Final Report
An analysis of crossing Whisky Creek

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Executive Summary

Whisky Creek in Grand Rapids, MI separates residents of the Holland Home from the Woodlawn Ministry Center and Calvin College, forcing them to walk around long distances in sometimes treacherous conditions to reach Calvin’s campus. The Holland Home is a retirement community, which means that the elderly are most inconvenienced by the lack of a direct path across the creek. A bridge or path project was proposed in order to provide a safe, quick, and elegant means of crossing the creek.

Challenges facing such an undertaking originate in both design and communication of the project. Logistically, many different clients could take part in the project. The north bank of the creek is owned by Calvin College (with nearby land leased to the Woodlawn Ministry Center), and the south bank is owned by the Holland Home and Raybrook Estates. This requires vigilance on the part of the design team to please all parties involved and sort out responsibility for the crossing.

In designing such a crossing, the team made some design choices. The first decision was to make a barrier-free crossing. As many people from the retirement community have physical limitations, to design for ramps with mild slopes as opposed to stairs was the right decision. A more difficult choice was whether to build a bridge or a pathway. Some alternatives discussed were building a bridge from one bank to the other, putting a culvert in the creek and filling the valley to create a surface for a bituminous path, or a mix of the two.
The team puts forth two designs, both of which strive to be economical, safe, and attractive. The recommendation is for a bridge and path design, though a culvert and path design would be satisfactory as well.
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1. Introduction

1.1 Team Description

Team Bridge consists of four senior engineering students with a civil/environmental concentration. Eric Eylander is from Lansing, IL, has also completed the pre-medical program and plans to attend medical school in 2011. Ryan LaReau would like to continue pursuing engineering, possibly in the field of hydraulics and water resources management near his hometown of Lansing, IL. Dan Vroom is from Orland Park, IL, and would also like to find work in the civil engineering field, with special interest in structural engineering. David Westlund does
not plan to return to his hometown of Bettendorf, IA long-term. He would like to pursue
civil/environmental engineering in Minneapolis as his fiancée attends University of Minnesota
graduate school for Speech Pathology. All four graduated with a B.S.E. in May, 2010.

1.2 Project Location

Our project includes building a crossing over Whisky Creek. The area of interest for this
project is located just south of Calvin’s Burton Street entrance. The crossing will be primarily
used by the retirement community on the south side of the creek and the Woodlawn Christian
Reformed Ministry Center on the north. Residents that live in both Raybrook Homes and the
Holland Home travel to Calvin’s campus regularly for both Calvin events and to attend
Woodlawn’s services at Calvin’s chapel. The ministry center and its parking lot lie immediately
to the north of this Whisky Creek tributary. This building is owned and operated by Woodlawn
CRC, though the land is owned by Calvin College and leased to Woodlawn. The crossing had to
be within about a 100 foot section of the creek between Little Heron Court to the south and the
Ministry Center’s parking lot to the north. Its exact location is 104 feet east of the west edge of
the parking lot, so as to preserve as many trees as possible and make ADA compliance more
financially and spatially attainable.
1.3 Project Definition

Team Bridge is focused on designing a crossing that will span Whisky Creek. This takes the form of two design alternatives: a bridge or a culvert. Either option must meet the needs of the retirement community sufficiently and provide its residents with a quick and safe way to commute to Calvin’s campus. This project explores these two alternatives to ensure that the clientele (Raybrook, the Holland Home, and Woodlawn) are offered the solution that would best suit them. In both design options, a bituminous ADA compliant path will lead to and from the crossing, providing a safe, efficient, and scenic path accessible to a vast array of people. The residents of the Raybrook Homes currently take alternative routes to Calvin that are both long and potentially unsafe. Our goal was to offer them a safe and fast way to travel to Calvin’s campus that will not cost more than necessary or ruin the surrounding environment.
2. Project Considerations

2.1 Objectives
Our main objective was to provide a safer, easier way for residents of Holland Home and the Raybrook community to access Calvin’s campus. The current route to Calvin’s campus from these communities, shown in Figure 2, requires walking down Raybrook drive to Burton St. From there, people must walk west down Burton St. to Calvin’s Burton St. entrance.

![Figure 2: Current Path from Retirement Communities](image)

Our proposed solution bypasses the route shown in Figure 3 by providing a safe, wheelchair accessible route that crosses Whisky Creek.
As shown in Figure 3, a route that crosses Whisky Creek would significantly decrease the length of a trip from Holland Home and the Raybrook community. The proposed solution across Whisky Creek also provides a safer, easier, wheelchair accessible route to Calvin’s campus. The design process was very enjoyable for our team, as it allowed us to participate in a project that has the potential to help others. It also allowed us to learn more about the design process as well.

**2.2 Design Norms**

There are two main design norms which we have considered for this project. The first is trust. The final product must be something that is sturdy and reliable. Whether a bridge is chosen or a pathway with a culvert is chosen, there are safety concerns. If the bridge is poorly
designed or constructed, people could get seriously injured or even killed. If the culvert design
does not properly handle flooding conditions, the backfill could be compromised, and the area
could potentially be flooded. There are many scenarios in which safety becomes an issue. The
final design must be one that has accounted for every possible safety concern so that potential
users of the bridge are confident in its reliability and trust the design.

The second main design norm we have considered is caring. It is very important that we
consider the consequences and ramifications of our design. Considerations such as proper
design fall into caring as well; however, caring encompasses more than just safety and trust
concerns. We must consider the potential users of the bridge, particularly the elderly. Our
design must account for those who cannot transport themselves as easily as they once might
have been able to. The design must also account for those with disabilities and provide
wheelchair access. Also, we must consider the environmental impact of our bridge. Our design
calls for clearing some trees and vegetation; however, while the south path design requires
minimal tree removal, the location selected for the actual crossing of Whisky Creek will not
require any large tree removal. This design also must also consider being stewards of the
resources given to us. We must make our design cost effective and efficient to properly use the
funds given to us, especially in such economic times as these.
3. Site Conditions

3.1 Elevations and Topographic Maps

Due to the location of the bridge site, determining the elevations and obtaining topographic maps is an important step. The site consists of a ravine ranging from 18 feet deep on one side to 10 feet deep on the other, with Whisky Creek flowing at the bottom of the ravine. Because the creek is small at this point, there are several alternative paths between the two sides other than just a bridge from the top of one bank to the top of the other bank. The topographical data plays a key role while considering alternative bridge designs. The elevations are especially important in determining how to account for the elevation different between the two banks. If the bridge was a straight shot across the ravine from the Ministry Center parking lot to Little Heron Court, then the elevations would determine the slope of the bridge and whether a curve would be needed to increase the bridge length and decrease the slope. Also, the contour maps would be necessary in deciding path and steps locations if a culvert or shorter bridge was used lower in the ravine. Earth used for backfill would also play a large role in the cost of the overall project. The total volume of fill necessary can be determined with topographical maps so that estimate can be made to the cost of fill needed.

Topographical data was provided by Brad Boomstra from Kent County Drain Commission. The topographical map shows two foot contours for the entire area. The topographical map of the bridge site can be seen in Figure 4.
Along with the topographical map, Brad Boomstra also provided the team with some hydrologic data such as peak flows and time of concentration of the surrounding areas that make up the watershed for Whisky Creek.
3.2 Soil Characteristics

The soil characteristics of the bridge location were also necessary information while designing the bridge. This information will help determine the bearing capacity and the necessary columns and supports. It will determine the piers of a bridge or the fill above a culvert. The soil characteristic of the site was approximated from nearby well boring information, which can be found in Appendix A. From the soil boring data found in Appendix A, it is seen that the areas surrounding Whisky Creek and Calvin College have very thick clay layers. The team’s industrial consultant Roger Lamer confirmed these results by suggesting this area consisted primarily of clay. Figure 5 displays the soil approximate soil characteristics, showing that the area for the project is primarily covered by 18B and 18C loam, which is comprised mostly of clay with some sand and other materials. Soil boring logs can be found in Appendix A.

Figure 5: Soil Properties of Whisky Creek and the Surrounding Area
**3.3 Creek Characteristics**

The section of Whisky Creek that applies to this project is located just south of Burton Street. The Creek flows east at this point. Whisky Creek itself ranges in width from 3 to 10 feet with typical water surface elevation up to 1 foot.

The ravine is completely overgrown with bushes, shrubs, and several large trees. There are several considerations that must be made when deciding which path to take through this landscape. The path across the creek must be aesthetically pleasing; therefore limiting the number of trees that are removed for the project is ideal. Cutting a straight line through the trees as is done for power lines is not desirable. This would both eliminate the isolation of the apartments from the busy Burton Street as well as detract from the natural feel of the site. The project must provide safe, reliable transport from one bank of the creek to the other while neglecting to impact the area negatively. Figure 6 shows possible locations to span Whisky Creek.

![Figure 6: Possible Locations to Span Whisky Creek](image)
As seen in Figure 6, the area is quite heavily wooded. However, as the seasons changed it became clear that locations “B” and “C” were more heavily wooded than location “A” shown in Figure 6. In Figure 6, locations to the left are on the east. This was a determining factor in choosing a location to span Whisky Creek.

4. Design Alternatives

The team came up with two different solutions for the problem at hand. The first solution is the design of a bridge to span Whisky Creek. The second is the design of a culvert and backfill system that would allow people to cross Whisky Creek. Included in both of these designs is a path system that is compliant with the American’s with Disabilities Act of 1990 design standards. Both of these designs provided unique challenges, and adequate solutions to the problem at hand.

4.1 Bridge Alternative

4.1.1 Modeling the Bridge

To model the bridge, the loadings of the bridge needed to be determined. To determine the loadings, a live load and dead load was assumed for the bridge. Since our goal was to allow full wheelchair accessibility, it was important that the assumed live load accounted for wheelchairs. After researching manufacturer specified wheelchair weights and capacities, it was determined that a worst case scenario would be a heavy duty motorized wheelchair. The assumed worst case load, including the heavy duty motorized wheelchair and passenger, was
1,100 lb. Assuming a conservative wheelchair footprint of 7.39 square foot, a live load of 148.85 lb. per square foot was determined. However, snow load must also be considered, so an additional 40 lb. per square foot was assumed. This allowed for a total live load of 188.85 lb. per square foot. Next the dead load must be determined.

To determine the dead load of the bridge, we needed to make a wood selection. After consulting with Mr. Mark Becker of EXCEL Bridge Manufacturing Company, we chose cedar. Cedar is a visually appealing wood and has a unit weight of 23.7 lb. per cubic foot. Using conservative estimates for the wood deck, a 10 lb. per square foot dead load was determined. For the remainder of the wood covering, a line load, to be on either side of the bridge, was determined to be 38.17 lb. per linear foot. With the loads determined, a steel framing plan could be modeled.

To model the bridge, RAM Structural System was used. This program allows the user to specify a steel framing plan to be analyzed for a specified loading. It was determined that the bridge should be 8 ft. wide, to provide some stability as well as extra breathing room while on the bridge. Since we were told that this could be a place for pictures and whatnot, providing enough width for comfort was important to us. It was also determined that 10, 6.5 ft. bays would be the best way to keep the size of the beams as low as possible. Columns were used to model the abutments on either side of the bridge. Figure 7 and Figure 8 shows a plan view and
3D view of the framing plan respectively as output from RAM Structural System.

Figure 7: RAM Structural System Bridge Framing, Plan View

Figure 8: RAM Structural System Bridge Framing, 3D View

Figure 7 and Figure 8 show RAM Structural System output of what the steel structure of the bridge. As shown, at location D there will be columns to provide additional support for the structure.
4.1.2 Designing the Bridge
The first design alternative is a bridge to span Whisky Creek. A few different options were considered for this design. Initially, we had planned on designing the bridge to span from one corner of the Woodlawn CRC Ministry Center to the existing dead end road, Little Heron Ct as shown in Figure 9.

![Figure 9: Initial Bridge Design Location](image)

The red line shown in Figure 9 illustrates the initial location for our bridge design. However, after consulting with our industrial consultant, Roger Lamer, it was confirmed that this would not be the best option for a couple of reasons. First, the span at this location would be about 165 feet and an elevation difference that is about 17 feet. Because of this large span and elevation difference, the cost and feasibility of a bridge at this location would be unreasonable. Second, even if the bridge were to be reasonably affordable, comparing its cost to a culvert
placed at a different location with a different span would be meaningless. For these reasons this location was ruled out, and other areas were considered.

Another option considered was to design a bridge to span Whisky Creek at a location east of Little Heron Ct. This span would be close to 100 feet if the bridge ran directly from the Woodlawn CRC Ministry Center parking lot to the south bank of the creek. However, it was quickly determined that this too would be an unreasonable solution.

The final location for the bridge was selected at a location east of Little Heron Ct. and is shown in Figure 10.

![Figure 10: Final Bridge Location](image)

The red line shown in Figure 10 illustrates the final bridge location east of Little Heron Ct. This span will be 65 feet, and will require abutments 4 feet and 1 foot above existing ground level for the respective north and south ends of the bridge. This is to accommodate high waters for
potential flooding. This also raises the south end of the bridge 2 feet higher than the north end.

This gives more flexibility for the path design, allowing for milder slopes on the south path. The bridge will be 8 feet wide, will be a steel structure covered in wood to make it visually appealing.

The steel structure will provide the strength necessary to span a 65 foot length, and will be supported at 19.5 feet from the north end by three W10x33 columns. The beam and column sizes given from RAM Structural System were checked using hand calculations. Vibration and deflection criteria were also considered, and beams were resized as necessary. It is recommended that ½ in. thick neoprene padding be used to mitigate vibration from walking on the W24x55 beams over the 45.5 ft. span on the south end. Figure 11 shows a section view of the south end of the bridge.

![Figure 11: Section View of South End of Bridge](image)
As shown in Figure 11, the neoprene padding would be bonded to the W24x55 beams, and the wood deck would be placed over top. An alternative mitigation for vibration would be to use HSS 14x0.312 beams in place of the W24x55 beams. For a full list of column and beam sizes, see Appendix C. Next, the abutments and column footings were designed.

The north and south abutments were designed for an 11.3 kip per foot reaction. However, because of the columns locations, the reaction at the north foundation is only 7.5 kips. A conservative soil bearing capacity of 2500 lb. per square ft. was assumed. For comparison, the soil bearing pressure of the soil beneath the engineering building is 4500 lb. per square ft. So 2500 lb. per square ft. should be a safe estimate. However, if our clients decided to go ahead and begin construction, soil borings will need to be done to determine the exact bearing capacity and re-design the foundations if necessary. Design was performed using the ACI handbook as a guide. The north and south abutment design specifications are shown in Figure 12.
Figure 12 shows the abutment details. To accommodate, excavation below the foundation location will be required so that 1 ft. of gravel sub-base can be placed, with 1 ft. of compacted backfill to be placed on top of that. Rebar specifications are also shown in the figure. Rebar sizes were calculated using the ACI handbook, and locations were selected based on a typical abutment detail.
For the column footings, a reaction of 3.8 kips was calculated. After design, it was determined that a 3 ft. by 3 ft., 12 inch thick footing was sufficient. Figure 13 shows the column footing specifications.

Figure 13: Column Footing Specifications

As shown in Figure 13, there is a 3 inch gravel sub-base, covered by 1 inch of sand and 5 inches of compacted backfill below the footing. The figure also specifies a 10 inch by 11 and ¾ inch baseplate, as specified by RAM Structural System. It was assumed that these baseplate dimensions were sufficient, since the column footing sized by RAM Structural System matched our hand calculated footing size. Rebar sizing and anchor bolt specifications are also shown in the figure.

Complete cost analysis of the bridge can be found in Appendix H. The total cost of the bridge design was about $56,000. However, Mark Becker of EXCEL Bridge Manufacturing CO. suggested that a prefabricated bridge of a similar design to ours from his company would cost
around $40,000. If the bridge were to be delivered without the wood deck, but with all the necessary hardware to install the wood deck, the cost would be about $30,000. This would allow Calvin, Woodlawn CRC, or Holland/Raybrook to explore opportunities for installation of the wood deck such as a contractor, a volunteer carpenter from Woodlawn’s congregation, or a service project.

4.2 Culvert Alternative

4.2.1 Modeling the Culvert

One of the proposed solutions to crossing Whisky Creek is designing a culvert with a bituminous path over it. For this solution, several cross sections of the ravine were taken using surveying equipment. These were taken both upstream and downstream of the actual proposed crossing. Before a culvert can be designed, data must be obtained to analyze the type of water flows that go through Whisky Creek.

Whisky Creek has two areas, or drainage basins, that drain into the stream. One of these is primarily the Calvin College parking lot on the West side of campus. The other is a storm drain that comes from the residential area just West of Calvin College. Through our resource at the Kent County Drain Commissioner, Brad Boomstra, we received several vital pieces of information about the two drainage basins, or watersheds. He gave us their respective area’s, times of concentration, and curve numbers which have been calculated and used by the Kent County Drain Commissioner. These are all important numbers when analyzing the type of flows that will be coming through Whisky Creek during different sized storms.
The Kent County Drain Commissioner sets the rules for this type of project, which can be found on the Kent County website. The Drainage Rules constitute that HEC-HMS and HEC-RAS be used for this watershed based on its size. The watershed totals to 148.33 acres and the SCS Method is built into the programs to be used to calculate peak discharge.

The first step in the SCS Method was to determine the drainage area. Since this was already given to us by Brad Boomstra, we did not need to do this. The drainage area consisted of 24.06 acres from the Calvin College parking lot and 124.27 acres from the storm drains of the nearby neighborhood. The next step was to determine the appropriate runoff curve number for the drainage area. The parking lot has a curve number of 94 and the storm drains have a curve number of 83. These were provided by the Drain Commissioner’s office but could also be found in any table of curve numbers. The curve numbers represent the kind of land use of the drainage area. A higher curve number means that more water will run off for every inch of rainfall that hits the area.

Next, a certain level of storm needs to be chosen to design by. The SCS Method suggests choosing a 24-hour duration storm. Storms are also classified by their return period. A 1-year storm is a size storm that only comes once a year. A 10-year storm is a storm that only comes once every ten years, therefore is much larger. The SCS Method determines this based on the land usage. A 10-year storm is suggested for residential areas and a 25-year storm is suggested for commercial or industrial and other high value areas. A 25-year storm will be used
as some of the watershed could be seen as a high value area. For Grand Rapids, the 24-hour 25-year storm has a rainfall depth of 4.45 inches. From this the direct runoff can be determined to estimate how much will then flow into the stream, as some will infiltrate into the ground. For permitting for this project, the Michigan Department of Natural Resources and Environment (MDNRE) requires the project does not affect the water surface level upstream of the site for a 100 year storm. Calculations were then done for a 100 year storm as well as a 25 year storm.

SCS storms are also classified by type. There are four different types that each change by rainfall distribution throughout the duration of the storm. An SCS Storm Type II was used in the hydraulic analysis. This storm type is used for most of the United States including the Michigan area. The other types are used mainly along the East and West coasts and along the Gulf of Mexico. Figure 14 shows the water surface profile for the creek at the project location before implementation.
4.2.2 Designing the Culvert

The culvert is designed based on a design flows of 102.2 cfs for a 2 year storm, 276.1 cfs for a 25 year storm, and 425.9 cfs for a 100 year storm, which were all found using the SCS Method as called for by the Kent County Drain Commissioner with the program HEC-HMS. HEC-RAS was used to input the specifications for the box culvert.

The culverts are designed to meet the requirements of the Michigan Department of Natural Resources and Environment (MDNRE). To approve construction of crossing a creek such as Whisky Creek, prove must be shown that the water surface profile will not increase upstream during a 100-year storm. This is even more important for this project because only 350 feet upstream is Burton Street. So it must be shown that the designed culverts do not cause the water to back up and flood Burton Street.
A concrete box culvert was chosen because the likely provider of the culvert would be a company (Premarc) that provides primarily box culverts. A 12’ x 6’ box culvert is the largest that could be placed in the channel without needing to raise the height of the path to cross the creek. The path is set to be at a height of 8.5 feet, which is the same height that the bridge design will be crossing the creek. A 12’ x 6’ box culvert is not large enough to control flows from a 100 year storm, so a 6’ x 3’ box culvert will be placed on the flood plain on the North side of the channel. The center of this culvert will be 18.7 feet from the center of the main box culvert. Both culverts will be 20 feet in length with wing walls that are 15° from perpendicular to direct flow into the culvert and cut down on entry losses. Fill will then be placed over and between these two culverts to make a crossing for the bituminous path. Many detail drawings of the culvert locations can be found in the Appendix.

![Figure 15: Culvert Crossing, Upstream End](image)

As you can see in Figure 15, the culverts are located as shown. Wing walls will be included with the culverts on the upstream end to cut down on entry losses as well as prevent
erosion of the banks. Rip rap and gravel will be placed in the channel as well as on the banks to prevent erosion. This will allow the culverts to continue performing with maximum efficiency for many years.

![Figure 16: Water Surface Profile after Culvert Installation](image)

This profile in Figure 16 showing the water elevation can be compared to Figure 14. As you can see, the water surface profile will not be increased from that of the unaffected flows. This proves that the culverts are sized appropriately and will be approved by the MDNRE. Therefore a successful alternative is provide for our clientele for their comparison, ensuring their needs be met. All of the final drawings can be found in the Appendix.
The costs of the entire culvert alternative can be found in Appendix J. The culvert pricing was obtained from Paul Marsh at Premarc. Paul is the box culvert specialist and gave prices for the culverts per foot. These costs include the delivery and setup at the project site. The cost of the fill, railings, and asphalt path were all estimated using the means book. The estimates are all to the nearest $100 due to the varying costs of each item. Also the project could not be carried out for a few years, by which time the pricing would change.

4.3 Path Design

4.3.1 Modeling the Path

Another important aspect of the project is the path design. The Whisky Creek crossing must be connected to convenient locations on both sides of the valley to allow for easy travel from Raybrook and the Holland Home to Calvin College. The main challenge in designing the path lies in safely and effectively accounting for the elevation differences between the crossing site and the top of the banks. Caring, which is one of the major design norms for the team, plays a large role while designing the path. Because much of the clientele will be residents of Holland Home, the team designed the path to be safe for both elderly foot travel and wheelchairs. This means that the path is barrier free and ADA compliant, based on the specifications laid out in the ADA handbook. The ADA standards that apply to the path design include the following:

- Any slope greater than 1:20 is considered a ramp and must comply with the standards listed for ramps.
• Nowhere shall the cross slope of an accessible route exceed 1:50.

• The maximum slope of a ramp in new construction shall be 1:12. The maximum rise for any run shall be 30”.

• The width of a path must be 60” in order for two wheelchairs to pass.

• Ramps shall have level landings at bottom and top of each ramp and each ramp run. Landings shall have the following features:
  1) The landing will be as wide as the ramp leading up to it
  2) The landing length shall be a minimum of 60" clear
  3) If ramps change direction at landings, the minimum landing size shall be 60" x 60".

• If a ramp has a rise greater than 6" or a horizontal projection greater than 72", then it shall have handrails.

In addition to these ADA standards, the path will have benches to allow for the users to rest along the way.

Another important consideration that was considered in the path design is cost. Because the project will possibly be funded by donations from Woodlawn CRC, it is important to minimize the cost of construction. The path will run perpendicular along a steep slope and therefore lots of fill will be needed to create a path with a level cross slope. Also, retaining structures will be needed to support the path and prevent it from collapsing down the slope. With these costs in mind, the path must be designed to minimize the amount of fill and retaining structure needed while still complying with the ADA standards.
Lastly, the team the design will be both culturally appropriate and environmentally consciousness. The design will be aesthetically pleasing and must fit into the surroundings. Ideally, the team would have liked to remove as few trees as possible. However, in order to maintain ADA standards, a few trees will have to be removed. Also, the retaining wall material was chosen to match the existing retaining walls, and the handrails and benches were chosen to be aesthetically pleasing.

4.3.2 Designing the Path
The path consists of two main sections: the north bank path and the south bank path.

Topographical data was collected for both banks to be used to design safe and effective slopes for the paths as well as to be able to estimate the cost of fill and retaining walls.

The first decision to make regarding the path was whether to make it bituminous or concrete. A bituminous path was chosen for two reasons. First, a bituminous path is less expensive than a concrete path. Second, the team believes the bituminous path will be more aesthetically pleasing especially in the environment setting of the site. The path was designed to be 2.5” thick with a 1% cross slope towards the creek to allow for rain runoff and to prevent pooling of water on the path. Figure 17 shows the typical cross section view of that path.
The minimum width of a path required to allow two wheelchairs to pass is 5 feet, therefore the team designed the path to be 6 feet wide which will allow extra room for handrails on both sides. A 6 foot width was chosen to minimize the fill and asphalt cost of the path, however, the path may need to be expanded to 8 feet due to existing paving equipment. More financial analysis must be done to determine whether the extra cost of installation for a narrower path will offset the decreased costs of fill and asphalt for the narrower path.

There are two existing stone retaining walls on the south bank of the valley. The new retaining walls were selected to match these existing walls. A gravity stone retaining wall was chosen both for aesthetic reasons and for effectiveness. Retaining structures greater than four feet high in the state of Michigan need to obtain a PE signoff and thus need to be sufficiently

---

**Figure 17: Typical Cross-Section of Path**
designed. The PreMarc Corporation provides pre designed gravity stone retaining walls and the team recommends that the needed retaining structures be purchased from PreMarc.

Handrails also are an important aspect of the safety of the design. As described further in the ensuing sections, the slopes of the paths were designed to be slightly shallower than a 1:20. This protects the design from any legal issues due to insufficient handrails; however the ethical responsibility still exists. Much of the path includes retaining structures with several feet or more of drop off, and hand railings are needed to provide a safe path. The team recommends that the path uses a picket railing which includes a 42” high picket with a 37” high grab bar. The team recommends that the railings are purchased from a company which provides ADA compliant handrails, such as Handi-Ramp, Inc. The team has left this specific aspect open to the clients who can select railings which they believe are aesthetically pleasing.

4.3.2.1 North Bank Path
The path along the north bank was considerably easier to design and cheaper to build than the south path. The path connects the north end of the crossing to the Woodlawn Ministry Center parking lot. The path rises 1.75 feet from the end of the bridge to the parking lot surface. The horizontal distance from the end of the bridge to the parking lot is 28.75 feet. There is also up to 102 feet of lateral distance along the parking lot which could be used to account for the elevation difference. There currently is a light pole located 3.5 feet from the parking lot which the path will be built around. Figure 18 shows the proposed path for the north bank.
Two 6’x 6’ landings are included to allow the path to turn 90 degrees and go around the light pole. Also, none of the slopes are greater than 1:20 which is ideal in making the path ADA compliant. Although going around the light pole adds some distance to the path, the team believes that keeping the slopes small and not altering the existing setting is more important than the extra cost for the little amount of added path length. The path meets the parking lot at the current level of the lot to avoid the need for a curb ramp. In order to provide safe crossing once the path reaches the parking lot, a crosswalk will be painted onto the Ministry Center parking lot leading from the end of the north path to an existing curb ramp at the front of the Ministry Center which than connects to the sidewalk on Burton Street. With this path in place, there will be a safe and barrier free method to travel from the crossing site to the sidewalk on Burton Street. Figure 19 shows the proposed cross walk across the Ministry Center parking lot.
The total calculated fill needed was 59.58 cubic yards, and at $6.83 per cubic yard from the Calvin Engineering Reference Library 2009 means book, this comes out to a total fill estimate of $406.91. The total retaining wall area needed is 80.58 square feet, with 113.24 total feet of hand railings (which includes railings on both sides of the path).

4.3.2.2 South Bank Path
The path from the south end of the crossing to Raybrook provides a more difficult challenge. The team designed the path to connect to Little Heron Ct. The distance from the
south end of the creek crossing to the west edge of Little Heron Ct. is approximately 174 feet, with about a 13 foot elevation difference. This yields an approximate 1:13 slope with a straight shot, which does not include the necessary landings. This slope would be greater than the desired slope, and therefore some curving of the path will be necessary in order to get a large enough length for the elevation difference. There are also several trees which would have to be removed in order to complete this path. The team believes that the extra cost to build the path around these trees would be too large to justify this maneuver. Figure 20 shows the south bank path, which has landings, railings, retaining structures, and no slope steeper than 1 foot rise for 20 feet run. Currently there are two retaining walls built into the south bank, one at the road and the other along the housing complex. The path will most likely be built to the north of these walls and therefore the walls will not have to be altered. There will have to be a retaining wall running the entire length of the path due to the steepness of the cross slope of the hill.

Figure 20: South Bank Path Design

The south path requires 206.29 cubic yards of fill, giving an estimate of $1408.93, and 25.85 cubic yards of excavation at $5.13 per cubic yard, for an excavation estimate of $132.62.
The south path retaining wall area was estimated at 1791 square feet, with 506.59 linear feet of railings. When combined with the north path, a total of 620 linear feet of railings are needed. Using the Calvin Engineering Reference Library 2009 means book, the railings will cost an estimated $2,336. The path was designed to fit with either the bridge or the culvert alternative. The total cost of the path including the backfill, railings, asphalt, and retaining structures is an estimated $6,900.

5. Future Work

The team has now finalized the designs of the bridge, the culvert, and the paths. The overall costs of both design alternatives have been calculated. The costs, along with several other aspects of each design, including safety, effectiveness, and aesthetics will be compared when considering which design is better overall for the community. Both the bridge and the culvert were visually modeled to allow the clients to see what each design will look like once it is put into place. This includes walkthroughs of the proposed designs, giving people a chance to experience the path and crossing.

On May 9th, the team presented the final designs to Woodlawn CRC, who likely will provide the primary funding for the project. The presentation allowed the Woodlawn members to hear the positives and negatives of both design alternatives and also allowed them to ask any questions they had about the operation or implementation of the crossing. The members seemed very interested in the possibility of implementing the design, although stated that it may not be for a few years down the road. On May 15th, Professor Aubrey Sykes, who is a member of Woodlawn
CRC, led a group of volunteers to clean up the site of the proposed crossing. This effect will hopefully draw further support to the implementation of the design.

On May 11, the team presented to Phil Beezhold, the head of Calvin’s Physical Plant. Although the design would benefit Woodlawn CRC members much more than Calvin College, Mr. Beezhold recognized the convenience of the design for Holland Home and Raybrook residents who would like to visit Calvin’s Campus. He offered support for the idea and said that Calvin likely would be able to help provide labor and machinery should the design be implemented.

On May 12, the team presented to Scott Hull, the Director of Facility Services at Holland Home. Mr. Hull expressed interest in the idea of the design, however mentioned that because the Holland Home is non profit and often gives away free aid to the residents, they would likely be unable to offer financial support. However, he graciously offered to have his grounds team work with Calvin College workers to aid in implementing the design. A study has shown that approximately 70 members of Woodlawn CRC are from Holland Home and Raybrook estates and design would be beneficial to Holland Home.

6. Conclusion

This project showed the importance of communication and care throughout a design. The design demonstrates a balance between elegance and functionality, which is done by ADA compliance, cost effectiveness, choice of materials, and path location. This project intended to serve a practical function to the residents of the Holland Home and Raybrook Estates, while providing a beautiful semi-naturalistic place for Woodlawn CRC, Calvin College, and all visitors to the site. Our final recommendation is the bridge design, while considering a pre-fabricated
bridge design from EXCEL Bridge Manufacturing CO. It is also our recommendation to close off the whole closing during the winter months, to avoid safety concerns caused by a snow covered bridge and path.

Acknowledgements

Team Bridge would like to thank:

- Professor J. Aubrey Sykes for proposing the project and remaining as a contact from Woodlawn Christian Reformed Church.
- Professor Leonard De Rooy for advising the team throughout the process.
- Professor Robert Hoeksema for help in preliminary hydraulic analysis
- Mr. Roger Lamer for aiding the team as the industrial consultant.
- Mr. Phil Beezhold for acting as the team’s contact from Calvin College’s Physical Plant.
- Mr. Scott Hull for being the project’s contact from the Holland Home and Raybrook Estates.
- Mr. Brad Boomstra from the Kent County Drain Commissioners Office for providing pertinent information about Whisky Creek.
- Bridge Specialist Mark Becker of EXCEL Bridge Manufacturing Co. for providing assistance with bridge design and material selection.
Appendices

Appendix A: Soil Boring Logs
Appendix B: Hydrologic Information
Appendix C: Column and Beam Sizes
Appendix D: Paving Estimates
Appendix E: Fill Estimates
Appendix F: Retaining Wall Estimates
Appendix G: Handrail Estimates
Appendix H: Cost Estimates
Appendix J: Hydraulic Analysis and Culvert Information
Appendix K: Bridge Details
Appendix L: Path Details
Appendix A: Soil Boring Logs

Figure A1: ¼ Mile East of Beltline, 200 ft. South of Fulton
### Figure A2: ½ Mile West of Crahan on Michigan

**Geological Survey Record**

**Location of Well**
- **County:** Kent
- **Township Name:** Grand Rapids
- **Section Number:** 26
- **Township:** 7
- **Range Number:** 11
- **E 1/2**

**Distance and Direction from Road Intersection**
- ½ Mile west of Crahan on Michigan

**Street Address & City of Well Location**
- **City:** Grand Rapids
- **Street Address:** 4015 Michigan St. NE

**Owner of Well**
- **Name:** Harry Rogell
- **Address:** 4015 Michigan St. NE
- **City:** Grand Rapids
- **State:** MI
- **ZIP Code:** 49506

**Well Depth**
- **Date Completed:** 01/18/89
- **Well Name:** New Well
- **Well Type:** Domestic
- **Intended Use:** Irrigation or for Public

**Construction Details**
- **Casing Diameter:** 4 in
- **Screen Diameter:** 6 in
- **Length:** 18 ft.
- **Drill:** 108 ft.
- **Surface:** 1 ft.
- **Height Above Surface:** 117 feet

**Well Surface**
- **Type:** Sand
- **Depth to Bottom of stratum:** 45 ft.

**Screen**
- **Type:** Sand Filter
- **Diameter:** 6 in
- **Length:** 18 ft.

**Fitting**
- **Type:** E-Foam F (Lead Packing & Iron Check)

**Static Water Level**
- **Depth:** 75 ft.

**Pumping Level**
- **Depth:** 102 ft.

**Well Head**
- **Completion:** None
- **Head Cement:** None
- **Drain:** None

**Remarks**
- **Additional Remarks:**
  - **Distance from previous well:** 60 ft.
  - **Well Drilled for:** Irrigation
  - **Well Drilled with:** V-Volt 220

**Pump**
- **Type:** Submersible
- **Model Number:**
- **Capacity:** Gallons

**Water Well Contractor's Certification**
- **Address:** 3541 East Spring St. Building 62800
- **Telephone:**
- **Authority:** Act 350 PA 1978
- **Certificate:** Required
- **Penalty:** Conviction of a violation of any provision is a misdemeanor.

**Survey Date:** January 18-89

**Geological Survey Copy**
Figure A3: 150 ft. SE of I-96
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Figure A4: 1 Mile West of East Beltline, 75 ft. South of Midland
Figure A5: 250 ft. East of Glenview Dr., 2807 Cascade Road
Figure A6: 100 ft. West of Lakeside Dr., 900 ft. North of Lake Drive
Figure A7: 200 ft. South of Franklin, 75 ft. East of Plymouth
Figure A8: North Side of Reeds Lake, 2638 Reeds Lake Blvd. SE.
Appendix B: Hydrologic Information

Figure B1: Flow of Whisky Creek
Figure B2: Hydrologic/Watershed Information of Whisky Creek
Figure B3: More Hydrologic Data, including Curve Numbers and Times of Concentration
Appendix C: Column and Beam Sizes

Column Sizing

Story level 1, Column Line D-1
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(Note, Columns on A and K grid do not exist. This is where bridge foundation is located.)
Beam Sizing
### Appendix D: Paving Estimates

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**Total** 1911.4 212.3778
# Appendix E: Fill Estimates

## North Path Fill: For 1:2 Slopes to Support Paths

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## North Path Fill: For Underneath the Path

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**TOTAL**

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**North Path Fill Totals**

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### South Path Fill (Hand Calculations were Completed)

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| Total Fill | 5569.71 ft³ |
|            | 206.285556 yd³ |

| Total Excavation | 698 ft³ |
|                 | 25.8518519 yd³ |
## Appendix F: Retaining Wall Estimates

### North Path Retaining Wall Structures

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**Total Wall**                                                                 80.58

### South Path Retaining Wall Structures (Hand Calculations)

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**Total Wall**                                                                 1791.05
## Appendix G: Handrail Estimates

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| **South Path Railings (ft)** |           |
| Section 1                  | 14.04     |
| Section 2                  | 120       |
| Section 3                  | 17.98     |
| Section 4                  | 54        |
| Section 5                  | 10.15     |
| Section 6                  | 20        |
| Section 7                  | 8.65      |
| Section 8                  | 37.4      |
| Section 9                  | 19.87     |
| Section 10                 | 26        |
| Section 11                 | 18.4      |
| Section 12                 | 115       |
| Section 13                 | 11.1      |
| Section 14                 | 34        |
| **Total**                  | 506.59    |

**Total** 619.83
### Appendix H: Bridge and Path Cost Estimates

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**TOTAL COST** $63,771.85

(Includes 10% Contingency Cost, and 10% Engineering Costs)
Appendix J: Hydraulic Analysis and Culvert Information

Figure J1: Plot of Flows through Whisky Creek during 25-year storm event
Figure J2: Plot of Flows through Whisky Creek during 100-year storm event
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<th>E.G. Slop</th>
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Table J2: Cross Sectional Data After Culvert Installation

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<th>Ctrl W.S. (ft)</th>
<th>E.G. Elev (ft)</th>
<th>E.G. Slope</th>
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Figure J3: Arial View of Culvert Crossing

Figure J4: Side View of Culverts
Figure J5: Downstream End of the Culvert Crossing

Figure J6: Upstream End of the Culvert Crossing

Figure J7: Culvert Cross Section showing necessary earthwork
Figure J8: Culvert Details and Sizing
### Table J3: Cross Sectional Data

Cross Section Information Used For HEC-RAS

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**Center Cross section:**

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<th>total height</th>
<th>Total Length (m)</th>
<th>slope distance</th>
<th>Horizontal Distance</th>
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**Creek Channel:**

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<th>Meier stick location</th>
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| Chan Width | 10 feet    |
| depth      | 0.92 feet  |
| N Bank     | 2 feet     |
| S Bank     | 2 feet     |
Table J6: Cross Sectional Data cont.

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<th>North side point</th>
<th>Height read</th>
<th>height [m]</th>
<th>height(total)</th>
<th>distance from bottom</th>
<th>Meter stick location</th>
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<th>distance from bottom</th>
<th>Meter stick location</th>
<th>Slope distance</th>
<th>Horizontal Distance</th>
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Chan Width: 10 feet  
Depth: 1.5 feet  
N Bank: 2.42 feet  
S Bank: 1.5 feet
Table J7: Cross Sectional Data cont.

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<tr>
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<td>Height read</td>
<td>height (m)</td>
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<tr>
<td>10 feet flat</td>
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<tr>
<td>1:2 slope: Up to six feet height</td>
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<tr>
<td>2 Streams</td>
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<tr>
<td>middle</td>
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<td>6 in above WS</td>
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# Table J8: Fill Calculations for Culvert

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<td>8.31444 yd³</td>
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**Estimated Total Fill Needed**
1744647 yd³

**Cost Per yd³ of fill**
$8.83

**Total Fill Cost**
$1,561,589

25 yd³ can be used from excavation

$102,084
Table J9: Cost Estimations for Culvert

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<td><strong>Total Cost</strong></td>
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Appendix K: Bridge Details

Walking Bridge Over Whisky Creek

Calvin Engineering Senior Design 2010: Team Bridge
Dan Vroom  Eric Eylander  David Westlund  Ryan LaReau

East Profile View
Typical Wood Deck and Railing Detail

- 3" or 4" CEDAR DECK, 1' BOARDS
- L6X4X⅝, WELD TO BEAM, 9.3' SPACING
- ⅛" NEOPRENE PADDING [NOTE: ONLY ON OUTERMOST BEAMS (W24X55) FOR 45.5' SECTION SOUTH OF COLUMNS]

Typical Wood Deck and Railing Detail, Section View

- CEDAR SIDE RAILS, HANDRAILS
- WOODE DECK, 3 OR 4" CEDAR W12X19
- WBX10
- 2"X4" WOOD SPACERS, CUT TO FIT ALONG ENTIRE SPAN
- 4" CLEARANCE REQD. FOR SPACERS, OFFSET WBX10 CONNECTIONS 4" FROM TOP OF CONNECTING BEAMS
Appendix L: Path Details

North Path Plan View

South Path Plan View
North Path Profile Detail

Typical Path Cross-Section Detail