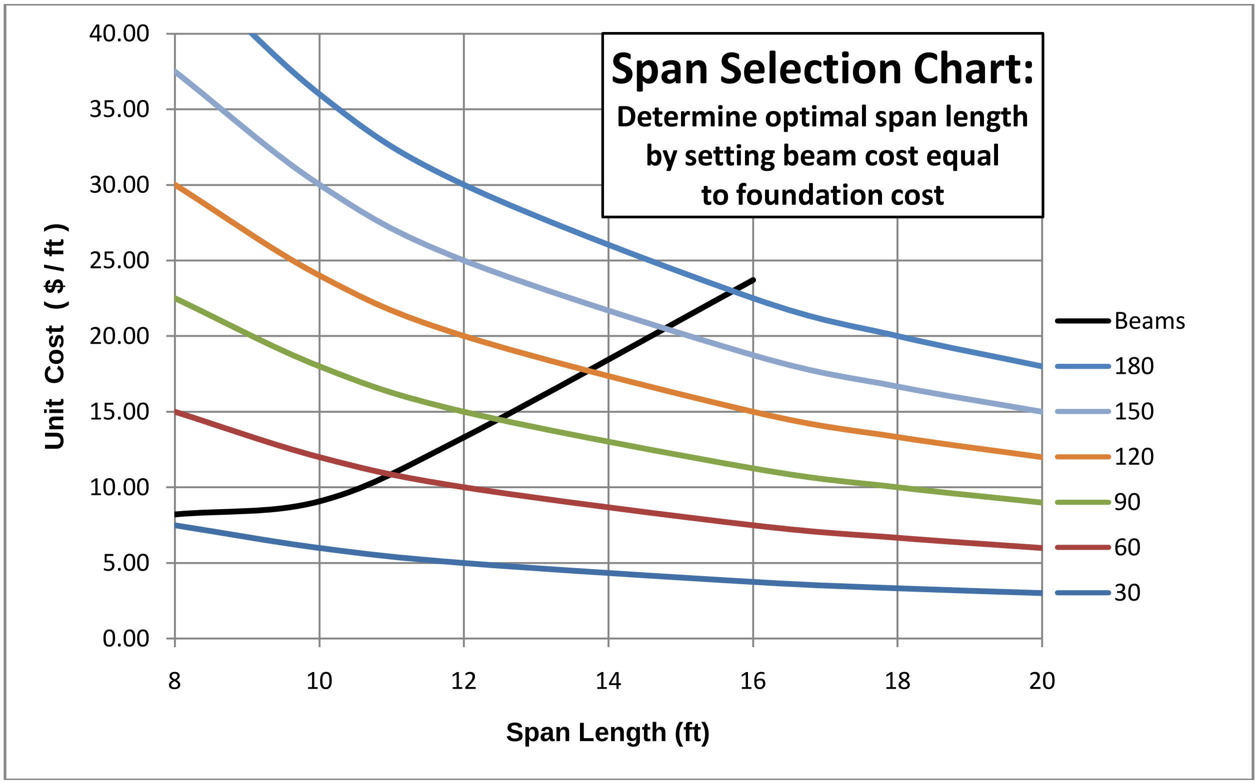

Figure 3 Span Selection Chart

To optimize the design of the boardwalk span and minimize cost, a span length should be selected such that the foundation costs and the beam costs are roughly equal. Decreasing the span length from this optimal point will decrease the number or size of beams; however, more foundations will be necessary and the overall cost will increase. The accompanying span selection chart is included to aid in this decision process.

The edge of the boardwalk should have curbs along the entire length to prevent pedestrians from slipping off of the deck (NCT ch.5). Railings are only required for structures elevated more than 30 in above grade, where they must take the form of a 'guard'. Guards are characterized by construction that does not allow the passage of a 4 in diameter sphere. They must be at least 42 in above the deck. Railings are required to withstand a strip load the highest point of 50 plf at in any direction, plus 50 psf over any 1 sqft of any other vertical surfaces; OR a point load of 200 lb in any direction at the applied at the highest point. Any attached handrails need to be between 34 in and 38 in high. Handrails should have a perimeter between 4 and 6.25 in and be no wider than 2.25 in with "rounded" edges, with a radius of at least 0.01 in. They should be at least 1.5 in off of any wall and must terminate at a post (Wagner). To eliminate the cost of constructing a guard plus a handrail, the structure should be less than 2.5 ft above grade at any point. A guard should be placed in the elevated section over open water in the region of Old Augusta Creek to eliminate the liability of falling. A complete railing may be desirable to further limit the liability of falls off of the boardwalk.

Implementation

Construction may require a NPDES site permit available from MDEQ. See Kusler for tips on easing construction. Costs associated with the project are shown in Table 1. A complete drawing will follow this report.

Table 1 Riverfront Trail Costs

Item	Unit	Quantity	Unit Cost	Total Item Cost
Decking - 1x4 pressure treated whitewood	ftT	420	$19.00	$7,980.00
Decking screws	ftT	420	$0.14	$58.80
Beams - pressure treated dimensional lumber	ftT	420	$26.00	$10,920.00
Foundations	ftT	420	$26.00	$10,920.00
Curb - pressure treated 2x6	ftT	370	$2.20	$814.00
Curb 2.5" outdoor screws	ftT	370	$0.14	$51.80
Guard_rail - 2x6	ftT	50	$12.85	$642.50
Guard Posts - 4x4	ftT	50	$2.05	$102.50
Chicken wire, 42" high	ftT	50	$0.53	$26.50
Guard screws 2.5" outdoor screws	ftT	50	$0.14	$7.00
Trail excavation	ftT	1224	$1.20	$1,468.80
Trail base aggregate	ftT	1224	$4.65	$5,691.60
Pavement	ftT	1224	$52.20	$63,892.80
Cut	cuyds	34	$21.00	$714.00
Fill	cuyds	52	$21.00	$1,092.00
Clearing	ftT	1644	$0.00	$0.00
Survey	hrs	16	$120.00	$1,920.00
			Subtotal	**$106,302.30**
			Engineering Design	$10,630.23
			Enginering Construction	$5,315.12
				$122,247.65
			Contractor Overhead	$18,337.15
				$140,584.79
			Contingency	$28,116.96
			TOTAL	***$168,701.75***

Augusta Millrace

Background

The millrace canal is the relocated channel of Augusta Creek which drains approximately 38 square miles from north of the village. It was dug in the mid 1800's for a saw milling operation. The canal runs north-south dividing the east and west halves of the village. The canal is crossed by three bridges. The Van Buren Street Bridges is historic in nature and has limited weight capacity. The Washington Street Bridge is not historic; however it also has limited weight capacity. A map showing the canal and its previous path is shown in Figure 4.

The Augusta Creek upstream of the dam located south of M-96 is a designated trout stream; however, according to village officials this artificial portion of the creek does not currently contain trout. This is partly due to the artificial geometry and low slope of this portion of the canal, but may also be due to sediment and pollutants from stormwater discharged from the village streets via an existing 18 inch pipe. Figure 5 shows the artificial millrace canal looking downstream from Washington Street. Figure 6 shows the natural Augusta Creek North of the millrace canal.

The Village of Augusta first expressed a desire in their working papers document to develop the millrace into a trout stream. The project is also included in the Village Recreation Plan for Augusta that is currently going through a public input process. The village would also like to improve the aesthetics of the millrace and decrease the possibility of flooding. Any project done should consider these objectives.

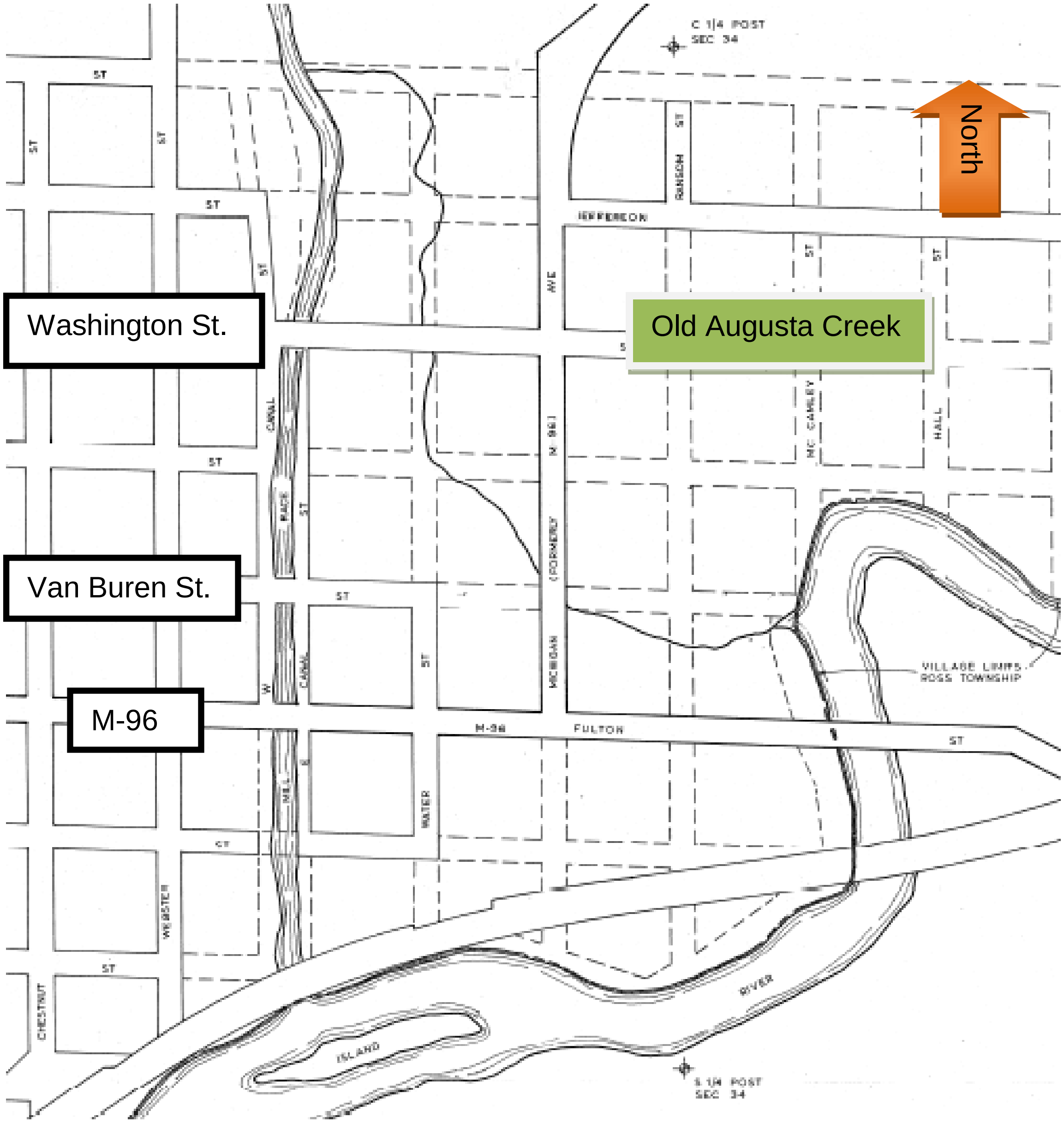

Figure 4 – Millrace Canal Path through Village

Figure 5 - Millrace Canal Looking South from Washington Street

Figure 6 – Natural Augusta Creek North of Millrace

Problem

The millrace channel does not currently support trout habitation and reproduction.

Objectives

Change the conditions of the canal in order to meet the needs of trout.
Improve the aesthetics of the canal and surrounding area.
Decrease the likelihood of flooding within the village.

Criteria

Any design seeking to meet this objective must follow the following criteria. These follow the pattern for design criteria set earlier in this document and are outlined to be specific to this problem.

1. *Objectives*
   The design must improve the trout habitat within the village as much as possible.

2. *Cost*
   Since the canal is currently underused for recreation a study of projected future use will be necessary.

3. *Maintenance*
   The design should require little maintenance and be inexpensive to implement. Any significant ongoing maintenance should be included in the total cost for the project.

4. *Constructability*
   During construction, access must be maintained to all houses along the Millrace Canal.

5. *Safety*
   Any project in this area must be safe for everyone. Any proposed work must also not increase the chance of flooding within the village.

6. *Appropriateness*
   The village would like this project to beautify its canal as a method for improving local and regional access. Any solution which diminishes the current aesthetics is clearly unacceptable. Any work in this setting will need to be done with the input of residents, particularly the residents who live along the canal.

7. *Equity*
   An important consideration is handicap accessibility. Currently handicap accessibility in this area is poor; we plan to improve it with our project.

Project Options

Restoring the millrace to a point where it will support trout is a complicated task discussed in detail later in this report.

Do Nothing

The benefits from restoring the millrace to a trout stream are largely immeasurable. Furthermore, the in-depth analysis necessary to determine the effectiveness of any such project is not available.

Design Overview

According the a report written by Ron Pierce for the Montana Fish, Wildlife, and Parks (a Montana state agency), identifying clear and attainable restoration goals is the first step in the process of any natural restoration project. The premise is that the natural environment around us has been irreversibly altered by human activity. Returning the environment to its natural state is not an attainable goal. Because of this having clearly defined standards in this area is not beneficial. Instead projects are done on a case by case basis, identifying goals that have the most benefit to the stream with the least effort. The effort can be both a cost issue and a political issue. The scope of project is also highly dependent on identified goals.

The specific restoration project categories laid out by Pierce are as follows:

- Enhance Stream Flow
- Enhance Spawning (Non Flow Limited)
- Restore Pool Quality or Quantity
- Stabilize Stream Banks and Reconstruct Channel
- Enhance Fish Passage (ex. Culverts)
- Restore Vegetative Health
- Eliminate Fish Losses to Drainage Ditches
- Dealing with Fish Diseases
- Management during Drought
- Working with Private Landowners

It is worth noting that many of these goals are more political goals than engineering goals, depending on prevailing land uses within the watershed. For example, in Montana where Pierce is working the low flow conditions necessary during drought can only be met by restricting water use to land owners across the entire watershed. These objectives are usually defined by biologists through years of careful data gathering and analysis. Ron Pierce is in fact a fisheries Biologist not an engineer. Further in his reports he outlines the rigorous process used to assess the needs and define foals for the entire black creek watershed.

This is important to know because in the case of the Augusta Creek none of this preliminary work is available. The only goal is to get trout to live in the artificial portion of the Augusta Creek. In this case, to parallel the possible goals listed above, the lack of fish is due to a lack of pool quality and quantity. Any design specified by Team 15 is for the engineering aspects of the project only and must be reviewed and verified through a biological study to ensure its effectiveness. This also leads to several design directives. First, it is not warranted to spend a significant amount of money or time on this project. The biological study that would assess the effectiveness of any proposed project is not available thus the chances of success in the biological goals of the project are uncertain. The engineering time spent on the project by Team 15 is educational in nature, but if done by an actual consultant it would likely make this project un-warranted unless a larger study was done to ensure the effectiveness of a more complex project. Secondly the project should be simple and easy to modify if it does not work. Again, since the data needed to assess the effectiveness of a solution is not available it will be difficult to ensure that it will work completely as designed. The flow and flooding aspect of the project is possible to analyze but the behavior of the fish is a much more difficult problem.

Project Specific Constraints and Assumptions

pH and Other Water Quality Constraints

Trout can tolerate pH levels between 4.1 and 9.5. Trout like slow flowing streams which allow them to exert less energy to stay in place, but they cannot handle stagnant water because they need plenty of dissolved oxygen. Water quality in this section should support trout, as it is similar to the water quality upstream, therefore the pH constraints should be met. Several village storm sewer outlets may be a significant reason that trout do not live in the portion of the stream within the village. A first flush rain event may alter the pH briefly though it is unclear how this would affect the fish. In depth testing would have to be done to establish a relationship. However, the village has already performed the design of an interceptor sewer that will carry all stormwater directly to the Kalamazoo River effectively solving the problem. This Design is shown in Figure 7. Because of this it is assumed that the outlets will not affect the design.

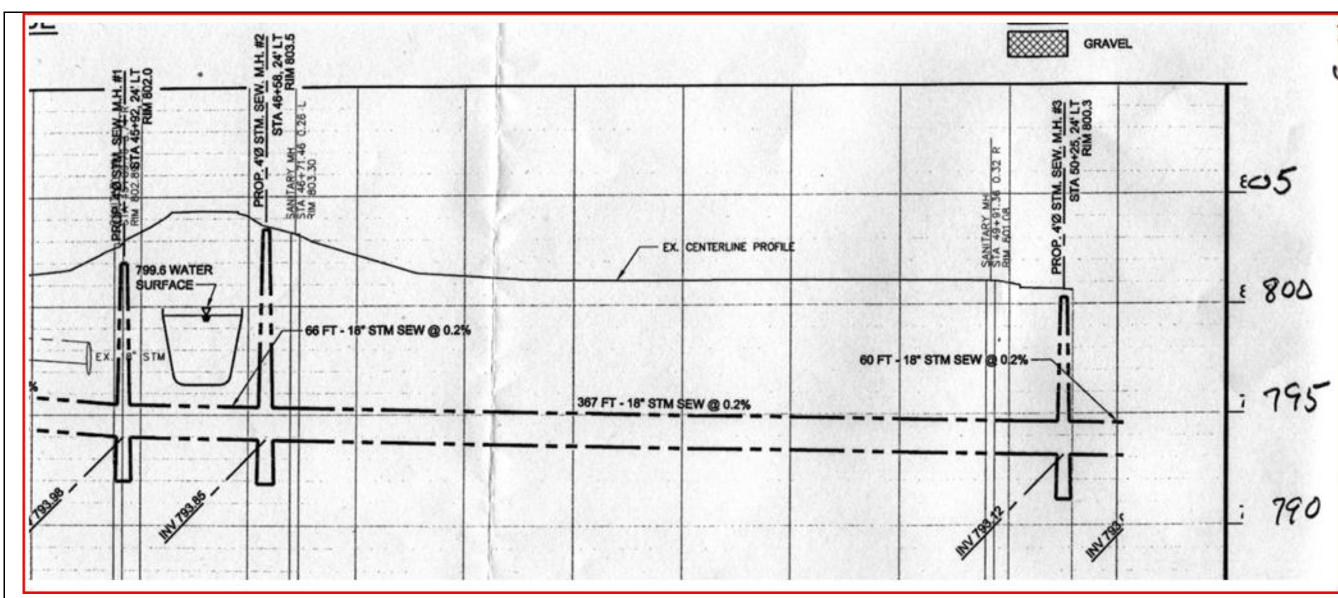

Figure 7 – Proposed Storm Sewer Design (By Others)

Temp Constraints

Trout prefer water temperatures between 50 and 65 degrees Fahrenheit. Bank cover is essential for maintaining this range. There should be shade from brush, fallen trees, or tree roots along the banks.

Velocity Constraints

The most productive trout streams have a gradient from 0.5 to 2 percent (drop of 25 to 100 ft per mile). This is a concern for the velocity of the channel. If the gradient is below 0.5 percent the stream is likely to have a silty bottom and water temperatures too high for trout as well as low dissolved oxygen content. If the gradient is more than 2 percent the velocity will likely be too high for trout to be comfortable.

Bridge Constraints

There are three existing bridges over the millrace within the village. These bridges represent points in the creek where we cannot modify the bottom or bank configuration to fit our design. The bridges also represent points in the channel where it is narrower thus the velocity is higher. This could be an asset if utilized correctly. Moreover, the M-96 highway bridge is planned for replacement in 2010 but the current plan is to keep the road surface at the same elevation. It is currently unclear if the center pier configuration will be replaced with a single span. This is significant for determining flood elevations and velocities. Because a center pier is the most severe case it will be assumed in all calculations.

Structural Constraints

The FEMA flood insurance study predicts that there will be no flooding within the village. According to the study in 1978 the village experienced a 500 year flooding event with no significant flooding. However, in the time that Glen Avis has worked for the Village of Augusta there has been two times where village workers have needed to sand bag the creek to protect homes from flooding. The first flooding event was due to a bank collapse north of Washington Street, when a tree uprooted during a storm, damaging the bank. This caused the water from the creek to follow the old course of the creek causing some backyards to flood. The village was able to sand bag the opening before significant damage happened. The second flooding was due to ice build up on the dam. The village sand bagged several low spots to prevent flooding. This indicates that the greatest risk of flooding is not high flows in the canal. While these concerns are beyond the scope of our project, the village currently maintains the bank and a 12” culvert that all the water must pass through to get to the Kalamazoo River if it leaves the millrace to prevent flooding of homes if bank overtopping occurs.

It was also noted during the survey that only 2 of the seven floodgates on the dam are operational. The other gates are immobilized due to failures in the lifting system. Improvements of these gates are beyond the scope of this project; however these other gates should be repaired or replaced in kind as they are accounted for in the flood insurance study. It is assumed that all gates are operational for the purpose of design. The gates are small enough so they could lifted or broken free easily by a person if a significant flooding occurred and then repaired or replaced afterward.

Problem Overview

The slope of the millrace is mostly below .5 percent so it will be a challenge to provide the required dissolved oxygen, velocity and temperature. Also, the unnatural shape of the channel will make these difficult to attain. The only ways to solve this are a modification of the geometry of the channel, strategic placement of obstructions within the channel to affect flow characteristics, or some combination of the two. The placement of obstructions is preferred because it is less expensive as well as easier to deploy and remove/replace should it fail. Trout streams usually have many sharp curves; these create deep pools and shallow areas. Since the creek is located in a developed area with existing bridges over it, it is impractical to relocate it to add curves. Possibility some water could be diverted down the old creek bed to lower the flood elevation if necessary.

This project has been difficult to design accurately. It is not entirely clear what will get trout to live in this area. Improvements can be made to improve the factors that encourage trout habitation and reproduction but it will still be unclear whether the trout will thrive. This type of work is based more on general guidelines on what types of things should be included than on actual codes that must be followed. Also modeling presented challenges because sparse survey data and difficulties with modeling extremely local conditions. For example the model will predict how an obstruction will affect the upstream water level for flooding purposes but will not adequately explain how the water flows around the object, especially if it is a complex shape. This design tries to account for as many factors as possible. Furthermore it will be beneficial to construct the project is several phases so that the effectiveness of one phase can be gauged before attempting the next phase.

Several similar projects use obstructions such as rocks and logs for shade and to direct flow. It does not appear that a hydraulic analysis was necessary in any of these cases. The solutions are reached by biologists and geologists with little engineering work. Figure 8 from montanatrout.org shows an example of this type of project where logs are used to provide shade and direct the flow of water. Figure 9 from the US fish and wildlife service shows an example of rocks being used in both a before and an after picture.

Figure 8 – Logs Used as Cover (montanatrout.org)

Figure 9 – Rocks Used to Create Habitat (montanatrout.org)

The obstructions are all naturally occurring objects that can randomly end up in the river. Although this largely overlooks the potential flooding aspects it is an acceptable assumption in most cases. Typical restoration projects are done in rural areas. The chances of small obstructions occurring within the low flow channel of a large floodplain drastically changing the flood elevation are minimal. However, in the case of Augusta there is no floodplain to speak of so the flood elevation is more volatile with changing flows. There is also direct flooding danger to property owners on the east side of the millrace if it were to overtop its banks. The millrace's primary purpose is to carry water through the village efficiently so the trout habitat is second to that.

FEMA Modeling

Because of direct flooding danger it is clear that a hydraulic analysis is necessary to ensure that that any modifications to the channel will not cause flooding. A FEMA flood insurance study of the area was done in 1978 by Commonwealth Associates. The survey data was obtained from this study and used again in a model for this project. The survey data was further verified by a Calvin College student survey crew on February 16, 2008. The model was constructed using the HEC-RAS program developed by the US Army Corps of Engineers. The model of existing conditions closely predicts the model of the previous flood insurance study. The model does vary slightly from the previous model with the same data. Likely this is due to differences in the way HEC-RAS calculates losses at bridges as opposed to its predecessor HEC-2. The survey from the previous study appears to be suspect in some places and deficient in others. For example there does not generally appear to be enough cross sections to accurately represent the stream shape. Also cross sections are re-used at different locations within the model. Because the project does not have money to re-do the survey the previous survey will be used. Several modifications were made to the survey, however, to account for differences seen in the field during the field survey. These changes are listed in the model notes and include bridge low chords, obstructions, and details with the weir.

It is also worth noting that there is a disparity between what the model suggests, which lines up with accounts by village officials, and the FEMA model. The FEMA report asserts that water does not leave the channel north of the village and flow down the old creek bed by overtopping the floodgates that were used to divert the creek originally. The village officials indicate that this does happen. The HEC RAS model shows the Washington Street Bridge being overtopped; if this were to happen water would certainly leave the channel. If water were to leave the channel it would provide a large amount of storage north of the village that would reduce the flow significantly through the village. Water leaving the channel north of the village does not immediately present a flooding danger to any homes. It is not feasible to investigate this further as is would require a significant amount of survey data. Assuming the water does not leave the channel is conservative so that assumption will be used for the remainder of the design.

Finally, according to the project HEC-RAS model, the distance between the 100 year water surface and the top of the bank is less than the three feet required by the new US Army Corps of Engineers regulations for them to act as levees. This means that if the FEMA study is re-done in the future, some or all of the village east of the creek could be included in the 100 year floodplain. This in no way affects the design of this project because it is not a change in actual conditions, just a change in the rules for what can act as a levee. Making the assumption that all water remains in the channel is still the most severe assumption because the flow area in that condition is the smallest. This change could, however, affect the rates paid for flood insurance by the affected property owners.

Design Summary

Figure 10 shows a longitudinal cross section of the creek through the village generated by HEC-RAS. A 10 year water surface is shown for reference. Notice the three bridges to gain perspective of the cross section.

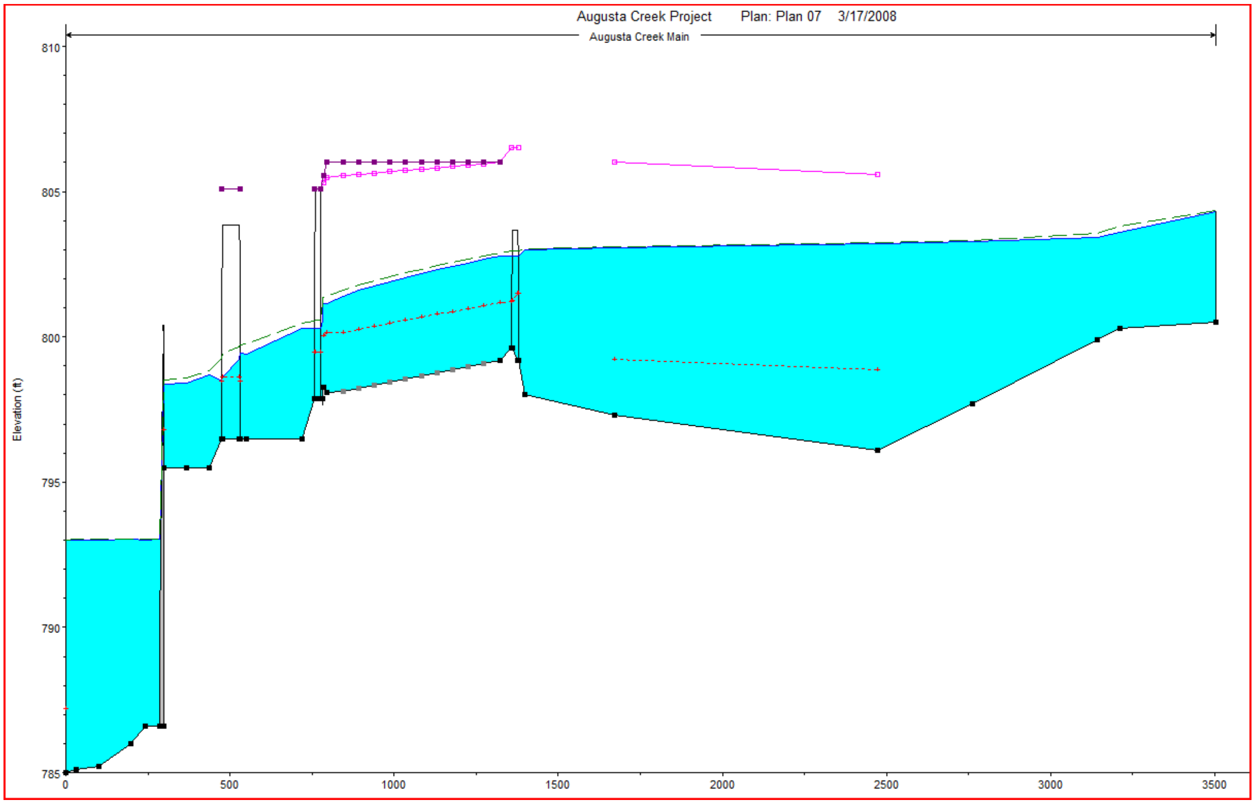

Figure 10 – Longitudinal Cross Section of the Millrace Canal Showing a 10 Year Water Surface

There are three distinct areas within the reach of the creek through the village: First the right half of the profile in Figure 10 is a wooded area north of the downtown area. The middle area is the regular channel through the developed part of the village. The area on the left side of Figure 10 is the area where water backs up behind the dam. The boundary between the second two areas is not as clear as the first but there is a point where there is a distinct change in flow characteristics. The change is somewhere between the M-96 Bridge and the Van Buren Street bridge. Each of these areas has different flow characteristics and thus different potential for developing habitat.

Areas

Millpond Area

The right half of the cross section of the profile is north of the village. This is the old millpond, it was flooded all the time when the dam was used for milling, but is now a swampy area. It is unclear whether trout currently reside in this area. It has ample tree cover as well as rocks and logs for trout but it is deep and slow. Work in this area would be difficult because of houses around the area with no good route in for equipment. The swampy soils would also make any construction difficult. Given that the area is not a barrier for trout passing downstream and it has some aspects that are favorable for trout life, no work is recommended in this area.

Area Upstream of the Dam

The area upstream of the dam is characterized by slow moving deep water. This makes it extremely difficult to create the pools and riffles necessary in this area without modifying the dam. The dam also presents a hazard for any trout residing in this area. Because of the impractibility of developing this area and to minimize trout losses over the dam no work is recommended in this area.

Middle Area
The area roughly between Washington and VanBuren Streets presents the best opportunity for trout habitat development. The stream reach is approximately 600' long and 25 to 50' wide depending on the water surface elevation. It is recommended that improvements be considered in this area to promote trout habitation and reproduction.

Procedure
There are two distinct problems that must be satisfied through the placing of structures within the channel. First, there is a lack of pools and riffles. These are normally caused by a meandering of the thalweg, or low flow channel, within the creek bed. This is especially important for trout reproduction. Secondly there is a lack of adequate cover for trout to hide under. The regular "V" bottom nature of the Millrace canal will make this difficult to achieve. In one way these problems are separate. The structures needed to solve them are unique. The structures will have to be placed in conjunction with each other. Cover areas need to be areas of low velocity. In a regular channel like the one in Augusta the only way to get areas of low velocity is to use deflectors or dams. Hunter recommends that the cycle be approximately 5 to 7 channel widths as shown in Figure 11.

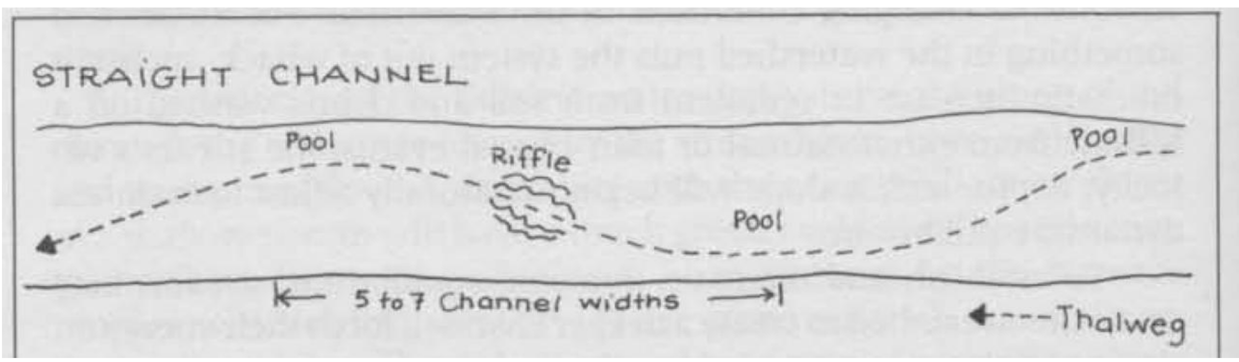

Figure 11 – Thalweg Meandering within a Straight Channel

Pools and Riffles
There are several options available to create a meandering of the thalweg within the regular channel. The first option is a dam. A dam is any structure that extends across the entire canal backing up water behind it. A dam is desirable because it creates a very good pool of slow water behind it for insects to breed. A downside to a dam is that it can accumulate sediment in the deep pool behind it. Dams are not useful in low gradient streams like Augusta Creek because they back water up too far upstream. A second option is a system of deflectors. A deflector guides the current instead of stopping it. We looked two types of deflectors. The first kind consists of triangular structures placed along the bank on alternate sides at regular intervals to create a sine wave like meandering of the thalweg. The second kind consists of obstructions placed in the middle of the creek, directing the flow around them. Deflators must not back significant amounts of water up behind them. They also must not accumulate debris behind them. Figure 12 shows a decision matrix used to select a structure to generate pools and riffles.

	Effectiveness	Cost	Maintnence	Saftey	Asthetics/Approiatness	Total
Weight (0-10)	10	2	5	10	7	
Dam	2	5	2	5	6	132
Deflectors in Middle	7	7	3	7	9	232
Deflectors on Bank	9	5	5	9	6	257

Figure 12 – Decision Matrix Used for Selection of Pools and Riffles Solution

Through the decision matrix it was decided that obstructions along the bank would be used. They are the best choice for the Augusta project because they are they are the most effective for a low gradient straight channel. They are also the safest because they do not direct flow into the banks. They are less natural than the obstructions in the middle but that is canceled out in the decision matrix. The dam is ruled out because of its unsuitability for low gradient channels and the danger of flooding.

Two different sizes of rock pile obstructions were considered. The two sizes are obstructions that extend halfway across the canal and obstructions that extend 1/3 of the way across the canal. These sizes were used because they would be aesthetically pleasing and simple to build. Their height of the obstructions was assumed to be the water surface elevation computed by HEC-RAS using the existing conditions with an average day flow rate. The small obstructions produce a maximum of .1 feet of rise to the 100 year flood elevation while the larger obstructions produce approximately .25 feet of rise. Figure 13 shows the HEC RAS predicted rise in water surface elevation. The small circle is a detail of the maximum rise location. While both of these are acceptable from a flooding standpoint the smaller obstructions are preferred because they produce less rise to the water surface elevation. The final design calls for 1/3 width obstructions however, it is assumed that the rock will taper down to the bottom of the canal at about the halfway point. In this case variability is preferred because it will generate more turbulence in the water.

Figure 14 shows the average velocities in the channel during both a 100 year storm event and the average base flow that we are designing the obstructions for. During the low flow condition the obstructions increase the average velocity by reducing the cross sectional area. They also reduce the velocity between them by increasing the water level and thus the flow area. This change in velocity is what is desired for the trout. During the flooding event the water level rises above the obstructions and they have a much smaller affect on the velocities.

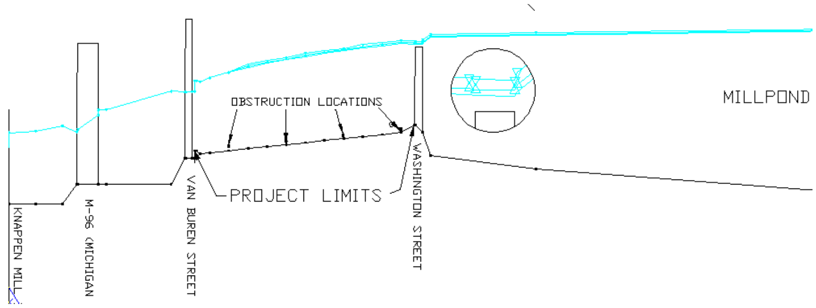

Figure 13 – HEC-RAS Predicted Rise in Water Surface Elevation

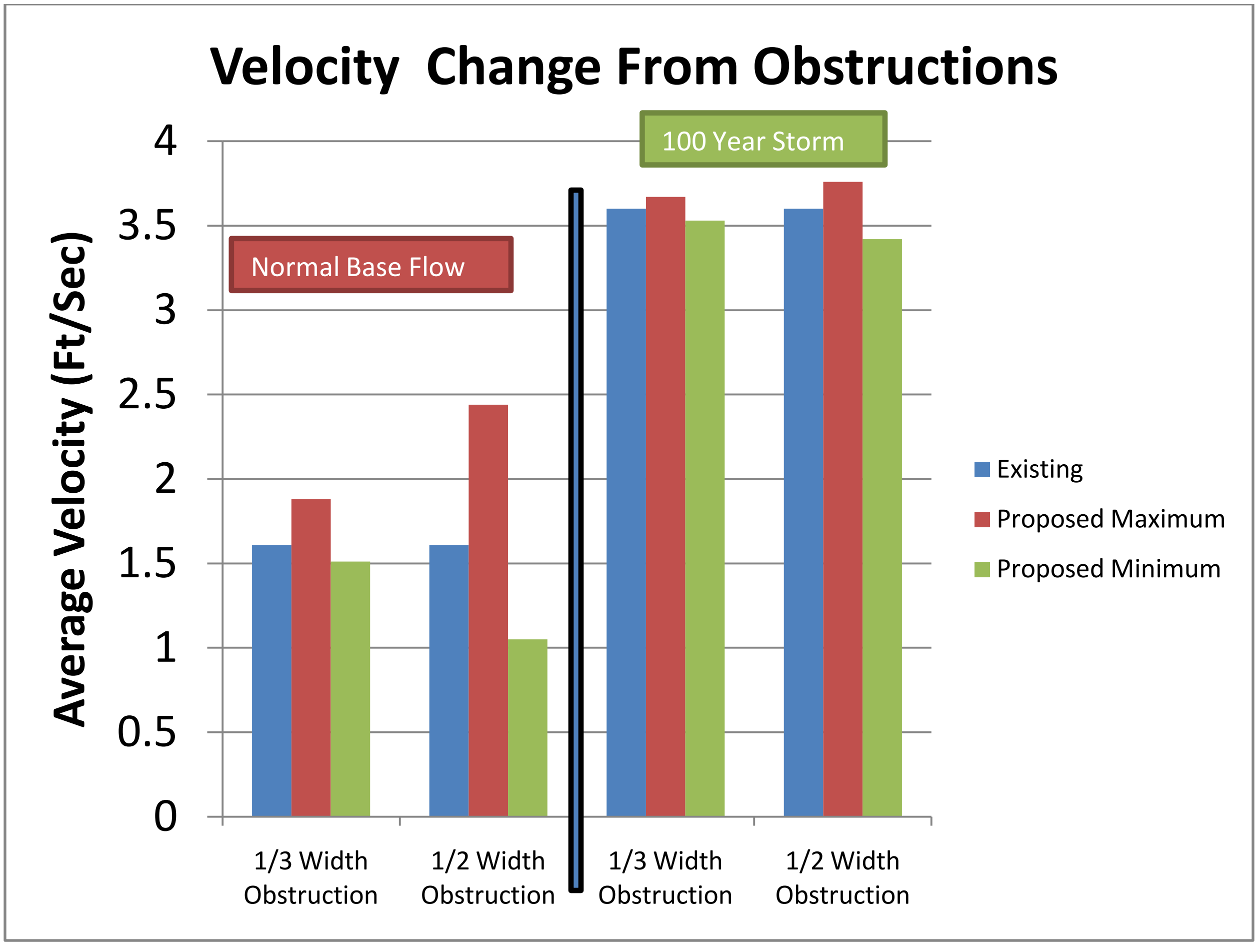

Figure 14 – Velocity Change from Obstructions

Cover

There are several options available for providing cover. Cover is best in areas with low velocity so it would be best to locate cover on the opposite banks across from the deflectors. The first option for providing cover is plant material. In order to provide cover it must be native plant material that the trout are used to. It must also be tall and thick enough to provide cover. It is doubtful whether this would work because of the lack of floodplain in the village. Plants usually grow in shallow areas along the side of the main channel. A second option is to engineered structures. Some examples of these are shown in Figure 15.

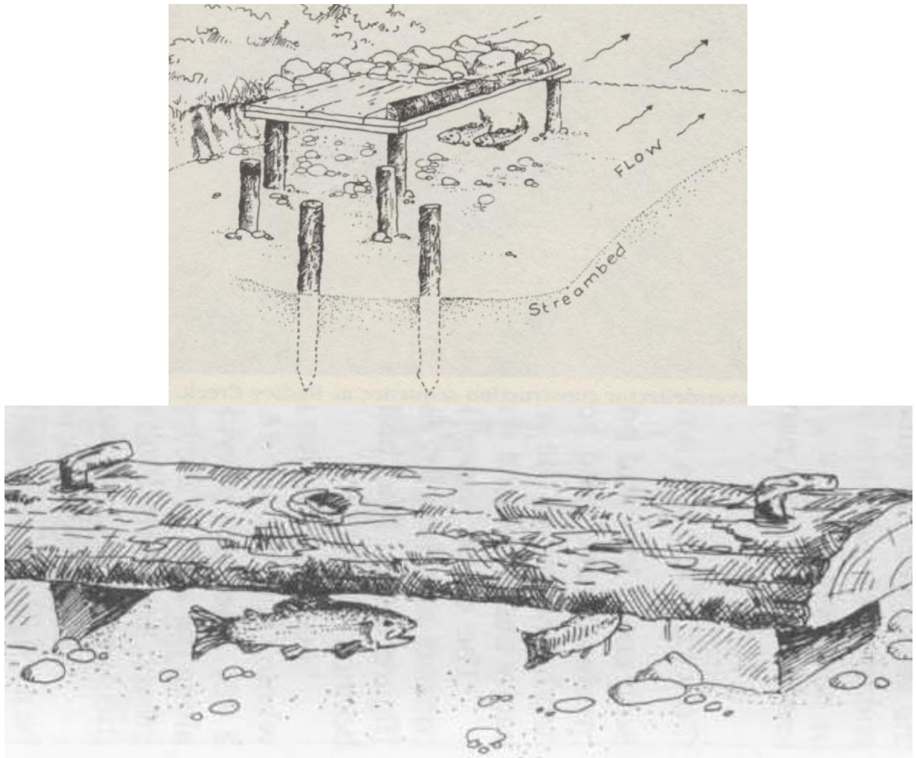

Figure 15 – Examples of Engineered Cover

The final option looked at is bank overhang. An example of this is shown in Figure 16.

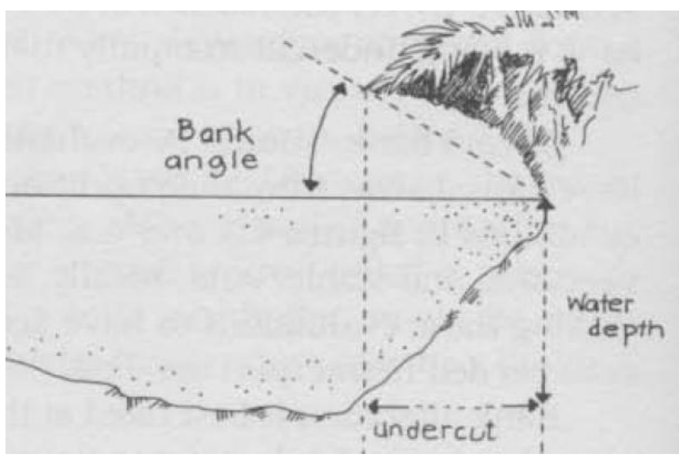

Figure 16 – Bank Overhang Cover

Bank overhang is one of the most common types of natural cover. In the village this may not be a good option because of safety concerns with undermining the banks as they function as levees during storm events. Figure 17 shows a decision matrix used to decide on a cover structure. The selection of type of cover made is strictly for the engineering feasibility aspect. The placement and amount of such cover must be made through a biological study.

	Effectiveness	Cost	Maintnence	Saftey	Asthetics/Approiatness	Total
Weight (0-10)	10	2	5	10	7	
Plant Material	6	7	2	9	6	216
Artifical Structures	5	3	8	9	5	221
Undercut Bank	6	5	3	1	1	102

Figure 17 – Cover Design Decision Matrix

Through the decision matrix it was decided that artificial structures would be used. The possibility of using plant matter as cover for artificial structures is still possible but it has been eliminated for exclusive use.

Budget

The possible budget for this project is still very much open for debate. The Village of Augusta is committed to completing this project regardless of cost. A lower cost will simply compress the timetable of the project. It may be beneficial to do this project in phases to spread the cost out over a longer period.

Permitting

Several permits will be required for this project. Completing these permits is beyond the scope of this project. A NPDES permit will be required for soil erosion because the construction site will be more than one acre. Although filing the permit is not part of the project, erosion control measures will be included in the plans and the cost analysis. A joint permit application between the Michigan Department of Environmental Quality and the Army Corps of Engineers will also be required because of the impact with the stream.

Village Work Participation

The village of August could perform some or all of the work for the project. It is unclear how much if any work the village would be able to perform as part of the project. For the cost analysis the prevailing labor rates will be used assuming the village will not do any work. If the village can perform any of the work themselves with excess capacity they already have it lower the total cost of the project.

Project Phasing

As indicated earlier it is beneficial to break this project into phases, making it possible to build the project slowly as funds become available. The project will be phased by breaking the design up into identical components along the stream reach. A single component is made up of a pair of deflectors, one on each bank, and the fish hiding structures associated with them. There are also some fixed costs that will be needed regardless of the size of the project. These include any mobilization fees and most of the erosion control measures. To facilitate this project phasing the costs will be broken up on a per-unit variable cost and a fixed cost. The total project cost will also be calculated.

Recommendations

Schedule

A biological study must be completed before this project can move forward.

Drawings

Three drawing sheets have been prepared for this project. Drawing TS-01 shows a plan view of the creek with approximate locations of obstructions shown. Drawing TS-02 shows profile plot of the creek and a typical cross section. Both of these show the change to the 100 year water surface elevation calculated by HEC-RAS. Drawing TS-03 shows details of the obstructions being recommended.

Costs

Figure 18 presents a line item cost estimate for the trout stream rehabilitation project. This estimate does not include a review by a biologist. This would likely be done by Michigan State University as they have a biological center in the area.

Item	Unit	Price	Quantity	Cost	
Rip-Rap Installed	Syd	37.95	50	$1,897.50	
Erosion Control	Ft	3.45	200	$690.00	
USACE/MDEQ Joint Permit	Ea	2000	1	$2,000.00	
Surveying	Hrs	120	16	$1,920.00	
			Sub Total	$6,507.50	
			Engineering Design	$650.75	10% of Subtotal
			Engineering Construction	$325.38	5 % of Subtotal
			Sub Total	$7,483.63	
			Contractor Overhead	$1,122.54	15% of Subtotal
			Sub Total	$8,606.17	
			Contingency	$1,721.23	20% of Subtotal
			Total	**$10,327.40**	

Figure 18 – Trout Stream Costing Sheet

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