

RIVER LEVEE TRAIL & BRIDGE

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
THE UNIVERSITY OF IOWA
SENIOR DESIGN CAPSTONE CLASS (CEE:4850:0001)

CONTACT

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CITY OF RED OAK, IOWA

MONTGOMERY COUNTY

May 5, 2018

Dear City of Red Oak,

Enclosed is the final report for the design of the river levee trail and bridge project.

Sincerely, Austin Sitzmann Joe Moslemian Kara Gibson



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I. Executive Summary

About JKA Consultants

Our organization is headquartered in the Seamans Center, located on 103 South Capitol Street, in Iowa City, Iowa 52240. We may be reached by email at austin-sitzmann@uiowa.edu, or by phone at (712) 541-9666. All three members of our team are seniors pursuing a Bachelor of Science degree in civil engineering at the University of Iowa. We have experience working with similar projects in the past, as we have all designed a roadway and produced alignments for it as part of a final project in our Transportation Design class. We also have experience designing retaining structures, such as abutments, from a foundation course that covered the design of footings and retaining structures.

Project Description

This project required the design of an extension of the existing Red Oak Trail, located in the city of Red Oak, IA. The trail extension begins at the intersection of Alix Street and HWY 48, and terminates adjacent to Red Oak's sewage treatment plant, for approximately 2 miles in total length. It was requested that the trail run along the crest of the nearby levee, and that it crosses the local railroad tracks, 200th Street, and West Coolbaugh Street. We developed two alignment alternatives for this trail design, with the difference in the designs being the method of crossing the railroad. Alternative 1 builds up the levee before reaching the railroad and then uses a bridge to cross the railroad, while Alternative 2 crosses the railroad at-grade, near the US-34 roadway crossing. A parking lot design that utilized the existing private drive near the intersection of Eastern Avenue and US-34 was also requested.

Work Performed

Both alternatives are designed with concrete and asphalt pavement alternatives. For both alternatives, we produced trail cross sections, horizontal and vertical alignments, trail grading, and various other elements of the trail in accordance with Section 12B-2 of the Statewide Urban Design & Specifications (SUDAS) Design Manual. Both alternatives are designed to be ADA compliant. The roadway crossings, signage, pavement markings, and detectable warnings are designed based on the results of a traffic warrant analysis, in accordance with the Manual for Uniform Traffic Control Devices (MUTCD). Given our design team's experience, designing a bridge is out of the scope of our abilities, and, therefore, unethical for us to design, so we went with a prefabricated bridge. We have, however, designed abutments for a prefabricated bridge to be placed on. While we did not design the actual bridge, we did research the Burlington Northern Santa Fe (BNSF) railroad requirements for overhead crossings, and specified these requirements in our bridge design recommendations. We also researched specific BNSF requirements for the at-grade crossing, and we abided by these requirements in our design. An accessible parking lot was also designed near the location requested. Further, we used AutoCAD to produce final plan sheets, and we used Infraworks to create 3D renderings of our design, for better visualization. Finally, we have provided a final cost estimate for both alternatives with concrete and asphalt.

Constraints & Challenges

The U.S. Army Core of Engineers (USACE) restricts certain construction practices, such as cutting into their levee, so abiding by their requirements was both a constraint and a challenge. The BNSF railroad also has their own set of construction requirements, such as horizontal and vertical clearances from their right-of-way (ROW), and these requirements restricted our bridge design. Further, the initial crossing of HWY 48 had limited space and designing the trail there required reducing the trail width. Another challenge was complying with ADA requirements at the initial crossing and when building up the levee to cross the railroad with a bridge.

Societal Impacts

This trail extension should help provide Red Oak with a cohesive, accessible network, which further links the city's schools, factories, parks, businesses, and homes, in a safe manner for both pedestrians and bicyclists. Community members will be able to cross three man-made barriers, ensuring all parts of the community are accessible by trail. Further, this trail addition will allow for more year-round outdoor recreation and fitness activities in the City of Red Oak, which will result in improved overall health of community members, while also acting as an important tourism asset for the city. The proposed trail does run through some private property, and these people will end up giving up part of their land if this trail is built.

Recommendations

If safety is a major concern for this trail, Alternative 1 with the bridge is recommended because it is a much safer method to cross the railroad. However, this alternative does cost considerably more than the at-grade crossing alternative. If the bridge alternative is chosen, there is power line near this location that may need to be raised; we recommend measuring the exact height of this power line, as we were unable to do this during our site visit. Also, when selecting the trail surface, there are pros and cons for both concrete and asphalt. Asphalt is cheaper, costs less to maintain, and is easier on pedestrians' joints than concrete is. The downside to asphalt, however, is that it is less durable and has a much shorter service life than concrete. Concrete is stronger than asphalt, and has a long service life, but it is expensive to repair, costs more than asphalt, and is harsher on users' joints. It is recommended that the final trail surface is selected while keeping these factors in mind. Also, we recommend placing collapsible safety bollards on the trail wherever the trail intersects a roadway. These collapsible bollards prevent unauthorized vehicles from driving on the trail surface, while still allowing emergency or utility vehicles access. Finally, the current STOP sign controlling Alix Street is mounted too low, based on the MUTCD requirements, and we recommend raising it.

Final Cost Estimate

We used the RS Means Landscape and Site Work, 2016 edition and the Iowa DOT Bid Tabs for all of our material costs, which includes labor, overhead, and profit. Also, we used The Beacon Land Property Management System to retrieve the listing prices and to estimate how much land must be acquired. A 10% markup is applied to the listing prices to estimate the true market value of the land. Finalizing engineering and

contingency are estimated at 10% of the construction cost. Our final engineering cost estimates are provided in Table 1.

Table 1: Engineering Cost Estimate

Cost		Bridge Alternative				At-Grade Alternative				
		Concrete		Asphalt	R	Concrete		Asphalt		
Construction	\$	1,400,737	\$	1,135,493	\$	990,444	\$	749,289		
Property Acquisition	\$	2,834	\$	2,834	\$	5,188	\$	5,188		
Finalizing Engineering	\$	140,074	\$	113,549	\$	49,522	\$	37,464		
Contingency	\$	140,074	\$	113,549	\$	99,044	\$	74,929		
Total	\$	1,683,719	\$	1,365,426	\$	1,144,198	\$	866,870		

II. Organization Qualifications & Experience

1. Name of Organization

Our official organization name is JKA Consultants.

2. Organization Location & Contact Information

Our headquarters is in the Seamans Center, located on 103 South Capitol Street, Iowa City, Iowa 52240; this is where design services were completed. JKA Consultants may be reached at the following:

Email (primary): austin-sitzmann@uiowa.edu

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3. Organization & Design Team Description

Our team is composed of three highly motivated seniors pursuing Bachelor of Science degrees in civil engineering at the University of Iowa College of Engineering. We are all currently enrolled in the University of Iowa capstone design class. Our team members are Austin Sitzmann, Joe Moslemian, and Kara Gibson. While our organization is together for the first time to work on this project, we have prior experience working with each other solving engineering problems through the past three and a half years. We have also all completed multiple other projects throughout our academic career. Administrative roles pertaining to this project included a project manager, an editor, and a technology specialist. Austin was the project manager, and was responsible for maintaining contact with the client, coordinating project tasks, preparing meeting agendas, and organizing presentations. Joe was the editor, and his responsibilities included coordinating reports and the graphics contained within the reports, making final editing decisions, formatting, overseeing the final presentation

design, and developing computer renderings of the final design. Kara was the technology specialist, and she served as the technology assistant.

4. Description of Experience With Similar Projects

All members of our firm have previous experience with roadway design and alignment. During the fall semester of 2017, we all designed a highway bypass around a small town for a final project in our Transportation Design course. For this project, we produced vertical and horizontal alignments, cross section views, performed cut and fill analyses, and estimated the materials needed for construction. We also verified our route was compliant with Iowa DOT and AASHTO design standards, and we implemented a design matrix to minimize the impact our design had on the surrounding community and other protected land. Our team also has experience in designing retaining structures, as Austin has completed a foundations course where they learned how to design footings and retaining structures.

III. Design Services

1. Project Scope

This project required the design of a trail that is an extension of the current Red Oak Trail System. The extension begins at the intersection of Alix Street and HWY 48, and it terminates near Red Oak's sewage treatment plant. The proposed trail runs through city, state, and private property. A majority of the trail extension runs along the crest of Red Oak's levee, which intersects a Burlington Northern Santa Fe (BNSF) railroad. This railroad had to be crossed in compliance with both the U.S. Army Core of Engineers (USACE) and BNSF railroad standards. After contacting the BNSF railroad and the USACE and investigating their standards, we believe to have found two feasible solutions to cross their railroad. As requested, we designed a solution that includes a bridge to serve as the crossing over the railroad. Designing the bridge was out of the scope of this project given our design team's experience and abilities, however we did design abutments for a prefabricated bridge to be placed on. Further, as an alternative, we have designed a trail that uses the existing at-grade crossing of the BNSF railroad with US-34 to avoid the expense of an overhead crossing. We investigated Iowa trail design standards to ensure the trail is designed in compliance with Iowa DOT, AASHTO and ADA requirements. We also obtained GIS data for the elevations of our site location, and we used this information to lay out the trail's horizontal and vertical alignments. Additionally, pedestrian and driver safety was considered at the three road crossings and the at-grade railroad crossing. This was done by performing a warrant analysis in accordance with the Manual for Uniform Traffic Control Devices (MUTCD), and using the results of the analysis to design the intersections with proper signalization, signage, and pavement markings. Further, we designed a parking lot to accommodate trail users, and to encourage more community members to use the trail. Once the trail was finalized, we used AutoCAD Civil 3D to create detailed plan sheets for the abutments, for the signage and pavement markings for the intersections, and for the parking lot. To conclude the design, we created a 3D rendering of the project, using Infraworks, to help provide a better understanding of what the final product will look like. Finally, after completing all design tasks, we put together an engineer's cost estimate.

2. Work Plan

Task	Week														
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1
Obtain GIS Data															
Preliminary Trail Layout		The state of the s													
Trail Design Standards Investigaton						S									
Prefabricated Bridge						P									
BNSF Standards Investigation						R									
Contacting the USACE						1									
Traffic Analysis						N									
Abutment Design						G									
Parking Lot Design															
Finalize Alignments															
Cross Section Views						В									
Storm Water Design				1		R									
Pavement Marking Layout						E									
Signage Layout						Α									
3D Rendering						К									
Cost Estimating															
Final Report Production															
Final Presentation Preparation				10											

Figure 1: Gantt Chart Displaying Major Tasks

Figure 1 summarizes the major tasks completed. This chart displays when each task began, its duration, when it was finished, and who completed it.

IV. Constraints, Challenges, & Impacts

1. Constraints

In order to ensure the levee maintains it integrity, the USACE restricts construction on the levee. These restrictions affected the pavement design for the trail. The USACE does not allow the levee to be cut in to, so the portion of the trail along the levee does not contain a subbase in our design. Not being allowed to cut into the levee also caused the grade of the shoulder to be greater than recommended by the Iowa DOT. Further, the trail must be placed directly on the levee, so the width of the levee crest restricts the trail shoulder width. Additionally, the trail passes through private and state property, and a property owner's reluctance to grant easement rights could influence where the final trail design may be placed. Further, ADA requirements limited how steep we could build up the levee to the bridge. Finally, there is also an active railroad the trail must cross, and there is no way to avoid intersecting this railroad, if the trail is to run along the levee; crossing this railroad with a bridge or an at-grade crossing must comply with BNSF requirements.

2. Challenges

One challenge we faced was designing a bridge approach and abutments under the constraints of the railroad and levee. Since the trail is on the levee, certain design standards cannot meet recommended specifications. Designing abutments also presented a challenge as we have little experience in doing so. Further, since the bridge crosses over a railroad, we needed to research specific criteria for bridge and abutment

design. Finally, the pedestrian crossing where the trail extension begins has limited space, so we had to make sure the crossing was safe and compliant with design specifications and standards.

3. Societal Impacts Within the Community &/or the State of Iowa

We hope this trail extension helps provide Red Oak with a cohesive, accessible network, which further links the city's schools, factories, parks, businesses, and homes, in a safe manner for both pedestrians and bicyclists. We believe by adding the safe trail crossings of the railroad, 200th Street, and West Coolbaugh, community members will be able to cross these man-made barriers, ensuring all parts of the community are accessible by trail. Further, this trail addition will allow for more year-round outdoor recreation and fitness activities in the City of Red Oak. This will result in improved overall health of community members, while also acting as an important tourism asset for the city. A few property owners will have to give up a portion of their land in order for this to trail to be constructed as proposed, but hopefully they will see the benefit of the trail and do so willingly. There should be little impact on the environment, as this trail utilizes existing infrastructure, and there are few obstructions in the way of the alignment. Some trees may need to be removed on the east side of the railroad tracks if the bridge crossing alternative is used.

V. Alternative Solutions That We Considered

Alternative 1: Bridge Crossing

A bridge crossing coincides with the initial plan, and using a bridge has both aesthetic and safety benefits. The higher elevation of the bridge gives users a great vantage point to look at their community. The bridge would also add a new element to the trail and add interest. In addition, the bridge could link with the community by adding metal work from a local business. Finally, a bridge crossing over the railroad will be a safer method of crossing it. There would be no need for pedestrians to look for oncoming trains and judge when to cross. This would also eliminate the need for users to stop in the event of an oncoming train. On the other hand, this alternate comes with a much larger cost. The design, material, and installation required for the bridge dramatically increases the total project cost.

Alternative 2: At-Grade Crossing

The at-grade crossing has the benefit of saving costs. By avoiding the railroad intersection at the levee, a bridge would no longer be needed. The cost savings associated with losing the bridge would be substantial. The drawbacks include a lack of community connection, loss of a unique vantage point, loss of an interesting asset for Red Oak, and decreased safety.

Note: Both alternates include an option for concrete or asphalt pavement. One benefit of an asphalt trail is that asphalt costs significantly less than concrete. Some trail users may prefer asphalt because it is smooth and easier on users' joints. Additionally, maintaining an asphalt trail is relatively easy. A downside to asphalt is that it is not as durable as concrete and requires frequent maintenance, which

ultimately results in a shorter service life than concrete. A concrete trail is beneficial because it does not need to be maintained as frequently as asphalt. Concrete is also much more durable, and it should provide a much longer service life than asphalt. A disadvantage to using concrete is that it is a more expensive trail surface than asphalt, and when it does require maintenance, it is often more expensive than asphalt. Concrete is also less flexible than asphalt, so it is harsher on pedestrians' joints.

VI. Final Design Details

Trail Pavement & Grading (Cross Sections)

The trail pavement and grading, as shown on Sheets B10 for Alternative 1 and B14 for Alternative 2, are designed using the Statewide Urban Design & Specifications (SUDAS) Design Manual Section 12B-2; this section is specific for shared path trails. Per its specification, we designed the trail with a recommended 5" depth concrete or asphalt surface. A 6" subbase is used in sections of the trial not on the levee. In compliance with the USACE, no subbase is added on the levee since we cannot cut into it. We believe the levee surface to be a sufficient subbase for the trail because it is already highly compacted. The pavement is designed to have a vertical cross slope of 1.5% to guide rainfall off the trail. A 2' wide shoulder was added to the off-levee portion of the trail. The grass shoulder is designed with the maximum grade of 6H:1V. The trail cross sections are graded to the existing surface. A steeper grade slope of 12H:5V is used for the trail's on-levee portion since we cannot alter the levee. A slope of 3H:1V is selected for the off-levee portion to provide a safer grading slope while minimizing fill.

Note: A 42" high safety rail is required along portions of the trail that have an adjacent grading of 3H:1V with a drop of 6' or more, a grading of 2H:1V with a drop of 4' or more, or a grading of 1H:1V with a drop of 1' or more.

Horizontal Alignments

For Alternative 1, the design begins at the end of the existing trail, crosses HWY 48, wraps around the farm land on the west side of HWY 48 and south of US-34, and then makes its way on to the levee. The trail continues along the crest of the levee until it ends near the sewage treatment plant, and the final horizontal alignment avoids trees and culverts wherever possible. Our horizontal curves abide by Section 12B-2 of the SUDAS Design Manual. Alternative 2 is laid out the same as Alternative 1, initially. Once the trail reaches the levee it is diverted from the levee crest by the US-34 levee gate, and then it runs adjacent to US-34 until it reaches the railroad, which it then crosses with and at-grade crossing. After crossing the railroad, the trail curves left onto an existing private road on a nearby farm lot, and then it continues along this road until it meets back up with the levee. Just as in Alternative 1, Alternative 2 then follows the remainder of the levee. Final horizontal alignments can be seen on Sheets B1-B13 for both design alternatives.

Vertical Alignments

Coinciding with the horizontal alignments, the vertical alignments are designed to minimize earthwork while providing appropriate grading for the levee and bridge approaches. Where possible, the vertical alignment is placed directly on the existing levee surface to avoid unnecessary cut or fill. In all other cases, the specifications for trail grades, provided in the SUDAS Design Manual Section 12B-2, are abided by. The maximum grade in our design is 8% at the bridge approaches. The length of the vertical curves is always more than the stopping sight distance for the corresponding grade change, as required by the SUDAS 12B-2. Alternatives 1 and 2 were both designed in this manner. Final vertical alignments for both alternatives can be seen on Sheets B1-B13.

Bridge

Designing a bridge is out of the scope of this project for our design team's abilities, so we recommend using a prefabricated bridge. According to Section 5.4.8.2 of the BNSF Guidelines for Grade Separation Projects (BNSFGGSP), this bridge must be designed with an 8' high curved chain link fence or a 10' high straight chain link fence. The BNSFGGSP also requires the openings of the chain link fence to be no greater than 2", according to Section 4.7.b.1. The vertical clearance of the bridge must be 23'- 6" above the railroad, measured from the top of the highest rail to the lowest obstruction under the bridge, per Section 5.2.1 of the BNSFGGSP. This vertical clearance must be abided by for a minimum of 9' in each direction from the centerline of the existing or future tracks, based on the requirements given in Section 5.2.1.a.1 of the BNSFGGSP. Further, the piers and abutments of the bridge are designed to be outside of the railroad's 100' wide right-of-way (ROW), per their requirement in Section 5.2.2.b of the BNSFGGSP. This results in the bridge span being 115'. Another requirement for the bridge is that the trail riding surface of the bridge is at least 10' below the power lines that pass overhead, as required by Section 12B-2.C.5.b of SUDAS. From our observation during our site visit, we believe there is currently enough vertical clearance, but we were unable to measure the exact height of the power lines, so if there is not a 10' clearance the power lines need to be raised.

Note: We have located an up and coming pre-fabricated bridge manufacturer that goes by the company name of Bridge Brothers. They are a small company that has been together for a couple years. We contacted them and received a quote on a 115' span bridge with a 10' width (to accommodate a potential ambulance); the quote includes the cost for them to design, fabricate, and deliver the bridge to the site. This quote also includes the design of an abutment, so an abutment design provided by them could be used as an alternative to the abutment we designed. All of their bridges are design in accordance with the AASHTO Guide Specifications for the Design of Pedestrian Bridges, 2009 edition. Details regarding this company, their bridge design, and the specifications they use are included in Appendix B: Bridge Design.

Abutment

The abutment is designed as a cantilever retaining wall. We used the United Soil Classification System's typical values for soil properties to design the abutment; these values are a friction angle of 25° and a cohesion value of 10 kPa. We used Rankine's Active Earth Pressure Theory to calculate the active earth pressure on the heel side of the abutment, and Vesic's equation to calculate the bearing capacity of the soil. We calculated the factor of safety for bearing pressure using the affective area method, and we used the strip method to calculate the factors of safety for overturning and sliding. Results from the stability analysis are presented in Table 2.

Table 2: Stability Analysis Results

Sanhilian Charle	Factors of Safety						
Stability Check	Without Geogrid	With Geogrid	Required				
Overturning	4.37	8.46	3.5				
Sliding	1.73	2.44	2				
Bearing Capacity	3.06	3.06	3				

As highlighted in red, the sliding stability of the abutment without the use of Geogrid does not fall in the acceptable range, so we used Geogrid in our final design of the abutment. To design the rebar in the abutment, we modeled the stem as a bearing wall and the footing as an eccentrically loaded footing. The appropriate sections from the ACI code are referenced next to the corresponding calculations in the Appendix A: Abutment Design. The detailing of the rebar can be found in our plan sheets in the A section. The final design resulted in an abutment that is 31'- 6" tall, with a footing that is 22'- 2" deep and 40'- 4" wide; see Sheets A1-A6 of Alternative 1 for detailed drawings of the abutment design. Appendix A: Abutment Design contains supporting design calculations for the abutment design.

Geogrid

Due to the bottom layer of Geogrid being deep into the ground, the Geogrid is required to have an ultimate tensile strength of 20 kip/ft. This results in a factor of safety of 2.1 against the Geogrid breaking. The Geogrid must be biaxial (equal strength in both directions) to increase the slope stability of the levee build-up soil, since the grading of the soil in the levee build-up region transitions from a 3H:1V slope near where the levee starts building up to a 1H:2V slope at the region the Geogrid lays. As noted in the plan sheet A1 for Alternative 1, the minimum Geogrid aperture needs to be 3.5 times larger than the average backfill soil particle diameter.

At-Grade Crossing

According to Section 7.1 of the BNSFGGSP, at-grade crossings are only permitted if they are immediately adjacent to an existing public roadway crossing with existing highway railroad warning devices, which we have with US-34. In order to comply with this requirement, the edge of trail is offset 12' from the edge of US-34. See Sheet D4 of Alternative 2 for a detailed plan view of this intersection. Per the BNSF Road Crossing Layout guidelines, the existing concrete crossing for the railroad to cross US-

34 must be extended at least 1' past the edge of the trail. Ten 10' ties must also be placed immediately adjacent to the edge of the extended concrete. A 12" minimum ballast, with 12" of compacted material or asphalt below that, and a subgrade is also required. Wheel openings in the concrete crossing need to be 3" on the inner side of the track and 2 ½" on the outer side of the track to allow train wheels to travel across the concrete panel. Appendix D: BNSF At-Grade Crossing Construction Requirements contains the BNSF's design sheets for crossing their railroad. Also, a culvert that currently passes underneath US-34 must be extended beyond the trail if the at-grade alternative is chosen, because the trail will need to pass over this culvert.

Parking Lot

In the design of the parking lot, Section 8B-1 of the SUDAS Design Manual was used. The parking lot is 60' wide by 75' long and provides 14 stalls with one ADA Accessible stall included. The driving aisle is 24' wide to accommodate both directions of traffic. Standard stalls are 9' wide by 18' long to account for larger vehicles, and the accessible stall is 11' wide and 18' long. A slope of 2% was used to direct rainfall to an inlet. An access route from the parking lot to the trail is provided, with a 30" tall collapsible bollard to prevent unauthorized vehicles from driving on the trail. A SUDAS standard 6" curb was added to the outside of the lot and a graded at a 4H:1V slope to the existing surface; see Sheet C1 for parking lot details.

Parking Lot Hydrology Analysis

In the hydrology assessment, a 25-year design storm was used. The rational method was used to calculate the volume of water generated by this storm. The rainfall intensity was selected from Table 2B-2.08 in Section 2B-2 of SUDAS Design Manual for Southwest Iowa. In the assessment the water volumes for the 5-year and 100-year design storms were also calculated. The water volume from the 25-year storm was selected for design because it provides a medium amount of protection. The 5-year design storm volume wasn't selected to avoid unnecessary damage to the new parking lot. The 100-year design storm wasn't selected because the lot is a minor structure that is reasonably allowed to flood every 100 years. An inlet will be required at the lower end of the parking lot; it will need to be able to handle a water volume of 523 ft³ at a max rate of 0.58 ft³/s; see Sheet C1 for both alternatives for the location of the inlet.

Traffic Analysis

To determine the impact the trail has on traffic, as well as how traffic will impact the trail, we analyzed crosswalk locations in accordance with Chapter 4C of the MUTCD. None of the nine signal warrants in this chapter were met, therefore no traffic control signals are required at any of the crosswalks. In addition, the necessity of a pedestrian hybrid beacon was considered in accordance with Chapter 4F of the MUTCD. According to this chapter, a pedestrian hybrid beacon is not warranted at any of the crosswalks. See Appendix C: Traffic & Pedestrian Analysis for the supporting traffic warrant analysis.

Signage

Iowa Trails 2000, Chapter 4 Section 5, was used as a guideline for the layout of the roadway crossings. We then used the MUTCD to determine the exact signage and sign locations for the roadway crossings. Trail sign codes and sizes are from the specifications provided by the MUTCD, in Chapter 9B, Table 9B-1. At all roadway crossings, an R1-1 "STOP" sign (18"x18") is required where the trail meets the street to control trail traffic. Chapter 2B, Section 10, standard 2, of the MUTCD, requires the R1-1 signs to be located as close as practical to the intersection it regulates. A W3-1 "STOP Ahead" sign (18"x18") is required to be placed 100' in advance of all R1-1 signs along the trail; the 100' offset is the recommended distance from the MUTCD, Chapter 2C, Table 2C-4. For the alternative at-grade crossing, R15-1 "Railroad Crossbuck" (24"x4.5"), R15-2 "1 Track", and R1-2 "Yield" (18"x18") signs shall all be mounted on the same post; this combination of signs shall be located on both sides of the railroad track, offset 12' from the nearest edge of track, according to Chapter 8D, Figure 8D-1, of the MUTCD. Per the same reference, a W10-1 "Advance Grade Crossing" (15" dia.) sign is also required to be placed 100' in advance of the previously mentioned sign combination. All trail signs must be laterally offset 2' from trail (measured from the edge of the trail to the edge of the sign face), per SUDAS 12B-2. For the roadways approaching the crosswalks a W11-2 "Pedestrian" sign (30"x30" for 200th Street and West Coolbaugh, and 36"x36" for HWY 48) with a W16-7P "Downward Diagonal Arrow" (24"x12") mounted directly below it shall be placed at both sides of the crosswalks, per the MUTCD, Chapter 2C, Table 2C-2. These roadways also require a W11-2 sign (30"x30" for 200th Street and West Coolbaugh, and 36"x36" for HWY 48) with a W16-9P "Ahead" (24"x12") sign mounted directly below it to be placed in advance of the crosswalks as a warning. Per the MUTCD, Chapter 2C, Table 2C-4, the location of this sign combination is 125' in advance of the crosswalk (in each direction) for HWY 48, 175' for 200th Street, 100' for the westbound approach of West Coolbaugh, and 125' for the eastbound approach of West Coolbaugh. There is a bridge in the way of this sign combination on the eastbound approach on 200th Street, so the sign shall be placed at the west side of this bridge. Also, the current STOP sign controlling Alix Street is not mounted high enough; it must be raised to 7' above the road surface. Finally, per the MUTCD, Chapter 2A, Section 2A.18, the minimum height of all signs along the trail, measured vertically from the bottom of the sign to the elevation of the trail surface shall be 6'; the height to the bottom of a secondary sign mounted below another sign may be 1' less. Add 1' to these requirements for street signs. Refer to Sheets D1-D3 for a plan view of the sign placements for the three intersections for Alternative 1 and Sheets D1-D4 for Alternative 2.

Pavement Markings & Detectable Warnings

Per SUDAS Section 12A-2, detectable warnings are located at all road crossings and at grade crossings. These warning strips have a width of 2', and extend the entire width of the path. The trail stop lines, yield lines, crosswalks, and centerlines are designed in accordance with PM-110 from the Iowa DOT Standard Road Plans. The stop lines along the trail are 2' wide and offset 1' from the edge of the detectable warnings. The crosswalk lines are 2'x10' and spaced at 2'. The centerline of the trail is 4" wide. For

the alternative at-grade crossing, the yield lines are 2' wide and offset 12' from the edge of the nearest track. The railroad pavement marking symbol is designed at a 3/8 scale (due to the narrow space) of the pavement marking dimensions provided by the MUTCD in Figure 8B-7A. This pavement marking is located 62' from the edge of the nearest track to the center of the pavement marking. Note, collapsible safety bollards that are 30" tall are recommended for the trail to prevent unauthorized vehicles from driving on the trail; these bollards are offset 10' from the edge of the road and placed in the center of the trail. Refer to Sheets D1-D3 for a plan view of the placement of pavement markings and detectable warnings for Alternative 1, and Sheets D1-D4 for Alternative 2.

Infraworks

We used Autodesk Infraworks to provide renderings of the trail design; see Section X Design Renderings & Models of this report for the final renderings. While we attempted to produce these rendering as accurate as possible, they are for visualization purposes only and are not exact representations of the final design.

Final Note:

A summary of design requirements for all elements of this trail is provided in Appendix E: Summary of Design Requirements.

VII. Engineer's Cost Estimate

To estimate the final project cost, we used two sources to find unit prices for material cost and one source to calculate the cost of acquiring the necessary land. We used the RS Means Landscape and Site Work, 2016 edition and the Iowa DOT Bid Tabs for all of our material costs, which includes labor, overhead, and profit. The Beacon Land Property Management System was used to retrieve the listing prices and to estimate how much land needs to be acquired. A 10% markup is applied to the listing prices to estimate the true market value of the land. Finalizing engineering and contingency are estimated at 10% of the construction cost. Our final engineering cost estimates are provided in Table 3.

C		Bridge Alternative				At-Grade Alternative				
Cost		Concrete		Asphalt	R!	Concrete		Asphalt		
Construction	\$	1,400,737	\$	1,135,493	\$	990,444	\$	749,289		
Property Acquisition	\$	2,834	\$	2,834	\$	5,188	\$	5,188		
Finalizing Engineering	\$	140,074	\$	113,549	\$	49,522	\$	37,464		
Contingency	\$	140,074	\$	113,549	\$	99,044	\$	74,929		
Total	\$	1,683,719	\$	1,365,426	\$	1,144,198	\$	866,870		

Table 3: Final Engineering Cost Estimate

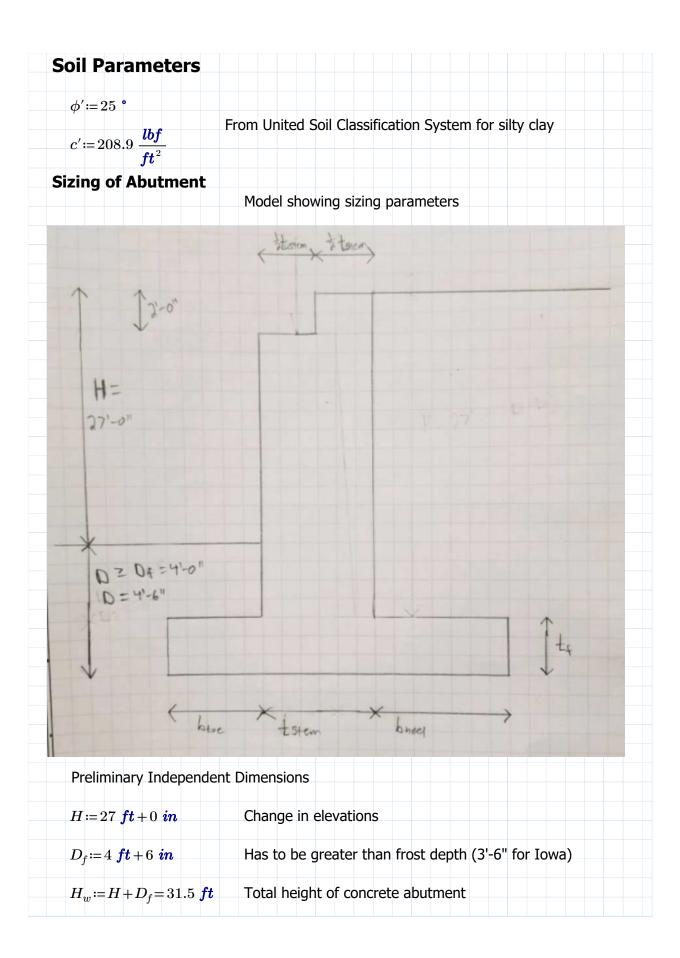
Appendix F: Cost Estimates contains details regarding the final cost estimates.

VIII. Appendices

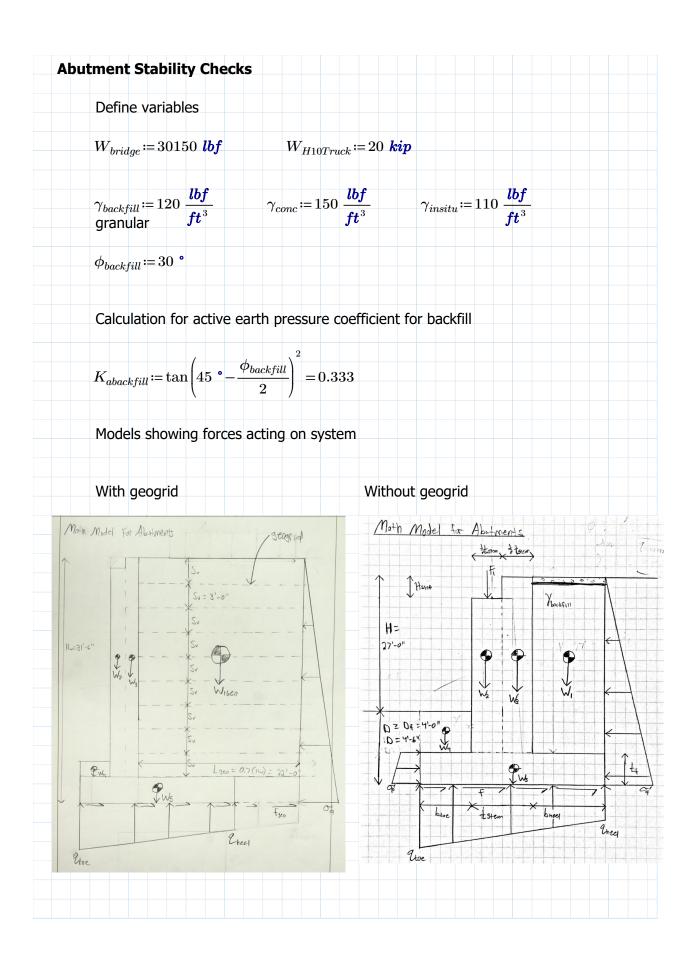
Appendices are provided within this section on the following pages.

Appendix A:Abutment Design

Table of Contents Page(s) Content Soil Parameters & Sizing of Abutment.....2-3 Abutment Stability Checks......4-10 Shear Force and Bending Moment Diagrams......11-13 Footing Reinforcement Calculations.....14-16



$W_{abutment}\!\coloneqq\!12\; extbf{ft}$	width of reguangular part of abutment into the page
$H_{step}\!\coloneqq\!2$ ft	Height of the step where bridge is anchored
Dependent Dimension	ns
$B = 0.7 \cdot H_w = 22.05 \ f$	0.4H < B < 0.7H Total width of footing
$t_f = 0.1 \cdot H_w = 3.15 \; ft$	Thickness of footing
$B_{toe} = 0.2 \; H_w = 6.3 \; ft$	Width of footing toe
$t_{stem} \coloneqq 0.1 \cdot H_w = 3.15$	ft Thickness of stem
$B_{heel}\!\coloneqq\! B\!-\!B_{toe}\!-\!t_{sten}$	$_{n}$ = 12.6 ft Width of footing heel
Final Dimensions to nearest	t inch to make construction easier
$B \coloneqq 22 \ \mathbf{ft} + 2 \ \mathbf{in}$	
$t_f = 3 ft + 2 in$	
$B_{toe} \coloneqq 6 \ ft + 4 \ in$	
$t_{stem} \coloneqq 3 \ ft + 2 \ in$	
$B_{heel} \coloneqq 12 \; ft + 8 \; in$	
$H_w := 31 \mathbf{ft} + 6 \mathbf{in}$	
Calculate total volume of	f concrete needed
$V_{footing} \coloneqq ig(B ullet t_f ig) ullet ig(W_{abut}$	$_{ment}$ + 28 $ extit{ft}$ + 4 $ extit{in}$)
$V_{stem} \coloneqq ig(ig(H_w - t_fig) \cdot t_{stem} \cdot$	$\left(12 \; extbf{\textit{ft}} ight) + \left(\left(14 \; extbf{\textit{ft}} + 2 \; extbf{\textit{in}} ight) \cdot \left(H_w - t_f ight) \cdot t_{stem} ight)$
$V_{step} \coloneqq 168 \; extbf{\textit{ft}} \cdot 2 \; extbf{\textit{ft}} \cdot t_{sten}$	n
$V_{reinforcingsteel} \coloneqq 40 \; ft^3$	From cost estimate excel file
$V_{concreteneeded}\!\coloneqq\!V_{stem}\!+\!V$	$V_{footing}\!-\!V_{step}\!-\!V_{reinforcingsteel}\!=\!150.922$ $ extbf{\emph{yd}}^3$



Calculating forces $F_1 \coloneqq rac{rac{1}{2} {m \cdot} W_{bridge}}{W_{abutment}} = 1.256 \; rac{m{kip}}{m{ft}}$ $W_1 \coloneqq \left(\left(H_w - t_f \right) \cdot B_{heel} \right) \cdot \gamma_{backfill} = 43.067 \frac{\textit{kip}}{\textit{ft}}$ $\boldsymbol{W}_{1Geo} \coloneqq \left(\left(\boldsymbol{H}_w - \boldsymbol{t}_f \right) \boldsymbol{\cdot} \left(\boldsymbol{B}_{heel} + \left(22 \ \boldsymbol{ft} - \boldsymbol{B}_{heel} \right) \right) \right) \boldsymbol{\cdot} \boldsymbol{\gamma}_{backfill} = 74.8$ $W_2 \coloneqq \left(\frac{1}{2} \cdot t_{stem} \cdot \left(H_w - t_{stem} - H_{step}\right)\right) \cdot \gamma_{conc} = 6.254 \; rac{m{kip}}{m{ft}}$ $W_{3} \coloneqq \left(\frac{1}{2} \cdot t_{stem} \cdot \left(H_{w} - t_{stem}\right)\right) \cdot \gamma_{conc} = 6.729 \frac{\textit{kip}}{\textit{ft}}$ $W_4 \coloneqq ((D_f - t_f) \cdot B_{toe}) \cdot \gamma_{backfill} = 1.013 \frac{kip}{ft}$ $W_5 := (B \cdot t_f) \cdot \gamma_{conc} = 10.529 \frac{kip}{ft}$ $F_a := \frac{1}{2} \cdot H_w^2 \cdot \gamma_{backfill} \cdot K_{abackfill} = 19.8 \frac{kip}{ft}$ Calculating moment arms for each force about the bottom left corner of the toe $d_{F1} := B_{toe} + \frac{1}{4} \cdot t_{stem} = 7.125 \ ft$ $d_{W1Geo} := B_{toe} + t_{stem} + \frac{22 \ ft}{2} = 20.5 \ ft$ $d_{W1} := B_{toe} + t_{stem} + \frac{B_{heel}}{2} = 15.833 \ ft$ $d_{W2} \coloneqq B_{toe} + \frac{1}{4} \cdot t_{stem}$ $d_{W3} := B_{toe} + \frac{3}{4} \cdot t_{stem} = 8.708 \; ft$

$$d_{W4} \coloneqq \frac{1}{2} \cdot B_{toc} = 3.167 \ ft$$

$$d_{W5} \coloneqq \frac{1}{2} \cdot B = 11.083 \ ft$$

$$d_a \coloneqq \frac{H_w}{3} = 10.5 \ ft$$
Calculate Factor of Safety due to overturning
With geogrid
$$M_{causing overturning} \coloneqq F_a \cdot d_a = 208.373 \ \frac{kip \cdot ft}{ft}$$

$$M_{resisting overturning} Geo \coloneqq (W_{1Coo} \cdot d_{W1Coo}) + (W_2 \cdot d_{W2}) + (W_3 \cdot d_{W3}) \downarrow = 1762.21 \ \frac{kip \cdot ft}{ft}$$

$$FS_{overturniGFO} \coloneqq \frac{M_{resisting overturning}}{M_{causing overturning}} = 8.457$$
Great
$$M_{resisting overturning} \coloneqq (W_1 \cdot d_{W1}) + (W_2 \cdot d_{W2}) + (W_3 \cdot d_{W3}) \downarrow = 910.699 \ \frac{kip \cdot ft}{ft}$$

$$+ (W_5 \cdot d_{W5}) + (F_1 \cdot d_{F1})$$

$$FS_{overturn} \coloneqq \frac{M_{resisting overturning}}{M_{causing overturning}} = 4.371$$
Good

Internal Geogrid Stability Calculations
$$Set \ geogrid \ length \ and \ spacing$$

$$L_{geo} \coloneqq 0.7 \cdot H_w = 22.05 \ ft$$

$$S_v \coloneqq 3 \ ft$$

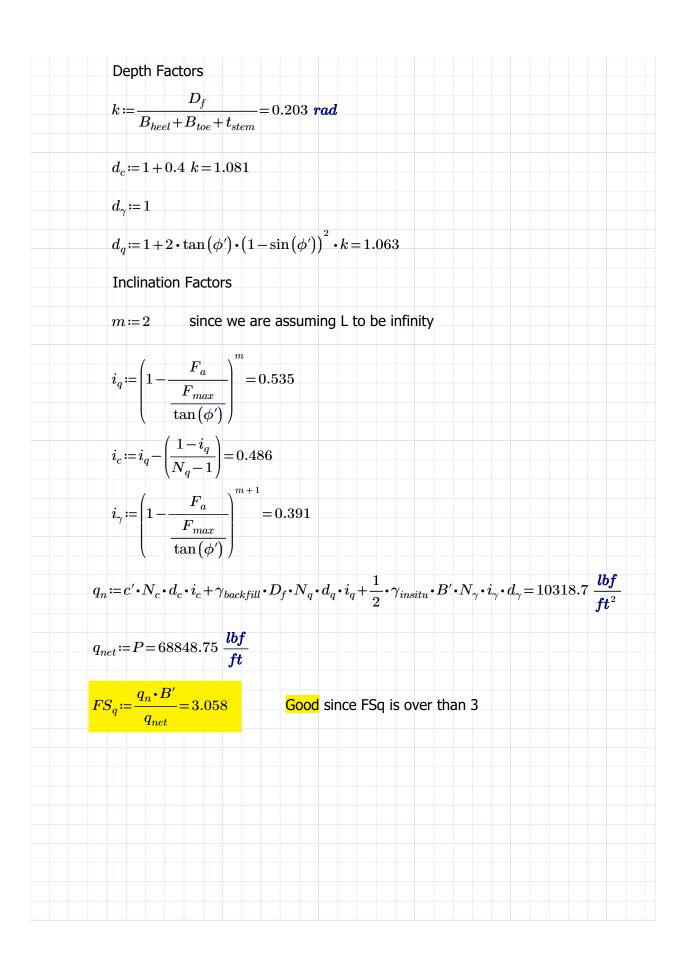
Calculate vertical earth pressure due to backfill weight $\sigma'_{o@3ft} := \gamma_{backfill} \cdot 4 \ ft = 480 \ psf$ $\sigma'_{o@6ft} := \gamma_{backfill} \cdot 7 \ \mathbf{ft} = 840 \ \mathbf{psf}$ $\sigma'_{o@9ft} := \gamma_{backfill} \cdot 10 \ ft = 1200 \ psf$ These calcs include a possible surcharge load which was modeled as an $\sigma'_{o@12ft} := \gamma_{backfill} \cdot 13 \ ft = 1560 \ psf$ extra foot of soil $\sigma'_{o@15ft} := \gamma_{backfill} \cdot 16 \ \mathbf{ft} = 1920 \ \mathbf{psf}$ $\sigma'_{o@18ft} := \gamma_{backfill} \cdot 19 \ ft = 2280 \ psf$ $\sigma'_{o@21ft} := \gamma_{backfill} \cdot 22 \ ft = 2640 \ psf$ $\sigma'_{o@24ft} := \gamma_{backfill} \cdot 25 \ ft = 3000 \ psf$ $\sigma'_{o@27ft} := \gamma_{backfill} \cdot 28 \ \textit{ft} = 3360 \ \textit{psf}$ Calculate active earth pressure due to backfill weight $\sigma'_{a3} := K_{abackfill} \cdot \sigma'_{a@3ft} = 160 \ psf$ $\sigma'_{a6} := K_{abackfill} \cdot \sigma'_{o@6ft} = 280$ **psf** $\sigma'_{a9} := K_{abackfill} \cdot \sigma'_{o@9ft} = 400 \ psf$ $\sigma'_{a12} := K_{abackfill} \cdot \sigma'_{a@12ft} = 520 \ psf$ $\sigma'_{a15} := K_{abackfill} \cdot \sigma'_{o@15ft} = 640 \ \textit{psf}$ $\sigma'_{a18} \coloneqq K_{abackfill} \cdot \sigma'_{o@18ft} = 760$ **psf** $\sigma'_{a21} := K_{abackfill} \cdot \sigma'_{o@21ft} = 880 \ \textit{psf}$ $\sigma'_{a24} \coloneqq K_{abackfill} \cdot \sigma'_{o@24ft} = 1000 \ \textit{psf}$ $\sigma'_{a27} \coloneqq K_{abackfill} \cdot \sigma'_{o@27ft} = 1120 \ \textit{psf}$

Factor of Safety for geogrid breaking http://www.retech.in/pdf/Retech% $T_{ult} = 20000 \frac{lbf}{ft}$ 20Uniaxial%20Geogrids.pdf $FS_{ID} \coloneqq 1.2 \qquad FS_{creep} \coloneqq 2 \qquad \qquad FS_{CBD} \coloneqq 1.2$ $T_{allow} \coloneqq \frac{T_{ult}}{FS_{ID} \cdot FS_{creen} \cdot FS_{CBD}} = 6944 \frac{lbf}{ft}$ $T_{required} \coloneqq \sigma'_{a27} \boldsymbol{\cdot} S_v = 3360 \ \frac{\textit{lbf}}{\textit{ft}}$ $FS_B \coloneqq \frac{T_{allow}}{T_{remixed}} = 2.067$ > 1.5 OK Calculate Factor of Safety for sliding With geogrid $B \coloneqq L_{qeo} + B_{toe} + t_{stem}$ accounts for geogrid contribution to friction capacity $P_{geo} \coloneqq W_{1Geo} + W_2 + W_3 + W_4 + W_5 + F_1 = 100.582 \ \frac{\textit{kip}}{\textit{ft}}$ $\delta \coloneqq \phi' = 25$ $F_{maxgeo} := P_{geo} \cdot \tan(\delta) + B \cdot (0.5 \cdot c') \cdot \tan(\delta) = 48.439 \frac{kip}{ft}$ $FS_{vGEO} := \frac{F_{maxgeo}}{F_{a}} = 2.441$ Good since Factor of Safety for sliding is greater than 2.0 Without geogrid $B \coloneqq B_{toe} + B_{heel} + t_{stem}$ $P := W_1 + W_2 + W_3 + W_4 + W_5 + F_1 = 68.849 \frac{kip}{ft}$ $\delta \coloneqq \phi' = 25$ $F_{max} := P \cdot \tan(\delta) + B \cdot (0.5 \cdot c') = 34.42 \frac{kip}{ft}$

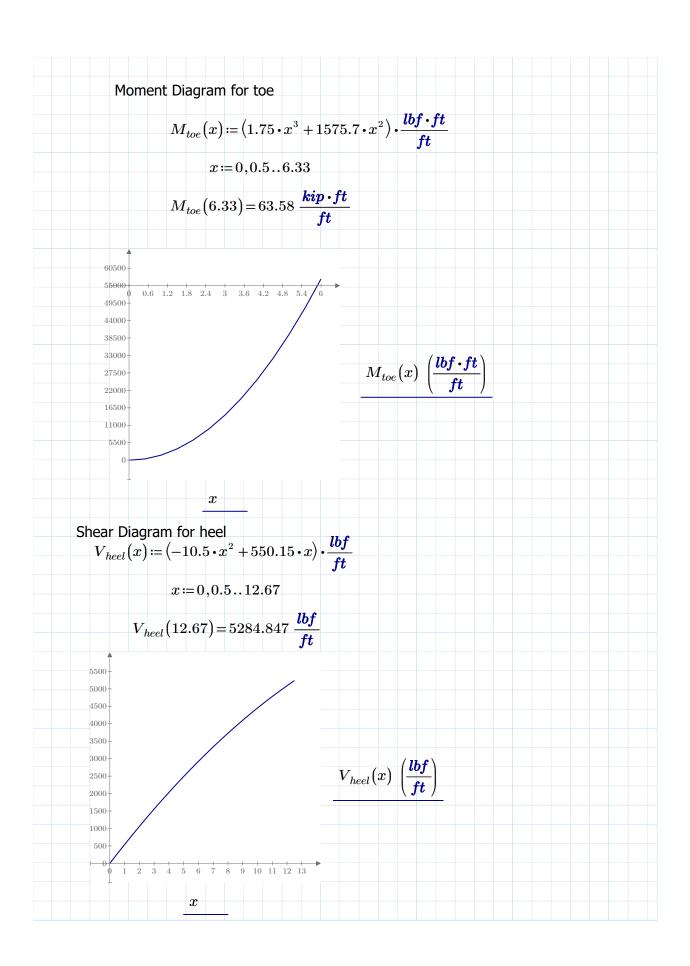
$FS_{vNOGEO} \coloneqq \frac{F_{max}}{F_a} = 1.734$	NOT OK since Factor of Safety for sliding i less than 2.0
Check for uplift	
With geogrid	
$x_r \!\coloneqq\! \frac{M_{resisting overturning Geo} \!-\! M_{causing overt$	$\frac{rning}{}$ = 15.448 ft
$e_{Geo} \coloneqq rac{L_{geo} + B_{toe} + t_{stem}}{2} - x_r = 0.327 \; extbf{\textit{ft}}$	$check \coloneqq rac{L_{geo} + B_{toe} + t_{stem}}{6} = 5.258 \; extbf{ft}$
OK since e <ch< td=""><td>neck</td></ch<>	neck
Without geogrid	
$x_r \coloneqq \frac{M_{resistingoverturning} - M_{causingoverturnin}}{P}$	$\frac{dg}{dt} = 10.201 \; ft$
$e\!\coloneqq\!rac{B_{heel}\!+\!B_{toe}\!+\!t_{stem}}{2}\!-\!x_{r}\!=\!0.882~ extbf{ft}$	$check \coloneqq rac{B_{heel} + B_{toe} + t_{stem}}{6} = 3.694 \; extbf{\textit{ft}}$
OK since e <ch< td=""><td>neck</td></ch<>	neck
Bearing Pressure Factor of Safety using V	Vesic's Equation (effective area method)
$B' \coloneqq \left(B_{heel} + B_{toe} + t_{stem}\right) - 2 \cdot e = 20$	0.402 f t
Vesics Factors	
$N_q \coloneqq e^{\pi \cdot an(\phi')} \cdot anigg(45 \circ + rac{\phi'}{2}igg)^2 = 10$	0.662

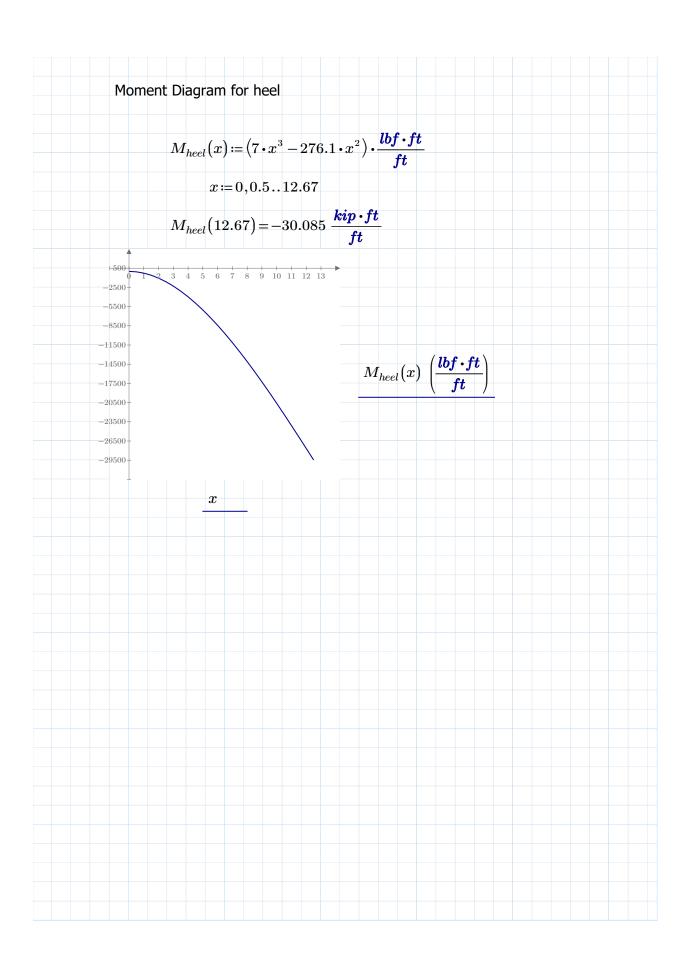
 $N_c := \frac{N_q - 1}{\tan(\phi')} = 20.721$

 $N_{\gamma} \coloneqq 2 \boldsymbol{\cdot} \left(N_q + 1 \right) \boldsymbol{\cdot} \tan \left(\phi' \right) = 10.876$



Shear Force and Bending Moment Diagrams $I \coloneqq \frac{1}{12} \cdot B^3 \cdot t_{stem} \cdot \frac{1}{ft} = 2874.235 \frac{1}{ft} \cdot ft^4$ $q_{toe} \coloneqq \left(\frac{P \cdot e \cdot \frac{B}{2}}{R} + \frac{P \cdot e \cdot \frac{B}{2}}{I}\right) = 3340.2 \text{ psf}$ $q_{heel} \coloneqq \left(\frac{P}{B} - \frac{P \cdot e \cdot \frac{B}{2}}{I}\right) = 2871.7 \ \textit{psf}$ $slope \coloneqq \frac{q_{toe} - q_{heel}}{B} = 21.135 \frac{\textit{psf}}{\textit{ft}}$ Shear Diagram for toe $V_{toe}(x) \coloneqq \left(-10.5 \cdot x^2 + 3151.4 \cdot x\right) \cdot \frac{lbf}{ft}$ x = 0, 0.5..6.33 $V_{toe}(6.33) = 19527.639 \frac{lbf}{ft}$ 20000 18000 16000 14000 12000 $V_{toe}(x) \left(\frac{m{lbf}}{m{ft}} \right)$ 10000 8000 6000 4000 2000 0.6 1.2 1.8 2.4 3 3.6 4.2 4.8 5.4 \boldsymbol{x}





Footing Reinforcement Calculations

Used this book to help design the reinforcement and check for moment and shear capacities

Reinforced Concrete Mechanics & Design 6th edition by James K. Wight and James G. MacGregor

Footing reinforcement calculations

Factored net pressure

$$q_{nu} \coloneqq \frac{1.2 \cdot \frac{0.5 \cdot W_{bridge}}{W_{abutment}} + 1.6 \cdot \frac{W_{H10Truck}}{W_{abutment}}}{B} = 188.308 \frac{\textit{lbf}}{\textit{ft}^2} \quad \text{Load factors from ACI Code section 9.2.1}$$

One way shear check

$$d \coloneqq t_{stem} - 3$$
 $in - 1.1285$ $in = 33.872$ in Assuming #18 bar (r=1.1285in)

$$V_u \coloneqq q_{nu} \cdot ((B-d) \cdot 1 \ ft) = 3.643 \ kip$$
 Required shear strength

 $\lambda := 1$ for normal weight concrete

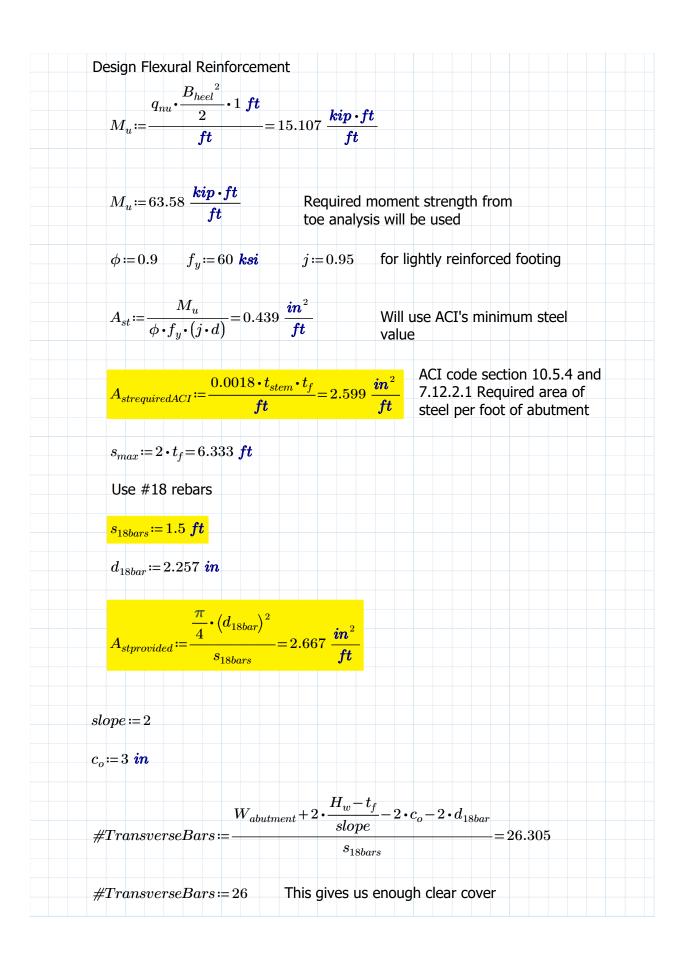
$$f_c' = 4000$$
 Concrete strength requirement

 $b_w = 1$ **ft** Analyzing 1 foot strip

 ϕ := 0.75 from ACI Code Section 9.3.2.3 for shear design when load factors from ACI Code Section 9.2.1 are used

$$\phi V_c := \phi \cdot 2 \cdot \lambda \cdot \sqrt[2]{f'_c} \cdot psi \cdot b_w \cdot d = 38.56 \ kip$$
 Available shear strength

Since the available shear strength is way greater than the required shear strength, this check is GOOD



Compute moment capacity

$$a \coloneqq \frac{A_{stprovided} \cdot 1 \ \boldsymbol{ft} \cdot f_y}{0.85 \cdot f_c \cdot \boldsymbol{psi} \cdot b_w} = 3.922 \ \boldsymbol{in}$$

$$\phi = 0.9$$

$$\phi \coloneqq 0.9$$
 $c_o \coloneqq 3$ in

clear cover to edge of transverse rebars

$$\phi M_n \coloneqq \phi \cdot A_{stprovided} \cdot 1 \ \textbf{\textit{ft}} \cdot f_y \cdot \left(\left(t_{stem} - c_o - d_{18bar} \right) - \frac{a}{2} \right) = 369.461 \ \textbf{\textit{kip}} \cdot \textbf{\textit{ft}}$$

Moment Capacity

Moment capacity is way greater than required moment capacity, so this check is GOOD

Select minimum temperature reinforcement (longitudinal rebars)

$$A_{strequired temp} \coloneqq \frac{0.0018 \cdot B \cdot t_f}{\mathbf{ft}} = 18.194 \ \frac{\mathbf{in}^2}{\mathbf{ft}}$$

ACI Code Section 7.12.2.1

 $s_{tempbars} = 4 \ ft$

$$\#bars \coloneqq \frac{B - 2 \cdot c_o}{s_{tempbars}} = 5.417$$

$$\#bars = 5$$

$$A_{stprovided temp} \coloneqq rac{\dfrac{\pi}{4} \boldsymbol{\cdot} \left(d_{18bar}
ight)^2 \boldsymbol{\cdot} \#bars}{ extbf{\textit{ft}}} = 20.004 \; rac{ extbf{\textit{in}}^2}{ extbf{\textit{ft}}}$$

Stem Reinforcement Calculations

Stem calculations- modeling the stem as a Bearing Wall

Check axial load capacity of stem (treating it as a bearing wall)

$$f'_{c} \coloneqq 4 \ ksi$$

$$A_q \coloneqq t_{stem} = 38$$
 in a

analyzing 1 ft strip

ACI Code Section 14.5.2

 $k \coloneqq 1$ -laterally braced at both ends (footing resisting translation, and bridge/soil acting a diaphram)

-footing also resists rotation

$$l_c := H_w - 2 \ \textit{ft} - t_{stem} = 26.333 \ \textit{ft}$$

clear vertical distance between lateral supports

$$h \coloneqq t_{stem}$$

 $\phi = 0.65$

ACI Code Section 9.3.2.2 for other type of member

$$\phi P_n \coloneqq 0.55 \boldsymbol{\cdot} \phi \boldsymbol{\cdot} f'_c \boldsymbol{\cdot} A_g \boldsymbol{\cdot} \left(1 - \frac{k \boldsymbol{\cdot} l_c}{32 \boldsymbol{\cdot} h}\right)^2 = 357.206 \ \frac{\textit{kip}}{\textit{ft}}$$

Axial load capacity (ACI eq. 14-1)

$$DL \coloneqq rac{rac{W_{bridge}}{2}}{W_{abutment}} = 1.256 \; rac{ extbf{\emph{kip}}}{ extbf{\emph{ft}}}$$

$$LL \coloneqq \frac{W_{H10Truck}}{W_{abutment}} = 1.667 \ \frac{\textit{kip}}{\textit{ft}}$$

$$P_u := 1.2 \cdot DL + 1.6 \cdot LL = 4.174 \ \frac{kip}{ft}$$

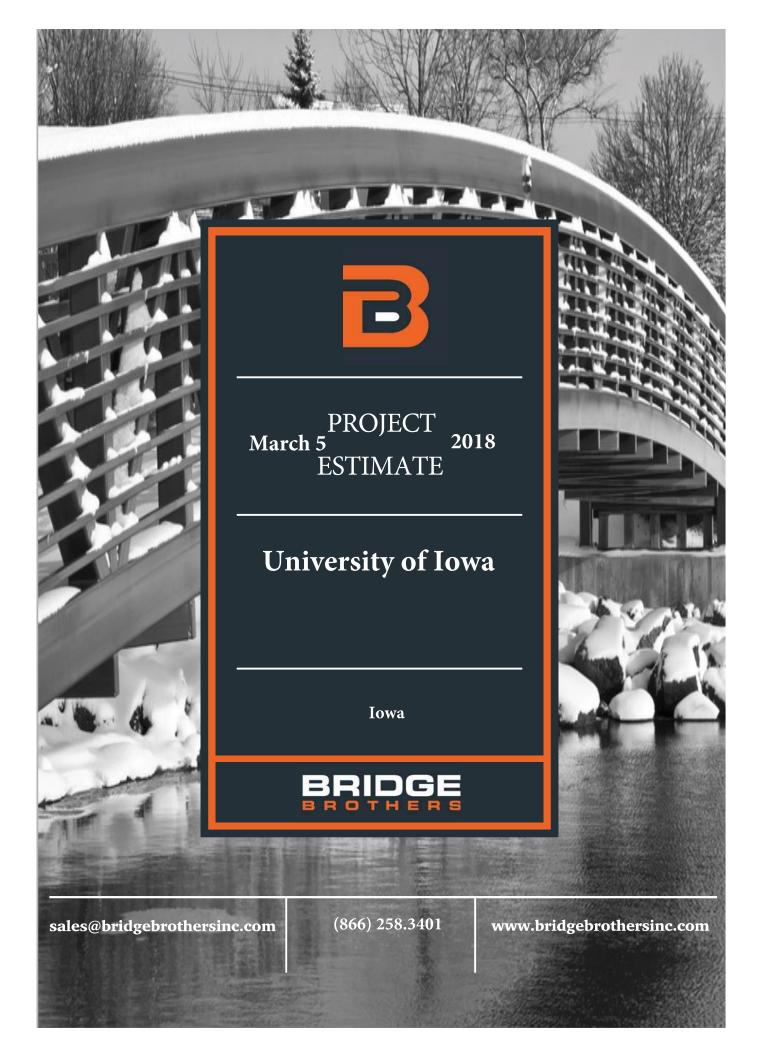
Required axial strength of stem

Since the capacity is way greater than the required strength, this is GOOD

	Vertical Reinford	ement	
	$A_v \coloneqq 0.79 \; \emph{in}^2$	Using #8 bars to be conservat doesn't rely on rebar for axial	
	$s_{hmax} \coloneqq \frac{A_v}{0.0012 \cdot}$	$\frac{1}{h} = 17.325 \ in$	
	$s_h = 16$ in	orizontal spacing of vertical rebars	in stem
	$\#Bars \coloneqq \frac{\left(40 \ \textit{ft}\right)}{}$	$+4 \ in) - 2 \cdot c_o - 2 \cdot 0.5 \ in = 29.813$	
	#VerticalBars:	going from edge of heel be stem, and from edge of toe stem, for a total of 29x2 #8 length	up through
	Horizontal Reinfo	orcement ACI Code Section 14.3.3	
	$A_h = 0.79 \; in^2$	Using #8 bars to be conservative doesn't rely on horizontal reinforcalculations	
	$s_{vmax} \coloneqq rac{A_h}{0.0020}$	$\frac{1}{h} = 10.395 \ in$	
	$s_v \coloneqq 10$ in		
	#HorizontalBa	$rrs \coloneqq rac{H_w - t_f - 2 m{\cdot} c_o - 2 m{\cdot} 0.5}{s_v} m{in} = 35$	3.3
	#HorizontalBa		away from tension e stem (#8 Bars)
#Hori	zontal Bars Comp	$ressionSide \coloneqq rac{H_w - 2 \; extbf{\textit{ft}} - t_f - 2 \cdot c_o}{s_v}$	$-2 \cdot 0.5 \ in = 30.9$
	#HorizontalBa	_	ches away from tension e (#8 Bars)

Appendix B:

Bridge Design





CONTACT |
COMPANY |
EMAIL |
PHONE |

Austin Sitzmann
University of Iowa
austin-sitzmann@uiowa.
(712) 541-9666

BRIDGE DETAILS

115'	Bridge Inside Width	10'
H-10	Live Load	90psf
Custom	Splice(s)	
Douglas Fir	Elevation Change	
	H-10 Custom	H-10 Live Load Custom Splice(s)

ATTRIBUTES

Rail ing St yl e	Horizontal	Ra il ing H eight	42"		
Weight	~ 35,000	Rubrail	N/A		
Bridge Finish	Weathered	AASHTO Design	✓		
Abutment Design	~	Anchor Design	~		
Freight Cost	7000	BRIDGE EST	IMATE		
Material Cost	100000	107000			

Additional Info:

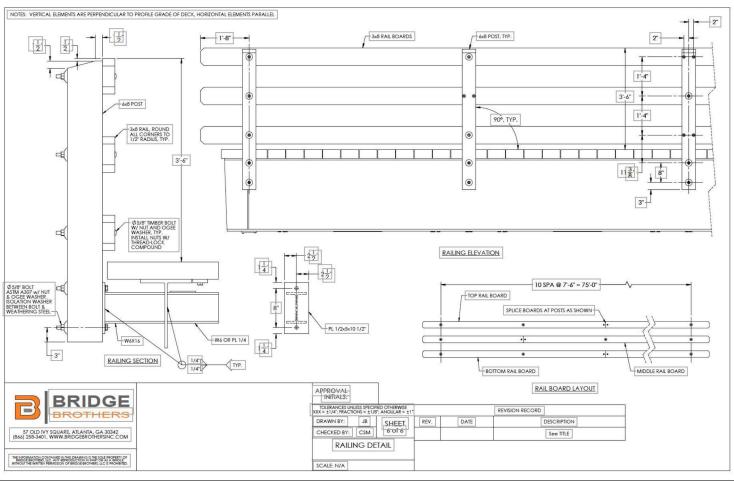
IA PE stamped drawings, abutments and anchor designs. Full bridge manufacturing and delivery.

This proposal does not include sales tax, unloading cost, bridge erection or construction cost. This proposal is based on the information provided and cannot be used to place an order

Design & Engineering - 3 Weeks Manufacturing & Delivery - 10 Weeks

BRIDGE









57 OLD IVY SQUARE, ATLANTA GA 30342 | 866/258-3401 | WWW.BRIDGEBROTHERS.COM



<u>Purpose and Scope</u> These specifications are for a fully engineered clear span bridge of welded steel construction and shall be regarded as minimum standards for design and construction.

Qualified Suppliers

Each bidder is required to identify the intended bridge supplier listed below as part of the bid submittal. Pre-approved Manufacturer:

Bridge Brothers Inc Atlanta, GA

Phone: 866.258.3401

Email: sales@bridgebrothersinc.com

Suppliers other than those listed above may be used provided the engineer or owner's agent evaluates the proposed supplier and approves the supplier ten (10) days prior to bid. The contractor must provide the following documentation, for any proposed supplier who is not listed above for approval:

- * Product Literature
- * All documentation to insure the proposed substitution will be in compliance with these specifications. This shall include:
 - Project specific design calculations
 - Project specific shop drawings
 - Splicing and erection procedures
 - Warranty information
 - Inspection and Maintenance procedures

Part 1 - Materials

1.1) Unpainted Weathering Steel Bridges which are not to be painted shall be fabricated from high strength, low alloy, and atmospheric corrosion resistant ASTM A847 cold-formed welded square and rectangular tubing and/or ASTM A588, ASTM A242, or ASTM A606 plate and structural steel shapes. Steel shall have a minimum yield strength of 50ksi. The minimum corrosion index of atmospheric corrosion resistant steel, as determined in accordance with ASTM G101, shall be 6.0.



- **1.2) Painted Steel** Bridges which are to be painted shall be fabricated from ASTM A36 or A572 and tubular sections from ASTM A500 GR B.
- **1.3) Galvanized Steel** Bridges which are to be galvanized shall be fabricated from ASTM A36 or A572 and tubular sections from ASTM A500 GR B.
- **1.4) Bolts** Field splices shall be fully bolted with ASTM A325 high strength bolts in accordance with the AASHTO Specifications for Structural Joints. Type 3 hardware shall be used for weathering steel bridge. Galvanized hardware shall be used for painted or galvanized finishes.
- **1.5) Deck** Decking shall meet one of the following criteria:
 - Pressure Treated Pine Decking shall be Southern Pine No. 1 Structural (1000# minimum extreme fiber bending) Grade. Wood decking shall have a minimum CCA (Copper Chromium Arsenate) content equal to .40 pounds per cubic foot. Equivalent pressure treating methods are acceptable. All wood shall comply with American Softwood Lumber Standard PS 20-70. Each piece of lumber shall be identified by the grade and treatment mark of recognized organization or independent agency certified by the American Lumber Standards Committee, Washington, DC to grade the species. All lumber specified for treatment shall be treated to the requirements of American Wood Preservers Bureau AWPB LP-22.
 - Tropical Hardwood
 Hardwood decking shall be IPE hardwood decking meeting or exceeding mechanical properties as defined by US Forest Products Laboratories testing methods. All decking material is to be produced from an IBAMA (Brazilian Institute for the Environment and the Renewal of Natural Resources) registered mill and produced from legally harvested logs as defined under Brazilian Forest Code Law 4771 as regulated by IBAMA and the ITTO (International Timber Trade Organization).
 - **ADA Floor Grating** The bridge shall be supplied with a steel bar grating floor meeting ADA requirements with a maximum opening of ½". The grating shall be attached to the bridge in accordance with the grating manufacturer's requirements. Grating main bars shall span transverse to the primary direction of roadway travel.
 - **Concrete** The bridge shall be furnished with a stay-in place galvanized steel form deck suitable for pouring a reinforced concrete slab. The form deck shall be designed to carry the dead load of the wet concrete, weight of form



decking, plus a construction load of 20 psf or a 150 pound concentrated load on a 1'-0" wide section of deck.

The form deck shall be either smooth or composite. Composite decking shall not be used as reinforcing when designing for concentrated loads (wheel loads). The decking shall be galvanized in accordance with ASTM A525 (G60). Concrete deck design shall be performed by the Bridge manufacturer.

Concrete decks shall be designed for concentrated load as specified in Section 4.1.3. The wheel loads used for deck design shall be distributed per AASHTO LRFD Bridge Design Specifications and using Steel Deck Institute C-2017 Standard for Composite Steel Floor Deck-Slabs.

Part 2 - Applicable Codes and Standards

2.1) Governing Codes and Standards Bridges shall be designed in accordance with the AASHTO Guide Specification for the Design of Pedestrian Bridges, 2009 edition, where applicable and unless otherwise stated in the document.

2.2) Reference Codes and Standards

- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, 2009.
- AASHTO LRFD Bridge Design Specifications, latest edition
- AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, latest edition
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, latest edition
- AASHTO M 133 Standard Specification for Preservatives and Pressure Treatment Processes for Timber, latest edition
- Steel Deck Institute (SDI), C-2017 Standard for Composite Steel Floor Deck-Slabs
- AISC Part 16.1-2010 Specification for Structural Steel Buildings
- AWS D1.1 Structural Welding Code Steel, latest edition
- Guide to Stability Design Criteria for Metal Structures, latest edition
- National Design Specification for Wood Construction, ANSI NDS, latest edition
- American Wood Preservers Association Standards, latest edition



<u>Part 3 - General Design Features</u>

		oridge span shall be _ red from each end c			a straight line
	n to structural	oridge width shall be ₋ I members or accout			
	agonal per p	The bridge shall be banel and square end therwise, shall be plu	ded vertical me	=	
3.	-	es may be designed s are placed up insid	-	ction configuration	where the
3.	members sh and/or ship height of th	listance from the top nall be determined b ping requirements. V e truss and distance as much as possible.	y the bridge fak Vhen the bridge	oricator based upor e is in the floodplain	n structural n, the overall
3.	=	op of the top chord s neasured from the hig		•	es (54'') above
	ed weight d	Veight The bridge shoes not exceed and installation.	_		
chord struc	ds, verticals, d tural steel tub	omponents All men and diagonals) shall l bing. Other structural apes or square and re	be fabricated fr members and	rom square and/or bracing shall be fal	rectangular
3.6)	Deck ordance with	Decking shall be section 1.3 of this do			, in



3.7) Attachments

- **3.7.1) Safety Rails** Horizontal safety rails shall be placed on the structure up to a minimum height of forty-two inches (42") above the deck surfaces. Safety rails shall be placed so as to prevent a four inch (4") sphere from passing through the truss. Safety rails shall be welded to the outside of the structure. Safety rails shall have their ends sealed and ground smooth so as to produce no sharp edges.
- **3.7.2) Toe plate** The bridge shall be supplied with a toe plate mounted to the inside face of both trusses. The toe plate shall be welded to the truss members at a height adequate to provide no more than a two inch (2") gap between the bottom of the plate and the top of the deck or the top of the bottom chord, whichever is higher.
- **3.7.3) Rubrails** The bridge shall be supplied with nominal two by six (2x6) pressure treated lumber. Rubrails shall be attached flush to the inside face of the bridge truss verticals and fastened at each support location. The top of the rubrail shall be two feet 10 inches (2'-10") above the top of the deck (measured at the outside edge of the deck).
- **3.8)** Camber The bridge shall have a vertical camber dimension at midspan equal to one hundred percent (100%) of the full dead load deflection.
- **3.9) Elevation Difference** The bridge abutments shall be constructed at the same elevation on both ends of the bridge.

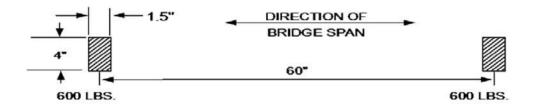
Part 4 - Engineering Structural design of the bridge shall be performed by or under the direct supervision of a professional engineer licensed within the project state, and in accordance with recognized engineering practices and principles.

- **4.1) Design Loads** In considering design and fabrication issues, this structure shall be assumed to be statically loaded. No dynamic analysis shall be required nor shall fabrication issues typically considered for dynamically loaded structures be considered for this bridge.
 - **4.1.1) Dead Loads** The bridge structure shall be designed considering its own dead load (superstructure and original decking) only. No additional dead loading shall be considered.



4.1.2) Pedestrian Live Load

- i. Main supporting members, including girders, trusses and arches shall be designed for a pedestrian live load of ninety pounds (90lbs) per square foot of bridge walkway area. The pedestrian live load shall be applied to those areas of the walkway so as to produce maximum stress in the member being designed. Pedestrian live loads shall NOT be reduced.
- ii. Secondary members such as bridge decks and supporting floor systems, including secondary stringers, floor beams, and their connections to main supporting members shall be designed for a live load of ninety pounds (90lbs) per square foot, with no reduction allowed.
- **4.1.3) Vehicle Load** The bridge superstructure, floor system, and decking shall be designed for the following point load conditions:
 - i. An occasional twelve hundred pound (1,200 lb) two wheeled vehicle with a wheelbase and tire print area as shown in the following diagram:



ii. An occasional six thousand pound (6,000 lb) four wheeled vehicle where 80% of the load is considered to act on the rear axle and 20% on the front. All deck members and stringers shall be designed for a concentrated load of 30% of the vehicle load.

All of the concentrated or wheel loads shall be placed so as to produce the maximum stress in each member being analyzed. Critical stresses shall be calculated assuming there is only one (1) vehicle on the bridge at any given time. Assumptions that vehicles only travel down the center of the bridge or that the vehicle load is a uniform line load shall not be allowed.

A vehicle impact allowance shall not be required.



4.1.4) Wind Load

i. Horizontal Forces The bridge shall be designed for a wind load as specified by AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, latest edition. The wind load shall be applied horizontally at right angles to the longitudinal axis of the structure.

The wind load shall be considered both in the design of the lateral load bracing system and in the design of the truss vertical members, floor beams, and their connections.

- **ii. Overturning Forces** The effect of forces tending to overturn structures shall be calculated assuming that the wind direction is at right angles to the longitudinal axis of the structure. In addition, an upward force shall be applied at the windward quarter point of the transverse superstructure width. This force shall be twenty pounds (20lbs) per square foot of deck.
- 4.1.5) Top Chord Railing Loads The top chord, truss verticals, and floor beams shall be designed for lateral wind loads, per Engineering Horizontal Forces, herein and for any loads required to provide top chord stability as outlined in Engineering Top Chord Stability herein. In no case shall the load be less than fifty pounds (50lbs) per lineal foot or a two hundred pound (200lb) point load, whichever produces greater stresses, applied in any direction at any point along the top chord, or at the top of the safety system (42" or 54" above the deck level) if higher than the top chord.
- **4.1.6) Safety Rails** The safety rail system shall be designed for all infill loading of two hundred pounds (200 lbs) applied horizontally at right angles, to a one (1) square foot area at any point in the system.

4.2) Design Limitations

4.2.1) Deflection

i. Vertical Deflection The vertical deflection of the main trusses due to service pedestrian Live Load shall not exceed one three-sixtieth (1/360) of the span.



The vertical deflection of cantilever spans of the structure due to service pedestrian Live Load shall not exceed one three-sixtieth (1/360) of the cantilever arm length.

The deflection of the floor beams due to service pedestrian Live Load shall not exceed one three-sixtieth (1/360) of its span.

The deflection of the deck and stringers due to service pedestrian Live Load or Vehicle Load shall not exceed one thousandth (1/1000) of their respective spans.

The service pedestrian Live Load shall NOT be reduced for deflection checks.

- **ii.** Horizontal Deflection The horizontal deflection of the structure due to lateral wind loads shall not exceed one three-sixtieth (1/360) of the span.
- **4.2.2) Vibration** The fundamental frequency of the unloaded pedestrian bridge shall be no less than 3.0 Hz to avoid the first harmonic.
- 4.2.3) Minimum Thickness of Metal The minimum thickness of all structural steel members shall be three-sixteenths of an inch (3/16") nominal and be in accordance with the AISC Manual of Steel Constructions "Standard Mill Practice Guidelines". For ASTM A500 and ASTM A847 tubing, the section properties used for design shall be per the Steel Tube Institute of North America, Hollow Structural Sections, "Dimensions and Section Properties".

4.3) Analysis

- **4.3.1) Load Combinations** The loads listed herein shall be considered to act in the following combinations, whichever produce the most unfavorable effects on the bridge superstructure or structural member concerned. [DL = Dead Load, LL = Live Load, WL = Wind Load, VL = Vehicle Load]
 - Strength I
 - o 1.25*DL+1.75*LL
 - o 1.25*DL+1.75*VL
 - Strength III
 - 1.25*DL+WL+OW
 - Service I



- o DL+LL+WL+OW
- Fatigue I
 - Fatigue WL Only

The foundation engineer will determine any additional loads (i.e. earth pressure, stream force on abutments, wind loads other than those applied perpendicular to the long axis of the bridge, etc.) and load combinations required for design of the abutments.

- **4.3.2) Frequency** Frequency analysis shall be completed to determine that the bridge frame is sufficient to avoid resonance due to frequencies likely encountered under normal use for the following load combinations and in accordance with section
- **4.3.3) Top Chord Stability** The top chord of a half-through truss shall be considered as a column with elastic lateral supports at the panel points
- **4.3.4) Welded Tubular Connections** All welded tubular connections shall be checked, when within applicable limits, for the limiting failure modes outlined in the ANSI/AWS D1.1 Structural Welding Code.

When outside the "validity range" defined in these design guidelines, the following limit states or failure modes shall be checked:

- Chord Wall Plastification
- Shear Yielding (Punching)
- Local Yielding of Chord Sidewalls
- Local Crippling of Chord Sidewalls
- Local Yielding of Branch Due to Uneven Load Distribution

All tubular joints shall be plain unstiffened joints and fabricated without the use of reinforcing plates, except as follows:

Floor beams hung beneath the lower chord of the structure may be constructed with or without stiffener (or gusset) plates, as required by design.

Floor beams which frame directly into the truss verticals (H-Section bridges) may be designed with or without end stiffening plates as required by design.



Where chords, end floor beams and in high profiles the top end struts weld to the end verticals, the end verticals (or connections) may require stiffening to transfer the forces from these members into the end vertical.

Truss vertical to chord connections.

4.3.5) Bolted Splices Bolted splice design shall be in accordance with Section 6.13 of the "AASHTO LRFD Bridge Design Specifications, 8th Edition" and in accordance with section 1.4 of this document. Bolted field splices shall be located on the bridge so as to produce a structure which can be economically shipped and erected. Splices across the width of the bridge (in floor beams and wind braces) may be used, when necessary, to keep the overall structure width within reasonable limits for shipping.

Part 5 - Welding

- **5.1) Welding** Welding and weld procedure qualification tests shall conform to the provisions of ANSI/AWS D1.1 "Structural Welding Code", 2015 Edition. Filler metal shall comply with the applicable AWS Filler Metal Specification (i.e. AWS A 5.28 for the GMAW Process). For exposed, bare, unpainted applications of corrosion resistant steels (i.e. ASTM A588 and A847), the filler metal shall comply with AWS D1.1, Section 3.7.3.
- **5.2)** Welders Each welder shall be a properly accredited operator, and shall:
 - **5.2.1)** submit certification of satisfactorily passing AWS standard qualification tests for all positions with unlimited thickness of base metal,
 - **5.2.2)** have a minimum of six (6) months experience in welding tubular structures and
 - **5.2.3)** have demonstrated the ability to make uniform sound welds of the type required.



Part 6 - Submittals

6.1) Submittal Drawings	Schematic drawings and diagrams shall be submitted
to the customer for their revi	ew after receipt of order. Submittal drawings shall be
unique drawings, prepared t	o illustrate the specific portion of the bridge(s) being
fabricated. All relative desig	n information such as member size, material specification,
bridge reactions, dimensions	, general notes, and required critical welds shall be clearly
shown on the drawings. Dra	wings shall have cross referenced details and sheet
numbers. All drawings shall k	be signed and sealed by a Professional Engineer
registered in the state of	A stamped electronic soft copy
shall be provided. Hard cop	ies may be provided at additional costs.

At minimum the following criteria must be included for approval:

- All Relevant Bridge Dimensions
- Bridge Cross sections
- Sufficient Detailing
- Member Cross sections
- General Notes indicating material specifications
- Weld Details
- Detail of Bolted Splices (if applicable)
- Signature and Seal of PE licensed in accordance with this specification
- Camber Details
- **Structural Calculations** Structural Calculations for the bridge superstructure shall be submitted by the bridge manufacturer. All calculations shall be signed and sealed by a Professional Engineer licensed within the project state. The calculations shall include all design information necessary to determine the structural adequacy of the bridge. A stamped electronic soft copy shall be provided. Hard copies may be provided at additional costs.

At minimum the following criteria must be included for approval:

- Applied loads and conditions for all load combinations
- All resistance checks for axial, bending, and shear in each critical member type (i.e. top chord, bottom chord, vertical, floor beam, etc.)
- Truss and Floor Deflection Checks
- FEA Boundary Conditions
- FEA Data Input
- FEA Results and Supplementary Calculations for all Stress & Deflection Analyses



- FEA Results for Frequency Analysis
- U-Frame Stiffness Checks
- Bolted Splice Connections (if applicable)
- Bearing Plate Analysis
- Critical weld connection check for each truss member type (i.e. vertical, diagonal)
- Welded Tubular Connections (see section 4.3.4 of this document for design check requirements)
- Bridge Reactions
- Expansion and Contraction Requirements and/or Induced Loads

Part 7 - Fabrication

7.1) General Requirements

- **7.1.1) Drain Holes** When the collection of water inside a structural tube is a possibility, either during construction or during service, the tube shall be provided with a drain hole at its lowest point to let water out.
- **7.1.2) Bolt Holes** Unless otherwise specified, standard holes shall be used in high-strength bolted connections. Oversize holes may be used in any or all plies of slip-critical connections. They shall not be used in bearing-type connections. Cut, drill, mechanically thermal cut, or punch bolt holes perpendicular to metal surfaces. Do not enlarge bolt holes by burning.
- **7.1.3) Bearing Holes/Slots** Cut, drill, mechanically thermal cut, or punch bearing holes/slots perpendicular to steel surfaces.

Part 8 - Finishing

8.1) Blast Cleaning

8.1.1) All Blast Cleaning shall use Best Management Practices and exercise environmentally friendly blast media recovery systems.



- **8.1.2)** To aid in providing a uniformly "weathered" appearance, all exposed surfaces of a weathering steel bridge shall be blast cleaned in accordance with Steel Structures Painting Council Surface Preparation Specifications No. 7 Brush-Off Blast Cleaning, SSPC-SP7 latest edition.
- **8.1.3)** Exposed surfaces of steel shall be defined as those surfaces seen from the deck and from outside of the structures. Stringers, floor beams, lower brace diagonals and the inside face of the truss below deck and bottom face of the bottom chord shall not be blasted.
- **8.1.4)** All finishing shall be completed in manufacturer's shop prior to shipping.
- **8.2) Painting** All exterior surfaces of steel shall be painted utilizing a 2-coat system. All exterior surfaces of steel shall be abrasively blast cleaned in accordance with SSPC-SP6 prior to application of the primer.
 - **8.1.1)** Epoxy Midcoat
 - **8.1.2)** Polyurethane Topcoat

Bridges shall be provided with paint for touch up after erection.

8.3) Galvanizing Proper drainage and venting shall be provided for the galvanization process. All structural steel shall be zinc coat (hot-dip) galvanized per the specifications listed in ASTM A123. Hardware shall be zinc coat (hot-dip) galvanized per the specifications listed in ASTM A153.

Part 9 - Bearing Devices

- **9.1)** Bridge bearings shall consist of a setting or slide plate placed on the abutment or grout pad. The bridge bearing plate which is welded to the bridge structure shall bear on this setting plate. One end of the bridge will be fixed by fully tightening the nuts on the anchor bolts at that end. The opposite end will have finger tight only nuts to allow movement under thermal expansion or contraction.
- **9.2)** Bridges in excess of 100 feet in length or bridges with dead load reactions of 15,000 pounds or more (at each bearing location) shall have Teflon on Teflon or stainless steel on Teflon slide bearings placed between the bridge bearing plate and the setting plate. The top slide plate shall be large enough to cover the lower Teflon slide surface at both temperature extremes.



Part 10 - Foundations

- 10.1) The owner shall procure all necessary information about the site and soil conditions. Soil tests shall be procured by the owner. Unless specified otherwise, the bridge manufacturer shall determine the number, diameter, minimum grade and finish of all anchor bolts. The anchor bolts shall be designed to resist all horizontal and uplift forces to be transferred by the superstructure to the supporting foundations. Engineering design of the bridge supporting foundations (abutment, pier, bracket and/or footings), including design of anchor bolt embedments, shall be the responsibility of the foundation engineer. The contractor shall provide all materials for (including anchor bolts) and construction of the bridge supporting foundations. The contractor shall install the anchor bolts in accordance with the manufacturer's bridge bearing dimensions.
- **10.2)** The bridge bearings shall sit in a recessed pocket on the concrete abutment. Minimum 28-day strength for the abutment concrete shall be 4,000 PSI. The bearing seat shall be a minimum of 16" wide. The step height (from bottom of bearing to top-of-deck) shall be determined by the bridge manufacturer.
- **10.3)** Information as to bridge support reactions and anchor bolt locations will be furnished by the bridge manufacturer after receipt of order and after the bridge design is complete.

Part 11 - Delivery and Erection

- **11.1)** Bridges will be delivered by truck to a location nearest to the site accessible by roads. Hauling permits and freight charges are the responsibility of the manufacturer.
- 11.2) The manufacturer will notify the customer in advance of the expected arrival. Information regarding delays after the trucks depart the plant such as weather, delays in permits, re-routing by public agencies or other circumstances will be passed on to the customer as soon as possible but the expense of such unavoidable delays will not be accepted by the manufacturer.
- **11.3)** The manufacturer will advise the customer of the actual lifting weights, attachment points and all necessary information to install the bridge. Unloading, splicing, bolting, and proper lifting equipment is the responsibility of others.
- **11.4)** The bridge manufacturer shall provide written inspection and maintenance procedures to be followed by the bridge owner.

Appendix C:

Traffic & Pedestrian Analysis

Introduction

This report documents the methodology used to analyze the intersections of the proposed trail with HWY 48, 200th Street, and West Coolbaugh. The purpose of the analysis is to determine if a traffic control signal is needed for any of the intersections. This analysis is performed in accordance with chapter 4C of the Manual for Uniform Traffic Control Devices (MUTCD). According to the MUTCD, there are nine warrants that must be considered when evaluating the necessity of a traffic control device. Additionally, a warrant analysis for the installation of pedestrian hybrid beacons at crosswalks is included.

Methodology for Determining Traffic and Pedestrian Volumes

It is our estimate that this trail will be completed in the next few years, and to be conservative, we are estimating this project to be completed in 2022. The most current year for which traffic volumes are available, from the Iowa DOT (IDOT), for all the streets being crossed, is 2012. For analysis of the intersections, the traffic volumes at each intersection are projected to the completion year of 2022. The 2012 and 2022 projected traffic volumes are given in Table 1.

Shroot	Val /Day in 2012	Veh/Day Projected to 20				
Street	Veh/Day in 2012	1% Growth	2% Growth	3% Growth		
HWY 48	6500	7180	7923	8735		
200th St.	2010	2220	2450	2701		
Coolbaugh	600	663	731	806		

Table 1: Vehicles/Day in 2012 & Projected to 2022

The future traffic volumes in Table 1 are determined using the equation,

$$v_p = v_i (1+g)^y, \tag{1}$$

where v_p is the projected volume, v_i is the initial volume, g is the growth rate, expressed as a decimal, and g is the amount of years being projected forward. According to the US Census Bureau, the population in Red Oak is slowly trending down, and has been for about the past fifteen years. However, to be conservative, a growth rate of one percent is used for the purpose of this analysis. Since hourly traffic volumes are not available from the IDOT, we are using data provided by the National Household Travel Survey (NHTS), shown in Figure 1, to estimate hourly volumes.

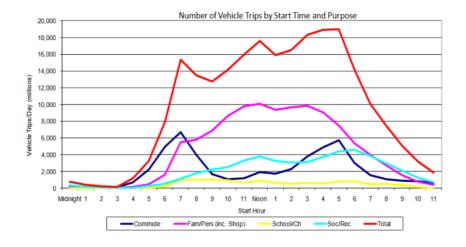


Figure 1: National Household Travel Survey Data

Referring to Figure 1, by dividing the total trips at each given hour by sum of the total trips, we are able to estimate the percentage of trips for each hour of the day. Then, by multiplying the estimated percentage for each hour by the total projected volume of each street (from Table 1), we estimate the hourly traffic volumes in 2022 to be those presented in Table 2.

Table 2: Hourly Traffic Volumes in 2022

	14-1-14		Veh/Hour in 2022			
Hour	Veh/Hour (from Figure 1)	Percentage	HWY 48	200th St.	Coolbaugh	
12:00 AM	800	0.34%	25	8	2	
1:00 AM	500	0.21%	15	5	1	
2:00 AM	200	0.09%	6	2	1	
3:00 AM	150	0.06%	5	1	0	
4:00 AM	1200	0.51%	37	11	3	
5:00 AM	3200	1.37%	98	30	9	
6:00 AM	8000	3.42%	246	76	23	
7:00 AM	15400	6.59%	473	146	44	
8:00 AM	13400	5.73%	412	127	38	
9:00 AM	12800	5.48%	393	122	36	
10:00 AM	14000	5.99%	430	133	40	
11:00 AM	16000	6.84%	491	152	45	
12:00 PM	17600	7.53%	541	167	50	
1:00 PM	16000	6.84%	491	152	45	
2:00 PM	16500	7.06%	507	157	47	
3:00 PM	18300	7.83%	562	174	52	
4:00 PM	18900	8.09%	581	180	54	
5:00 PM	19000	8.13%	584	180	54	
6:00 PM	14000	5.99%	430	133	40	
7:00 PM	10000	4.28%	307	95	28	
8:00 PM	7600	3.25%	233	72	22	
9:00 PM	5100	2.18%	157	48	14	
10:00 PM	3200	1.37%	98	30	9	
11:00 PM	1900	0.81%	58	18	5	
Total	233750	100.00%	7180	2220	663	

The peak hour volume is the hour in which the traffic volume is the greatest. By our estimate, the peak hour occurs at 5:00 PM, which can be seen highlighted in red above in Table 2. The eighthour volume is the sum of volumes for every consecutive four-hour interval, and the four-hour volume is the same thing, but for every consecutive eight-hour interval. These volumes are given in Tables 3 and 4 on the following pages.

Table 3: Eight-Hour Traffic Volumes in 2022

	Traffic Volume 2022					
Time						
	HWY 48	200th St.	Coolbaugh			
12 AM through 7 AM	905	280	84			
1 AM through 8 AM	1292	399	119			
2 AM through 9 AM	1669	516	154			
3 AM through 10 AM	2093	647	193			
4 AM through 11 AM	2580	798	238			
5 AM through 12 PM	3084	954	285			
6 AM through 1 PM	3477	1075	321			
7 AM through 2 PM	3738	1156	345			
8 AM through 3 PM	3827	1184	353			
9 AM through 4 PM	3996	1236	369			
10 AM through 5 PM	4187	1295	386			
11 AM through 6 PM	4187	1295	386			
12 PM through 7 PM	4002	1238	369			
1 PM through 8 PM	3695	1143	341			
2 PM through 9 PM	3360	1039	310			
3 PM through 10 PM	2952	913	272			
4 PM through 11 PM	2448	757	226			
5 PM through 12 AM	1892	585	175			
6 PM through 1 AM	1324	409	122			
7 PM through 2 AM	900	278	83			
8 PM through 3 AM	597	185	55			
9 PM through 4 AM	401	124	37			
10 PM through 5 AM	342	106	32			
11 PM through 6 AM	490	152	45			

Table 4: Four-Hour Traffic Volumes in 2022

Time	Traffic Volume in 2022					
Time	HWY 48	200th St.	Coolbaugh			
12 AM through 3 AM	51	16	5			
1 AM through 4 AM	63	19	6			
2 AM through 5 AM	146	45	13			
3 AM through 6 AM	385	119	36			
4 AM through 7 AM	854	264	79			
5 AM through 8 AM	1229	380	113			
6 AM through 9 AM	1524	471	141			
7 AM through 10 AM	1708	528	158			
8 AM through 11 AM	1726	534	159			
9 AM through 12 PM	1855	574	171			
10 AM through 1 PM	1954	604	180			
11 AM through 2 PM	2030	628	187			
12 PM through 3 PM	2101	650	194			
1 PM through 4 PM	2141	662	198			
2 PM through 5 PM	2233	691	206			
3 PM through 6 PM	2156	667	199			
4 PM through 7 PM	1901	588	176			
5 PM through 8 PM	1554	481	143			
6 PM through 9 PM	1127	349	104			
7 PM through 10 PM	796	246	73			
8 PM through 11 PM	547	169	50			
9 PM through 12 AM	338	104	31			
10 PM through 1 AM	197	61	18			
11 PM through 2 AM	104	32	10			

Since there is no data for pedestrian use on the existing trail, and we do not have the means to go out and observe this, we need to develop a way to estimate the pedestrian use of the trail. First, we estimate the population in Red Oak to be approximately 5,800 people in 2022. This is calculated by taking the most recent population estimate of Red Oak, which is 5,476 people in 2016 according to the US Census Bureau, and then projecting this population to the year 2022, again using Equation 1 with a conservative one percent population growth. Next, we estimate the percentage of people in Red Oak that are of age and able to walk the trail. This is estimated by using US Census Data for 2016, provided in Table 5.

Table 5: Population Distribution

Age (years)	Percentage
Under 5	6.5%
5 to 17	17.5%
18 to 24	9.9%
25 to 44	26.6%
45 to 64	26.4%
65 and older	13.0%
	80.4%

The 80.4% in Table 5 represents the percentage of the population that is of age and able to walk the trail, and it is calculated by summing the percentage of the population that is between five and sixty-four years old. Multiplying this percentage by the projection of about 5,800 people in 2022, we estimate about 4,670 potential trail users in Red Oak in 2022. However, not all of those people will actually use the trail; we estimate that fifty percent of the potential trail users may actually use the trail, though we do believe this estimate to be highly conservative. This brings the new number of potential trail users to 2,330 people. Not all of these people will be using the trail every single day, though. Our final adjustment is to multiply the number of potential trail users (2,330) by the fraction of 3/7. This accounts for the assumption that those that will use the trail will use it an average of three out of seven days a week, and it brings our daily pedestrian use estimate to a final total of approximately 1,000 people per day; again, we believe this to be a very conservative estimate. In order to determine the hourly distribution of these 1,000 people per day, we follow the same process as before with vehicle volumes, except we use the blue social/recreational line, since using the trail is primarily a recreational activity. The pedestrian distribution by hour is given in Table 6.

Table 6: Hourly Pedestrian Volumes in 2022

Hour	Trips/Day (from Figure 1)	Percentage	Pedestrians/Hour
12:00 AM	300	0.61%	6
1:00 AM	200	0.41%	4
2:00 AM	20	0.04%	0
3:00 AM	10	0.02%	0
4:00 AM	0	0.00%	0
5:00 AM	300	0.61%	6
6:00 AM	500	1.01%	10
7:00 AM	1200	2.43%	24
8:00 AM	1900	3.85%	39
9:00 AM	2200	4.46%	45
10:00 AM	2600	5.27%	53
11:00 AM	3300	6.69%	67
12:00 PM	3800	7.70%	77
1:00 PM	3200	6.49%	65
2:00 PM	3100	6.28%	63
3:00 PM	3200	6.49%	65
4:00 PM	3800	7.70%	77
5:00 PM	4400	8.92%	89
6:00 PM	4600	9.32%	93
7:00 PM	3800	7.70%	77
8:00 PM	3000	6.08%	61
9:00 PM	2000	4.05%	41
10:00 PM	1200	2.43%	24
11:00 PM	700	1.42%	14
Total	49330	100.00%	1001

By our estimate, the peak pedestrian volume occurs at 6:00 PM, and this is highlighted in red in Table 6. The four-hour pedestrian volumes are found following the same methodology as

mentioned earlier in this report for finding the four-hour vehicular volumes, and these volumes are given in Table 7.

Table 7: Four-Hour Pedestrian Volumes in 2022

Time	Pedestrians in 2022
12 AM through 3 AM	11
1 AM through 4 AM	5
2 AM through 5 AM	7
3 AM through 6 AM	16
4 AM through 7 AM	41
5 AM through 8 AM	79
6 AM through 9 AM	118
7 AM through 10 AM	160
8 AM through 11 AM	203
9 AM through 12 PM	242
10 AM through 1 PM	262
11 AM through 2 PM	272
12 PM through 3 PM	270
1 PM through 4 PM	270
2 PM through 5 PM	294
3 PM through 6 PM	325
4 PM through 7 PM	337
5 PM through 8 PM	321
6 PM through 9 PM	272
7 PM through 10 PM	203
8 PM through 11 PM	140
9 PM through 12 AM	85
10 PM through 1 AM	49
11 PM through 2 AM	25

The estimated traffic and pedestrian volumes in this methodology section are used to consider each of the following nine warrants for a traffic signal. The first intersection of Alix Street and HWY 48 is the only intersection all of the warrants apply to, because it is the only intersection that has a major and minor road. Only warrant four applies to 200th Street and Coolbaugh, because pedestrians crossing these roads while using the trail is the only form of conflicting traffic.

Warrant 1: Eight-Hour Vehicular Volume

This warrant considers the average hourly volume of vehicles during the peak eight-hour traffic period for the both the major and minor roads. Table 4C-1 from the MUTCD is used to check this warrant, and this table is given in Table 8 on the following page.

Table 8: Eight-Hour Vehicular Volume Limits

Condition A—Minimum Vehicular Volume

Number of lar traffic on ea	Vehicles per hour on major street (total of both approaches)			Vehicles per hour on higher-volume minor-street approach (one direction of			olume ction only)		
Major Street	Minor Street	100%ª	80%b	70%	56% ^d	100%a 80%b 70%c 56%c			56% ^d
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lar traffic on each	Vehicles per hour on major street (total of both approaches)			Vehicles per hour on higher-volume minor-street approach (one direction on					
Major Street	Minor Street	100%ª	80%b	70%°	56% ^d	1 100% ^a 80% ^b 70% ^c 56%			56% ^d
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

A traffic signal is warranted if the vehicles per hour given in both of the seventy percent columns of Condition A in Table 8 exist on the major street and the higher-volume minor street approaches, or if the vehicles per hour given in both of the seventy percent columns of Condition B in Table 8 exist on the major street and the higher-volume minor street approaches. The first row of condition A and B in Table 8 applies to the intersection of HWY 48 and Alix Street, since there is only one lane in each direction for both roads. There is no IDOT information available on the traffic volumes of Alix Street, however, by our engineering judgement, we do not expect to see volumes that exceed 105 vehicles per hour (VPH) in one direction during any hour of a typical day. Therefore, condition A in Table 8 is not met. For condition B, the greatest eight-hour projected volume on Alix Street is 4,187 vehicles (from Table 3), and the hourly average for this peak eight-hour period comes out to be 524 vehicles, which is less than the 525 vehicle threshold. Thus, condition B is not met, either, so warrant one does not indicate a need for a traffic signal.

Warrant 2: Four-Hour Vehicular Volume

According to the MUTCD, the four-hour vehicular volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal. The need for a traffic control signal shall be considered if for each of any four hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor street approach (one direction only) all fall above the applicable curve in Figure 2, on the following page.

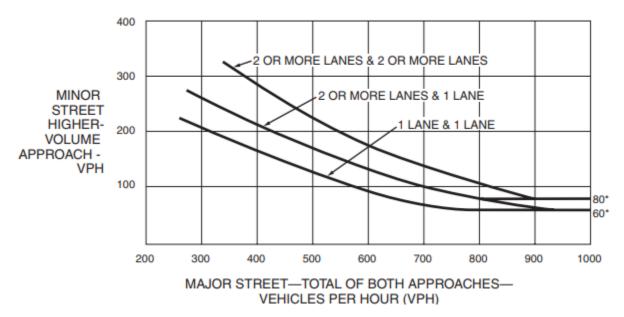


Figure 2: Four Hour Vehicular Volume

The greatest projected four-hour vehicular volume on HWY 48 is 2,233 vehicles (from Table 4), and this comes out to be about 560 VPH during that period. This volume allows for approximately just over 100 VPH in one direction on Alix Street to remain below the "one lane and one lane" curve. By our engineering judgement, we do not expect to see vehicular volumes exceed 100 VPH in one direction on Alix Street during any typical one-hour period of a day. Therefore, this warrant is not satisfied.

Warrant 3: Peak Hour

There are two categories, A and B, which must be considered for this warrant, and they come from the MUTCD:

- A. If all three of the following conditions exist for the same 1 hour of an average day:
 - 1. The total stopped time delay experienced by the traffic on one minor street approach (one direction only) controlled by a stop sign equals or exceeds: four vehicle-hours for a one-lane approach or five vehicle-hours for a two-lane approach; and
 - 2. The volume on the same minor street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes; and
 - 3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.
- B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor street approach (one direction only) for one hour of an average day falls above the applicable curve in Figure 3, on the following page, for the existing combination of approach lanes.

Condition 2 in category A is not satisfied, since we do not expect vehicular volumes to exceed 100 VPH on Alix Street during any hour throughout a typical day. Category B requires the use of Figure 3.

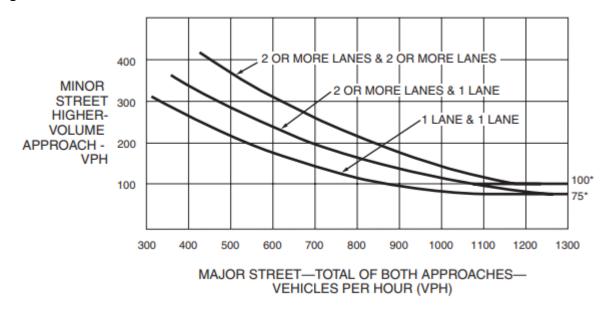


Figure 3: Peak Hour Vehicular Volumes

The peak hour traffic flow on HWY 48 is estimated to be 584 vehicles (from Table 2). In order for this condition to be met, there would need to be approximately 170 vehicles in one direction during that same hour on Alix Street. We do not expect to see nearly that many vehicles on Alix Street moving in one direction for any hour, thus condition B is not met, either.

Warrant 4: Pedestrian Volume

As previously mentioned, this is the only warrant that applies to all of the roads the proposed trail crosses. The MUTCD intends this warrant for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street. The need for a traffic control signal at a crossing shall be considered of one of the following criteria is met:

- A. For each of any four hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street all fall above the curve in Figure 4; or
- B. For one hour of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street falls above the curve in Figure 5.

The peak projected four-hour pedestrian volume is 337 pedestrians during the hours of 4:00 PM through 7:00 PM. This comes out to about 85 pedestrians per hour (PPH). The corresponding four hour traffic volume is 1901 vehicles, which comes out to approximately 475 VPH. Plotting this point on Figure 4, on the following page, we see that the point falls well below the curve. Therefore, condition A is not satisfied.

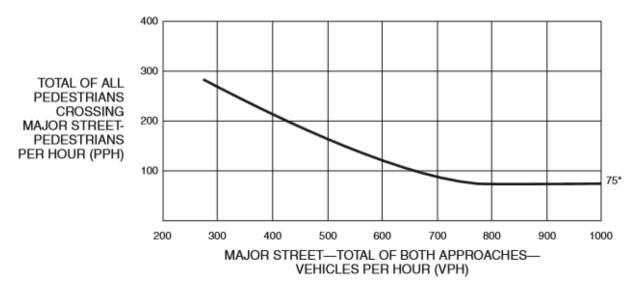


Figure 4: Pedestrian Four-Hour Volume

For condition B, the projected peak pedestrian volume is 93 people (from Table 6) during the peak hour of 6:00 PM. The corresponding peak traffic volume at 6:00 PM is 430 vehicles. Plotting this point on Figure 5 below, we find that the point is well below the curve. All other hours have pedestrian volumes below 93 people, so no other points will fall above the curve in Figure 5. Thus, condition B is not met.

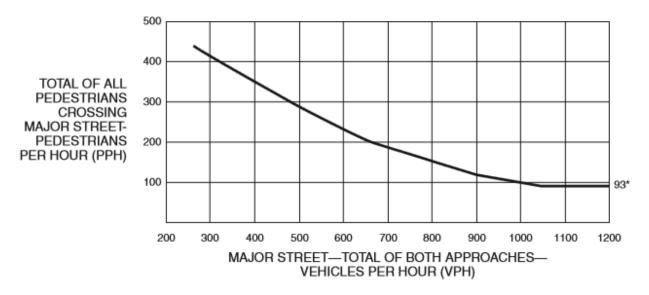


Figure 5: Pedestrian Peak Hour

Warrant 5: School Crossing

Per the MUTCD, this warrant is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider a traffic signal. The nearest school is about half a mile away, and there are no homes within walking distance to the west of HWY 48. Thus, by our engineering judgement, we do not anticipate schoolchildren crossing this intersection to get to or from school, therefore, we do not believe this warrant to be met.

Warrant 6: Coordinated Signal System

The MUTCD states that this warrant shall be considered if on a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation. Since there is a stop sign located approximately 900 feet north of the intersection of HWY 48 and Alix Street, and a stoplight located about 1,500 feet south of the intersection, we do not believe platooning of the vehicles to be an issue.

Warrant 7: Crash Experience

Alix Street is a minor road, it has proper traffic control with the current stop sign, and there is good visibility in all direction for all approaches. Therefore, we do not believe crashes to warrant a traffic signal.

Warrant 8: Roadway Network

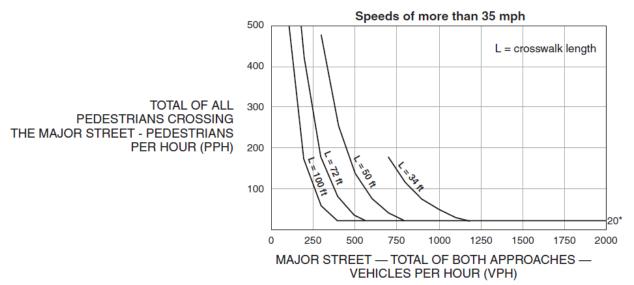
This warrant considers the intersection of two or more major routes. Since HWY 48 is the only major route, this warrant can be dismissed.

Warrant 9: Intersection Near a Grade Crossing

This warrant considers intersections that are within 140 feet of a railroad crossing. The intersection of HWY 48 and Alix Street is much further from the nearest railroad crossing, so this warrant does not apply.

Pedestrian Hybrid Beacon Warrant Analysis

A pedestrian hybrid beacon is a yield sign that has flashing yellow lights affixed to it, which are activated by pedestrians pushing a button. These beacons are warranted if the plotted point representing the vehicles per hour on the street and the corresponding number pedestrians crossing that street fall above the applicable curve in Figure 6.



* Note: 20 pph applies as the lower threshold volume

The maximum projected vehicles per hour on HWY 48 is approximately 580 vehicles, from Table 2, and the corresponding projected pedestrian volume is about 90 pedestrians. The point corresponding with these estimates fall well below the corresponding curve. Since this is the most extreme condition, none of the other hourly volumes will fall above the curve; therefore, a pedestrian hybrid beacon is not warranted for installation at any crosswalks.

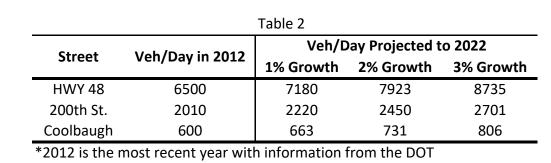
Conclusion and Recommendations

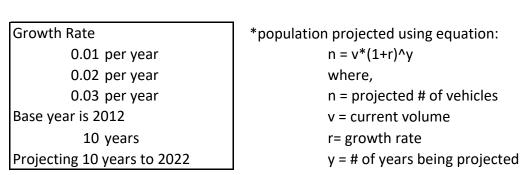
None of the nine traffic signal warrants were met, and the vehicular and pedestrian volumes we used are believed to be very conservative projections. Combining this with our own observations of the intersections during our site visit, we do not believe any of the intersections or pedestrian crossings for the proposed trail to warrant the installation of a traffic signal. Pedestrian hybrid beacons are not believe d to be necessary, either. That being said, we do have three pedestrian crossings in which pedestrians will be crossing relatively high-speed roads. Accordingly, we will be designing the pedestrian crossings with this in mind, and we will be paying attention to signage, detectable warnings, warning lights, illumination of the intersections, and sight distances, for both vehicular and pedestrian traffic, in order to assure the highest level of safety for everyone.

Supporting Calculations for Warrant Analysis

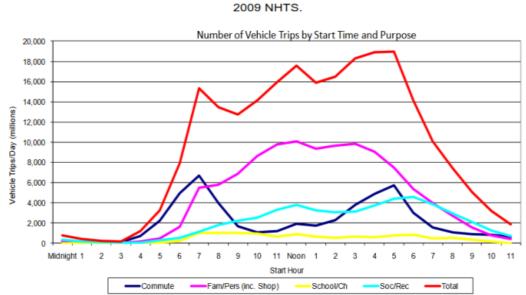
*Population is consistently trending down slowly for at least the last 15 years according to the US Census Bureau, so 1% growth is probably safe to assume

			rable T			
		Vah /Harry /frage Figure 12\	Doverntono	V	eh/Hour in 20	022
	Hour	Veh/Hour (from Figure 12)	Percentage	HWY 48	200th St.	Coolbaugh
	12:00 AM	800	0.34%	25	8	2
	1:00 AM	500	0.21%	15	5	1
	2:00 AM	200	0.09%	6	2	1
	3:00 AM	150	0.06%	5	1	0
	4:00 AM	1200	0.51%	37	11	3
	5:00 AM	3200	1.37%	98	30	9
	6:00 AM	8000	3.42%	246	76	23
Peak AM Hour	7:00 AM	15400	6.59%	473	146	44
	8:00 AM	13400	5.73%	412	127	38
	9:00 AM	12800	5.48%	393	122	36
	10:00 AM	14000	5.99%	430	133	40
	11:00 AM	16000	6.84%	491	152	45
	12:00 PM	17600	7.53%	541	167	50
	1:00 PM	16000	6.84%	491	152	45
	2:00 PM	16500	7.06%	507	157	47
	3:00 PM	18300	7.83%	562	174	52
	4:00 PM	18900	8.09%	581	180	54
Peak PM Hour	5:00 PM	19000	8.13%	584	180	54
	6:00 PM	14000	5.99%	430	133	40
	7:00 PM	10000	4.28%	307	95	28
	8:00 PM	7600	3.25%	233	72	22
	9:00 PM	5100	2.18%	157	48	14
	10:00 PM	3200	1.37%	98	30	9
	11:00 PM	1900	0.81%	58	18	5
	Total	233750	100.00%	7180	2220	663









Coolbaugh is 35mph posted number by the percentage

HWY 48 is 40 mph posted

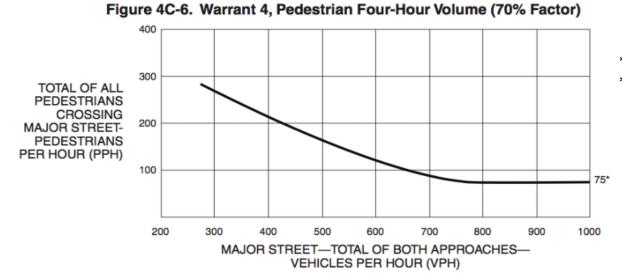
200th St. is 45 mph posted

*posted or 85th percentile speed of all intersections exceeds 35mph so use graphs 4C-6 & 4C-8 (pg 442 MUTCD)

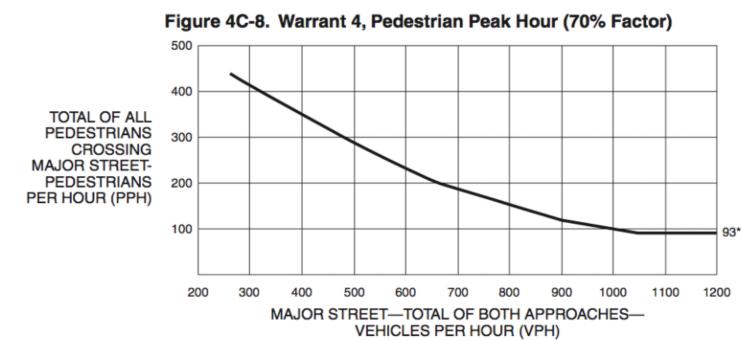
*veh/hour in Table 1 above calculated

by taking projected volumes in 2022

(from table 2) and multiplying that



*No traffic signal is warranted, as none of the 9 traffic warrants in the MUTCD are satisfied *Still should consider some sort of signage/ligths to alert drivers of crossing pedestrians



*Note: 75 pph applies as the lower threshold volume.

*Note: 93 pph applies as the lower threshold volume.

Table 3: 4-hour				
Time	Traffic Volume in 2022			
Tillle	HWY 48	200th St.	Coolbaugh	
12 AM through 3 AM	51	16	5	
1 AM through 4 AM	63	19	6	
2 AM through 5 AM	146	45	13	
3 AM through 6 AM	385	119	36	
4 AM through 7 AM	854	264	79	
5 AM through 8 AM	1229	380	113	
6 AM through 9 AM	1524	471	141	
7 AM through 10 AM	1708	528	158	
8 AM through 11 AM	1726	534	159	
9 AM through 12 PM	1855	574	171	
10 AM through 1 PM	1954	604	180	
11 AM through 2 PM	2030	628	187	
12 PM through 3 PM	2101	650	194	
1 PM through 4 PM	2141	662	198	
2 PM through 5 PM	2233	691	206	
3 PM through 6 PM	2156	667	199	
4 PM through 7 PM	1901	588	176	
5 PM through 8 PM	1554	481	143	
6 PM through 9 PM	1127	349	104	
7 PM through 10 PM	796	246	73	
8 PM through 11 PM	547	169	50	
9 PM through 12 AM	338	104	31	
10 PM through 1 AM	197	61	18	
11 PM through 2 AM	104	32	10	
	*C	totals from	Table 1 fee	

*Sums the totals from Table 1 for specified time period

175 1892 585 5 PM through 12 AM 122 6 PM through 1 AM 409 900 278 83 7 PM through 2 AM 597 55 185 8 PM through 3 AM 9 PM through 4 AM 401 124 37 342 106 32 10 PM through 5 AM 152 490 45 11 PM through 6 AM

Table 4: 8-hour

905

1292

1669

2093

2580

3084

3477

3738

3827

3996

4187

4002

3695

3360

2952

2448

Time

12 AM through 7 AM

1 AM through 8 AM

2 AM through 9 AM

3 AM through 10 AM

4 AM through 11 AM 5 AM through 12 PM

6 AM through 1 PM

7 AM through 2 PM

8 AM through 3 PM

9 AM through 4 PM

10 AM through 5 PM

11 AM through 6 PM

12 PM through 7 PM

1 PM through 8 PM

2 PM through 9 PM

3 PM through 10 PM

4 PM through 11 PM

Traffic Volume 2022

HWY 48 200th St. Coolbaugh

280

399

516

647

798

954

1075

1156

1184

1236

1295

1295

1238

1143

1039

913

757

119

154

193

238

285

321

345

353

369

386

386

369

341

310

272

226

*Sums the totals from Table 1 for specified time period

Pedestrian Use Estimation

Population in 2016	5476	from US Census Bureau
1% Growth to 2022	5813	
2% Growth to 2022	6167	
3% Growth to 2022	6539	

National Median Age 37.9 years US Census 2016 Red Oak Median Age 39.8 years from master plan

A majority of 60 people	surveyed walked	at least 2 times a week>>	Estimate
			50% (of
Age (years)	Percentage		those that
Under 5	6.5%	_	are able/of
5 to 17	17.5%	US Census 2016	appropriate
18 to 24	9.9%		age)
25 to 44	26.6%		*those that
45 to 64	26.4%		were
65 and older	13.0%	_	surveyed
	80.4%	Percentage of population that n	nay use trail

(assumes under 5 is too young and over 64 is

Population that is of age to walk trail

4674 * (Z22*Z6)

Number of potential trail users

2337 Using 50% of population that is of age to walk

trail (Z25*0.5) Adjustment assuming people walk three out of seven days

1001 * (Z27*(3/7))

Table 5

	Table 3			_
Hour	Trips/Day (from Figure 12)	Percentage	Pedestrians/Hour	_
12:00 AM	300	0.61%	6	*equals 1001*percentag
1:00 AM	200	0.41%	4	
2:00 AM	20	0.04%	0	
3:00 AM	10	0.02%	0	
4:00 AM	0	0.00%	0	
5:00 AM	300	0.61%	6	
6:00 AM	500	1.01%	10	
7:00 AM	1200	2.43%	24	
8:00 AM	1900	3.85%	39	
9:00 AM	2200	4.46%	45	
10:00 AM	2600	5.27%	53	
11:00 AM	3300	6.69%	67	
12:00 PM	3800	7.70%	77	
1:00 PM	3200	6.49%	65	
2:00 PM	3100	6.28%	63	
3:00 PM	3200	6.49%	65	
4:00 PM	3800	7.70%	77	
5:00 PM	4400	8.92%	89	
6:00 PM	4600	9.32%	93	
7:00 PM	3800	7.70%	77	
8:00 PM	3000	6.08%	61	
9:00 PM	2000	4.05%	41	
10:00 PM	1200	2.43%	24	
11:00 PM	700	1.42%	14	_
Total	49330	100.00%	1001	

* This column is estimated using soc./rec. totals from

Figure 12 to estimate

hourly use

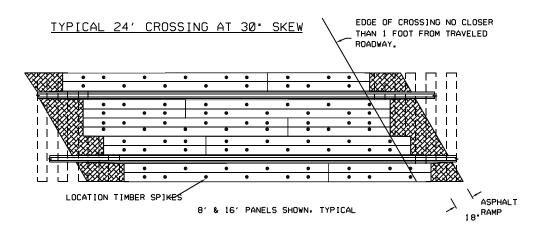
Table 6

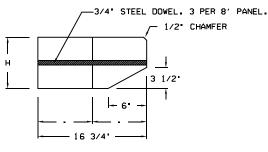
Time	Pedestrians in 2022
12 AM through 3 AM	11
1 AM through 4 AM	5
2 AM through 5 AM	7
3 AM through 6 AM	16
4 AM through 7 AM	41
5 AM through 8 AM	79
6 AM through 9 AM	118
7 AM through 10 AM	160
8 AM through 11 AM	203
9 AM through 12 PM	242
10 AM through 1 PM	262
11 AM through 2 PM	272
12 PM through 3 PM	270
1 PM through 4 PM	270
2 PM through 5 PM	294
3 PM through 6 PM	325
4 PM through 7 PM	337
5 PM through 8 PM	321
6 PM through 9 PM	272
7 PM through 10 PM	203
8 PM through 11 PM	140
9 PM through 12 AM	85
10 PM through 1 AM	49
11 PM through 2 AM	25

*Sums the totals from Table 6 for specified time period

Appendix D:

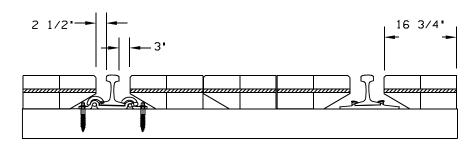
BNSF At-Grade Crossing Construction Requirements





TWO PIECE PANEL

H - 7° FOR 100 LB RAIL H - 7 1/2° FOR 115 LB RAIL H - 8° FOR 136 LB. RAIL



8'6" CROSS TIE

MATERIAL & FABRICATION

- HARDWOOD PANELS TO BE TREATED (BNSF SPECIFICATIONS) MIXED HARDWOOD, FREE OF WANE.
- 2. BRANDING: EACH CROSSING PANEL SHALL BE IDENTIFIED ON THE END WITH MANUFACTURER ID, MO/YR MANUFACTURED, WEIGHT RAIL.

INSTALLATION

- BALLAST THROUGH CROSSING AREA SHALL BE CLEAN CRUSHED ROCK BALLAST.
 BELOW BOTTOM OF TIES. TOP OF BALLAST TO BE 2' BELOW TOP OF TIES.
 TIES THROUGH CROSSING SHALL BE NO. 5 TREATED HARDWOOD 19 3/16' ON CENTERS.
 IN GOOD CONDITION.
- 2. IF REQUIRED BY GDLM, PERFORATED DRAINAGE PIPE RECOMMENDED FOR PROPER DRAINAGE PER BNSF DWG. 2259.01.
- 3. ENDS OF CROSSING PANELS SHOULD BE CENTERED ON TIE.
- 4. THERMITE WELDS OR RAIL JOINTS SHOULD BE LOCATED OUTSIDE THE CROSSING. WHEREVER POSSIBLE, WELDED RAIL SHOULD BE RELAYED THROUGH CROSSING (MINIMUM RAIL WEIGHT, 112 LB.) BEFORE NEW TIES AND CROSSING PANELS ARE INSTALLED.
- PANELS SHALL BE HANDLED CAREFULLY, SLATTED AND STACKED ON LEVEL GROUND TO PREVENT WORPAGE.
- 6. PUBLIC CROSSINGS SHALL BE OF SUCH WIDTH AS PRESCRIBED BY LAW. BUT IN NO CASE SHALL THE WIDTH BE LESS THAN THAT OF THE ADJACENT TRAVELED ROADWAY PLUS 2 FFFT.
- 7. TWIN LEAD TIMBER SPIKES FURNISHED SEPARATELY.
- 8. 3/8" DIA. HOLES SHOULD BE BORED IN FIELD, TO PATTERN SHOWN.
- 9. GAGE SIDE AND FIELD SIDE PANELS ARE INTERCHANGEABLE.
- 10. ALL CROSSING PANELS HAVE CLEARANCE FOR PANDROL PLATES AND CLIPS.
- 11. USE OF 10' TIES [S REQUIRED IN HEAVILY RAIL TRAFFIC CROSSINGS SEE DWG. 2253.03.
- 12. PANELS ARE FURNISHED FOR ANY LENGTH CROSSING IN INCREMENTS OF 8 AND 16 FEET.
 THE ITEM NUMBERS LISTED BELOW COVERS THE REQUIRED PANELS BY THE TRACK FOOT.

	BILL OF MATERIAL	
WT. RAIL	DESCRIPTION	STOCK CODE
100 LB	8' FULL DEPTH PANEL (2 PCS. DOWELED)	004938916
115 LB	8' FULL DEPTH PANEL (2 PCS. DOWELED)	004938940
115 LB	16' FULL DEPTH PANEL (2 PCS. DOWELED)	004938932
136 LB	8' FULL DEPTH PANEL (2 PCS. DOWELED)	004938866
136 LB	16' FULL DEPTH PANEL (2 PCS. DOWELED)	004938957
	3/4" X 12" TWIN LEAD TIMBER SPIKE	004744074
	3/4" X 13" TWIN LEAD TIMBER SPIKE	004743985

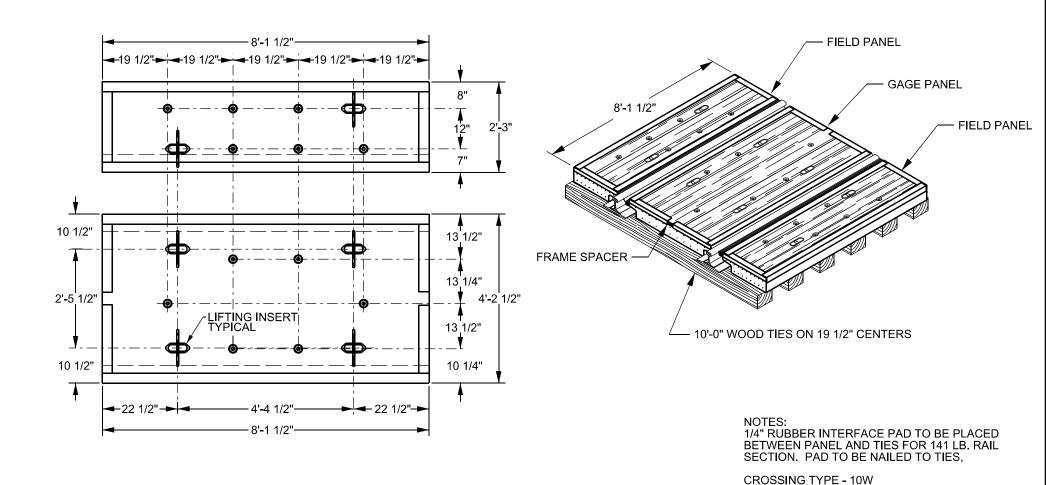


STANDARD PLAN

TIMBER CROSSING PANELS FOR LOW DENSITY RAIL TRAFFIC ON 8'6" WOOD TIES

SCALE: NONE

FILE OWNER BNSF | DATE: MAY 11, 2010 | REV. NO.: 07 | DWG NO: 225302



RAIL SIZE	PANEL HEIGHT	GAGE PANEL WEIGHT	FIELD PANEL WEIGHT
115	7 1/8"	2850 LBS.	1550 LBS.
132-141	7 7/8"	3125 LBS.	1675 LBS.





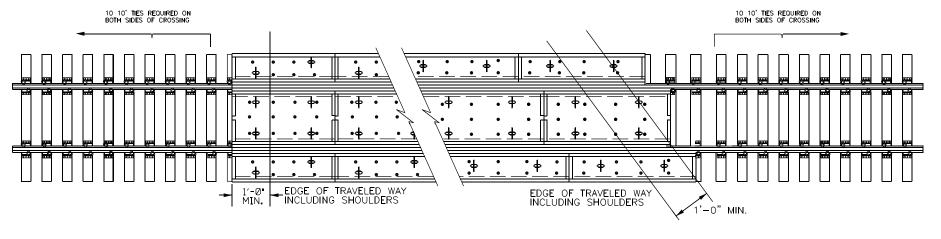
COMMON STANDARDS

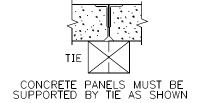
LAYOUT FOR CONCRETE PANELS ON 10'-0" LONG WOOD TIES (10W)

ITEM NUMBERS				
141 LB. BNSF	133-141 LB. UPRR	132-136 LB. BNSF	115 LB. UPRR	115 LB. BNSF
054374616	540-1301	004935722	540-0202	004935706

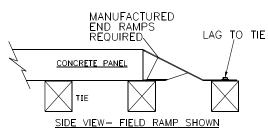
FILE OWNER: UPRF DATE: DEC. 6, 2010

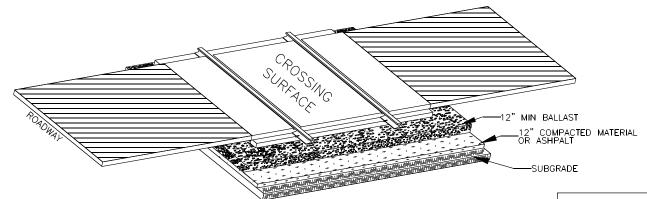
REV. NO.: 2 DWG NO: 200100





CONCRETE CROSSING ON WOOD TIES





BALLAST SECTION

NOTES:

SEE E.I. 10 FOR ROAD CROSSING REQUIREMENTS

- 1. DIRECT DRAINAGE AWAY FROM THE TRACK
- 2. PREVENT MATERIAL FROM FOULING THE ROAD CROSSING BALLAST SECTION
- 3. DIVERT SURFACE WATER FLOWING ALONG THE ROADWAY OR APPROACHES AWAY FROM THE TRACK
- 4. SEE BNSF STANDARD PLANS 2258.03, 2258.04 AND 2258.05 FOR END RAMP SYSTEM



ROAD CROSSING LAYOUT

DRAWING: 2259 SHEET: 01

REVISION: 07

DATE: OCTOBER 29, 2013

OWNER: BNSF

Appendix E:

Summary of Design Requirements

Trail

Width 10-14 ft 12B-2.C.1 10' minimum, ecommended is 11'. Going with 10' because top of levee is not very wide and there needs to be room for the shoulder

Depth 4-5 in 12B-2.C.2 minimum is 4", recommended is 5" Cross Slope

Requirements in section 12A-2 Type 1 & 2

1.5% cross slope recommended, 1% minimum and 5% maximum. Cross slopes greater than 2% should be sloped to the inside of horizontal curves. Type 3

Separation of Roadway & Path 5 ft min, if less than 5 ft a barrier or railing is necessary 12B-2.C.4 Lateral Clearance

2 min for lateral obstructions 12B-2.C.5.a 6:1 max cross slope for shoulder area

min for lateral offset from barrier or rail

Vertical Clearance 10 ft 12B-2.C.5.b (8 ft according to Iowa Trails 2000, so 10 ft is probably safe) Shoulder Width 2 ft 12B-2.C.6 min with max cross slope of 6:1

42 in Safety Rails min 12B-2.C.7 Design Speed & Horizontal Curves 12B-2.C.8

Terrain	Design Speed (mph)	Minimum Radius ¹ (Horizontal Curve) (feet)
Grades less than 2%	18	60
Grades less than or equal to 5%	25	115
Grades 6% and more	30	166

Vertical Alignment 12B-2.C.8

Table 12B-2.04: Vertical Alignmen

Grade Range	Maximum Segment Length (feet)		
Grade Kange	Preferred	Acceptable ¹	Allowed ²
< 5%	Any length	Any Length	Any Length
≥ 5% and < 8.33%		50	200
≥ 8.33% and < 10%		30	30
≥ 10% and < 12.50%	1		10

¹ Derived from AGODA Section 1016 (Outdoor Recreation Access Routes)

rived from AGODA Section 1017 (Trails) Accessibility Requirements 12A-2 (curb ramps and detectable warnings)

Curb Ramps 12A-2.E.4.b **Technical Requirements:** 1) Cross Slope: The maximum cross slope is 2.0% with a target value of 1.5%; however, for intersection legs that do not have full stop or yield control (i.e. uncontrolled or

- signalized) and at mid-block crossings, the curb ramp cross slope is allowed to match the cross slope in the pedestrian street crossing section. See "pedestrian street crossings" for additional details. (R304.5.3) 2) Running Slope: Provide curb ramps with a target running slope of 6.25% and a
- maximum slope of 8.3%; however, curb ramps are not required to be longer than 15 feet, regardless of the resulting slope. (R304.2.2 and R304.3.2) 3) Width: The minimum width of a curb ramp is 4 feet, excluding curbs and flares. If the sidewalk facility is wider than 4 feet, the target value for the curb ramp is equal to the
- width of the sidewalk. (R304.5.1) 4) Grade Breaks: Grade breaks at the top and bottom of curb ramps must be perpendicular to the direction of the curb ramp run. Grade breaks are not allowed on the surface of curb
- ramp runs and turning spaces. (R304.5.2) 5) Flared Sides: For perpendicular curb ramps on Class A sidewalks, or configurations where the pedestrian circulation path crosses the curb ramp, PROWAG requires the flares along the sides of the curb ramp to be constructed at 10% or flatter. (R304.2.3) This allows pedestrians to approach the curb ramp from the side and prevents a tripping hazard. It is recommended to design these flares at a slope between 8% and 10%, which
- will clearly define the curb ramp from the sidewalk. 6) Clear Space: At the bottom of perpendicular curb ramps, a minimum 4 foot by 4 foot area must be provided within the width of the pedestrian street crossing, but wholly outside of the parallel vehicle travel lanes. (R304.5.5)
- 7) Turning Space: Turning spaces allow users to stop, rest, and change direction on the top or bottom of a curb ramp (R304.2.1 and R304.3.1). a) Placement: A turning space is required at the top of perpendicular curb ramps and at the bottom of parallel curb ramps.
- b) Slope: The maximum cross slope and running slope is 2.0% with a target value of 1.5% (R304.2.2 and R304.3.2). When turning spaces are at the back of curb, cross slopes may be increased to match allowable values in the pedestrian street crossing section (R304.5.3).

Detectable Warnings 12A-2.E.6

- a. General: Detectable warning surfaces are detected underfoot or with a cane by blind and low vision individuals. The warnings indicate the location of the back of curb. Detectable warnings also provide a visual queue to pedestrians with low vision and aid in locating the curb ramp across the street. For these reasons, the detectable warning shall contrast visually (light on dark or dark on light) from the surrounding paved surfaces (R305.1.3).
- b. Location: Detectable warnings shall be installed at all pedestrian street crossings and atgrade rail crossings (R208.1). Detectable warning surfaces should not be provided at crossings of residential driveways since the pedestrian right-of-way continues across the driveway. Where commercial driveways are provided with yield control, stop control, or traffic signals at the pedestrian access route, detectable warnings should be installed at the junction between the pedestrian access route and the driveway (Advisory R208.1).
- c. Size: Detectable warning surfaces shall extend a minimum of 2 feet in the direction of pedestrian travel and extend the full width of the curb ramp or pedestrian access route
- d. Dome Orientation: On curb ramps, the rows of truncated domes should be aligned perpendicular to the grade break so pedestrians in wheelchairs can track their wheels between the domes. On surfaces less than 5% slope, dome orientation is less critical.
- e. Parallel Curb Ramps: On parallel curb ramps, detectable warning shall be placed on the turning space at the back of curb (R305.2.2).

Parking 12A-2.H

Table 12A-2.01 On-Street Accessible Parking Spaces		
Minimum Required Number of		
Accessible Parking Spaces		
1		
2		
3		
4		
5		
6		
4% of total		

- Identify accessible parking spaces by displaying signs with the International Symbol of Comply with R403 Operable Parts for parking meters and pay stations that serve accessible
- parking spaces.

 Locate accessible parking spaces where the street has the least crown and grade (R309.1).
- Accessible parking spaces located at the end of the block can be served by the curb ramps or blended transitions at the pedestrian street crossing (R309.4).
 Keep sidewalks adjacent to parallel accessible parking spaces free of signs, street furniture, and other obstructions. Locate curb ramps or blended transitions so the van side-lift or ramp can be deployed to the sidewalk (R309.2)
- At parallel accessible parking spaces, locate parking meters at the head or foot of the parking space (R309.5.1). Ensure information is visible from a point located 3.3 feet maximum above the center of the clear space in front of the parking meter or parking pay station (R309.5.2).
 For areas where the sidewalk width or available right of way exceeds 14 feet, provide an access aisle 5 feet wide at street level the full length of the parallel parking space and connect it to a pedestrian access route (R309.2.1). When an access aisle is not provided due to the sidewalk or right-of-way not exceeding 14 feet, locate the accessible parallel parking space at the end of the block face (R309.2.2)
 Provide an 8 feet wide access aisle the full length of the parking space for accountable accessible parallel.
- Provide an 8 feet wide access aisle the full length of the parking space for perpendicular or angled accessible parking spaces. Two accessible parking spaces are allowed to share a common access aidle (P200.2). For perpendicular or angled spaces, connect the access aisle to the pedestrian access route with a
 curb ramp. Do not locate curb ramps within the access aisle (R309.4).

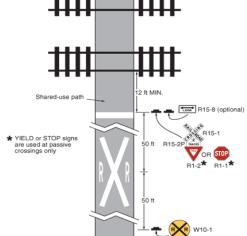
Surface 12B-2.E

It is important to construct and maintain a smooth riding surface on shared use paths. Shared use path pavements should be machine placed. Surface texture is needed but care must be exercised not to cause operational problems with too little or too much texture. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes. Joints shall be sawed, not hand tooled.

At-Grade Crossing 12B-2.G

Whenever it is necessary to cross railroad tracks with a bicycle, special care must be taken. The crossing should be at least as wide as the approaches of the shared use path. Whenever possible, the crossing should be straight and between 90 and 60 degrees to the rails. The greater the crossing angle deviates from being perpendicular, the greater the chance that a bicyclist's front wheel may be trapped in the flangeway causing a loss of control. (AASHTO 4.12).

Figure 8D-1. Example of Signing and Markings for a Pathway Grade Crossing



From part 8D Pathway Grade Crossing of the MUTCD https://mutcd.fhwa.dot.gov/htm/2009/part8/part8_toc.htm

Drainage 12B-2.H Shouldn't be an issue along levee beause the purpose of the levee is to block drainage Urban Areas: The minimum recommended pavement cross slope of 1% usually provides enough slope for proper drainage. Sloping in one direction, usually toward the street, instead of crowning is preferred and usually simplifies the drainage and surface construction. However, care must be exercised not to trap water on the high side of the shared use path, particularly in

curved areas. (AASHTO 5.2.11). Pavement Markings 12B-2.J *In Transverse Markings Section fo the MUTCD

Ladder or zebra pavement markings per MUTCD are recommended at crosswalks. Other pavement markings are not required, except as mitigation strategies. (AASHTO 5.4).

width length as wide as the crossing (trail)

Crosswalk Makings

Signage 12B-2.K *pg 46 and 107 of MUTCD has sign sizes and code numbers

there are regulatory and warning sign types

https://mutcd.fhwa.dot.gov/HTM/2003r1/part2/part2-toc.htm Warning sign placement https://mutcd.fhwa.dot.gov/HTM/2003r1/part2/part2c.htm

Mounting Height *2A.18 MUTCD 7 feet

6 feet if a secondary sign is also mounted

All signs should be retroreflective and conform to the color, legend, and shape requirements described in the MUTCD. In addition, guide signing, such as to indicate directions, destinations, distances, route numbers, and names of crossing streets should be used. In general, uniform application of traffic control devices, as described in the MUTCD, should be used and will tend to encourage proper bicyclist behavior. (AASHTO 5.4).

Lighting 12B-2.L

Fixed-source lighting reduces conflicts along shared use paths and at intersections. In addition, lighting allows the bicyclist to see the shared use path direction, surface conditions, and obstacles. Lighting for paths is important and may be considered where heavy nighttime riding is expected (e.g., paths serving college students or commuters) and at roadway intersections. Lighting should be considered through underpasses or tunnels and when nighttime security could be a problem. Where special security problems exist, higher illumination levels may be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. (AASHTO 5.2.12).

Collectors are streets of moderate size that either serve as secondary connections within communities or as primary routes in rural parts of the state. These roadways may have high traffic speed but typically have

Crossings at signals, at controlled intersections, or mid-block with flashing lights

lower volume than arterial roads. They often have only one lane in each direction, but may be wider in

congested areas. The following elements should be included in crossings of collectors (see Figure 4-29):

- Marked crosswalks
- · Cautionary and regulatory signage on trail
- Cautionary signage on roadway

*For crossings we need stop signs for trail, stop ahead sign for trail, crossing signs for roads

Pavement Markings:

https://iowadot.gov/design/SRP/CurrentBook/Sections/epm_section.pdf

Bridge

needs to accommodate emergency vehicle Width 10 ft Vertical Clearance 23'-6" minimum 5.2.1.a

Width of Vertical Clearance 9 ft minimum in each direction from the centerline of the existing or future tracks 5.2.1.a.1 Piers and Abutments must be located outside of the railroad right of way (100 ft wide) 5.2.2.b

Fencing 8 ft high for a curved fence or 10 ft high for a straight fence 5.4.a.2 openings should not exceed 2 in for a chain link fence 4.7.b.1

Drainage drainage shall be diverted away from the railroad right of way at all times

At Grade Rail Crossing

No new at grade crossings allowed 7.1.a

At grade crossings immediately adjacent to existing public roadways with existing warning devices are allowed **Pavement Marking Dimensions** https://mutcd.fhwa.dot.gov/htm/2003r1/part8/fig8b-07_longdesc.htm

Signage https://mutcd.fhwa.dot.gov/htm/2009/part8/part8b.htm#figure8B01

7.1.b

5.8.a

Iowa Trails 2000 DOT Collector Road Crossing Layout

Appendix F:

Cost Estimates

Bridge Alternative w/ Concrete

Category	Item	Quantity	Units	Unit Price	Cost
	Structural Concrete	302.0	CY	\$ 500.00	\$ 151,000
Abutments	Reinforcing Steel	39070	LB	\$ 0.90	\$ 35,163
Abutilients	Biaxial Geogrid	404	SY	\$ 4.50	\$ 1,818.00
	Geotechnical Investigation	1	LS	\$ 5,000.00	\$ 5,000.00
	Granular Backfill	6,314.0	CY	\$ 40.00	\$ 252,560.00
	Concrete	1739.0	CY	\$ 350.00	\$ 608,650
	Safety Rail - 42 in. high steel, primed, straight & level	740	LF	\$ 170.00	\$ 125,800.00
	Excavation	304	CY	\$ 6.05	\$ 1,839.20
	6" Deep, 3/4 in. Stone Subbase	210	CY	\$ 40.00	\$ 8,400.00
Trail	Sign Plaques	1	LS	\$ 1,400.00	\$ 1,400.00
	Sign Posts	17	Each	\$ 42.00	\$ 714.00
	Sign Anchors	17	Each	\$ 26.00	\$ 442.00
	Collapsible Bollards 30" Tall	5	Each	\$ 300.00	\$ 1,500.00
	Pavement Markings	12722	LF	\$ 0.17	\$ 2,162.74
	Detectable Warnings	120	SF	\$ 14.40	\$ 1,728.00
	Installation of signs, bollards, pavement markings	1	LS	\$ 2,000.00	\$ 2,000.00
Bridge	Materials, Fabrication, and Delivery	1	LS	\$ 107,000.00	\$ 107,000.00
bridge	Bridge Placement	1	LS	\$ 65,000.00	\$ 65,000.00
Doubing Lat	Concrete	72	CY	\$ 350.00	\$ 25,200.00
Parking Lot	6" Deep, 3/4 in. Stone Subbase	84	CY	\$ 40.00	\$ 3,360.00
	Construction Total				\$ 1,400,737

At-Grade Alternative w/ Concrete

Category	ltem	Quantity	Units	Į	Jnit Price	Cost
	Granular Backfill	5,577.0	CY	\$	40.00	\$ 223,080.00
	Concrete	1788.0	CY	\$	350.00	\$ 625,800
	Safety Rail - 42 in. high steel, primed, straight & level	450	LF	\$	170.00	\$ 76,500.00
	Excavation	313	CY	\$	6.05	\$ 1,893.65
	6" deep 3/4 in. stone subbase	565	CY	\$	40.00	\$ 22,600.00
Tuell	Sign Plaques	1	LS	\$	2,000.00	\$ 2,000.00
Trail	Sign Posts	21	Each	\$	42.00	\$ 882.00
	Sign Anchors	21	Each	\$	26.00	\$ 546.00
	Collapsible Bollards 30" Tall	5	Each	\$	300.00	\$ 1,500.00
	Pavement Markings	13403	LF	\$	0.17	\$ 2,278.51
	Detectable Warnings	160	SF	\$	14.40	\$ 2,304.00
	Installation of signs, bollards, pavement markings	1	LS	\$	2,500.00	\$ 2,500.00
Darking Lat	Concrete	72	CY	\$	350.00	\$ 25,200.00
Parking Lot	6" deep 3/4 in. stone subbase	84	CY	\$	40.00	\$ 3,360.00
	Construction Total					\$ 990,444

Bridge alternative w/ Asphalt

Category	Item	Quantity	Units	Į	Unit Price	Cost
	Structural Concrete	302.0	CY	\$	500.00	\$ 151,000
Abutments =	Reinforcing Steel		LB	\$	0.90	\$ 35,163
Abutilients	Biaxial Geogrid	404	SY	\$	4.50	\$ 1,818.00
	Geotechnical Investigation	1	LS	\$	5,000.00	\$ 5,000.00
	Granular Backfill	6,314.0	CY	\$	40.00	\$ 252,560.00
_	Hot Mix Asphalt	3404.0	TON	\$	75.00	\$ 255,300
	Safety Rail - 42 in. high steel, primed, straight & level	740	LF	\$	170.00	\$ 125,800.00
	Excavation	304	CY	\$	6.05	\$ 1,839.20
	6" Deep 3/4 in. Stone Subbase	210	CY	\$	40.00	\$ 8,400.00
	Asphalt Paving	4118	SY	\$	24.00	\$ 98,832.00
Trail	Sign Plaques	1	LS	\$	1,390.00	\$ 1,390.00
	Sign Posts	17	Each	\$	42.00	\$ 714.00
	Sign Anchors	17	Each	\$	26.00	\$ 442.00
	Collapsible Bollards 30" Tall	5	Each	\$	300.00	\$ 1,500.00
	Pavement Markings	12722	LF	\$	0.17	\$ 2,162.74
_	Detectable Warnings	120	SF	\$	14.40	\$ 1,728.00
	Installation of signs, bollards, pavement markings	1	LS	\$	2,000.00	\$ 2,000.00
Bridge	Materials, Fabrication, and Delivery	1	LS	\$	107,000.00	\$ 107,000.00
Bridge	Bridge Placement	1	LS	\$	65,000.00	\$ 65,000.00
	Hot Mix Asphalt	140	TON	\$	75.00	\$ 10,500.00
Parking Lot	Asphalt Paving	166	SY	\$	24.00	\$ 3,984.00
	6" Deep 3/4 in. Stone Subbase	84	CY	\$	40.00	\$ 3,360.00
	Construction Total					\$ 1,135,493

At-Grade Alternative w/ Asphalt

Category	ltem	Quantity	Units	U	Init Price	Cost
	Granular Backfill	6,314.0	CY	\$	40.00	\$ 252,560.00
	Hot Mix Asphalt	3500.0	TON	\$	75.00	\$ 262,500
	Asphalt Paving	4244.0	SY	\$	24.00	\$ 101,856
	Safety Rail - 42 in. high steel, primed, straight & level	450	LF	\$	170.00	\$ 76,500.00
	Excavation	565	CY	\$	6.05	\$ 3,418.25
	6" Gravel Subbase	565	CY	\$	40.00	\$ 22,600.00
Trail	Sign Plaques	1	LS	\$	2,000.00	\$ 2,000.00
	Sign Posts	21	Each	\$	42.00	\$ 882.00
	Sign Anchors	21	Each	\$	26.00	\$ 546.00
	Collapsible Bollards 30" Tall	5	Each	\$	300.00	\$ 1,500.00
	Pavement Markings	13403	LF	\$	0.17	\$ 2,278.51
	Detectable Warnings	160	SF	\$	14.40	\$ 2,304.00
	Installation of signs, bollards, pavement markings	1	LS	\$	2,500.00	\$ 2,500.00
	Hot Mix Asphalt	140	TON	\$	75.00	\$ 10,500.00
Parking Lot	Asphalt Paving	166	SY	\$	24.00	\$ 3,984.00
	6" deep 3/4 in. stone subbase	84	CY	\$	40.00	\$ 3,360.00
	Construction					\$ 749,289

Bridge Alternative Property Acquisition Costs

Name of Landowner	Parcel ID	Acres Needed	Listing	g Price (\$/acre)	10 % Market Value (\$/acre)	Total	
Evan & Debra Belt	620200018	1.048	\$	2,038	\$ 2,242	\$ 2,349	
Iowa DOT	620426008	0.441	\$	1,000	\$ 1,100	\$ 485.10	
Property Acquiition Total							

At Grade Property Acquisition

Name of Landowner	Parcel ID	Acres Needed	Listi	ng Price (\$/acre)	10 % Market Value (\$/acre)		Total
Evan & Debra Belt	620200018	1.048	\$	2,038	\$	2,242	\$	2,349
Tiffany Powell	620200013	1.624	\$	931	\$	1,025	\$	1,664
Tiffany Powell	620200014	0.6	\$	1,183	\$	1,302	\$	781
Tiffany Powell	620402006	0.202	\$	1,771	\$	1,948	\$ 3	393.55
	Property	Acqusition Total					\$	5,188

Trail Accessories Cost Estimate

diamond 10+

https://www.ricesigns.com/warning/symbol-warning-signs/w11-2.htm

engineering prismatic

up to 7

7 to 10

Sign Plaque	Code	Dimensions	# of Signs	Co	st/Unit	Cos	st for All	Grade of Reflective Aluminum	Durability	Service Temperature
Stop (Trail)	R1-1	18" x 18"	6	\$	22.61	\$	135.66	High Intensity Prismatic	7-10 y	-10 to 130
Stop (Street)	R1-1	36" x 36"	1	\$	81.40	\$	81.40	High Intensity Prismatic	7-10 y	-10 to 130
Stop Ahead	W3-1	18" x 18"	4	\$	85.20	\$	340.80	High Intensity Prismatic	7-10 y	-10 to 130
Pedestrian Warning Single Lane	W11-2	30" x 30"	8	\$	74.10	\$	592.80	High Intensity Prismatic	7-10 y	-10 to 130
Pedestrian Warning Multiple Lanes	W11-2	36" x 36"	4	\$	91.90	\$	367.60	High Intensity Prismatic	7-10 y	-10 to 130
Downward Arrow	W16-7P	24" x 12"	6	\$	27.84	\$	167.04	High Intensity Prismatic	7-10 y	-10 to 130
"Ahead"	W16-9P	24" x 12"	6	\$	29.30	\$	175.80	High Intensity Prismatic	7-10 y	-10 to 130
Crossbuck (Trail)	R15-1	24" x 4 1/2"	2	\$	141.30	\$	282.60	High Intensity Prismatic	7-10 y	-10 to 130
Number of Tracks (1)	R15-2P	4 1/2" x 4 1/2"	2	\$	63.60	\$	127.20	High Intensity Prismatic	7-10 y	-10 to 130
Advance Grade	W10-1	15"	2	\$	64.50	\$	129.00	High Intensity Prismatic	7-10 y	-10 to 130
Yield	R1-2	18" x 18" x 18"	2	\$	36.30	\$	72.60	High Intensity Prismatic	7-10 y	-10 to 130
		Total for Bridge Alt.	35	;		\$	1,861.10			
		Total for At Grade alt.	43	3		\$	2,472.50			

https://safety.fhwa.dot.gov/roadway_dept/night_visib/policy_guide/	sign_15mins
Sign reflectivity requirements	

MUTCD Table 2A.3 Minimum Maintained Retroreflectivity Levels

	Sheeting	Sheeting Type (ASTM D4956-04) 1							
Sign Color	Beaded	Sheeting		Prismatic Sheeting	Additional Criteria				
	1	II							
White on	W" G≥7	W ⁺ G ≥ 15	W* G≥25	W ≥ 250; G ≥ 15	Overhead				
Green	W° G≥7		Ground- mounted						
Black on Yellow or	Y*, O*		(2)						
Black on Orange	Y": 0"		(3)						
White on Red			W≥35,R≥7						
Black on White			W≥50						

10' Square 2"x2" Sign Posts	#		In	d. Cost		Total
Bridge Alt.		23	\$	41.78	\$	960.94
At Grade Alt.		27	\$	41.78	\$	1,128.06
Sign Anchor Bases	#		In	d. Cost		Total
Bridge Alt.		23	\$	26.00	\$	598.00
At Grade Alt.		27	\$	26.00	\$	702.00
Collapsible Bollards	#		In	d. Cost		Total
30" Tall		5	\$	298.00	\$	1,490.00
48" Tall		5	Ś	323.00	Ś	1.615.00

*Gotta chose a type; can't find standards

https://www.ricesigns.com/warning/symbol-warning-signs/w11-2.htm

https://www.uline.com/Product/Detail/H-5517/Outdoor-Signs-and-Accessories/Squar-Sign-Post-Anchor-Base-3?pricode=WA9874&gadtype=pla&id=H-5517&gclid=EAIaIQobChMIw57PofLC2gIViZ-

*Heavy base supports that don't ppenetrate ground for stop ahead warning signs on levee?

http://www.belson.com/Collapsible-Bollards

Pavement Markings	Cost/lin. ft \$ 0.17	Lir Bridge At Grade		Total Cost \$ 2,214.50 \$ 2,337.12	https://www.fhwa.dot.gov/publications/research/safety/humanfac/041	42/costest.cfm
Crosswalk	Linear ft/10' x 2' cros # of crosswalk stripes Total number of lane	s/lane crossed s crossed	8	60 t	*assuming each linear paint stripe is 4" wide	
Stop Lines		swalk stripes ar ft for crosswalk	is.	24	1440 ft Total cost for Trail Accessories	Bridge Alt. A \$ 8,851.21

Bridge Alt. At Grade Alt. Total cost for Trail Accessories \$ 8,851.21 \$ 10,431.90

Linear ft/5' x 2' stop line 30 ft # of 5' stop lines Linear ft/2.5' x 2' stop line 15 ft # of 2.5' stop lines Total linear ft for stop lines 165 ft Railroad Markings 60 ft Linear ft/10' x 2' railroad line # of railroad lines Linear ft for railroad X markings 273 ft Total linear ft of railroad markings 393 ft

Trail Centerline

Bridge Alt. 11270 ft

At Grade Crossing Alt. 11590 ft

Detectible warnings https://www.ada.gov/regs2010/RIA_2010regs/ria_appendix03.htm

Cost/sq ft \$ 14.39 Sq ft/10' x 2' detectable warning

20 sq ft

of 10' x 2' detectable warnings

Bridge Alt. At grade Alt. 8 Total cost for detectable warnings

\$ 1,726.67 Bridge Alt. At grade Alt. \$ 2,302.22

Appendix G:

Bibliography

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IX. Design Drawings

Drawing sheets are provided within this section on the following pages.

River Levee Trail and Bridge

City of Red Oak, IA 51591



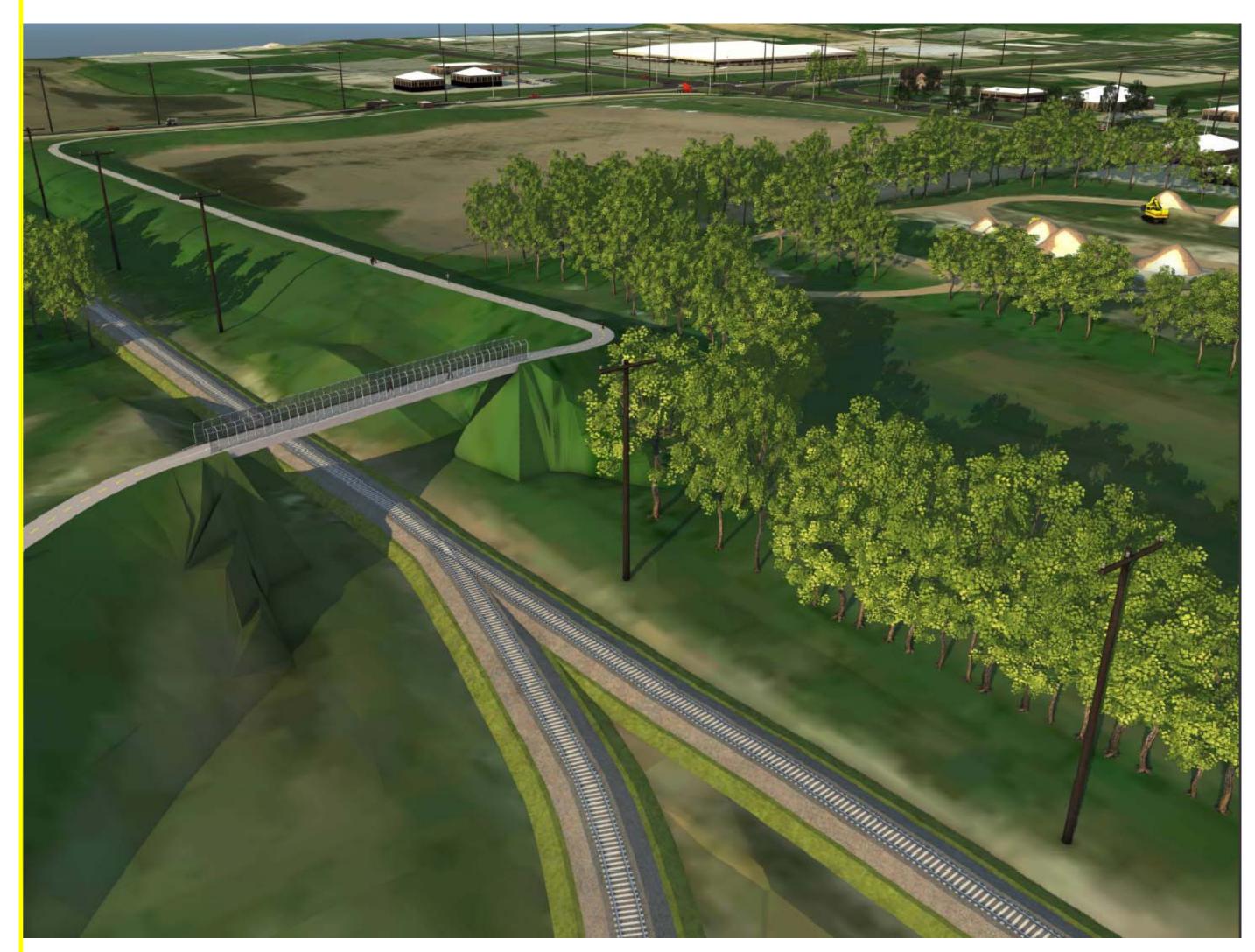


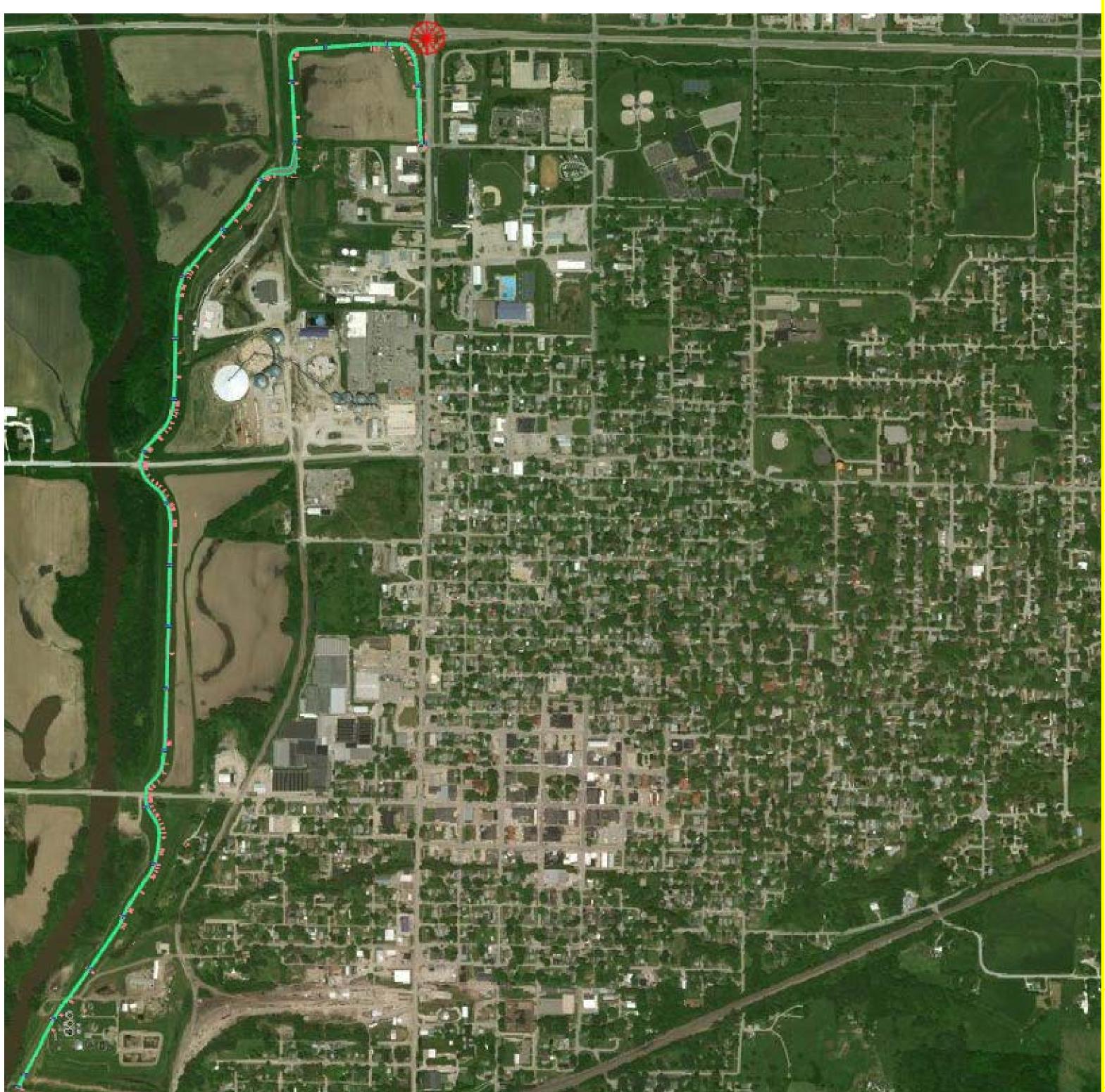
Project Team: Austin Sitzmann

Kara Gibson

Joe Moslemian

Alternative 1







HEET NAME

Cover Sheet

	Index					
Sheet No.	Sheet Name					
G1	Cover Sheet					
G2	Index					
A1	Abutment Dimensions					
A2	Heel Side Dimensions					
A3	Toe Side Dimensions					
A4	Abutment Rebar Details					
A5	Heel Side Rebar Details					
A6	Toe Sid Rebar Details					
B1	Trail Plan and Profile					
B2	Trail Plan and Profile					
B3	Trail Plan and Profile					
B4	Trail Plan and Profile					
B5	Trail Plan and Profile					
B6	Trail Plan and Profile					
B7	Trail Plan and Profile					
B8	Trail Plan and Profile					
B9	Trail Plan and Profile					
B10	Trail Cross Sections					
C1	Parking Lot Plan and Profile					
D1	Pavement Markings and Sign Details					
D2	Pavement Markings and Sign Details					
D3	Pavement Markings and Sign Details					

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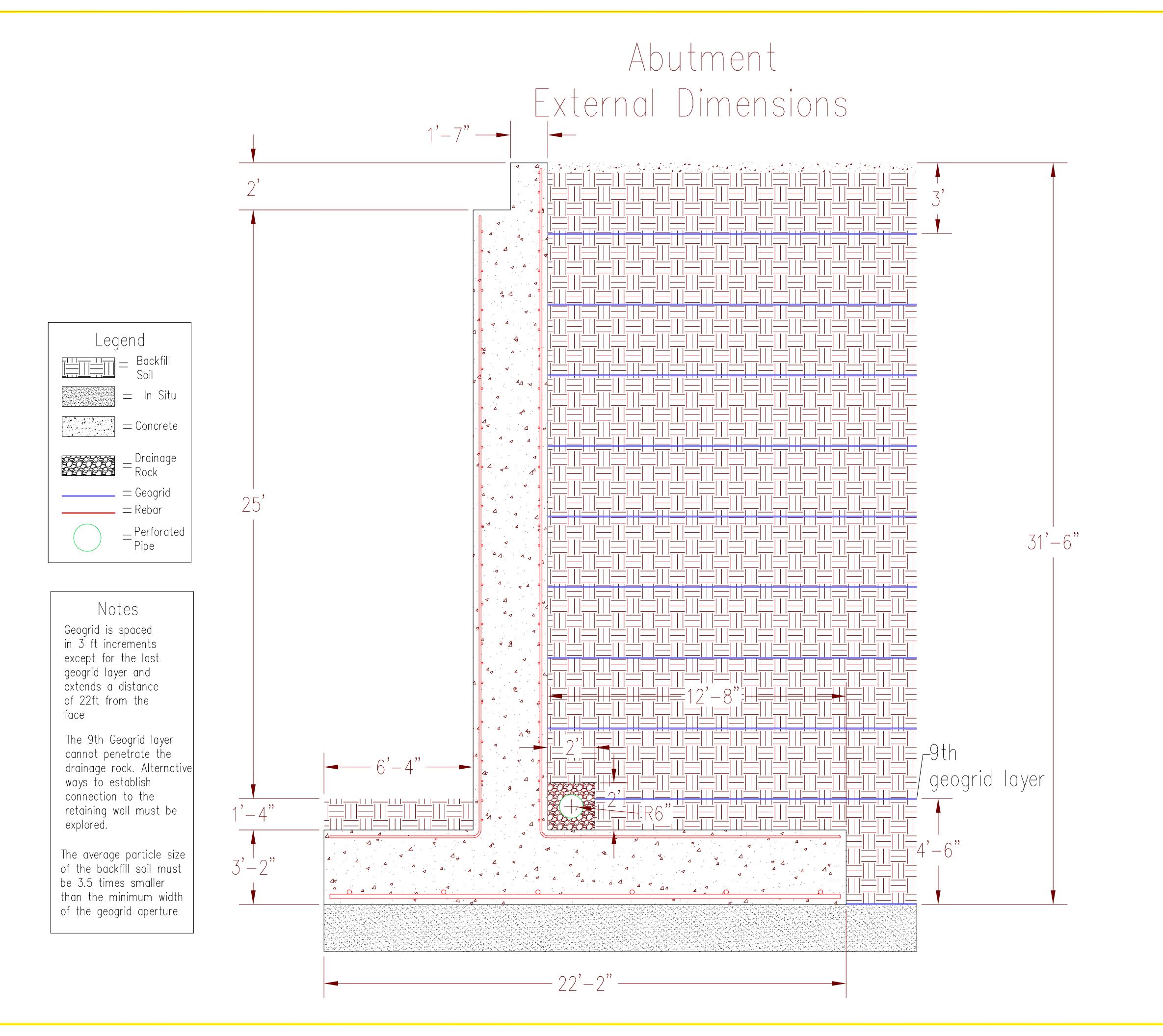
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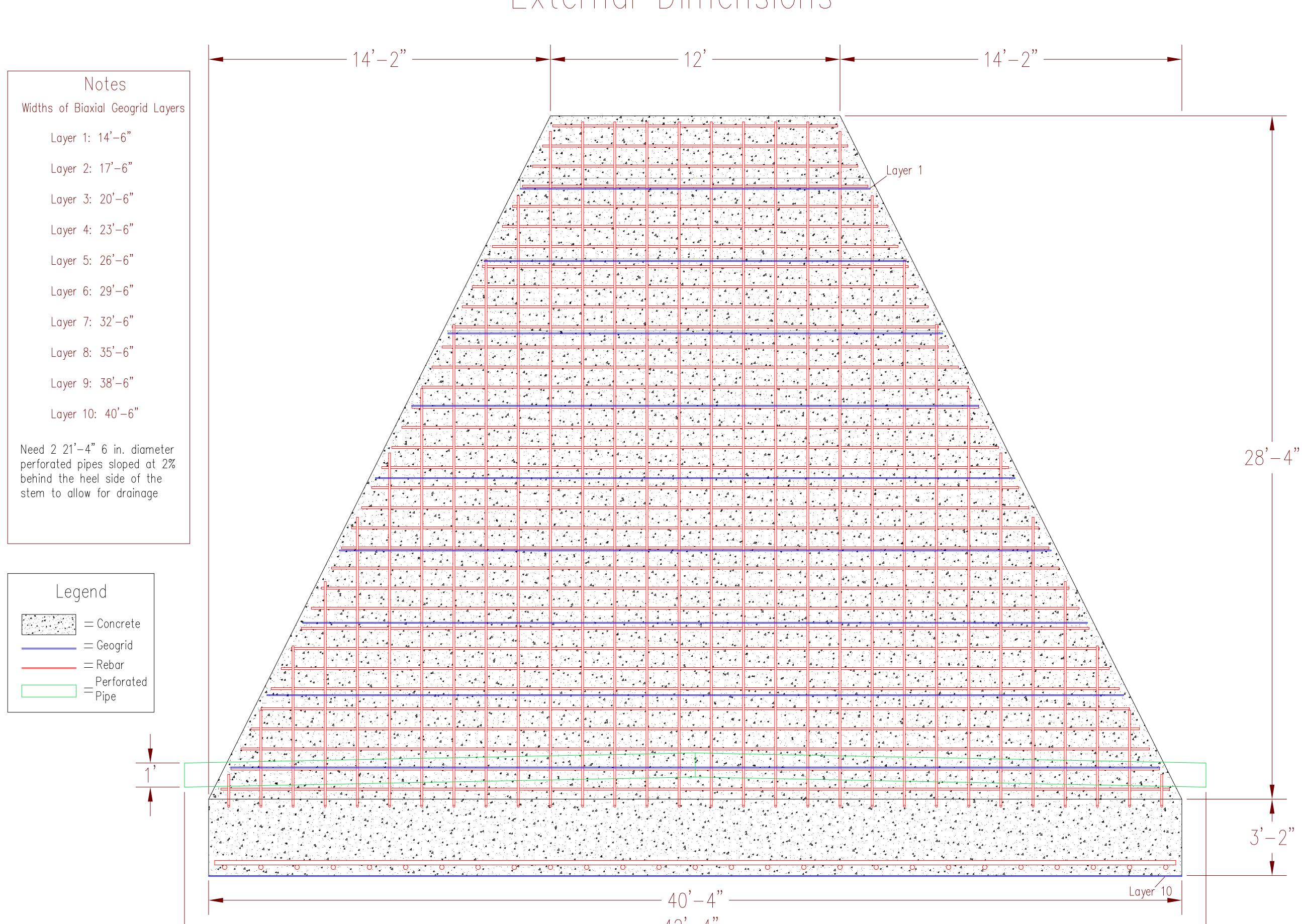
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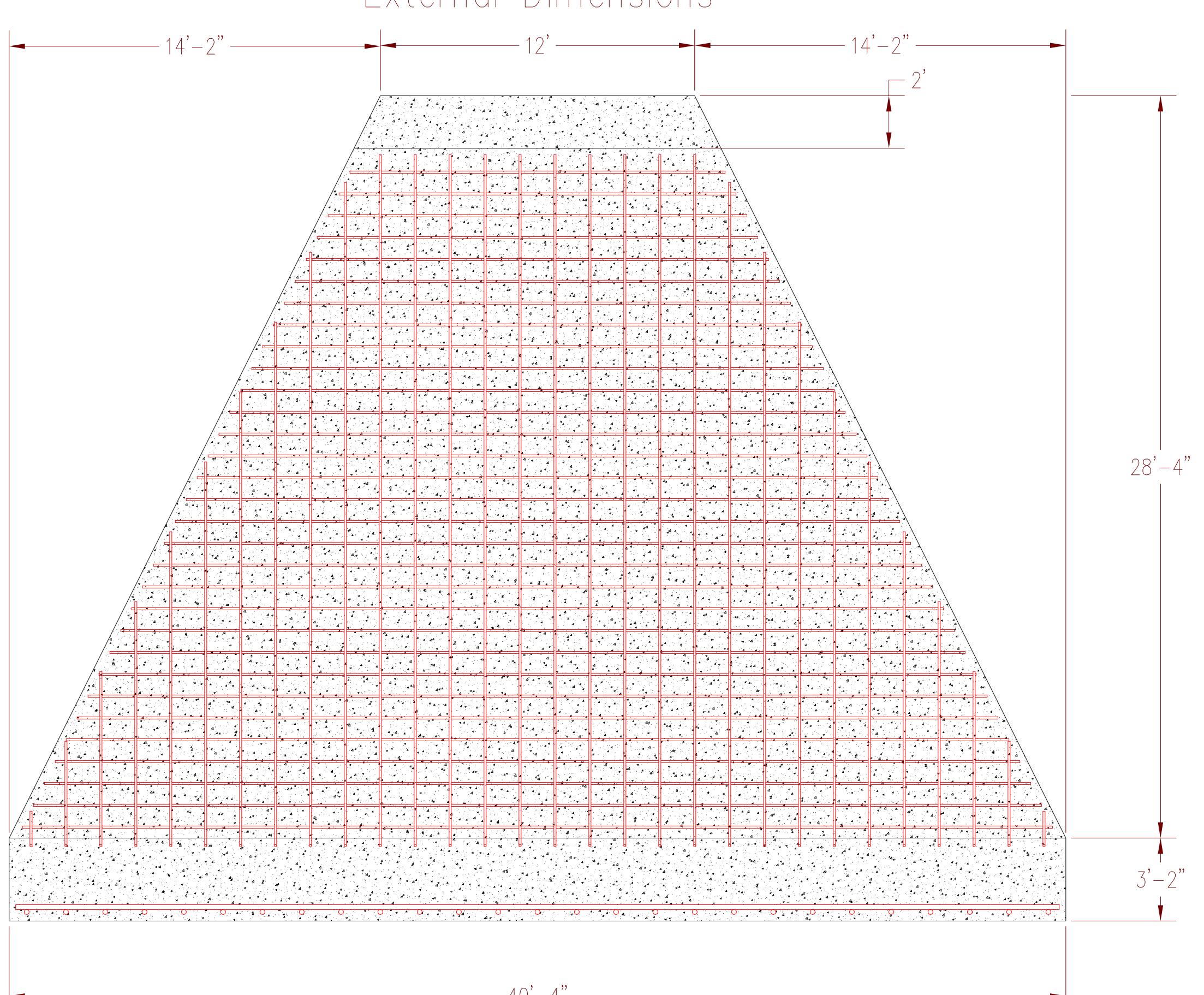
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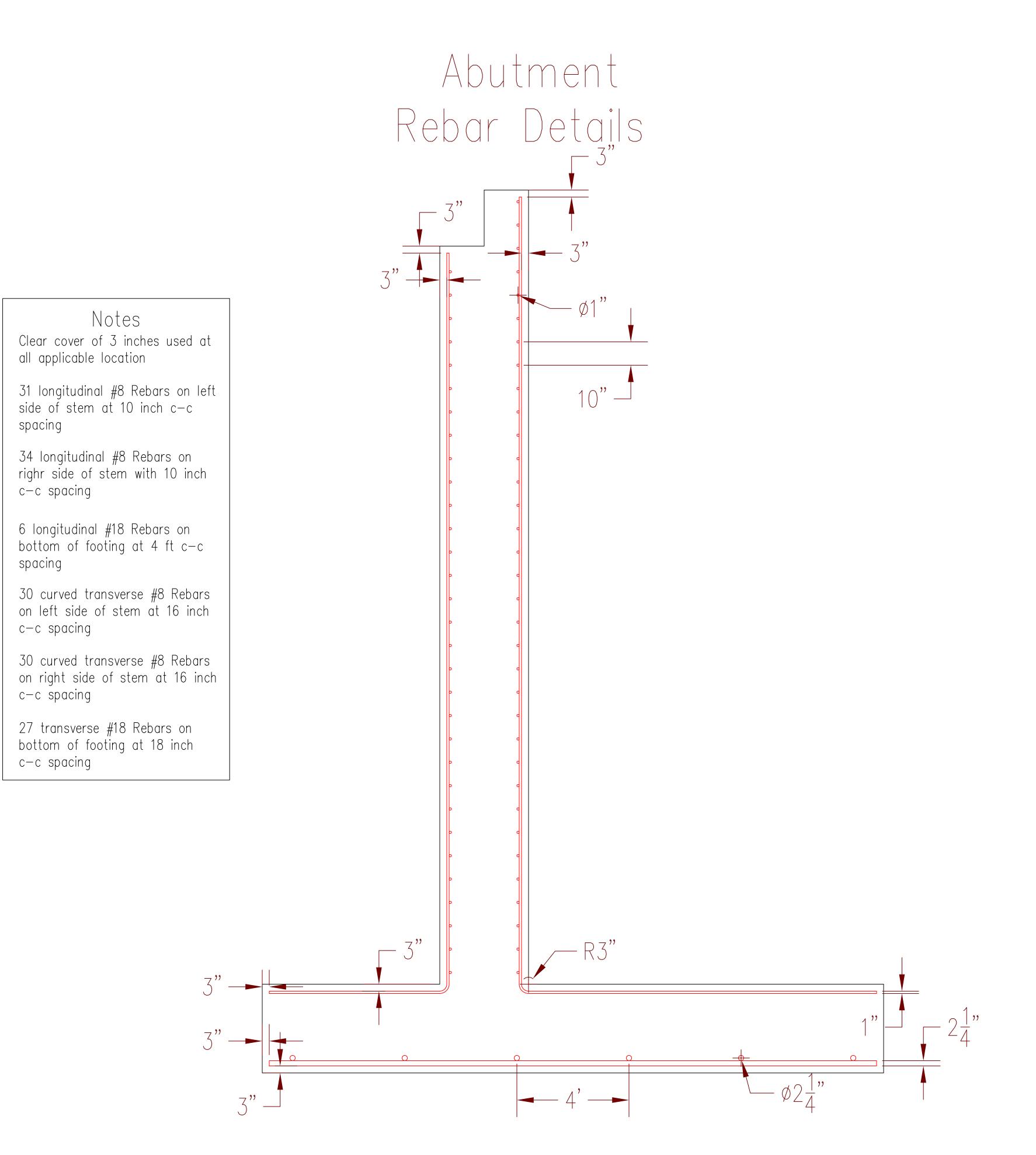
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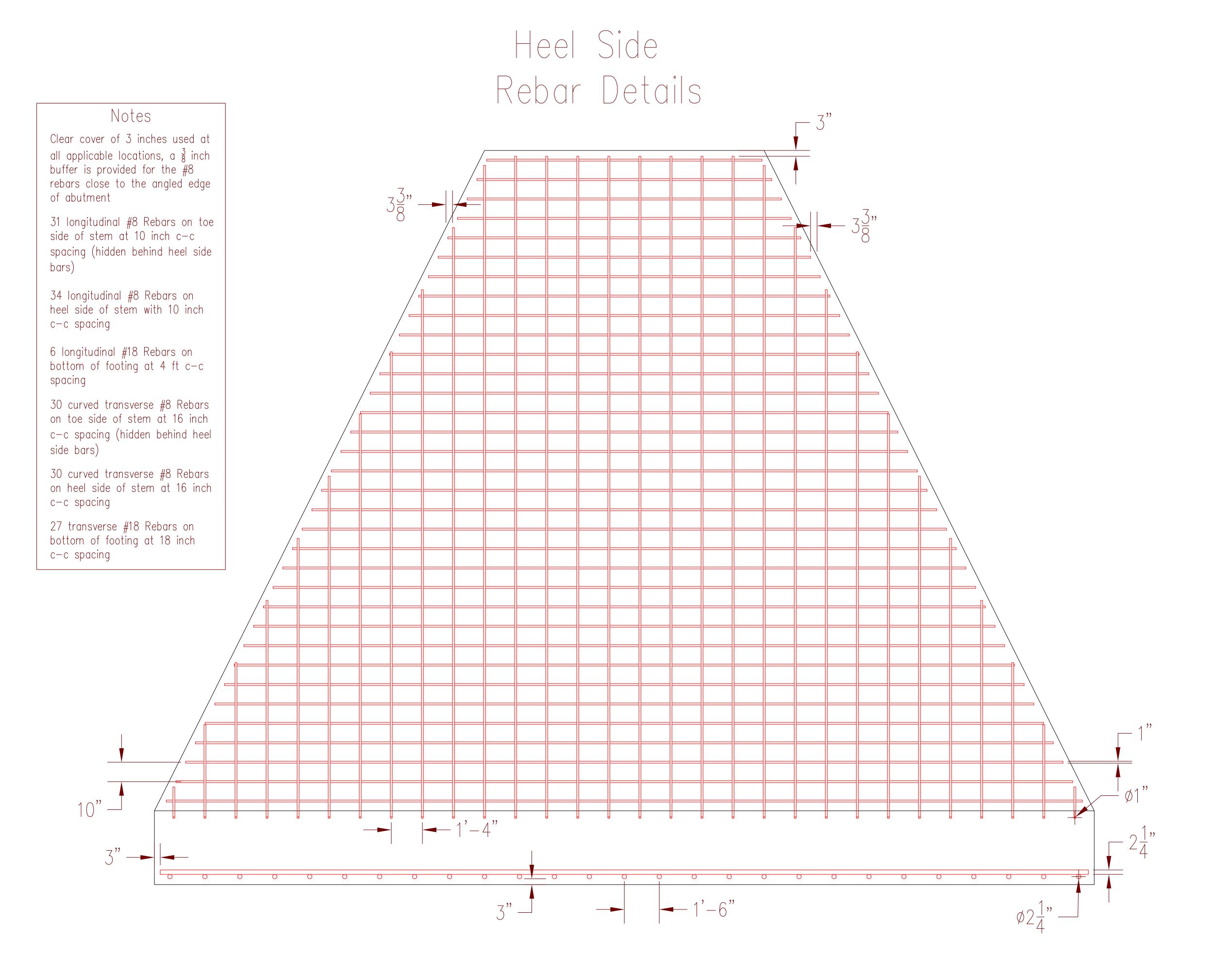
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River Levee Trail &

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Abutment Rebars Details





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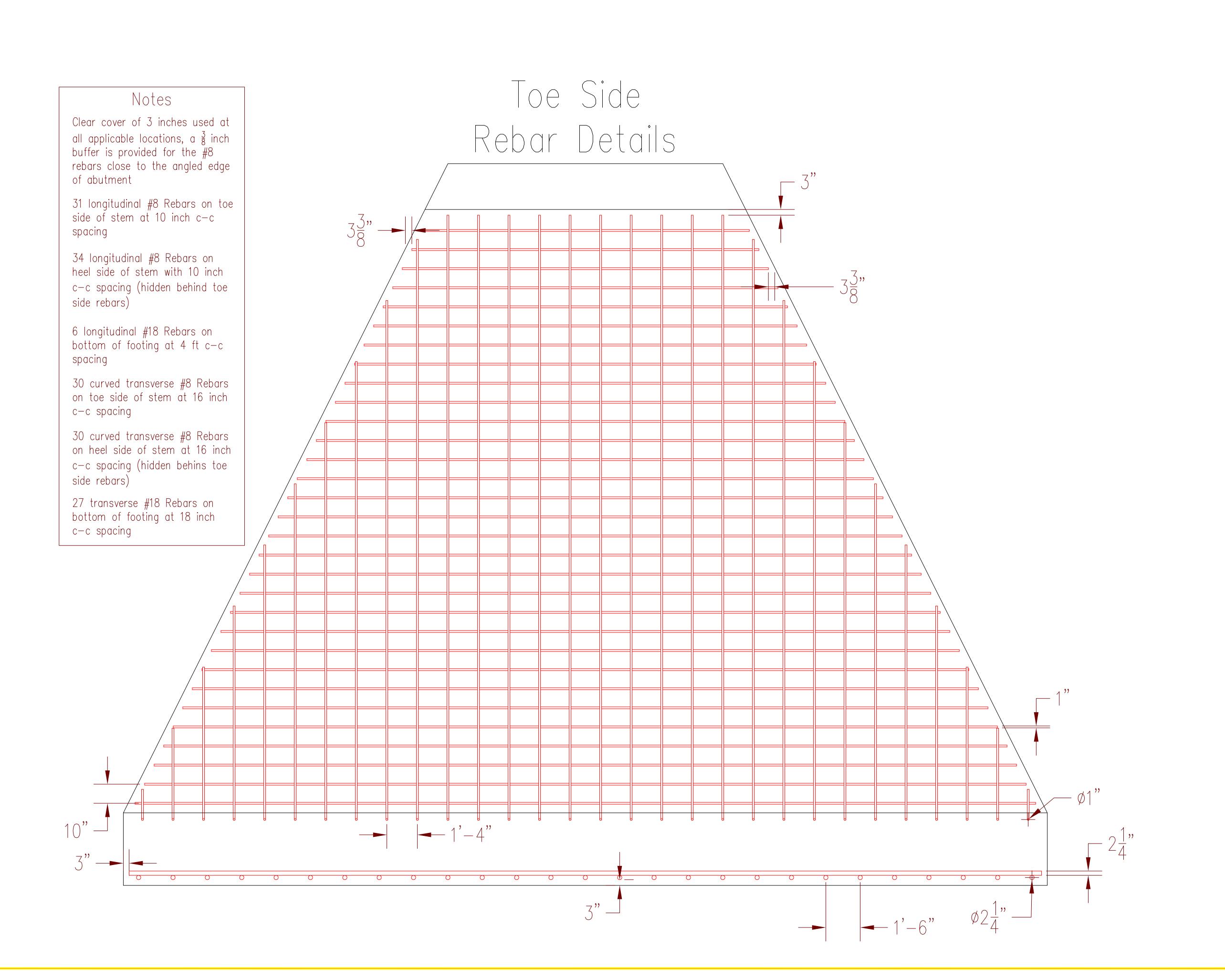


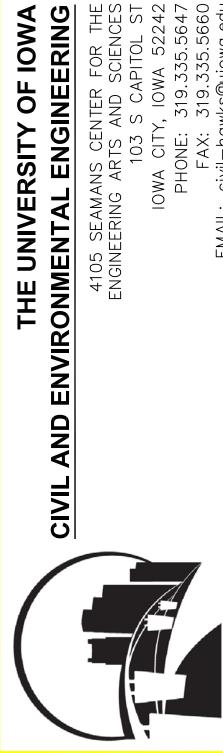
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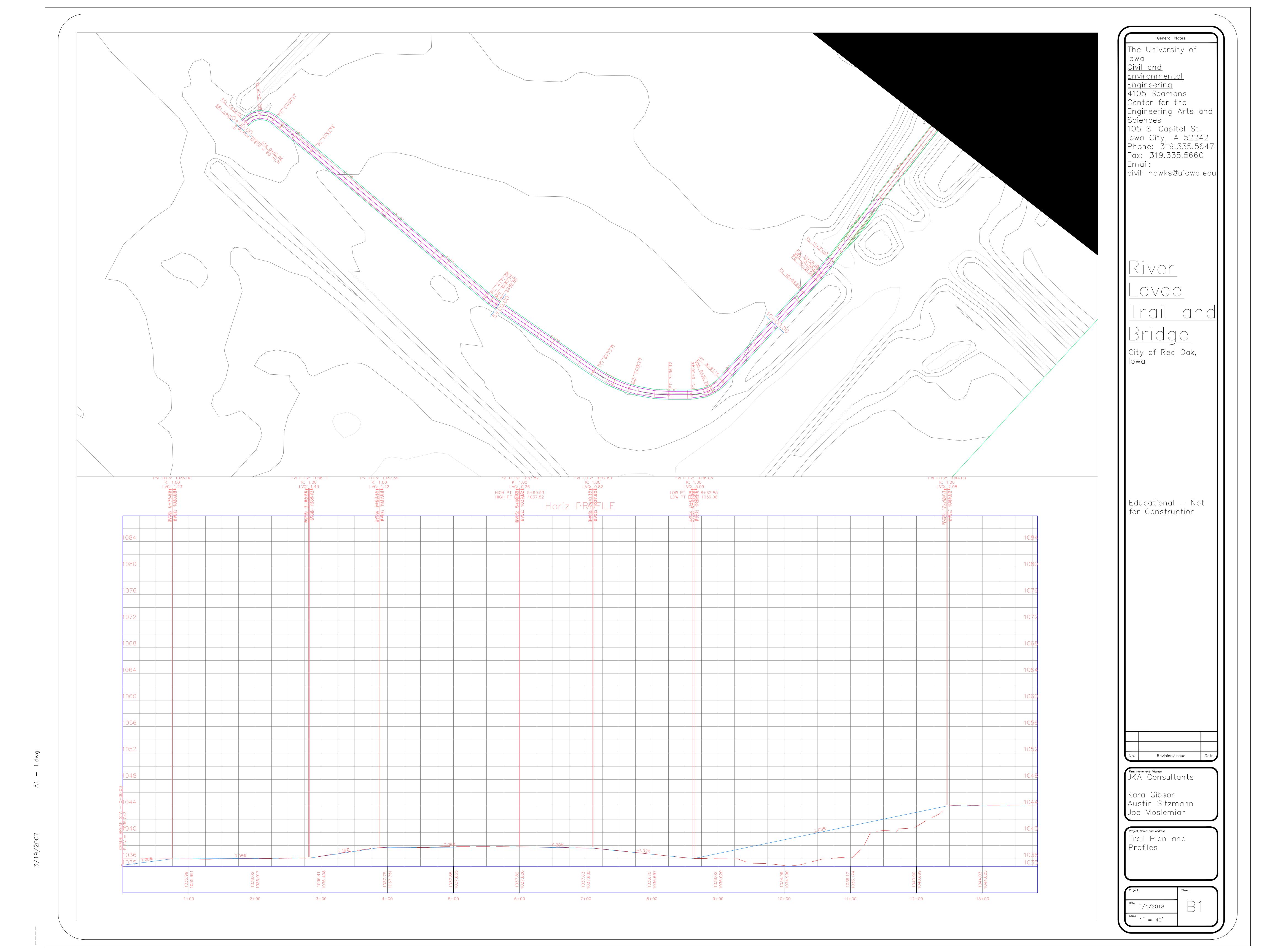


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Toe Side Rebar Details



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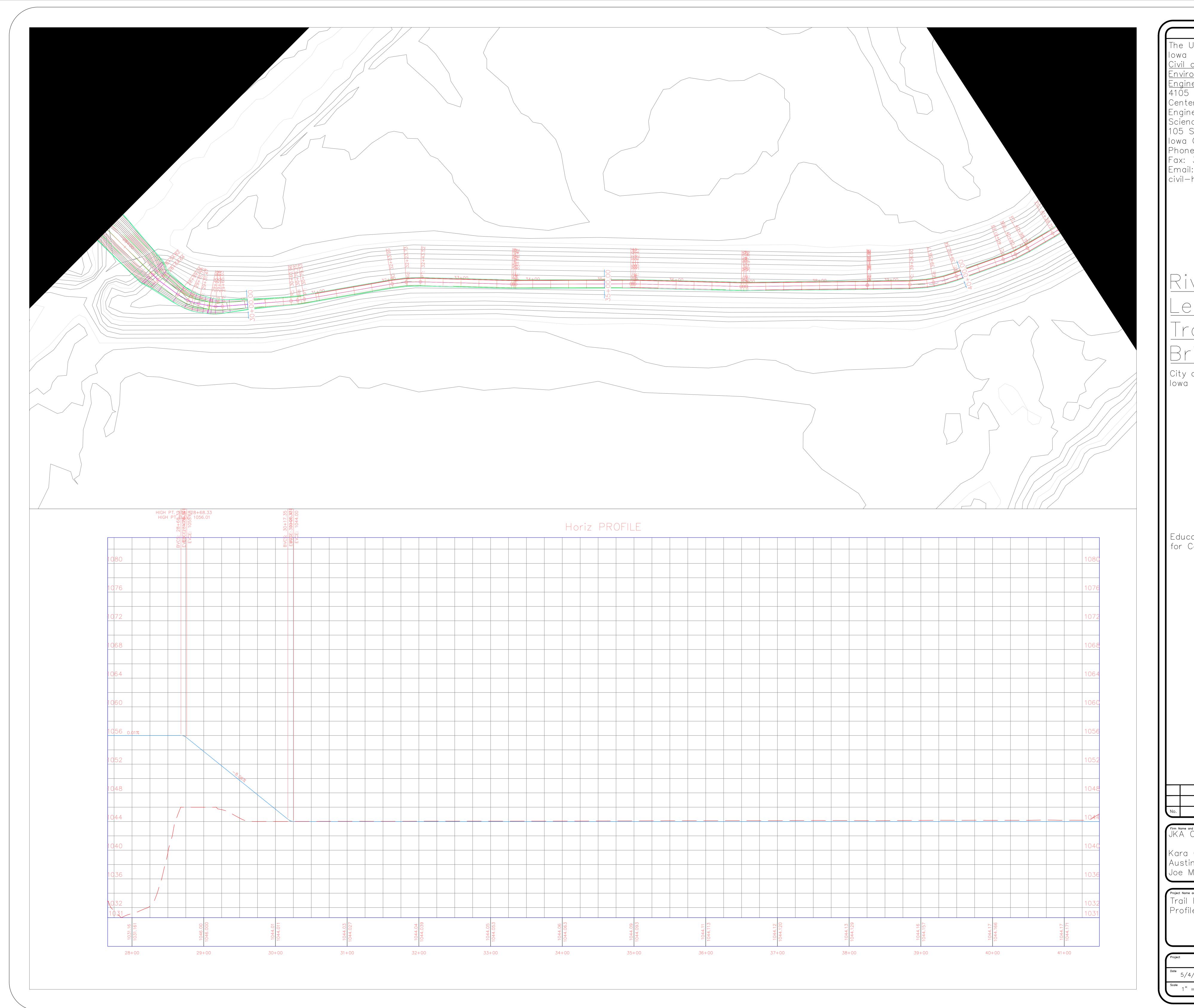
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Kara Gibson Austin Sitzmann Joe Moslemian

Project Name and Address

Trail Plan and Profiles

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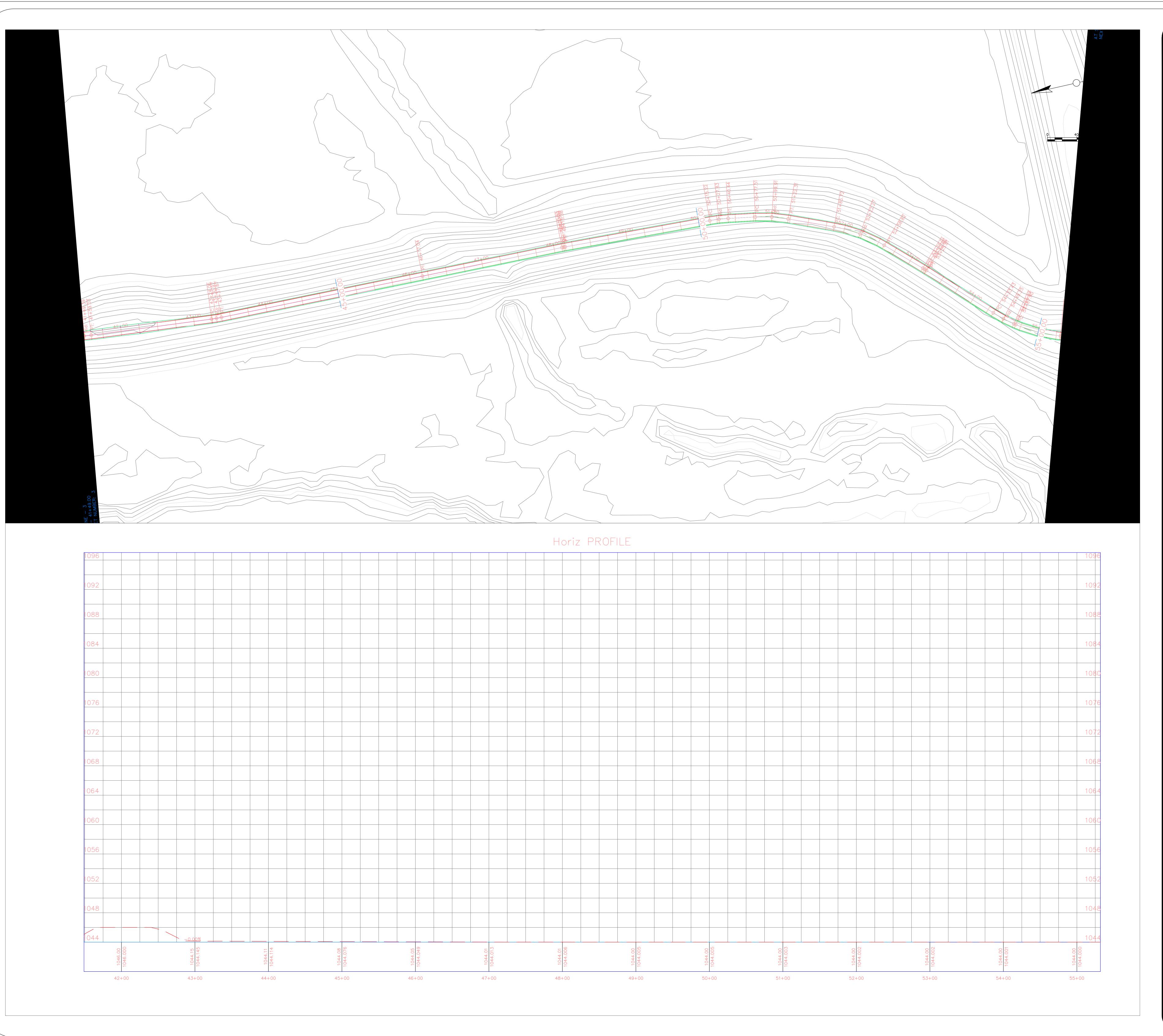
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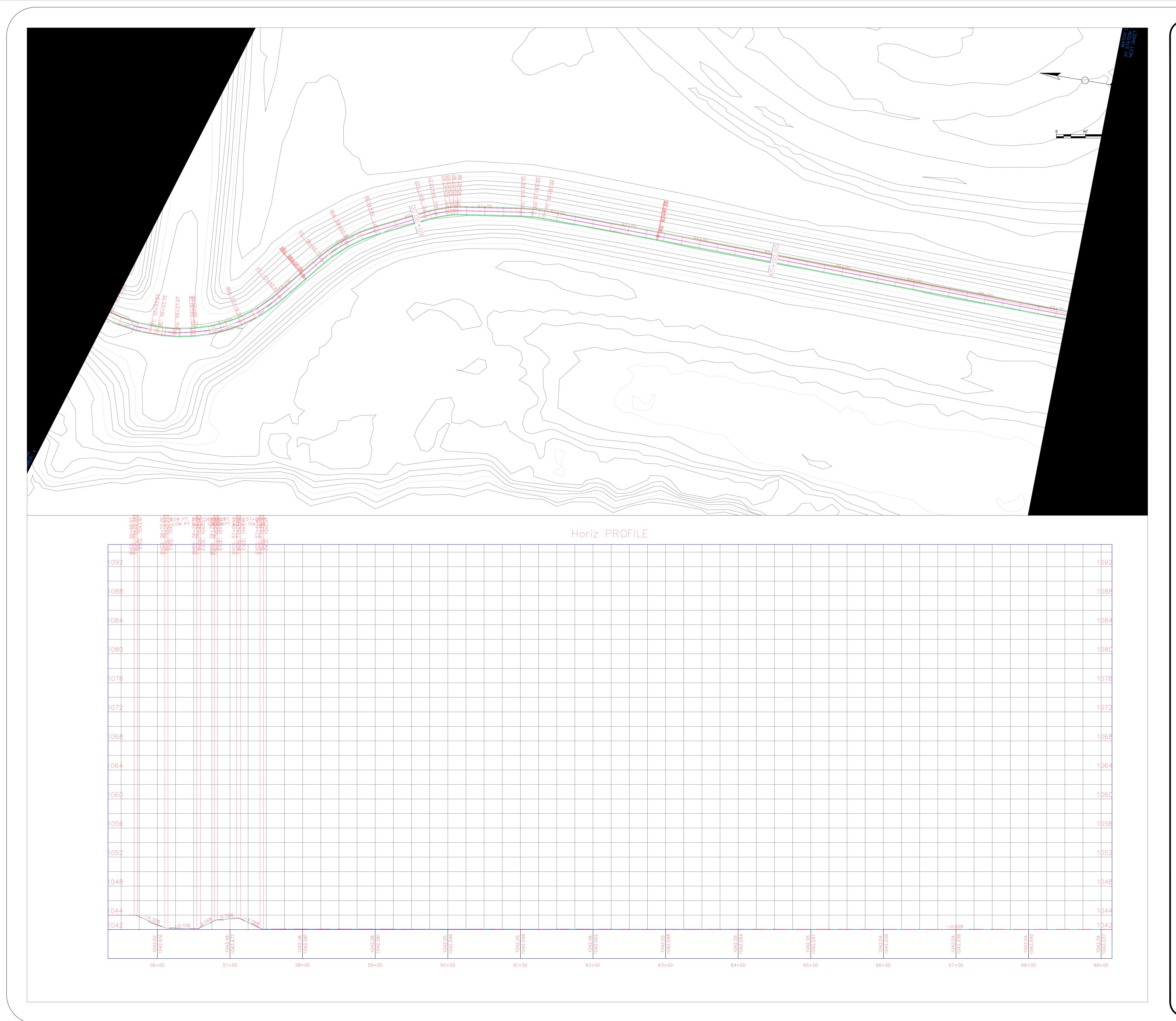
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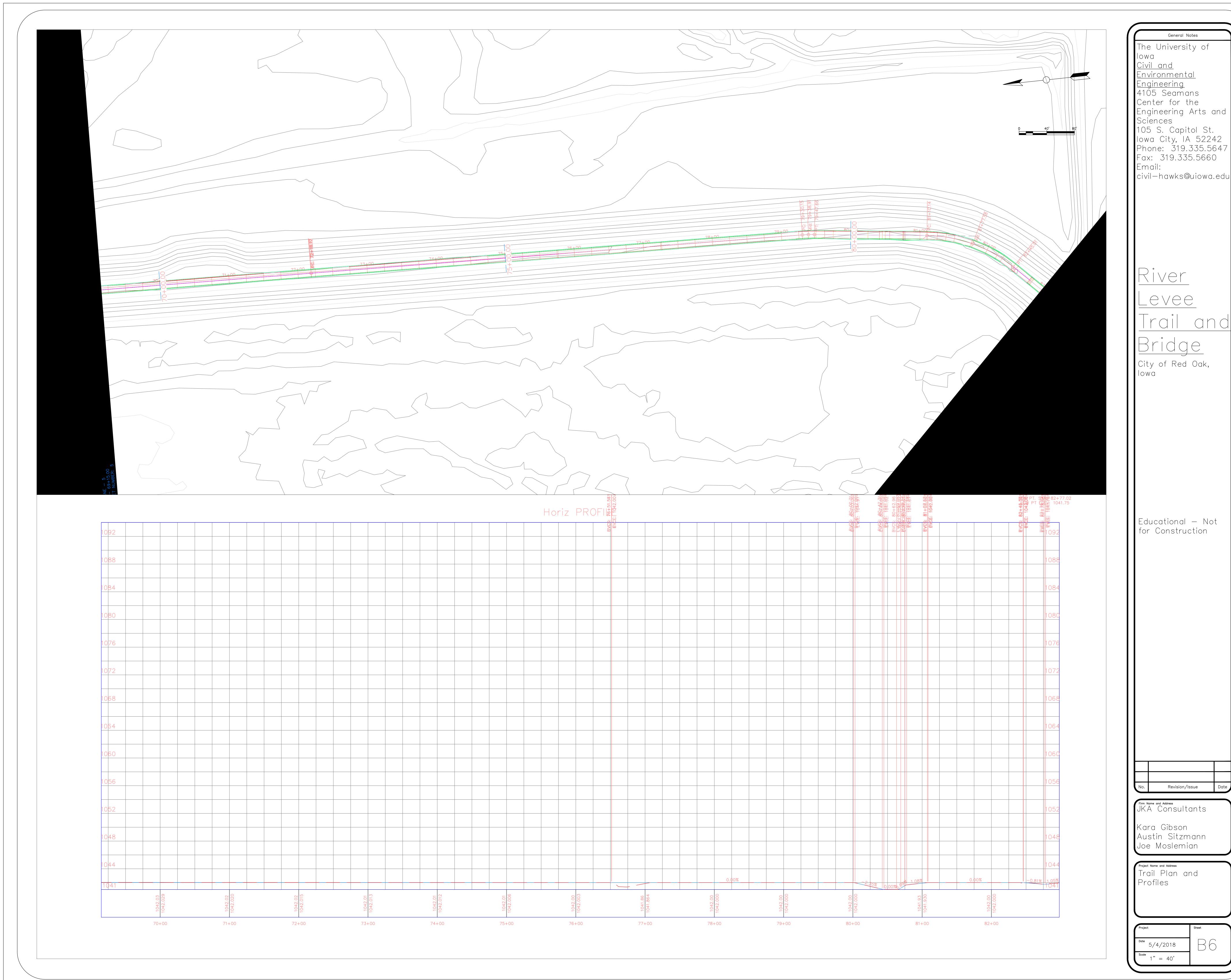
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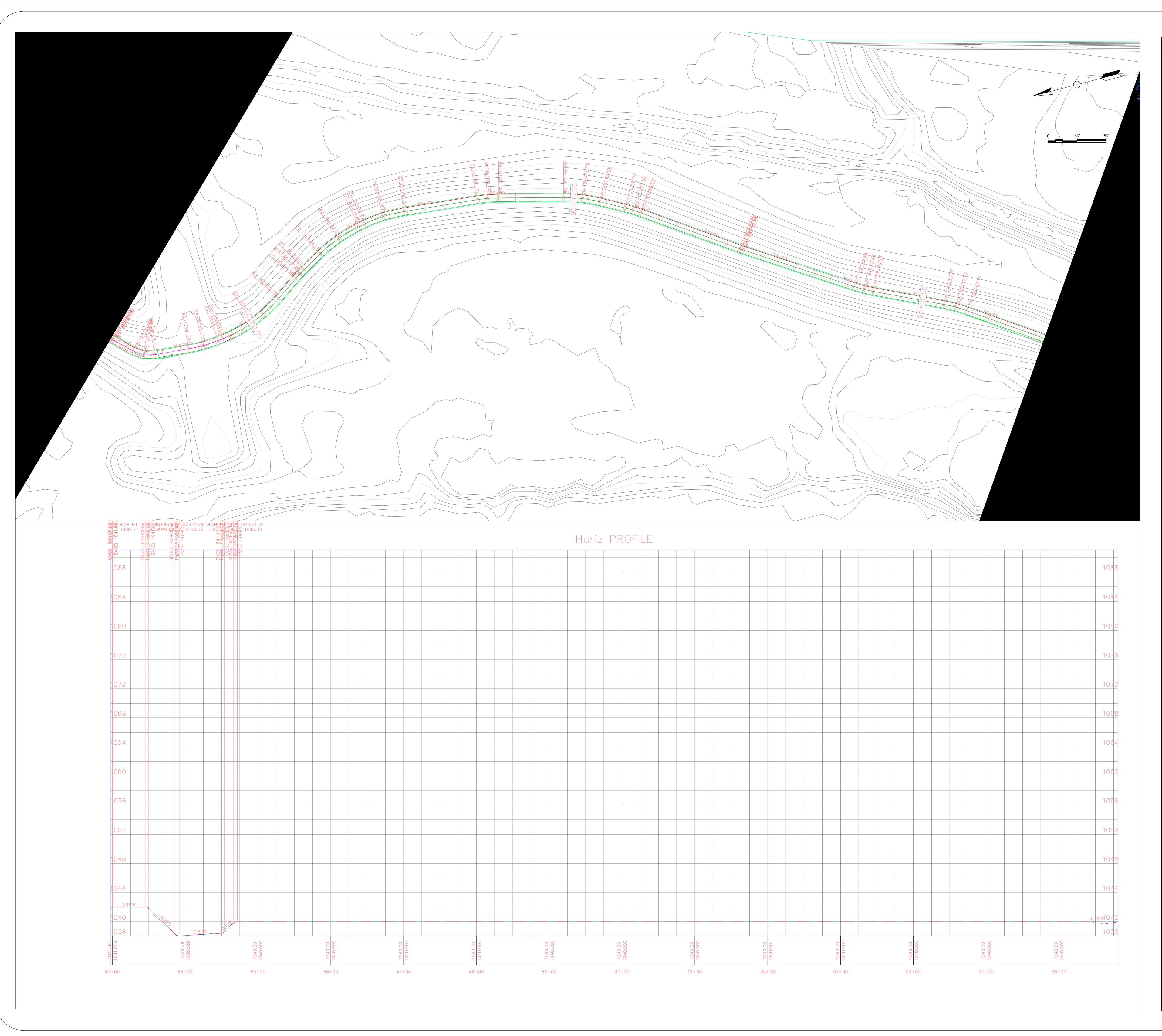
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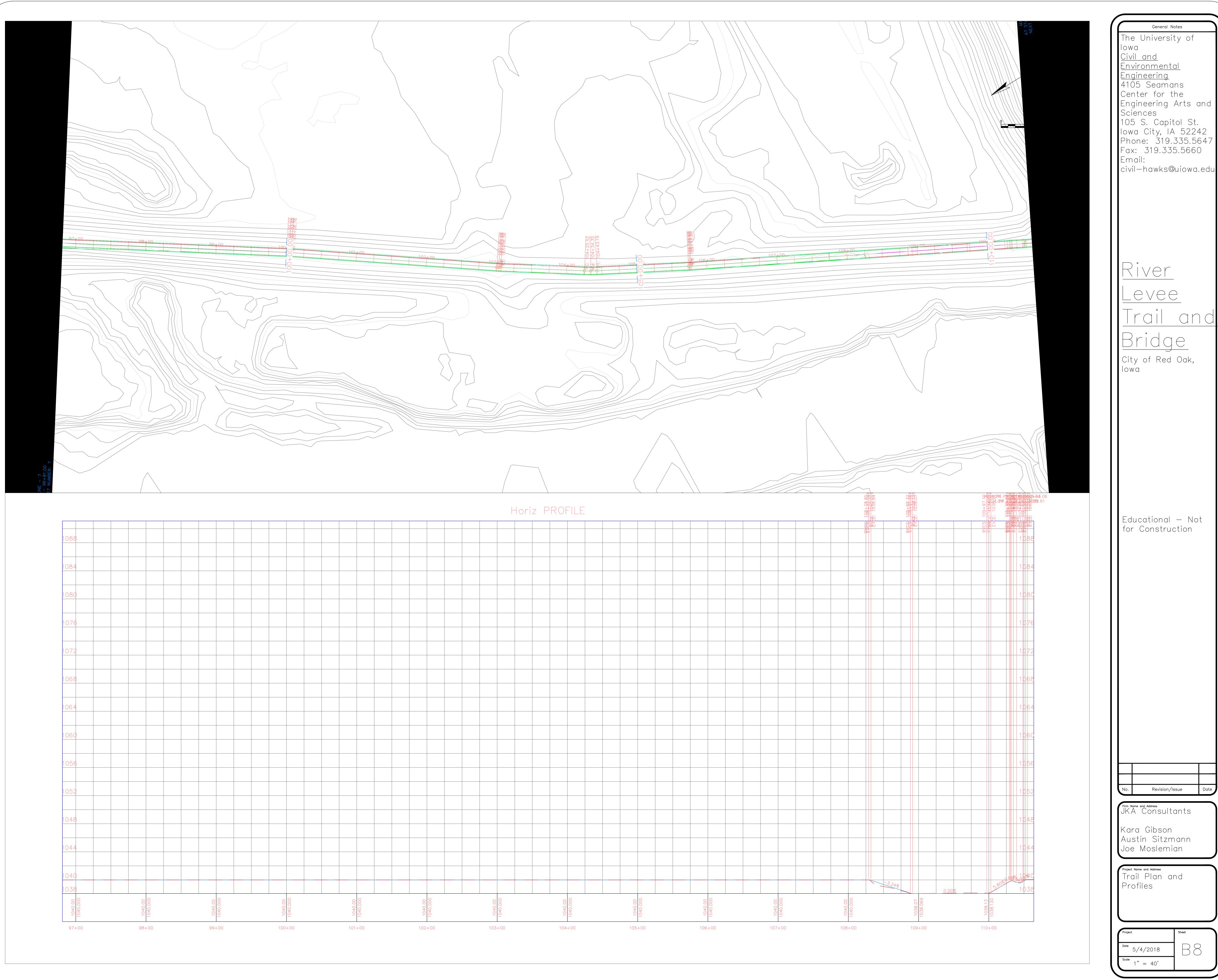
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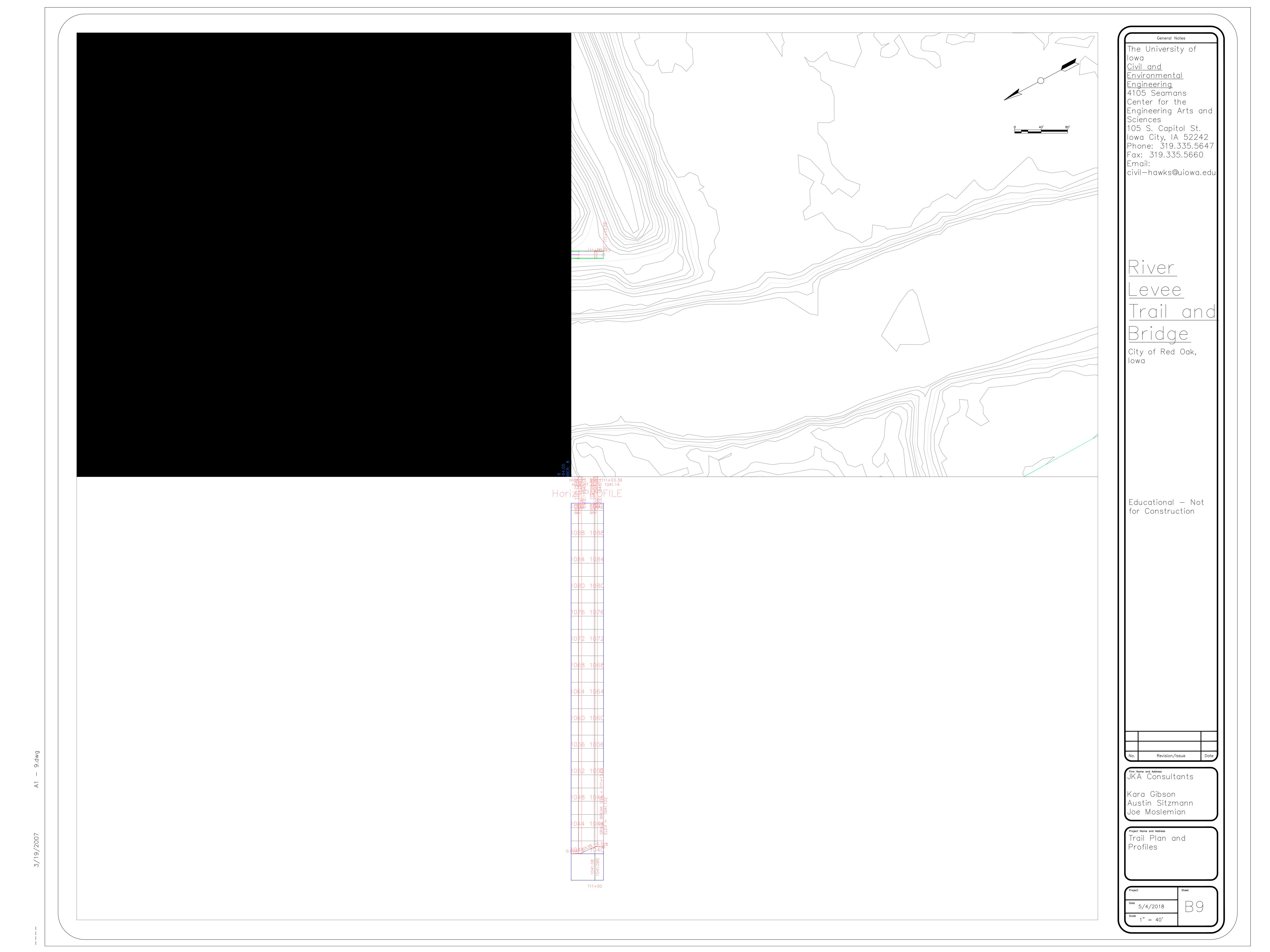
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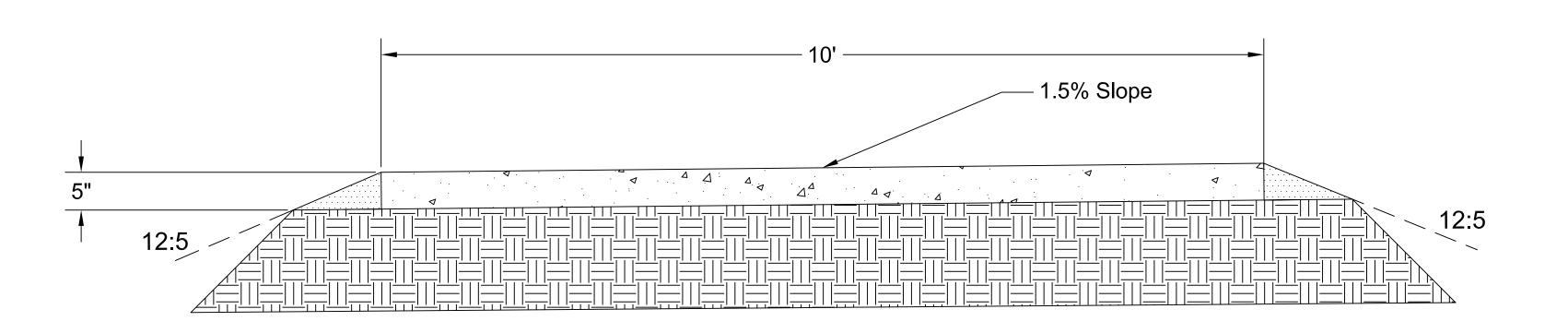
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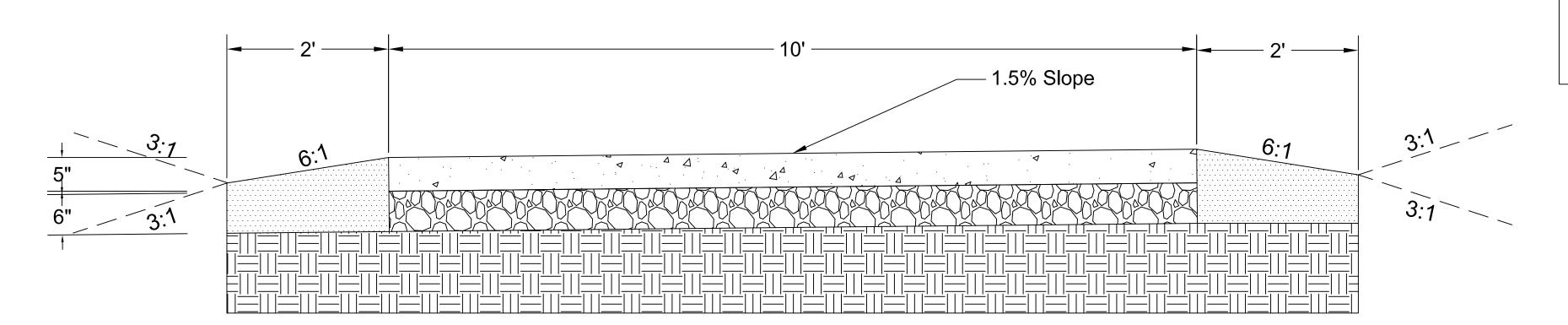
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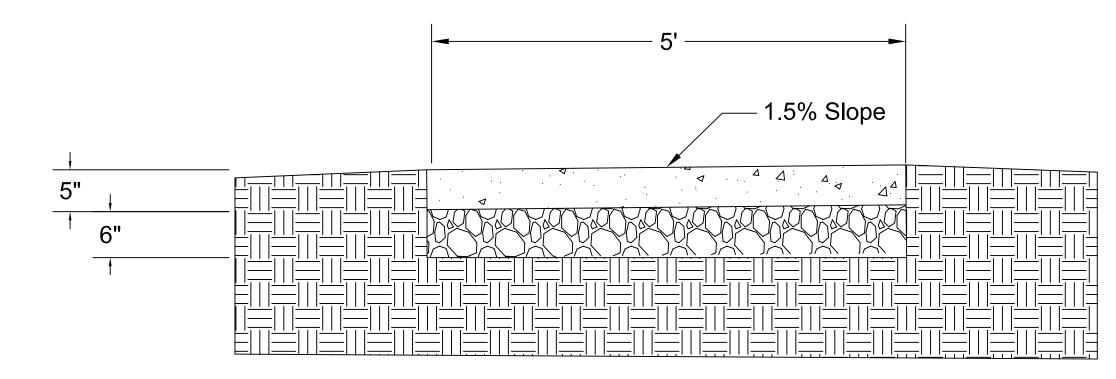




Cross Section 1 - On Levee



Cross Section 2 - Off Levee and Build-up

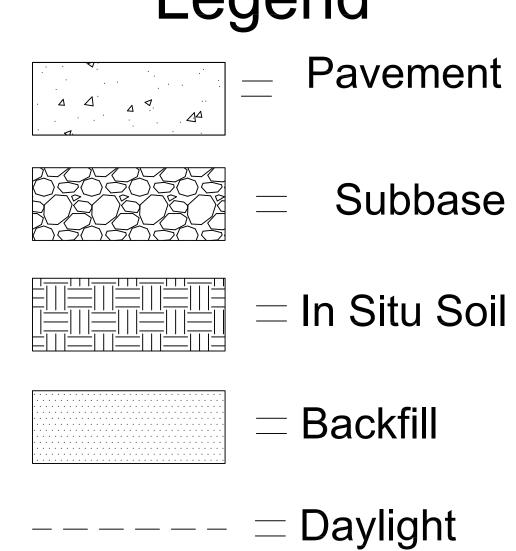


Cross Section 3 - At Alix St Crossing

Cross Section Notes:

- 1. Vertical slope of 1.5% is applied to all cross sections
- 2. Shoulders are added to each side of Cross Section 2. Shoulders are to be 2 feet wide grass shoulders sloped at 6:1 away from the trail.
- Pavement material can be concrete or asphalt
- Cross Section 1 shall not cut into existing levee.

Legend



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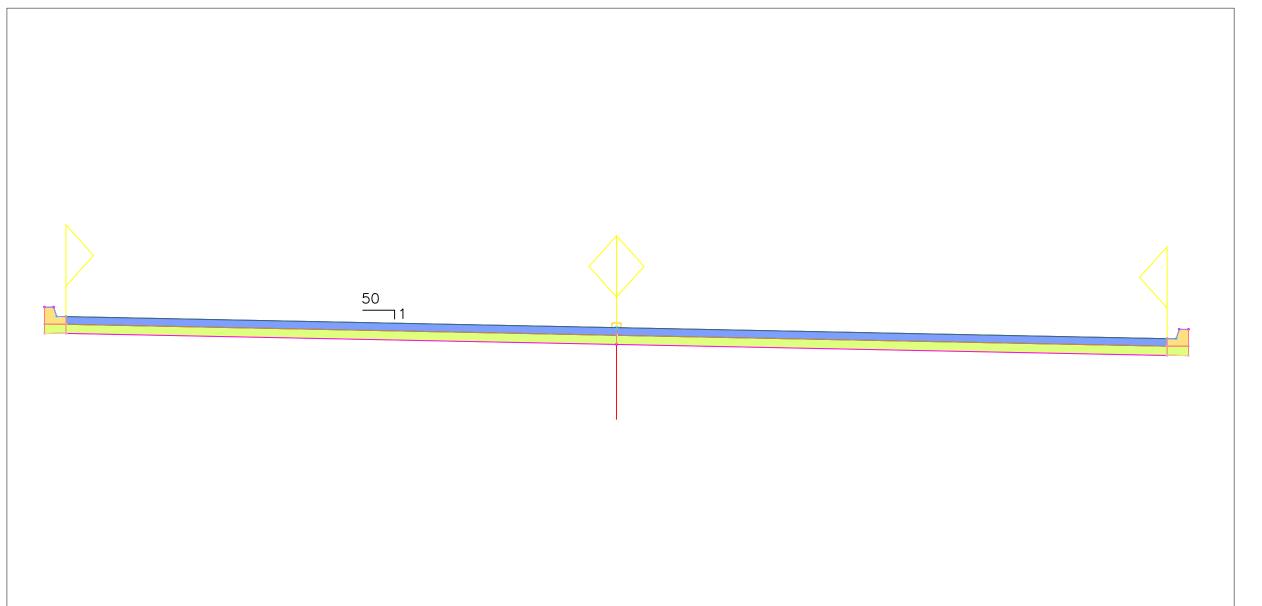


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SHEET NAME

Trail Cross Sections





Section A

Parking Lot Notes:

- Lot boundary to be graded at 4:1 to existing surface
 Drainage inlet to be located at Point B. Designed to service a 100 yr design storm volume of 674 ft³.
 Typical stall dimensions are 9' wide and 18' long and Accessible stalls
- are 11' wide and 18' long. Lot drive aisle and driveway are 24' wide to service both cars entering and exiting. These dimensions are within specifications of Section 8B-1 of Iowa SUDAS Design Manual.

 4. Design contains 14 standard stalls and one ADA Accessible stall located nearest to the existing trail.
- 5. Pavement design is comprised of 5" of pavement surface with the option to use concrete or asphalt and 6" of sub-base.



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Plan and Profile

Signage Notes

A: W11-2 (36"x36") sign w/ W16-9P located 125'
North and South of signs B near the crossing

B: W11-2 (36"x36") sign w/ W16-7P offset 2' from edge of trail and 2' from edge of HWY 48 (to edge of sign)

C: R1-1 (18"x18") offset 2' from edge of trail (to edge of sign) and 3' from edge of HWY 48 (to edge of sign)

D: R1-1 (36"x36") located 25' from edge of HWY 48 and centered in grass as shown

E: W3-1 (18"x18") offset 2' from the edge of trail (to edge of sign) located 100' from sign C along the path of the trail

The bottom of every sign must be elevated 6' from the trail pavement surface

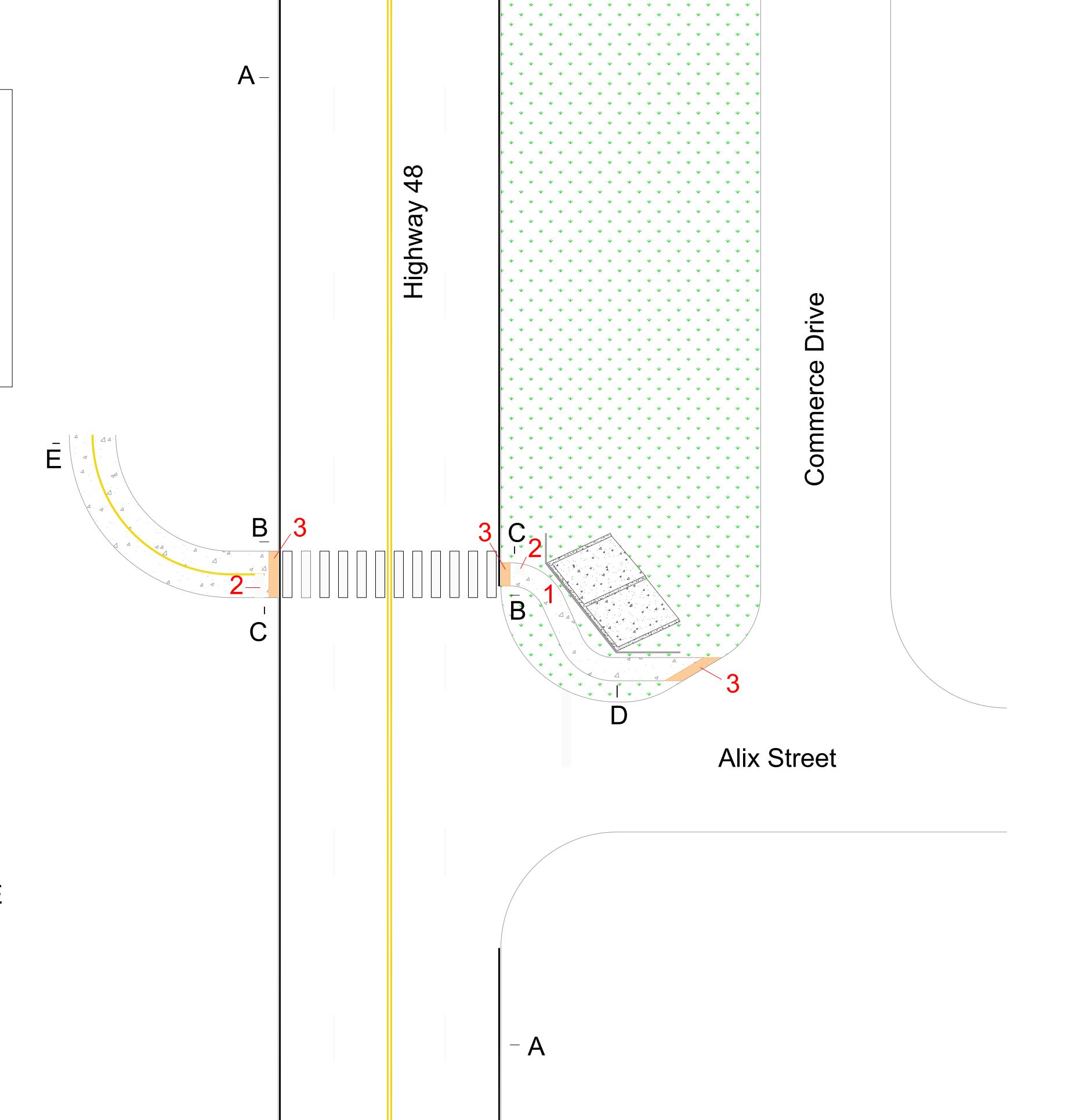
Pavement Marking Notes

1: Edge of sidewalk to rail has to be no less than 1'

2: 2' wide stop lines covering right half of trail; street edge of stop line located 3' from edge of HWY 48

3: All 3 detectable warnings shall be 2' wide and cover the entire width of the trail:

4: Crosswalk lines are 2'x10' spaced at 2'



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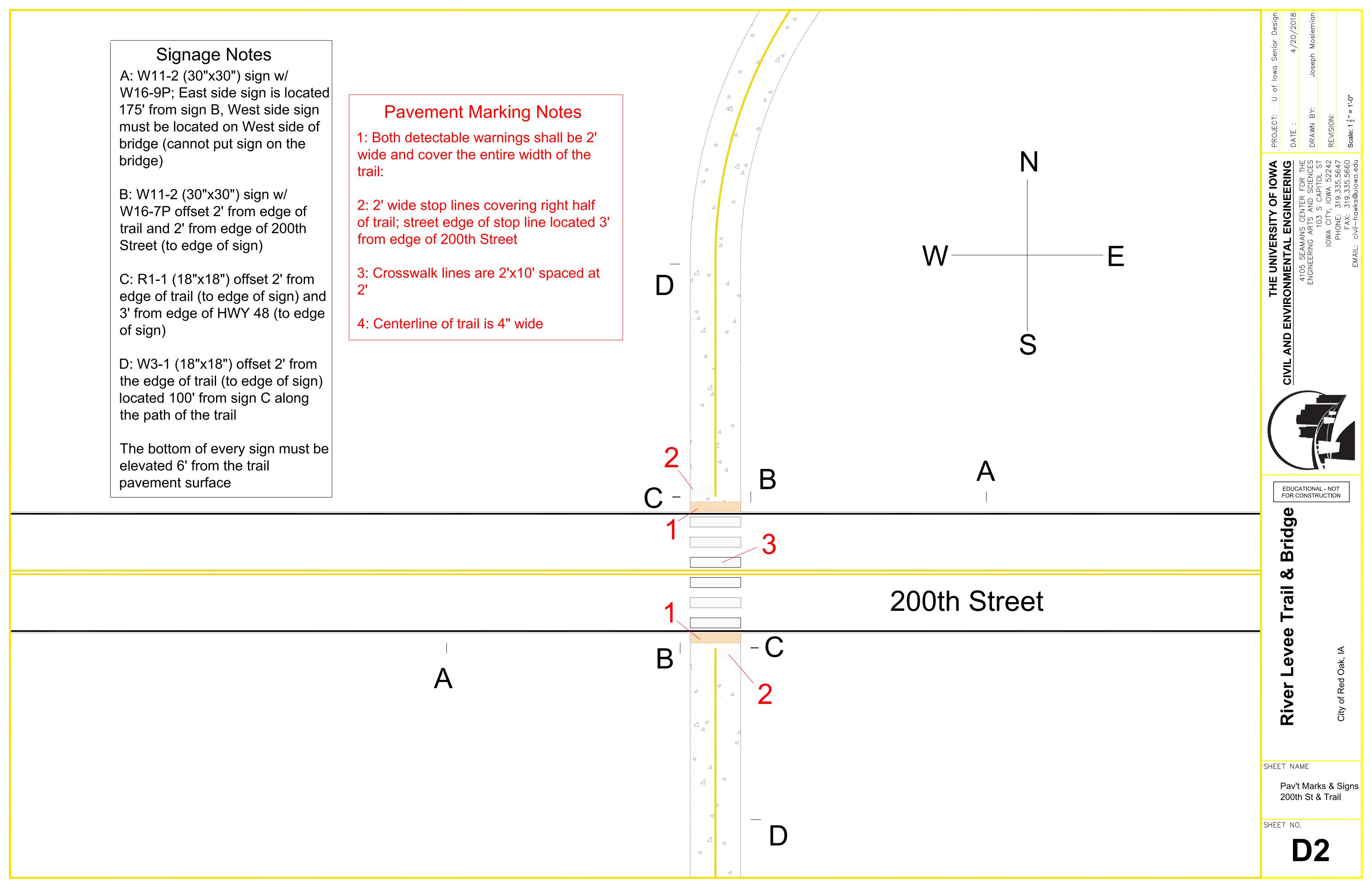
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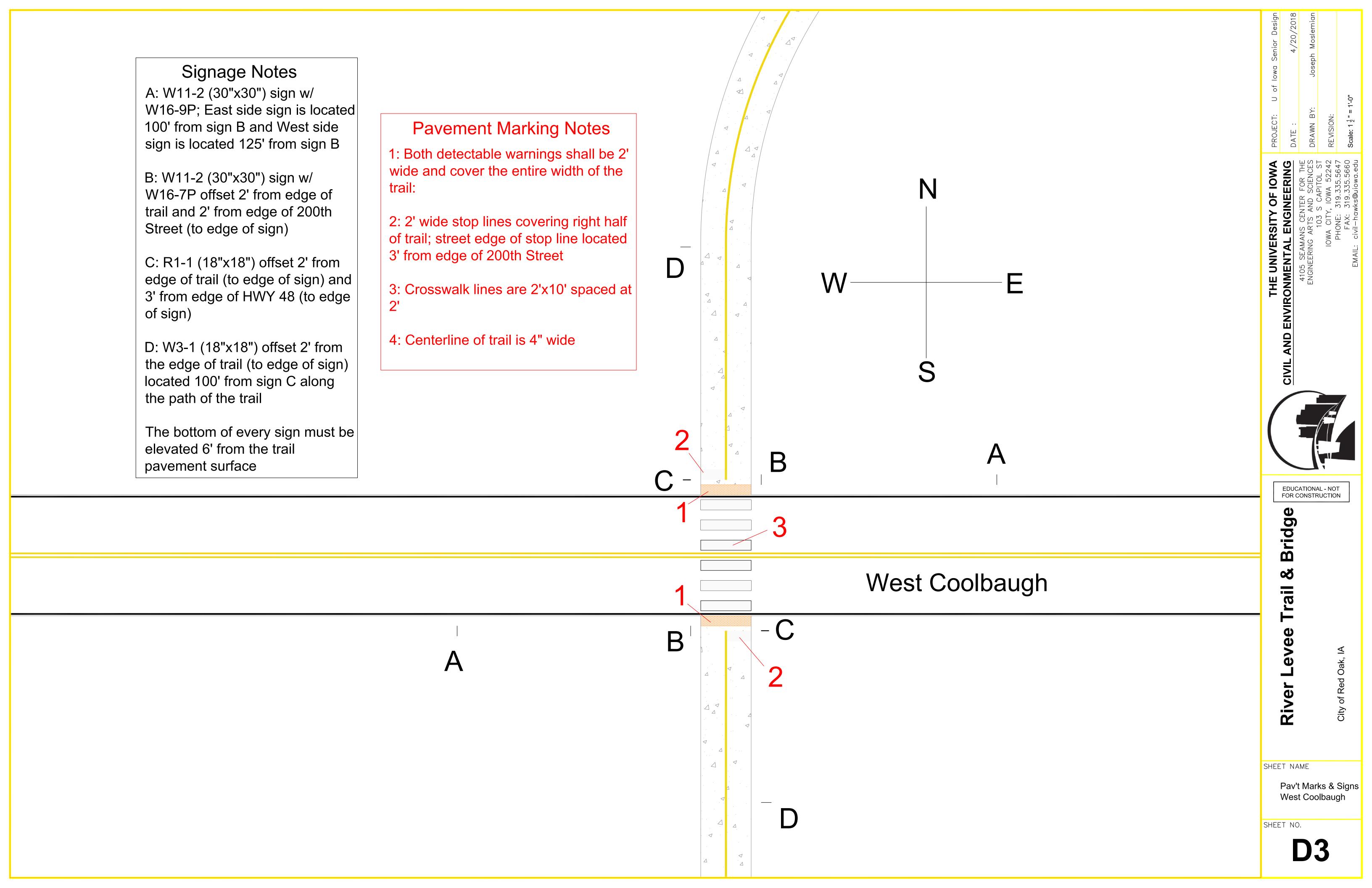
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River Levee Trail and Bridge

City of Red Oak, IA 51591



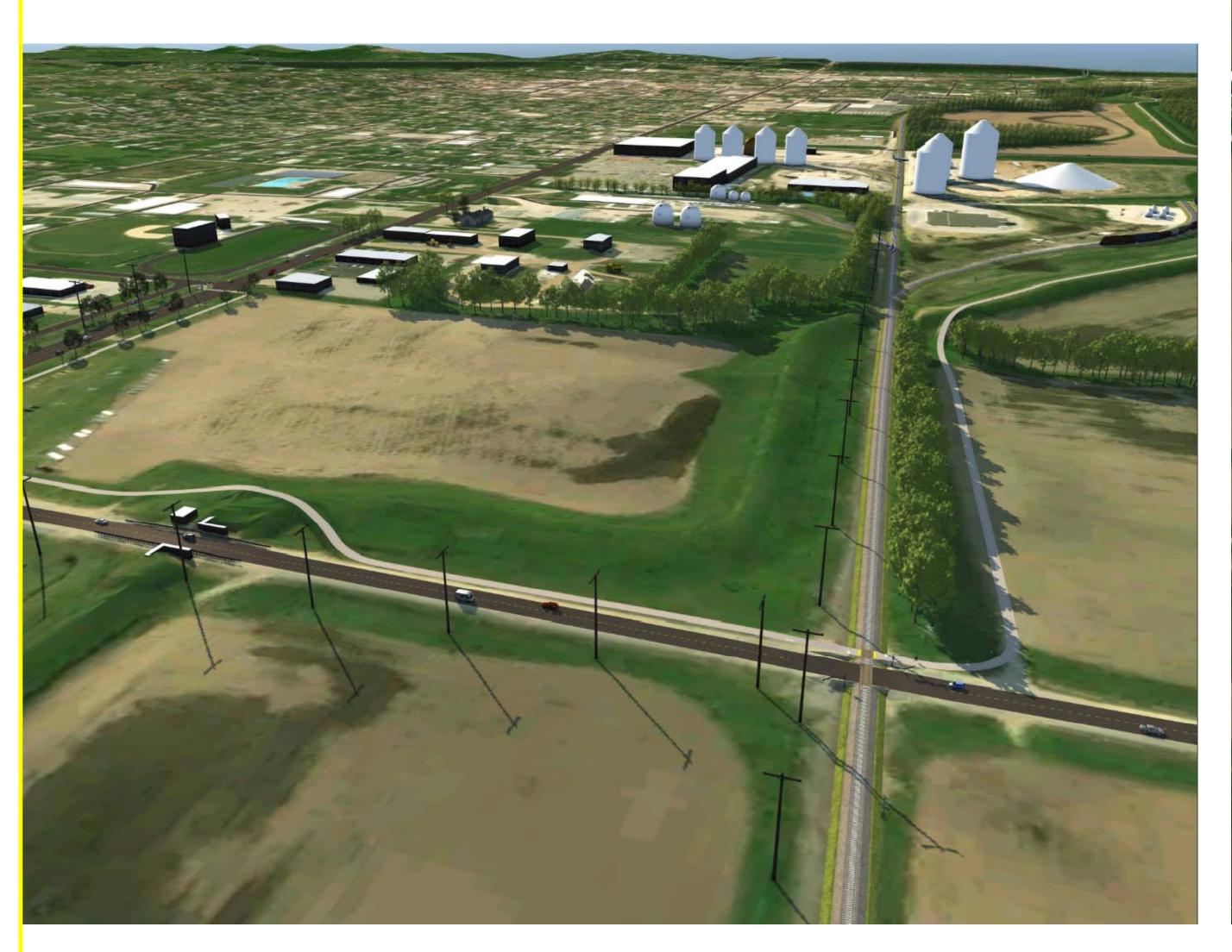


Project Team: Austin Sitzmann

Kara Gibson

Joe Moslemian

Alternative 2





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Cover Sheet

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G2	Index		
B1	Trail Plan and Profile		
B2	Trail Plan and Profile		
B3	Trail Plan and Profile		
B4	Trail Plan and Profile		
B5	Trail Plan and Profile		
B6	Trail Plan and Profile		
B7	Trail Plan and Profile		
B8	Trail Plan and Profile		
B9	Trail Plan and Profile		
B10	Trail Plan and Profile		
B11	Trail Plan and Profile		
B12	Trail Plan and Profile		
B13	Trail Plan and Profile		
B14	Cross Section Details		
C1	Parking Lot Plan and Profile		
D1	Pavement Markings and Sign Details		
D2	Pavement Markings and Sign Details		
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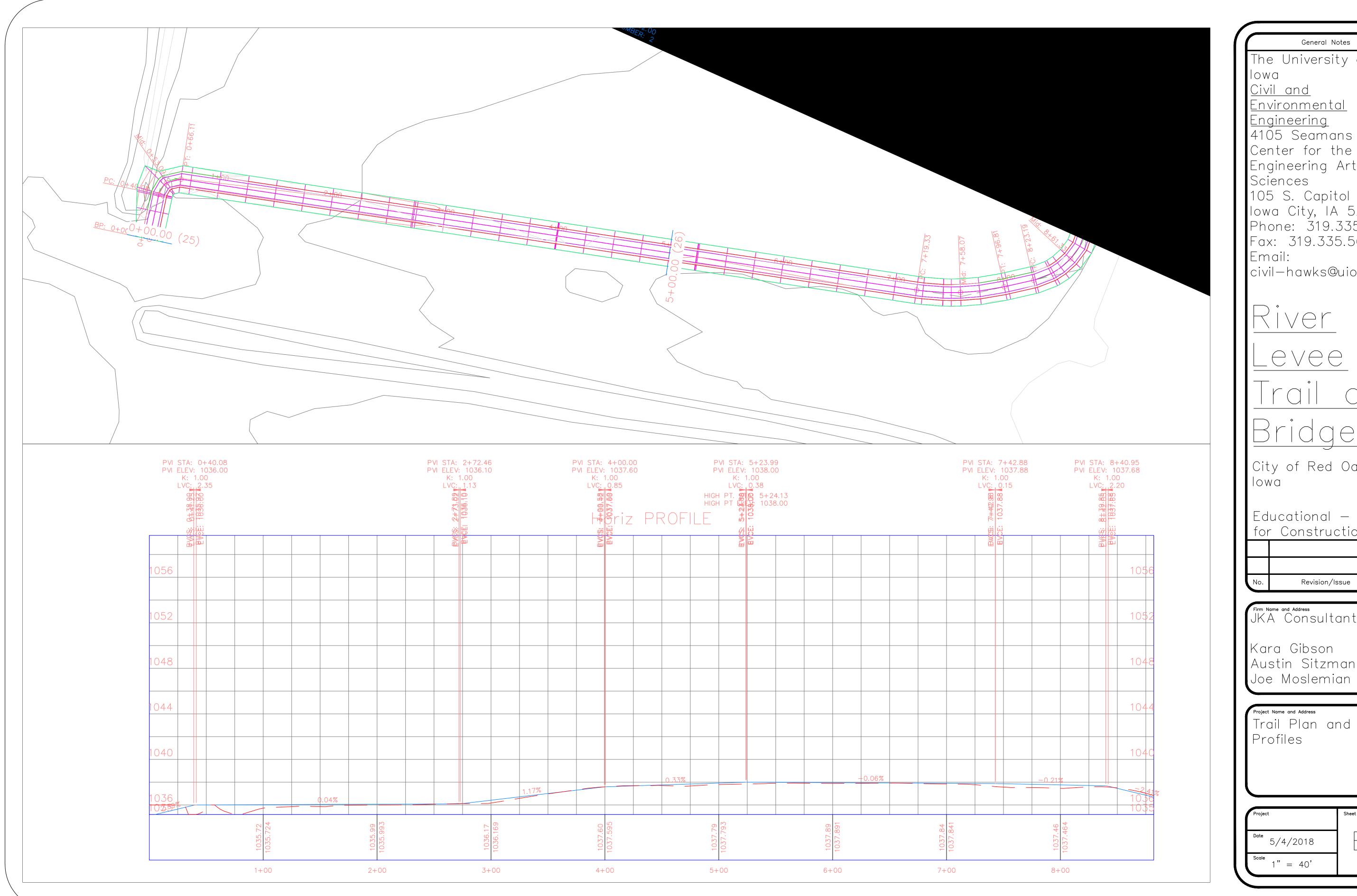
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SHEET NAME

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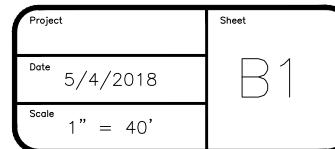
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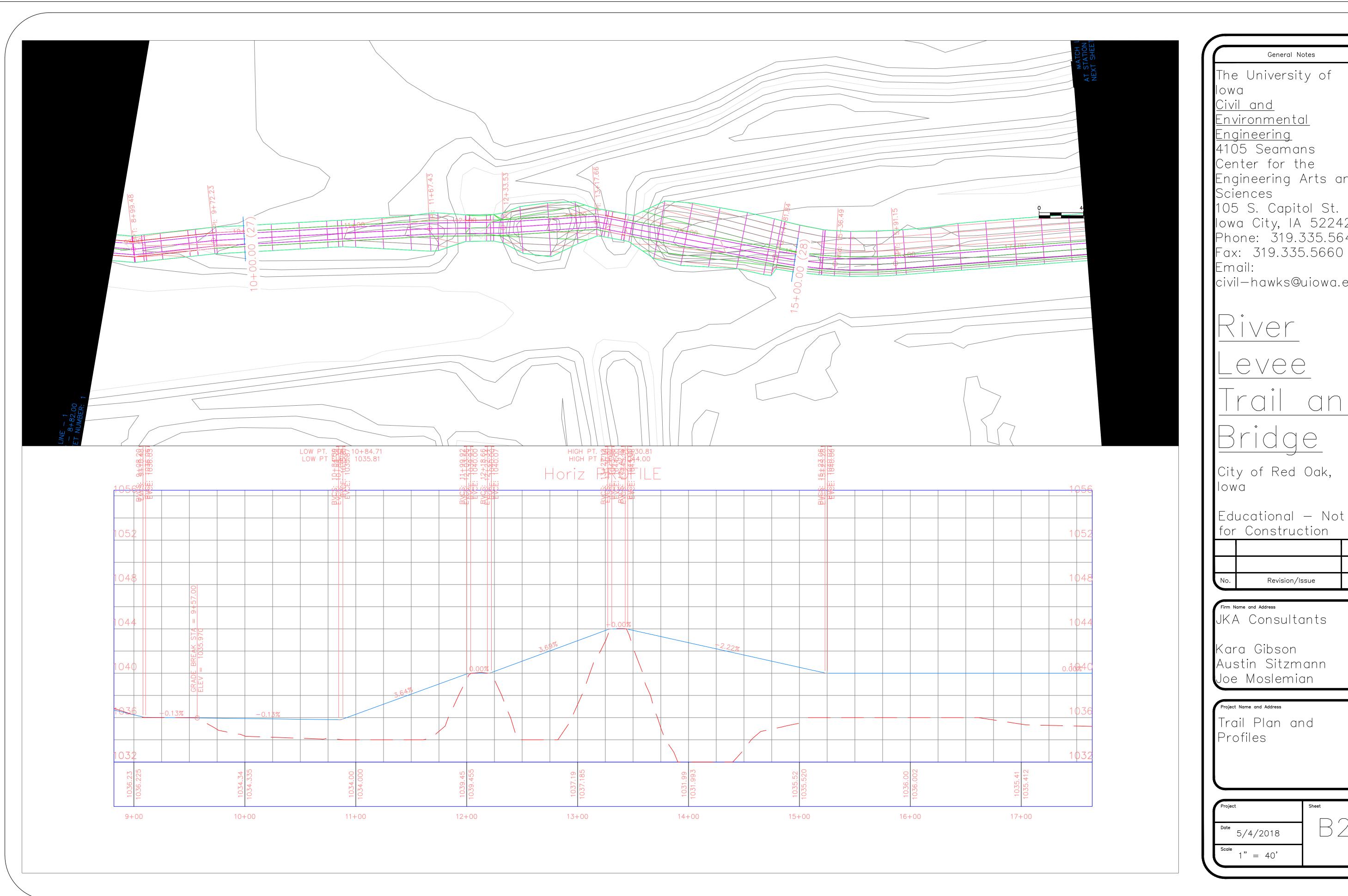
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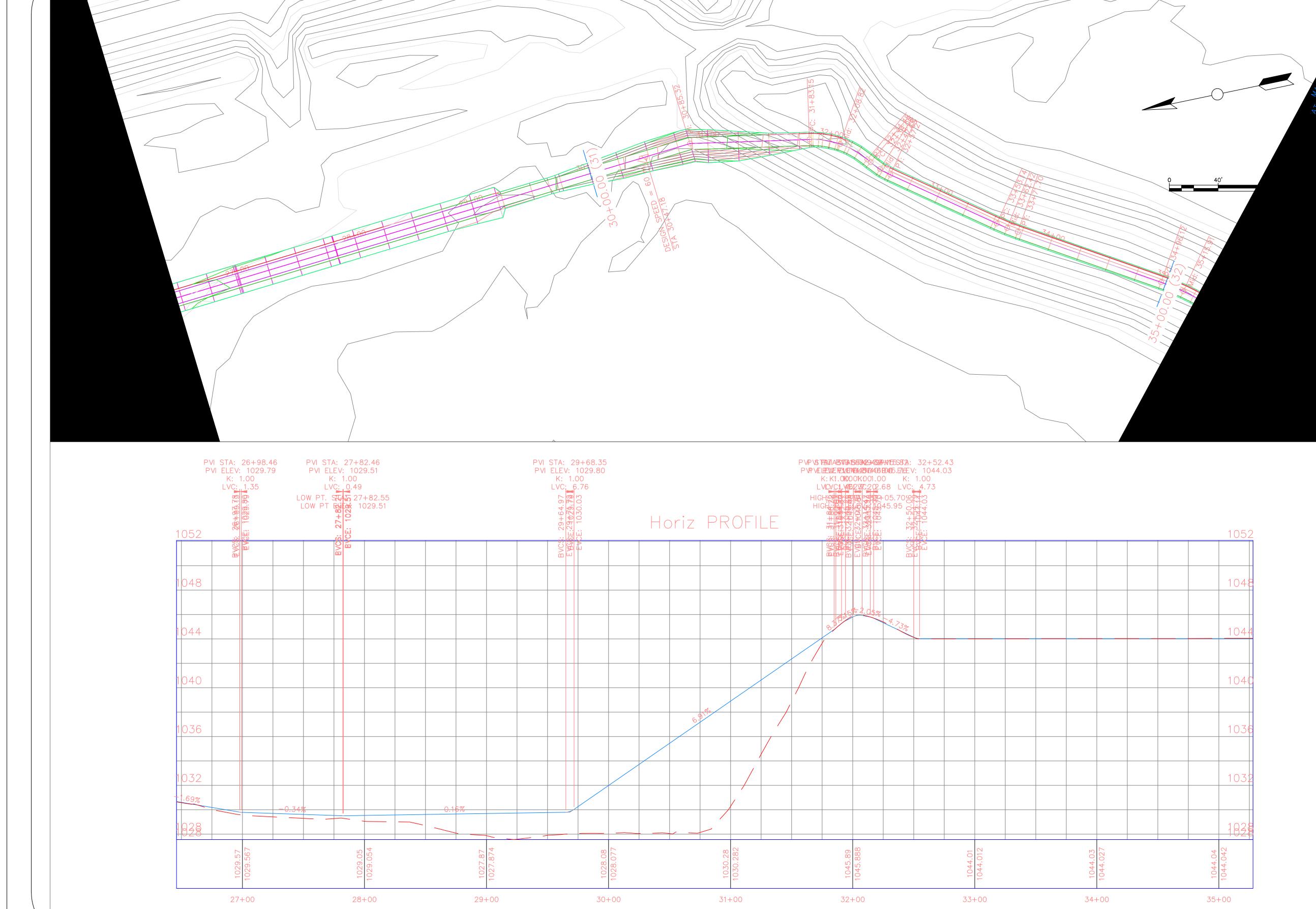
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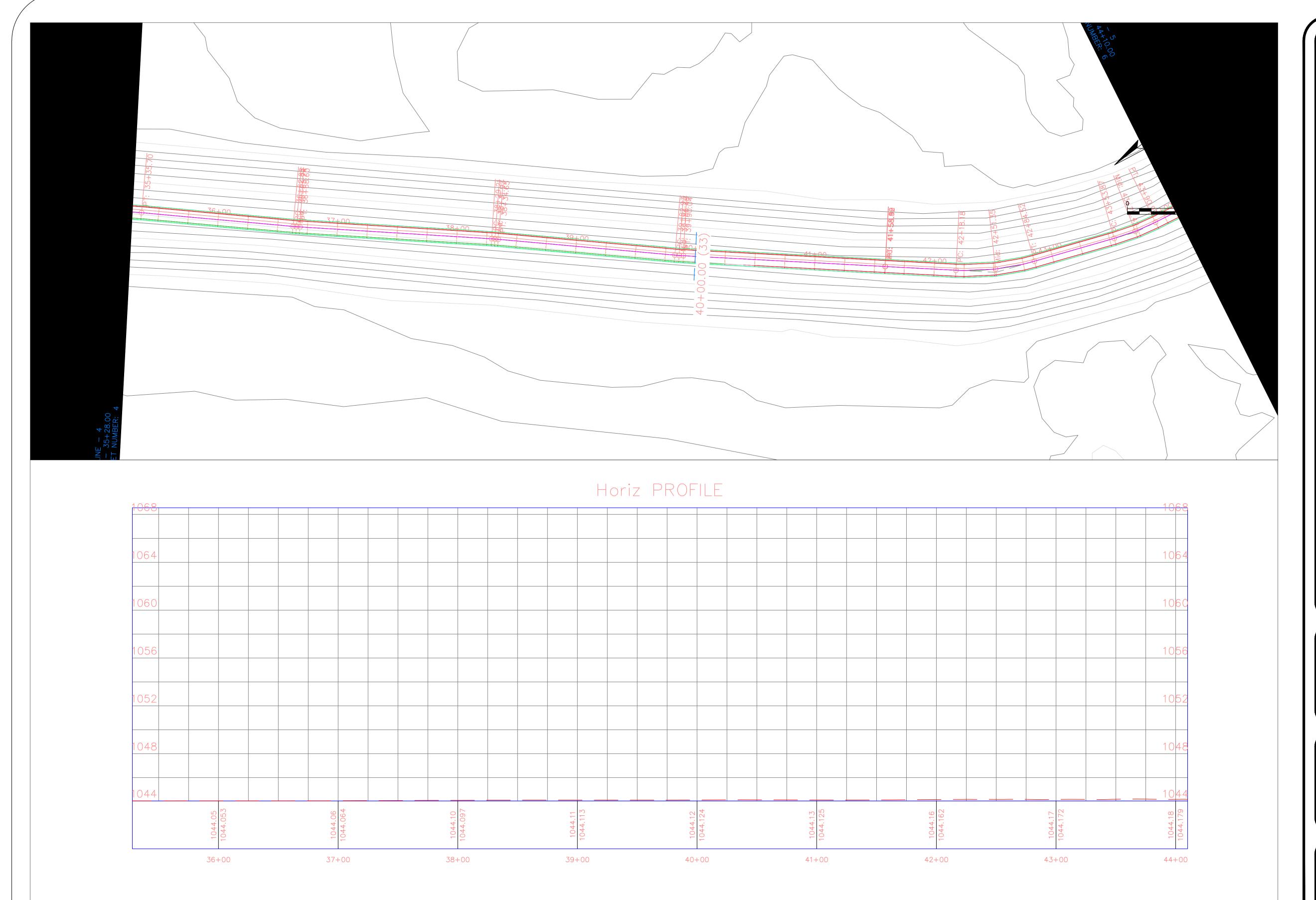
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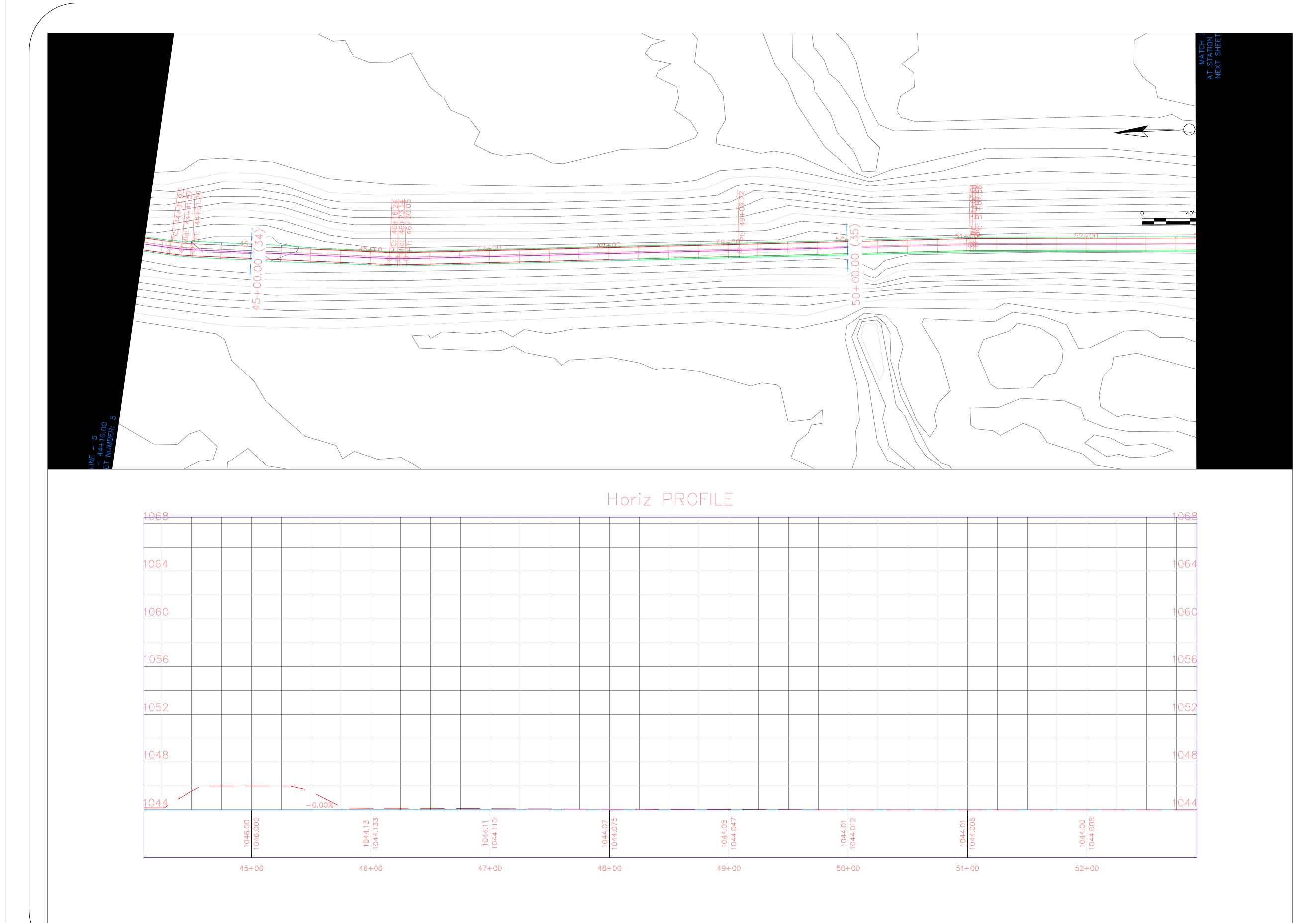
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River Levee Trail and Bridge

City of Red Oak, Iowa

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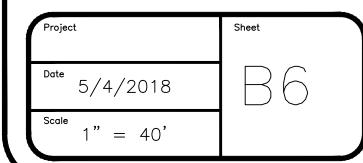
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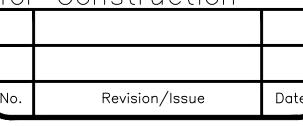
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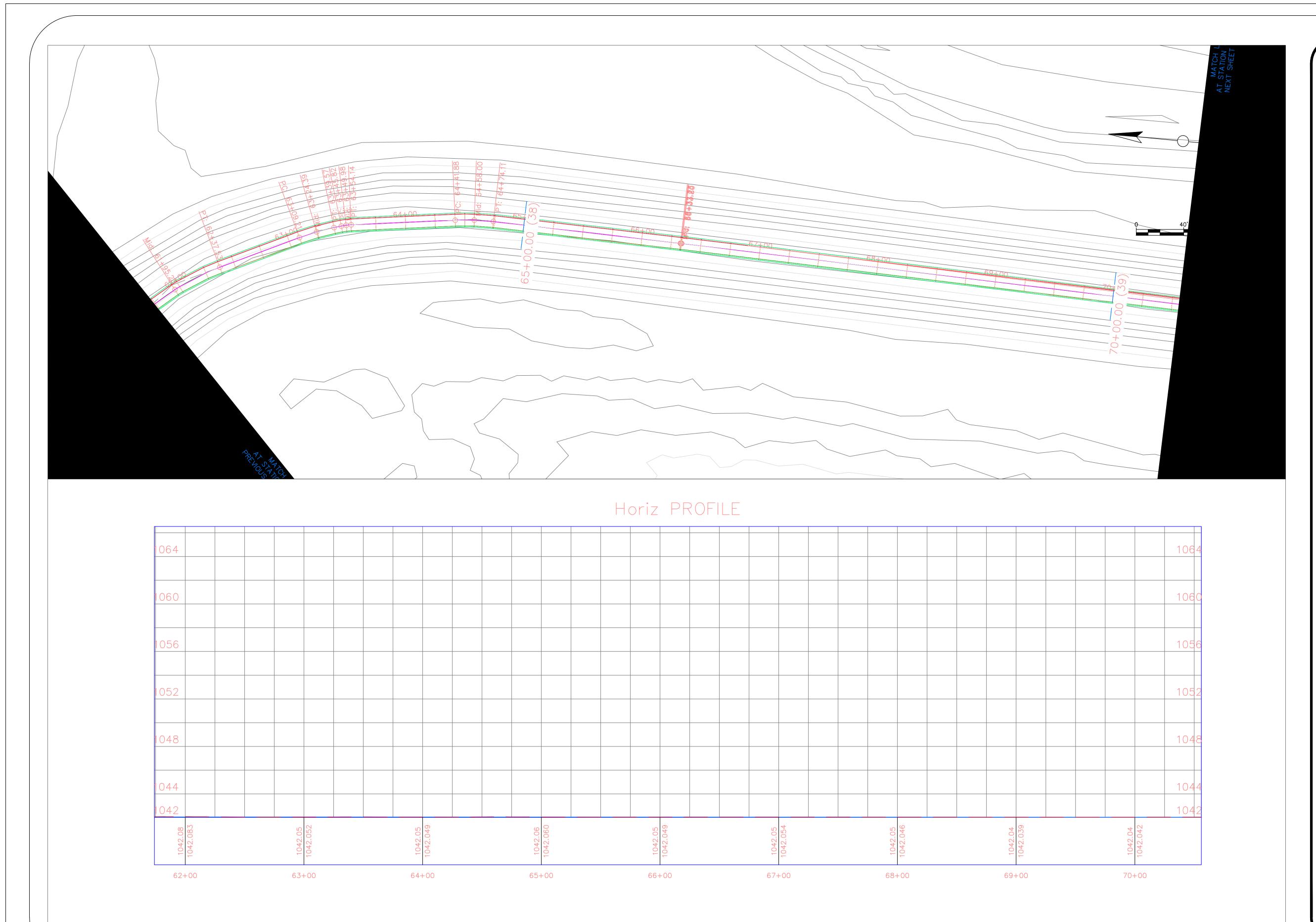
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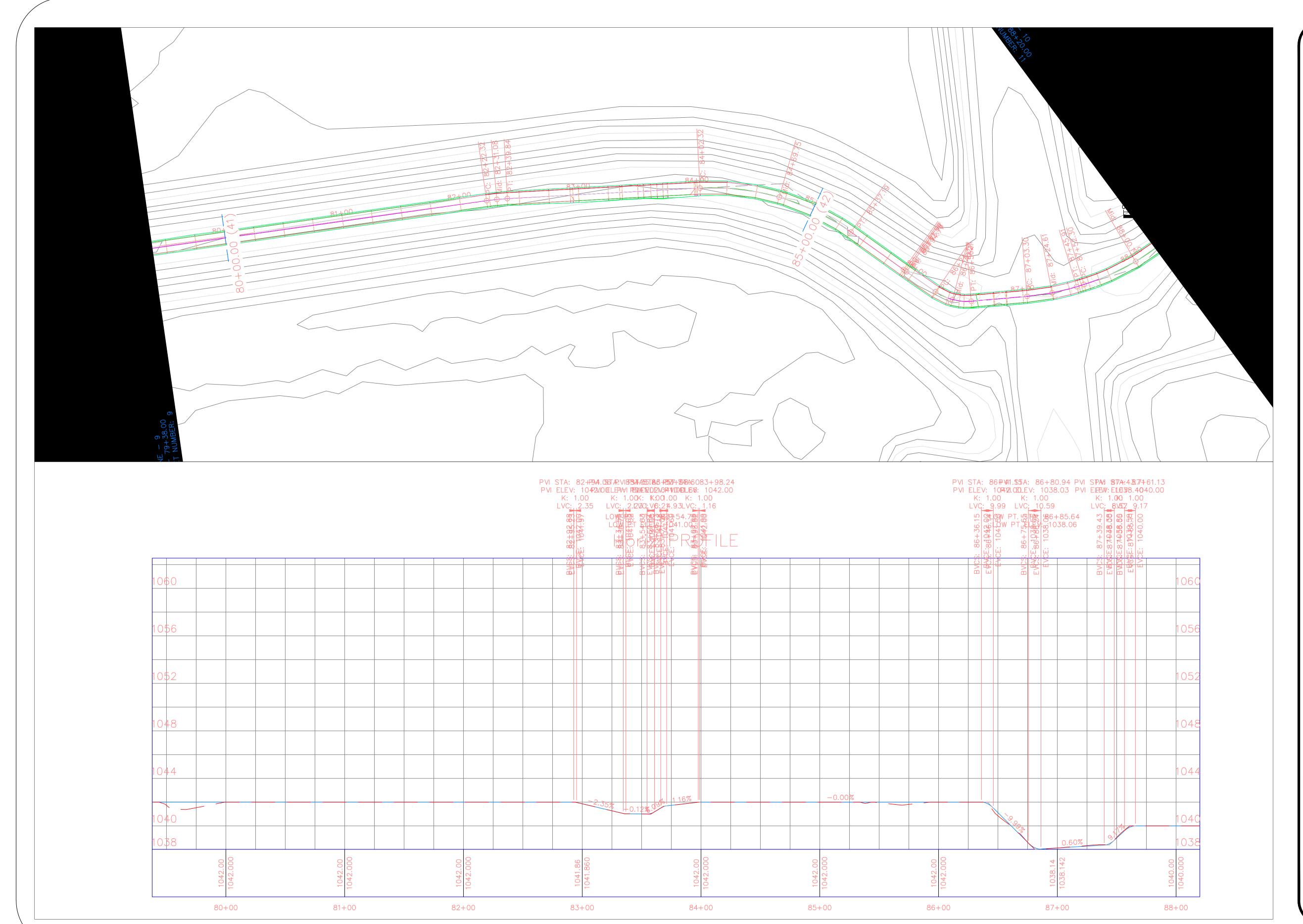
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City of Red Oak, Iowa

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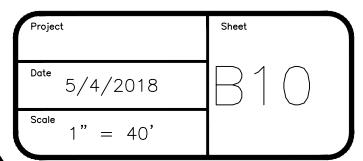
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No.	Revision/Issue	Date

Firm Name and Address
JKA Consultants

Kara Gibson Austin Sitzmann Joe Moslemian

Project Name and Address

Trail Plan and Profiles



3/19/2007

The University of lowa <u>Civil and</u> <u>Environmental</u> <u>Engineering</u> 4105 Seamans

Center for the Engineering Arts and Sciences 105 S. Capitol St.

lowa City, IA 52242 Phone: 319.335.5647 Fax: 319.335.5660 Email: civil—hawks@uiowa.edu

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City of Red Oak,

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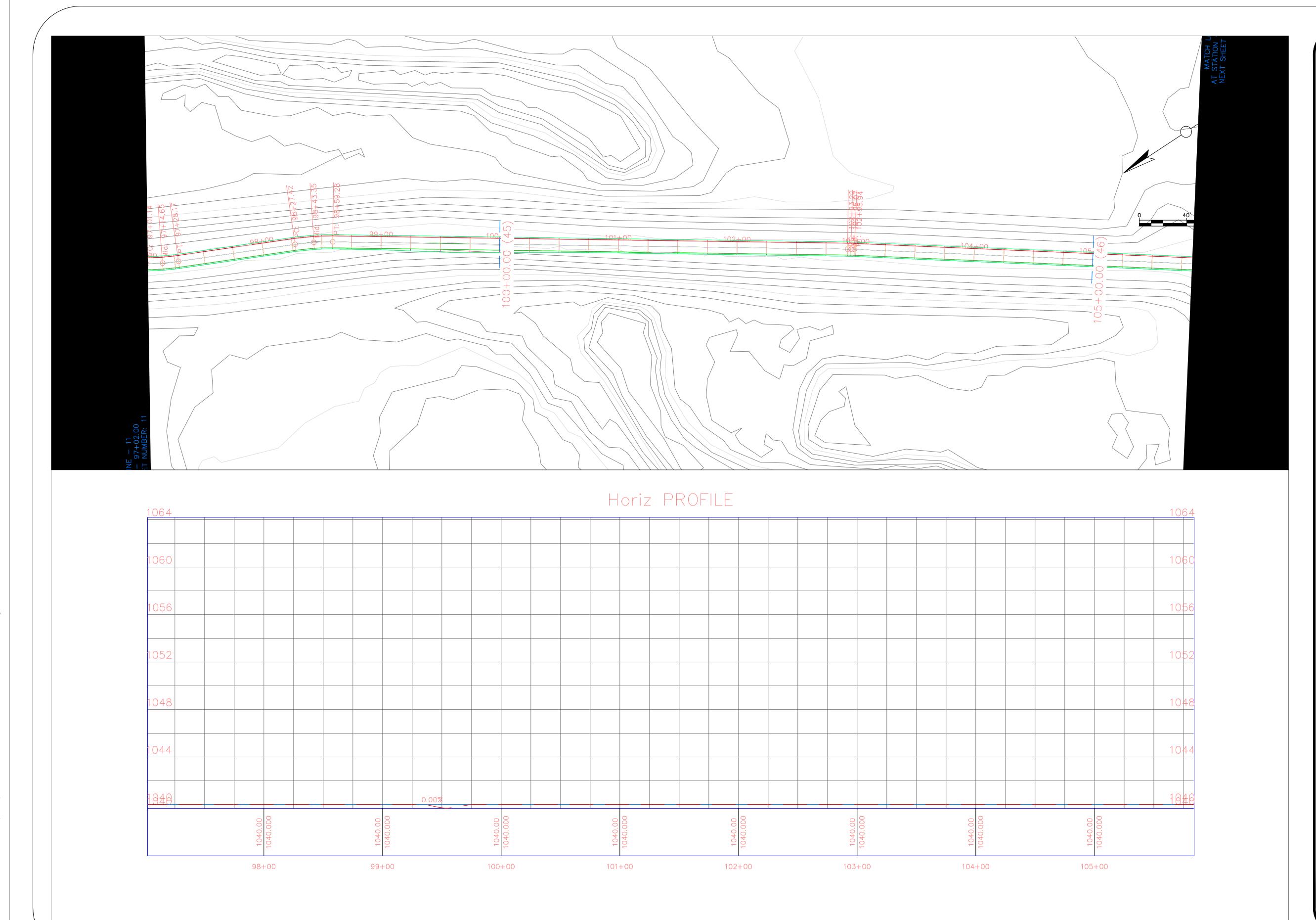
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Date 5/4/2018 1" = 40'



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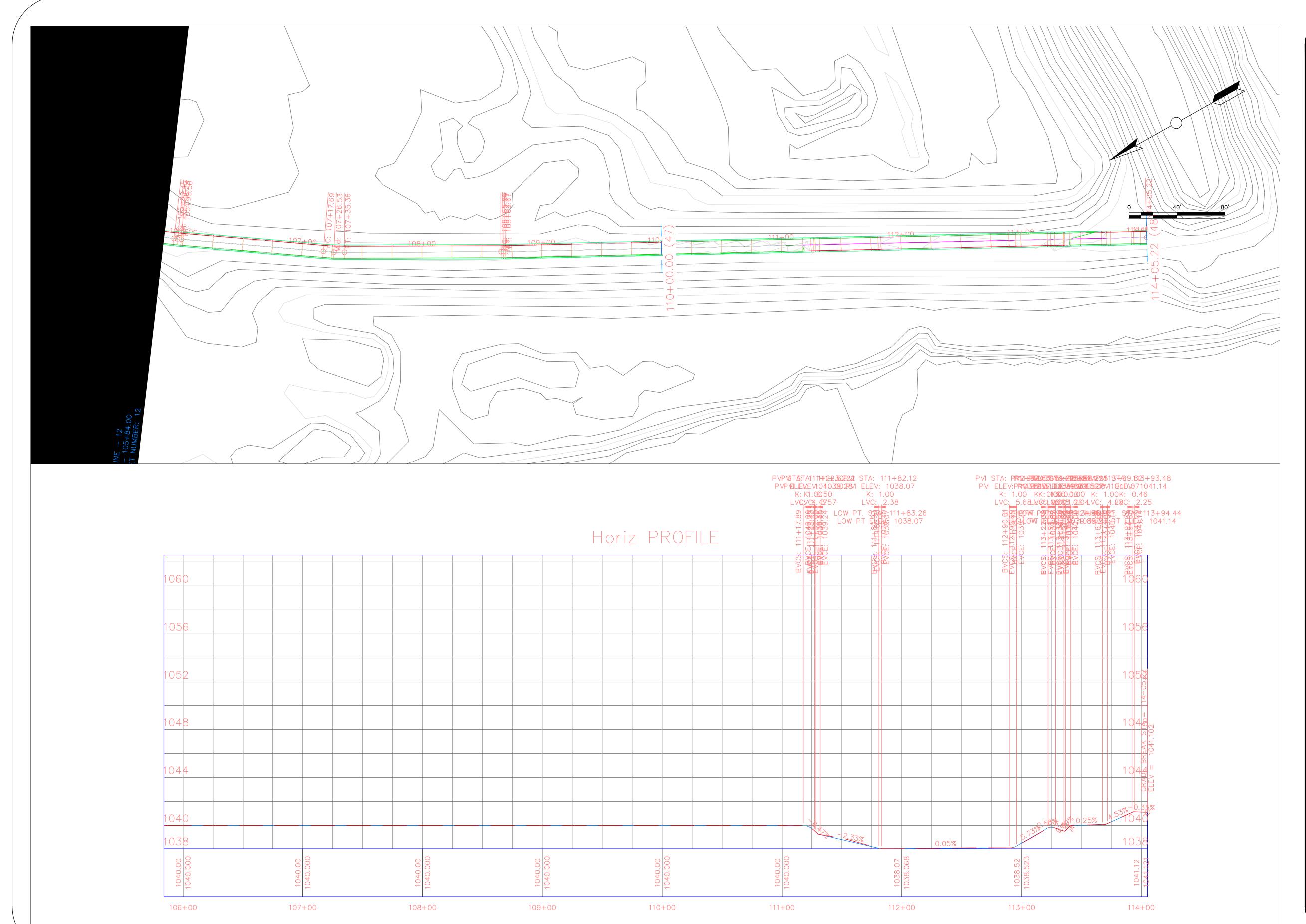
JKA Consultants

Kara Gibson Austin Sitzmann Joe Moslemian

Project Name and Address

Trail Plan and Profiles

Project	Sheet
Date 5/4/2018	1 B12
Scale 1" = 40'	



The University of lowa

<u>Civil and</u>

<u>Environmental</u>

<u>Engineering</u>

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River Levee

Trail and

Bridge

City of Red Oak, Iowa

Educational — Not for Construction

ior	Construction	
No.	Revision/Issue	Date

Firm Name and Address

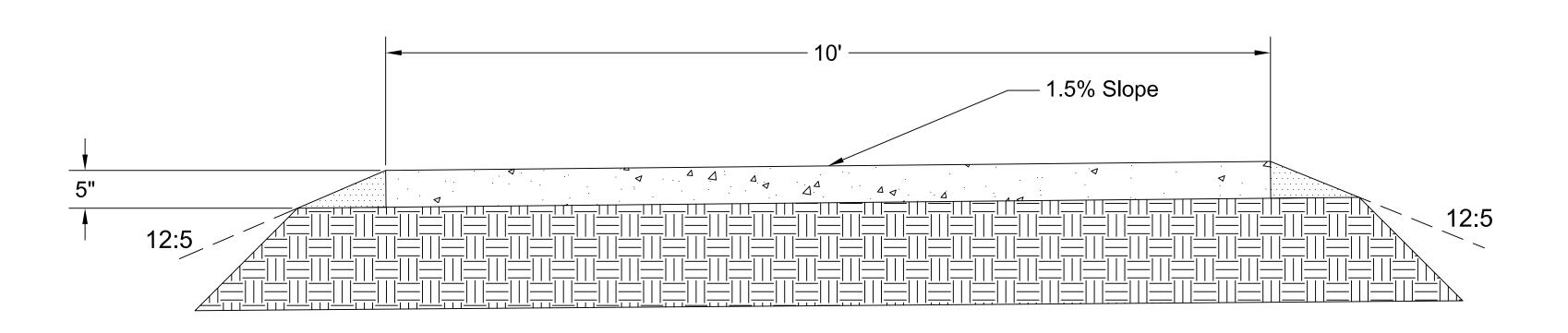
JKA Consultants

Kara Gibson Austin Sitzmann Joe Moslemian

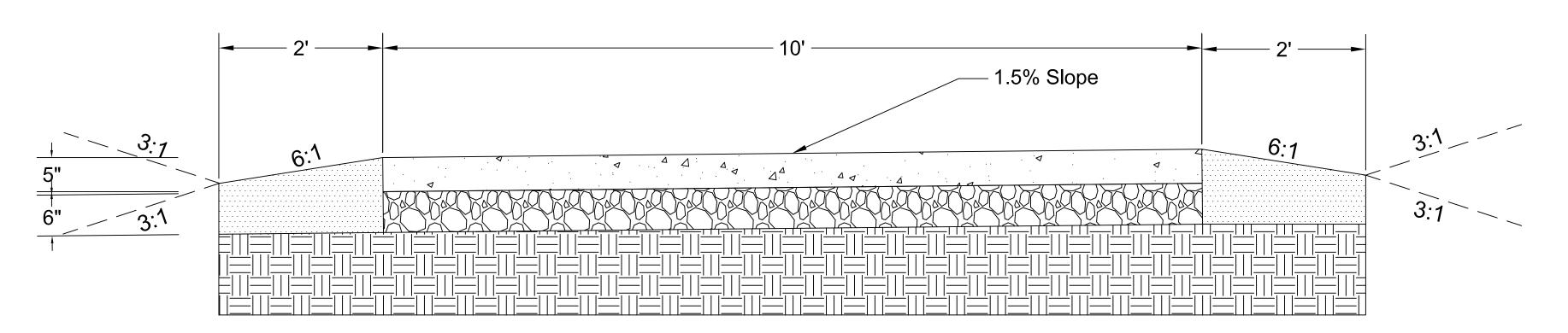
Project Name and Address

Trail Plan and Profiles

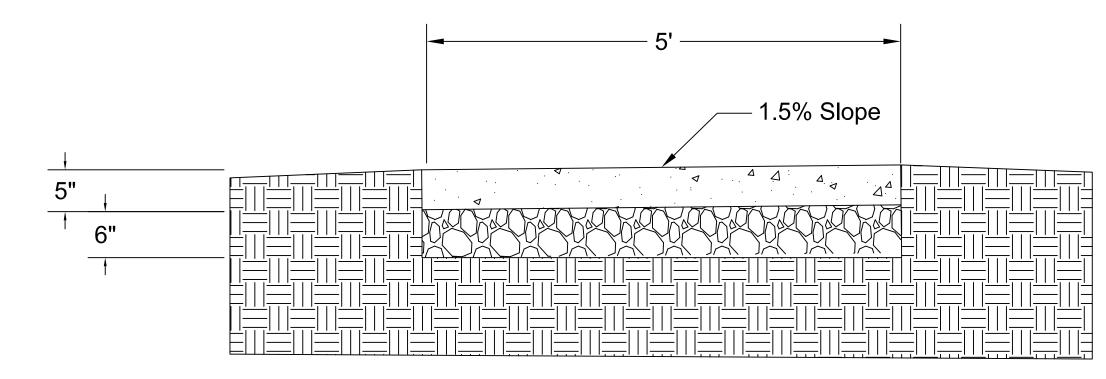
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Cross Section 1 - On Levee



Cross Section 2 - Off Levee and Build-up

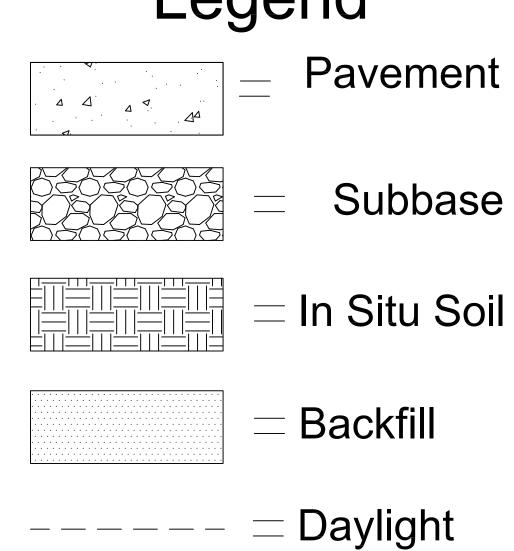


Cross Section 3 - At Alix St Crossing

Cross Section Notes:

- 1. Vertical slope of 1.5% is applied to all cross sections
- 2. Shoulders are added to each side of Cross Section 2. Shoulders are to be 2 feet wide grass shoulders sloped at 6:1 away from the trail.
- Pavement material can be concrete or asphalt
- Cross Section 1 shall not cut into existing levee.

Legend



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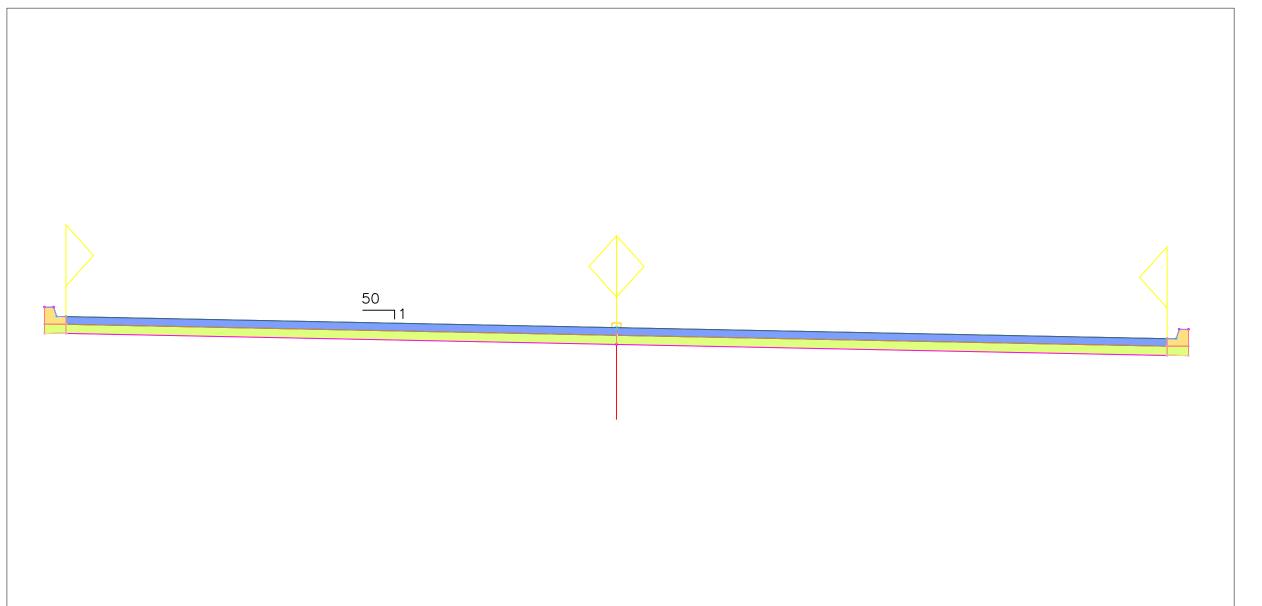
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SHEET NAME

Trail Cross Sections

SHEET NO.





Section A

Parking Lot Notes:

- Lot boundary to be graded at 4:1 to existing surface
 Drainage inlet to be located at Point B. Designed to service a 100 yr design storm volume of 674 ft³.
 Typical stall dimensions are 9' wide and 18' long and Accessible stalls
- are 11' wide and 18' long. Lot drive aisle and driveway are 24' wide to service both cars entering and exiting. These dimensions are within specifications of Section 8B-1 of Iowa SUDAS Design Manual.

 4. Design contains 14 standard stalls and one ADA Accessible stall located nearest to the existing trail.
- 5. Pavement design is comprised of 5" of pavement surface with the option to use concrete or asphalt and 6" of sub-base.



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SHEET NAME Parking Lot

Plan and Profile

SHEET NO.

Signage Notes

A: W11-2 (36"x36") sign w/ W16-9P located 125'
North and South of signs B near the crossing

B: W11-2 (36"x36") sign w/ W16-7P offset 2' from edge of trail and 2' from edge of HWY 48 (to edge of sign)

C: R1-1 (18"x18") offset 2' from edge of trail (to edge of sign) and 3' from edge of HWY 48 (to edge of sign)

D: R1-1 (36"x36") located 25' from edge of HWY 48 and centered in grass as shown

E: W3-1 (18"x18") offset 2' from the edge of trail (to edge of sign) located 100' from sign C along the path of the trail

The bottom of every sign must be elevated 6' from the trail pavement surface

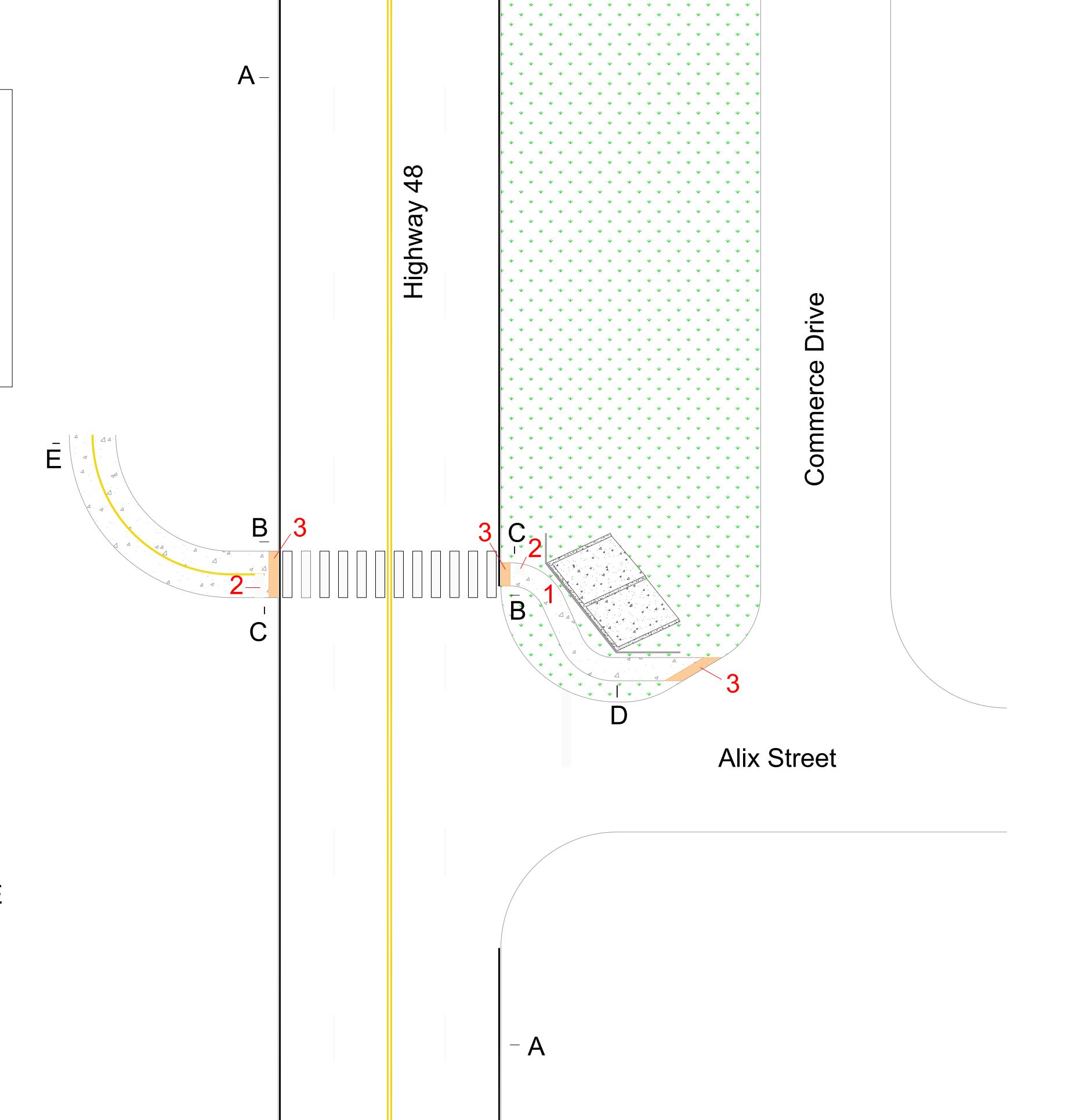
Pavement Marking Notes

1: Edge of sidewalk to rail has to be no less than 1'

2: 2' wide stop lines covering right half of trail; street edge of stop line located 3' from edge of HWY 48

3: All 3 detectable warnings shall be 2' wide and cover the entire width of the trail:

4: Crosswalk lines are 2'x10' spaced at 2'



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Bridge

evee Trail &

River

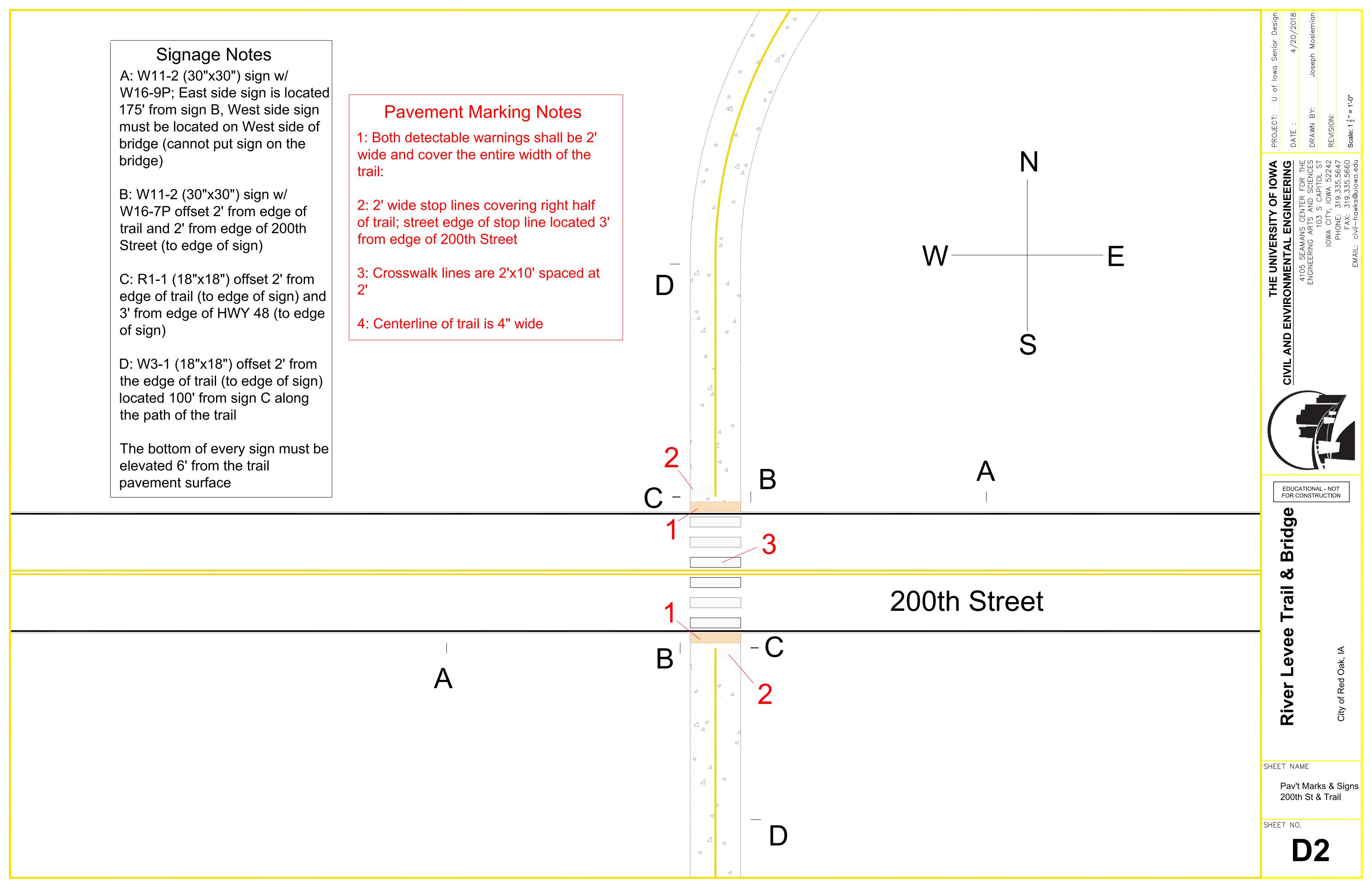
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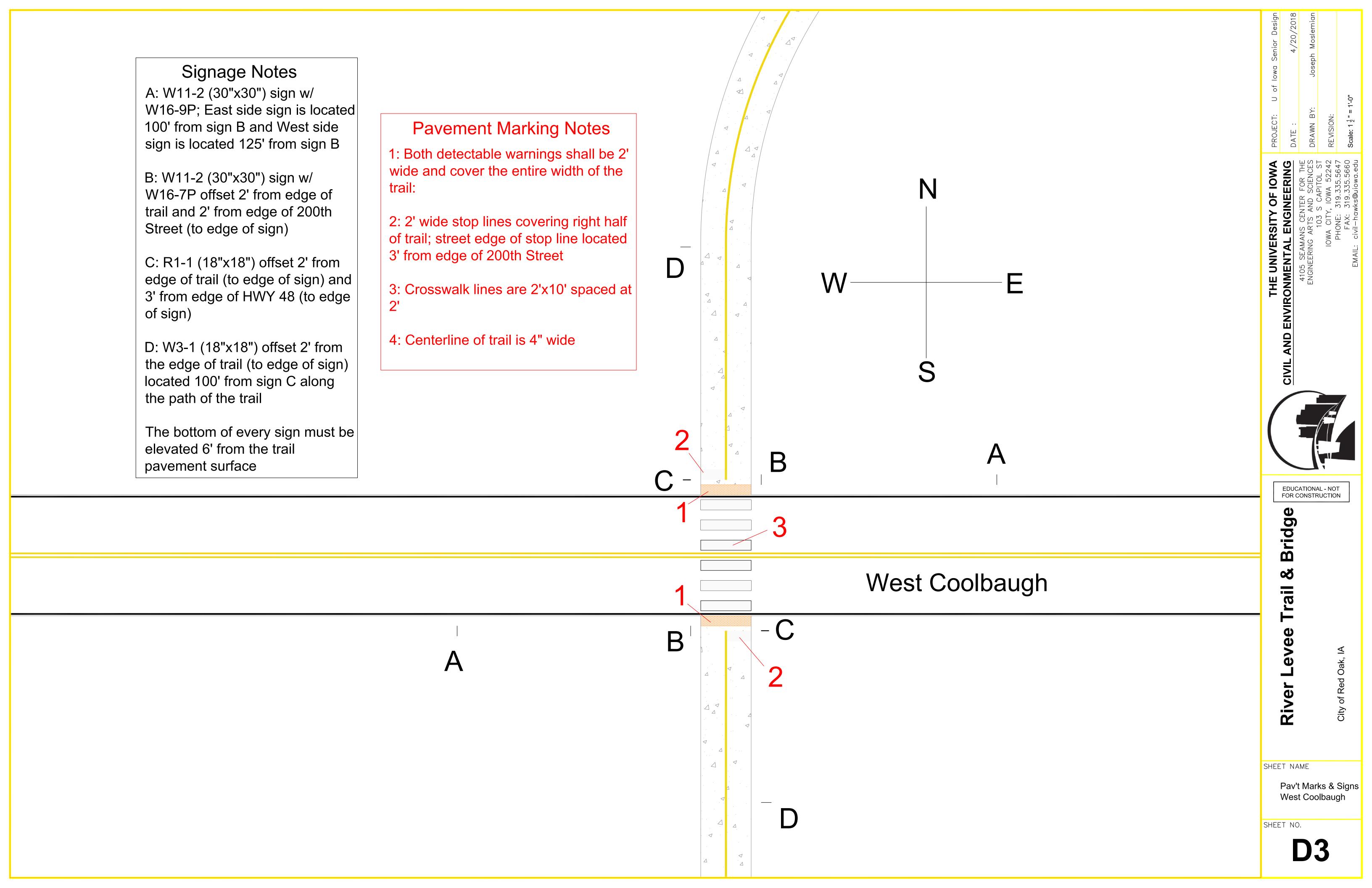
THE UNIVERSITY ENVIRONMENTAL ENG

Pav't Marks & Signs Alix St. & HWY 48

SHEET NO.

D1





Pavement Marking Notes 1: RR Crossing Markings are located 50' from signs B and are $\frac{3}{8}$ scale relative to figure 8B-7 in the MUTCD 2: Both detectable warnings shall be 2' wide and cover the entire width of the trail and be placed as close as possible to the edge of the railroad concrete

the trail

3: Yield lines shall be 2' wide and

extend the width of the right side of

Signage Notes

A: W10-1 (15" dia.) located 50' along the curve of the trail from pavement marking 1 ofset 2' from edge of trail

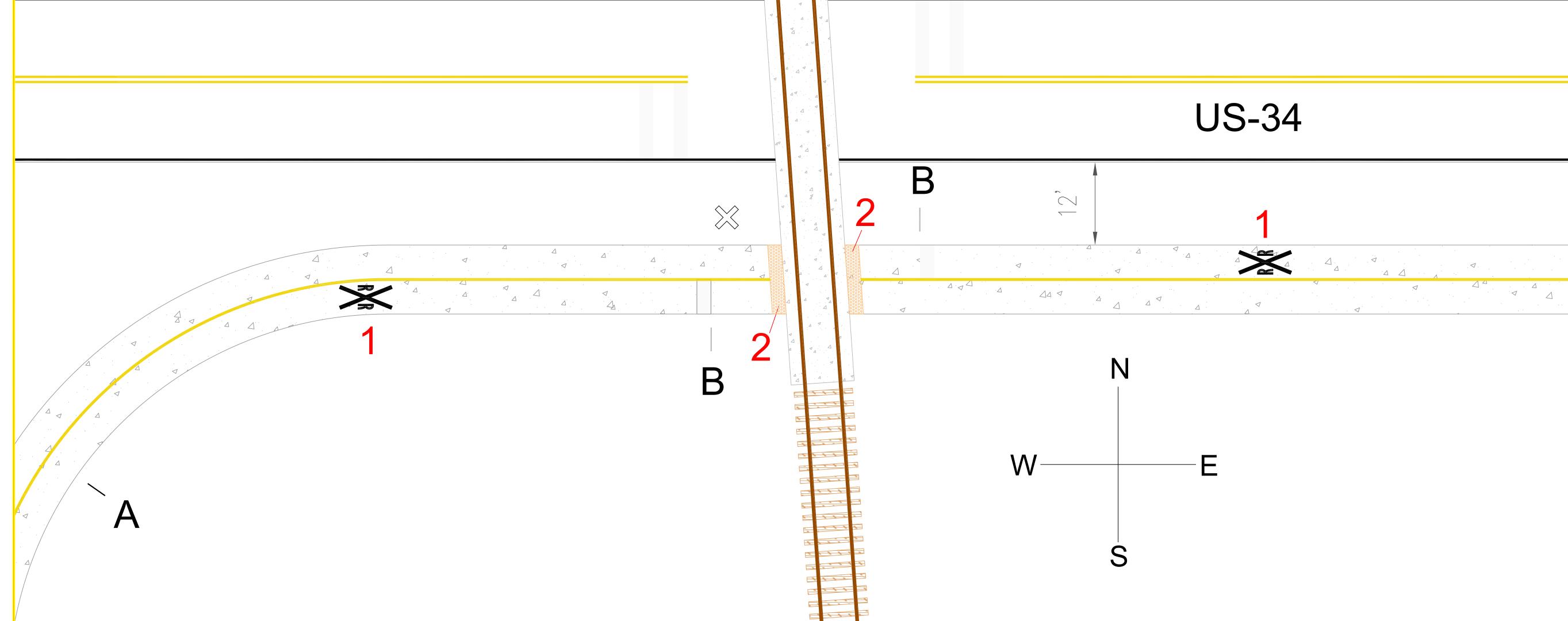
B: R15-1 (24"x4 $\frac{1}{2}$ ") w/ R15-2P (4 $\frac{1}{2}$ "x4 $\frac{1}{2}$ ") mounted below & R1-2 (18"x18"x18") also mounted below; these signs are offset 12' from the edge of the nearest track

The bottom of every sign must be elevated 6' from the trail pavement surface

SHEET NAME

Pav't Marks & Signs At-Grade Crossing

SHEET NO.



X. Design Renderings & Models



Aerial of Alternative 1 Looking Northwest



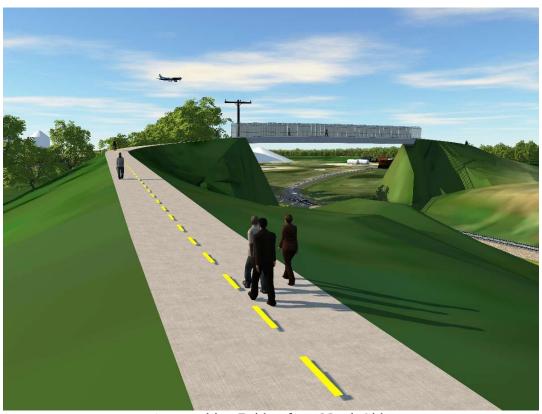
Aerial of Alternative 1 Looking Northeast



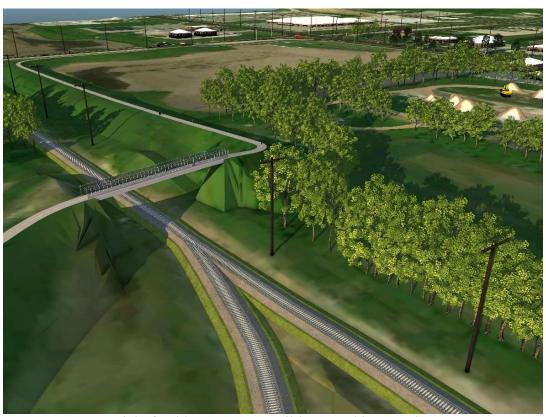
HWY 48 Crossing Looking West



HWY 48 Crossing Looking Northwest



Approaching Bridge from North Side



Aerial of Bridge & Levee Build-up Looking Northeast



Aerial of Bridge & Levee Build-up Looking Southwest



200th Street Crossing Looking North



West Coolbaugh Crossing Looking North



West Coolbaugh Crossing Street View



At-grade Crossing Alternative Aerial Looking South



At-grade Crossing Alternative Looking Northeast



Parking Lot Looking Northwest

Video Rendering (Digital File):

https://www.dropbox.com/s/0mp2dftizolrhbd/BridgeAlternativeNew.wmv?dl=0

Image Renderings (Digital Files):

https://www.dropbox.com/sh/552xrdqifss4gly/AABhr38N4KbQvBKZlEvdWM1Pa?dl=0

United States Army Corps of Engineers

Contact info: Jennifer Gitt, jennifer.l.gitt@usace.army.mil

Larry Boardman, larry.e.boardman@usace.army.mil

Email sent from Larry Boardman to U of Iowa Students below:

Austin,

Jennifer Gitt forwarded your email regarding biking/running trails on federal levees to me.

Many of our urban levees have biking/running trails on the levee crests; including Omaha, Council Bluffs, and the Papillion Creek system through the Omaha area. Since the federal government's primary interest is to provide flood control, we do not construct the trails; however, the local levee Sponsors are allowed to fund, design, construct recreational features such as trail systems if they have the interest to do so.

The Corps of Engineers process for construction on or in the vicinity of a federal levee is that the local Sponsor, in your case, the City of Red Oak, would be responsible for receiving a design for a project, reviewing the project to assure that they are in agreement with the project, and then forwarding it to the Corps of Engineers for review and approval prior to construction. Regarding agreements between the Corps of Engineers and the a local levee Sponsors, the following are two paragraphs that are typically included in our response memo's back to a Sponsor:

"The Red Oak Flood Protection System is a congressionally authorized and federally constructed levee project along the Missouri River. The City of Red Oak is the local sponsor that maintains and operates this levee system per agreement with the Corps of Engineers.

The Corps of Engineers has a congressionally mandated responsibility to ensure that the federally constructed levees are appropriately operated and maintained. No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of way, nor shall any change be made in any feature of the works without prior approval of the Corps of Engineers."

Regarding design considerations, the Corps of Engineers would review the design primarily to assure that the project does adversely affect the integrity of the federal flood control project. For construction a trail on the levee crest, these considerations would include any cutting into the levee sideslopes, which could reduce seepage resistance or create slope stability concerns; any lowering of the levee profile; and any rutting of the levee crest or sideslopes.

- For a biking/running trail, access would obviously be very important. At Red Oak, access at Oak Street and Coolbaugh Street would be relatively easy, but there would be major restrictions at Highway 34, the railroad closure structure, and the railroad embankment at the downstream end of the project that you would need to plan around.
- If access ramps on the levee sideslopes are required, a major consideration is that they do not cut into the existing levee cross section. The slope of the ramp would typically be a minimum of 1V:8H, with 1V:3H sideslopes. The width of the ramps would need to be discussed with the levee Sponsor and dependent on the final end use. If vehicle access on these ramps will be acceptable with the City, a minimum 10 foot width would be required. Assuming that only bicycles and pedestrians will be allowed on the trail, a lesser width could be used. The placement of bollards on the ramps would be a method to help keep unauthorized vehicles from using the ramps. We typically would try to minimize the number of ramps, especially on the riverside of the levee where scour frequently occurs immediately downstream of riverside ramps during high water events.
- Another major consideration is that the project should not cut into the levee crest, thus lowering the authorized level of protection of the project. We would recommend that profile survey be performed along the entire length where construction activity would take place. It would also be prudent to compare this survey with the project design and as-built survey. This way the levee crest could be brought back to design grade prior to the trail construction in an instance where excess settlement or degradation of the levee crest has taken place. To my knowledge, these conditions do not exist along the Red Oak levee. Note that the levee crest height, in the viewpoint of the Corps of Engineers, will be the elevation of the earthen levee crest and not the elevation on top of trail surfacing.
- A surfacing material (granular, concrete, or asphalt) would be required. A situation where rutting of the levee crest due to trail activity would not be allowed. Most trails on levee crests that I have seen are concrete; however, I have also seen some asphalt. The standard levee crest width is 10 feet with most trails being approximately 8 feet wide. Although the intent of the trail will be for biking/walking/running, the design of the surfacing should be of sufficient strength and thickness to withstand the weight of vehicles (cars/pickup trucks) since the levee crest is also driven on for routine levee inspections, routine levee operation and maintenance, and flood fight surveillance.

Hopefully this information will help and good luck with your project!

Feel free to contact either Jennifer Gitt or myself if there is anything else that we can assist you with.

Sincerely,

Larry E. Boardman, P.E.
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Geotechnical Engineering and Sciences Branch, Omaha District, U.S. Army Corps of Engineers
1616 Capitol Avenue
Omaha, Nebraska 68102-4901

Office Phone: 402-995-2241

Burlington Northern Santa Fe Railway

Contact info: calvin.nutt@BNSF.com

Bridge Brothers

Contact info: agentilucci@bridgebrothersinc.com