THE UNIVERSITY OF IOWA
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

FINAL DELIVERABLE

Title	North Liberty Ranshaw Way Underpass
Completed By	Mason Rahe, Loren Moffitt, and Lucas Dahl
Date Completed	May 2023
UI Department	Department of Civill and Environmental Engineering
Course Name	Project Design and Management CEE:4850
Instructor	Rick Fosse
Community Partners	City of North Liberty

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a community engagement program at the University of Iowa. IISC partners with rural and urban communities across the state to develop projects that university students and IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

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North Liberty Ranshaw Way Underpass

Design Report – May 5, 2023

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Design Report

Section I Executive Summary

We are pleased to have the opportunity to prepare this design report for the Ranshaw Way Underpass. Our team believes we designed the best underpass for the final phase of the revamping of Ranshaw Way. We are a trio of students at the University of Iowa: Mason Rahe (project manager), Loren Moffitt, and Lucas Dahl. Rahe is a Civil Engineering major with a focus area in pre- architecture. Moffitt is a Civil Engineering major with a focus area in water resources. Lucas Dahl is a Civil Engineering major with a focus area in transportation. Our different backgrounds all contributed in being able to successfully complete the design of the project.

This project is a trail underpass for Ranshaw Way. The tunnel will create a safe connection from the developed east side of the roadway to the future commercial and residential area on the west side. The tunnel needs to support Ranshaw Way, which will be renovated to a 4-lane road with a center median while also incorporating a stormwater drainage plan. Landscaping and aesthetics were a major priority for this project. We gave a lot of attention to creating a recognizable theme for the tunnel. The tasks we completed during the design process were site selection, structural design of the site (including the tunnel, retaining walls, and the trail system), a basic plan for the aesthetics of the structures, a work plan, a cost estimate, and the identification of a traffic detour route. Our trail and tunnel system used SUDAS standards and IDOT specifications. A stormwater drainage plan was developed in company with the grading of the site. This drainage plan involves storm sewer that will take storm water directly into the detention pond southeast of the site.

Figure 1: Project Location and Example Underpass

This project presented many constraints and challenges mainly due to site location. Finding the ideal tunnel location was difficult as on one side of the trail is a detention pond and the other side is a building. Keeping all aspects of the site up to SUDAS code and IDOT specifications was difficult to do while not interfering with the existing elements. The ditch where the tunnel was designed is not much lower than the existing roadway elevation, so fundamental changes had to be made to leave enough room for the tunnel to be properly supported as well as ensuring our tunnel entrance was above the emergency spillway elevation of the detention pond. The other main constraint was cost. Although we weren't given a budget, keeping the cost at a minimum was a main priority.

Our full construction cost for the project is shown in Table 1 in Appendix E. Split into four main categories, our storm sewer system is $33,000, the retaining walls and tunnel are $485,000, the trail system is $420,000, and the other site work and grading costs are $64,000. Using a 20% contingency, the final construction cost for the North Liberty Ranshaw Way Underpass came out to $1,100,000.

Our work schedule can be found in Figure 1 in Appendix E. The work schedule shows the tasks we completed as well as the time it took to complete them. These tasks include preliminary design alternatives, trail design, structural design, drainage concepts, utility relocations, grading and drainage, water mitigation, a traffic control plan, and preparation of the final report and presentation.

Figure 2: Final Site Plan

Section II Organization, Qualifications, and Experience

Organization and Design Team Description

Our team at the University of Iowa consists of 3 members. Mason Rahe is our project manager. Rahe’s a Civil Engineering major with a focus area in pre-architecture. Loren Moffitt is a Civil Engineering major with a focus area in water resources. Lucas Dahl is a Civil Engineering major with a focus area in transportation. Mason’s pre-architecture path involves experience in structural engineering. That combined with Lucas’ transportation background were essential in the design of the main tunnel portion and the support walls. Loren’s knowledge allowed him to handle the stormwater and environmental aspects of the project. Combined, our team represents all categories of civil design well and came with valuable experience for all aspects of this project.

Section III Design Service

1. Project Scope

This project will establish a trail underpass below Ranshaw Way located about halfway between Ashley Ct. and Sara Ct. The tunnel creates a safe connection from the developed east side of the roadway with the future commercial and residential area on the west side. The tunnel needs to support Ranshaw Way, which will be renovated to a 4-lane road with a center median while also incorporating a stormwater drainage plan. Landscaping and aesthetics were an important priority for this project so plenty of space was allotted for that as the trail is brought back to road level. The tasks we have completed during the design process were site selection, structural design of the site (including the tunnel, retaining walls and the trail connection), a work plan, a cost estimate, a basic aesthetics plan, and the identification of a traffic detour route. We have designed everything using SUDAS and ADA standards as well as Iowa DOT specifications to ensure safety for the trail users. Along with this, a stormwater drainage plan was developed in company with the grading of the site. Property acquisition was researched as well as relocations and restructuring of all utilities at the site location.

2. Work Plan

The work plan we created includes the completed project tasks and their duration. With a start date of February 6, 2023, the design process of the Ranshaw Way underpass was completed May 5, 2023. Tasks in the design schedule included the preliminary design alternatives, trail design, structural design, drainage concepts, utility relocations, grading and drainage, water mitigation, traffic control plan, and a final version presentation. A full-scale schedule can be found in Figure 1 in Appendix E.

Section IV Constraints, Challenges, and Impacts

1. Constraints

This project comes with its own unique set of constraints. The location presented a serious constraint for our project as the client wanted to limit the affected area. Getting the trail to the correct elevation while following code and maintaining a small project area was a huge concern. The existing detention pond caused another elevation concern. We had to ensure our minimum tunnel elevation was above the emergency spillway elevation as well as make certain our trail wasn't too close to the pond. To ensure the roadway was properly supported and the tunnel stayed above that spillway, the centerline of Ranshaw Way will need to be raised 1.5' from the existing elevation. The most important constraint to the client was time. The roadway that is being cut through is an extremely busy and vital route so construction time must be kept at a minimum as all lanes will be closed during construction. Although we did not design the aesthetics and landscaping for the project, it is essential that we leave opportunities for this aspect of the project. There is currently no budget for the underpass, but we have kept costs at a minimum.

2. Challenges

The site location comes with multiple challenges. There is a minor drop off from the roadway to the right-of-way for a ditch, so a key challenge was getting the tunnel to a proper depth while also allowing the trail back up to the roadway elevation. With the limited drop-off from the roadway, the actual tunnel construction was a major challenge as it required a lot of excavation and serious calculations to ensure safety. The west side of Ranshaw Way/HWY 965 is also a potential wetland and significant stormwater specifications were put in place.

3. Societal Impact within the Community and/or State of Iowa

   The connection of the east and west sides of Ranshaw Way is a vital component for the future of North Liberty. As a rapidly growing community, establishing connections to future developments is especially important. Our site involves the west side of Ranshaw Way just north of West Forevergreen Road. This open land will be developed for both residential and commercial usage. As this development occurs, Ranshaw Way will become a pedestrian barrier. As a major arterial, the road gets heavy traffic, and an at-grade pedestrian crossing would not be the safest option. Having a connection underneath the road from the residential east side to the future site on the west side is a huge priority to ensure safety for these people. Many of the buildings on the east side of Ranshaw Way are manufactured homes, so the ability to create a safe route to get around without having to use automobiles is essential. Just southwest of our site, is a newly built section of University of Iowa Hospital, making it even more important to connect residents to a large employer. Because Ranshaw Way/HWY 965 is a major roadway with high speeds, it isn't logical to incorporate road crossings. The underpass will create an aesthetically pleasing and safe crossing for pedestrians.

Section V Alternative Solutions That Were Considered

The alternatives for this project were locational rather than structural. Per client request, the underpass needed to be located between Ashley Ct and W Forevergreen Rd. The other considerations were space and access to North Ridge Trail. The existing detention pond was a large factor in our decision making. It impacted the stormwater drainage and the trail system's overall layout. From these constraints we proposed three locations to the client. The final consensus was that the underpass will be in an area between that of Alternative 1 and Alternative 3. We also considered alternatives to the size of the tunnel. The tunnel height was up for debate as we originally planned for a 12-foot-high tunnel but eventually agreed on 9-feet high. We also investigated the use of a boring tunnel rather than a cut-and-cover, but with Ranshaw Way being reconstructed it is not necessary to maintain traffic flow during construction.

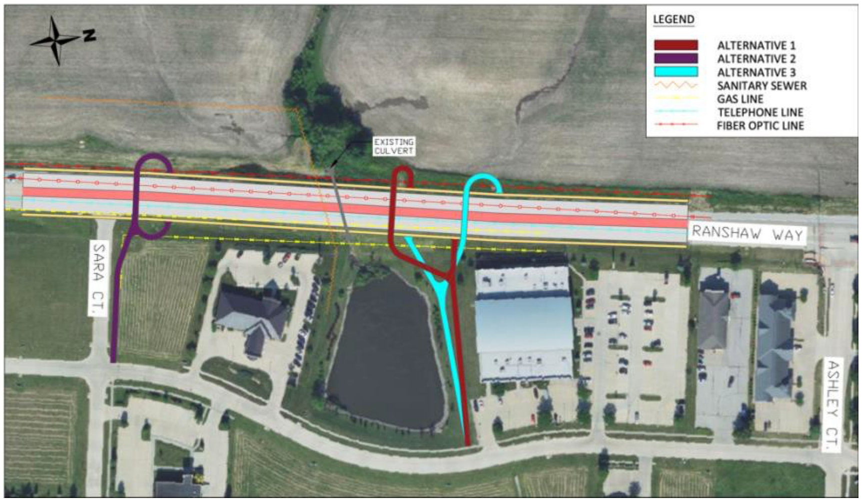


Figure 1 Alternative Locations

Section VI Final Design Details

Trail

The trail design is based on SUDAS and IDOT specifications and standards. We used the IDOT manual, chapter 12B-2, for our specifications and the shared use path design with a design speed of 20 miles per hour. The design speed was based on a type 3 trail category. The trail design includes 762 linear feet of trail with approximately 1237 square yards of PCC (Portland Concrete Cement) pavement. Under this section, our path width was determined to be 10-feet to accommodate two-way traffic. A 2-foot-wide shoulder was also placed on each side of the trail to provide the minimum lateral clearance, making the total trail width 14-feet. In the sections of trail that require a railing, the shoulder will be PCC pavement. These PCC shoulders were included in the 1237 square yards of PCC. The sections that did not require any railing have a two-foot grass shoulder.

PCC was chosen to provide users with a smooth ride and longer design life than other materials. The trail's thickness was determined to be 6 inches. This was based on the minimum of 4 inches and a recommended thickness of 5 inches in IDOT 12B-2. Providing a thickness of 6 inches will help with cracking and deterioration during high volumes of users and allow snow removal equipment to operate on it. Underneath the 6-inches of PCC pavement, 6-inches of granular subbase will also be used to ensure proper support for the trail.

All cross slopes for the trail follow the 1.5% recommended percentage. With a maximum cross slope being 2%, some transitions and curves vary between 1.5%-2% in chapter 12B-2 of the SUDAS Design Manual. Grade ranges for the vertical alignment shown in figure 1 and 2 (see Appendix) were used when selecting grades for our trail. The tunnel entrance on both the east and west sides of Ranshaw Way have a longitudinal slope of 5% or less. Due to the restraints found coming back up to the roadway elevation, the longitudinal slopes vary between 5%-

8.33% grade range. This range is allowed up to 200-feet of a continuous segment. Both segments are less than 200-feet long and vary between 5%-7.5%. Transitions from trail-roadway and trail-trail connections have a grade of less than 5% to allow for a safe transition from each segment. The vertical profile of the trail sections is shown in figures 4-6 in appendix A.

Sections of our trail that connect back up to the roadway elevation have a daylight side slope of 2:1 from the trail to existing ground and a drop of 4-feet or more, which requires a safety rail be installed. Figure 3 in Appendix A shows the details followed when determining safety rail requirements. A safety rail will also be installed for the trail near an existing pond.

Underpass

The underpass design is based on the IDOT manual, while resorting to SUDAS standards when necessary. All DOT specifications for the tunnel can be found in PPT G1-20 in the IDOT manual for precast pedestrian tunnels. The tunnel barrel has an opening of 9' (H) x 14' (W) with a wall thickness of 10". Although the IDOT specification accounts for a 10' by 14' tunnel section, we needed to raise the elevation to ensure the tunnel was above the emergency spillway of the detention pond. The tunnel will be precast, with each section 12' long. The underpass is 112.8 linear feet long and uses 181.27 cubic yards of structural concrete. This results in 9 precast sections with a 2.4' long section at the entrance of both sides. A 4" layer of PCC will be used as a top slab on the bottom of the tunnel to ensure a smooth surface that is able to be ridden on. This extra slab uses 19.50 cubic feet of PCC pavement.

On both entrances, there is a pipe handrail to prevent anyone from falling over the tunnel entrance. The handrails are also taken from the IDOT PPT G1-20. Details of these handrails as well as a cross section of the tunnel with them can be shown in Figure 1 in Appendix B.

The tunnel allows for 10" of PCC roadway paving, 6" of modified subbase, and about an extra 1' of modified subbase above it. This extra 1' allows for added support from the roadway to ensure the tunnel can handle the load. The strength of the tunnel was evaluated for flexural strength using the dead load of the area of PCC and subbase above a tunnel section as well as a live load based on the AASHTO H5 truck which is expected to be the largest vehicle operating on Ranshaw Way. All rebar used will be plain steel and used the IDOT specification to determine location in the tunnel barrel. To help support the pressures on the underpass, rock backfill was used on either side at a slope of 2:1 as well as an extra layer of added rock backfill on the North side because of the trail connection on that side. For support, 1' of thick rock backfill is placed below the tunnel and 2' out on either side. A cross section of this can be found in Figure 2 in Appendix B.

The tunnel itself drains west to east at a slope of 0.50% with a cross slope going north to south at 0.50% as well. The trail directly outside the tunnel drains away from it to ensure stormwater in the tunnel will not be an issue.

Retaining Wingwalls

The wingwalls used as support on either side of the tunnel entrances were designed with IDOT specifications found in PPT G1-20. The wingwalls are cantilever retaining walls that are 13.85' off the ground at the highest and 2' at the lowest. The walls are all about 43' long with a thickness of 1.05' throughout. They each extend 2.5' below ground with a base 10' wide at the largest and 2.6' wide at the smallest. One retaining wall uses 33.29 cubic yards of PCC concrete and there are 4 total walls, using a total of 133.16 cubic yards of structural concrete. Cross sections of the tallest and shortest sections of the wingwalls can be found in Figures 2 and 3 respectively in Appendix C.

The wingwalls have a pipe handrail to prevent anyone from falling over them. The handrails are also taken from the IDOT PPT G1-20. Details of these handrails as well as a side view of the wall with them can be shown in Figure 1 in Appendix C.

Both the tallest section and shortest section of the walls were evaluated for their factors of safety against overturning, sliding, and bearing capacity. All the values used for the soil were assumed to be common values for soil in the area using soil borings from a nearby project. The rebar used in the wingwalls follows the direction of the IDOT specification with minor changes made to account for the modified base of the wall. To help support the wall, 2' of free draining granular fill at a 2:1 slope was placed on the backside of the wall. A layer of filter fabric was also placed between the backfill and the free draining granular fill. A 6" foundation drain was then placed just above the supporting base to help drain stormwater away from the tunnel.

The wall will clear the backfill at the top by 0.5", and the backfill slopes away from the wall at an angle of 20 degrees.

Storm Water Management

Once the grading was completed the water catchments were modeled using Autodesk. The area, length, and time of concentration were calculated from the water catchments that drained into the trail and underpass. To size the stormwater pipe network, the Rational Method as specified in the Iowa DOT Design Manual, Chapter 4A-5 was used to estimate the peak flow for a 5-year storm event; using the Hydraflow Express Extension for Autodesk that peak flow would require a 12" diameter circular reinforced concrete pipe (RCP). However, according to Iowa DOT Design Manual Chapter 4A-10, the minimum diameter for stormwater RCP is 15" with a Manning's roughness coefficient n = 0.013. The minimum pipe slope in the pipe network is 0.2% and the maximum slope is 0.5%, with minimum velocity at 3.3 ft/sec and maximum at 5.6 ft/sec. We were able to achieve the minimum cover of 3' required by IDOT chapter 4A-10.

All intakes are circular area intakes, and all manholes are 48" cone concentric. The two manholes north of the underpass trail will be stubbed and capped for future connection. The outlet is flared, and riprap is used as a scour countermeasure. See Figure 1 in Appendix D for site location and plan/section drawings.

Estimate of materials:

- 4 of the 48” Cone Concentric Manhole
- 14 LF of the 15” RCP
- 147 LF of the 18” RCP
- 75 LF of the 21” RCP
- 1 of the 38” x 6” x 37” Concrete Rectangular Headwall

Section VII Engineers Cost Estimate

The unit prices in the cost estimate were estimated from the IDOT website and average prices taken from local construction projects. The low, high and average prices for each bid item are listed for the most recent month on the IDOT and were compared to local prices to determine each unit price shown in Table 1 in Appendix E. It is important to note our cost estimate is assumed to be part of the larger Ranshaw Way project. This means our cost does not include traffic control, temporary sidewalks, or removal of pavement as those would be included in the overall project cost for Ranshaw Way Phase 6. Our cost estimate came to a sub-total of $900,000. A 20% contingency was applied to account for inflation and other items bid items that may need to be applied to this project at the client's discretion. With this 20% contingency, our final project cost estimate for the construction of the North Liberty Ransaw Way Underpass came to $1,100,000.

Appendices

Appendix A: Trail

Table 12B-2.04: Vertical Alignment

Grade Range	**Maximum Segment Length (feet)**		
	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%	--	--	10

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

[2] Derived from AGODA Section 1017 (Trails)

Figure 1: Vertical Alignment Grade Ranges for Shared Use Path

rise	run	rise/run	degrees	% slope	max run (ft)
1	20	0.050	2.86	5.0	unlimited
1	12	0.083	4.76	8.3	200
1	10	0.100	5.71	10.0	30
1	8	0.125	7.13	12.5	10

CHAPTER 4: ACCESSIBLE ROUTES TECHNICAL

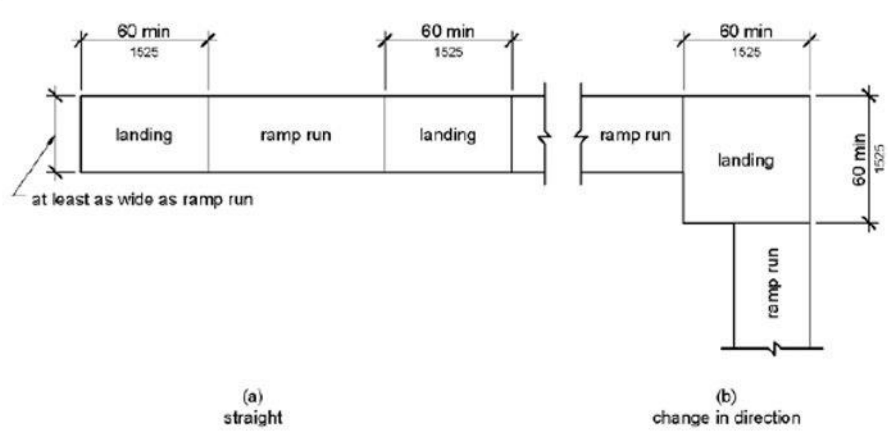


Figure 405.7
Ramp Landings

405.7.1 Slope. Landings shall comply with 302. Changes in level are not permitted.
EXCEPTION: Slopes not steeper than 1:48 shall be permitted.

Figure 2: ADA Requirements for Shared Use Path

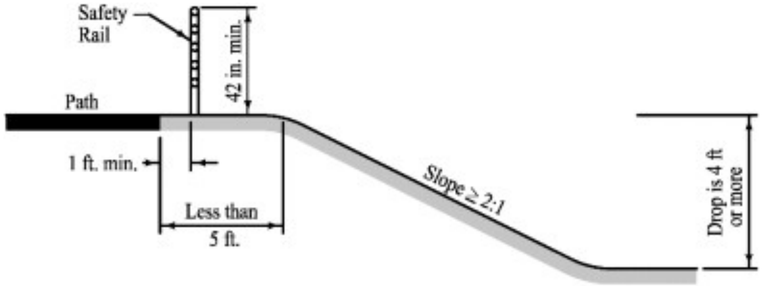


Figure 3: Safety Rail Requirements

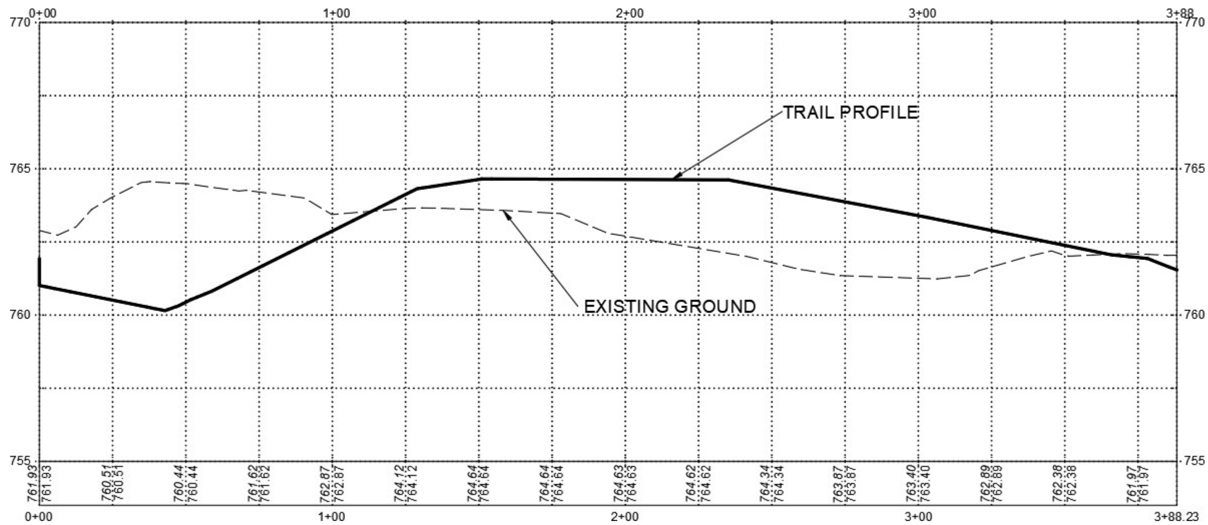


Figure 4: Main Trail Vertical Alignment

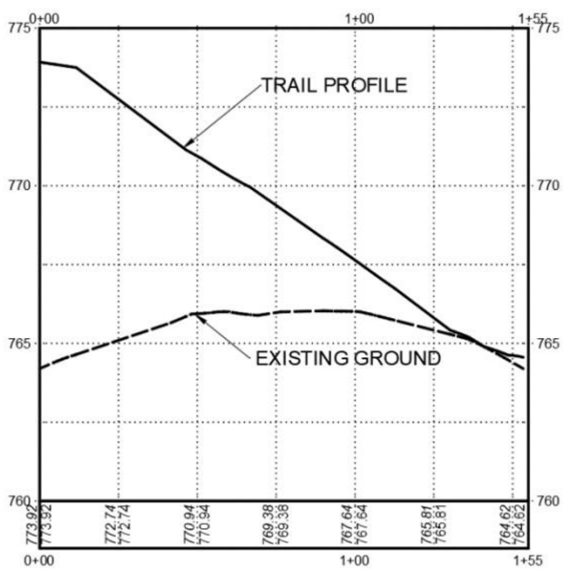


Figure 5: East Trail Roadway Connection Vertical Alignment

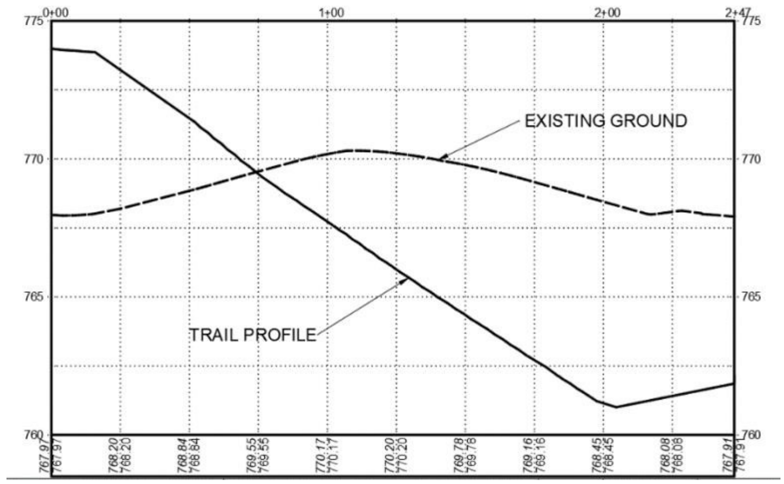


Figure 6: West Trail Roadway Connection Vertical Alignment

Appendix B: Underpass

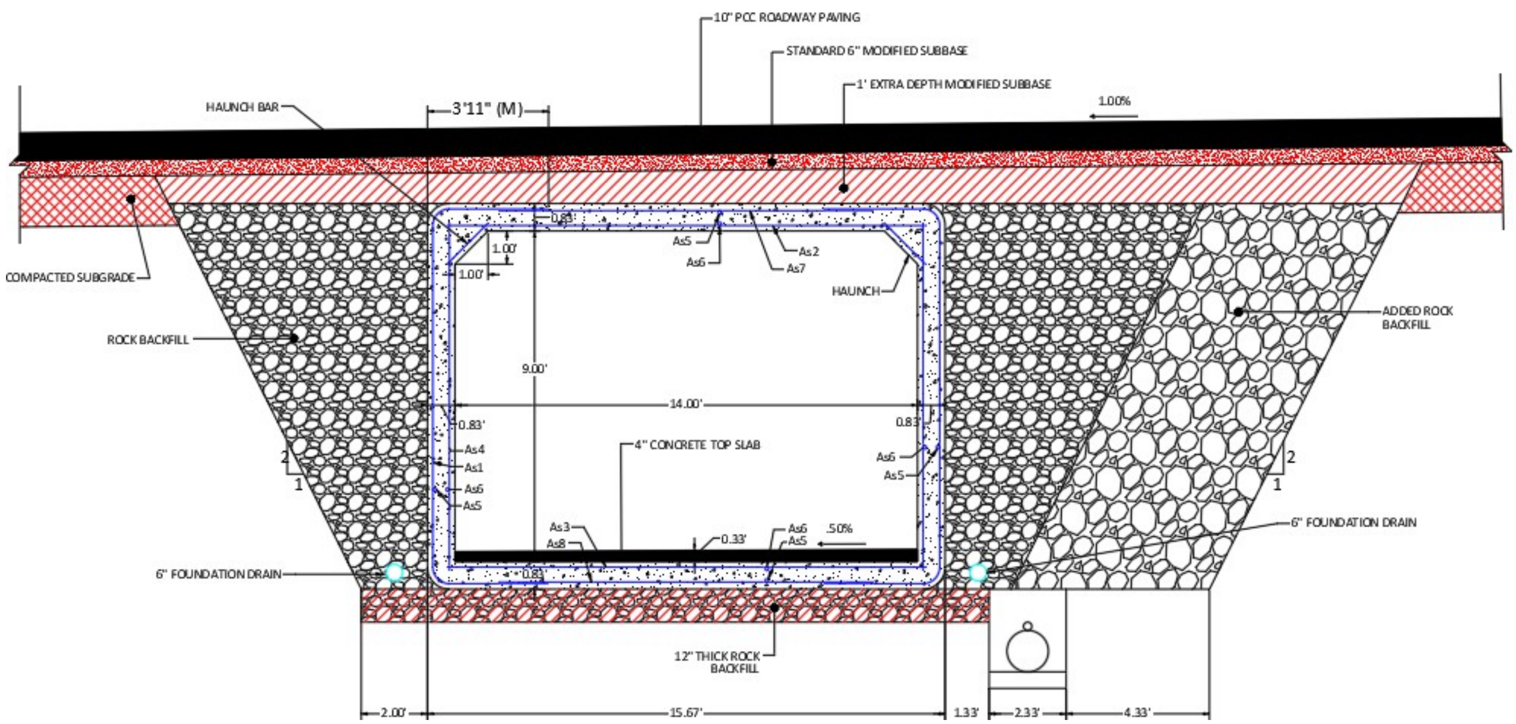


Figure 1: Tunnel Cross Section at Road Centerline

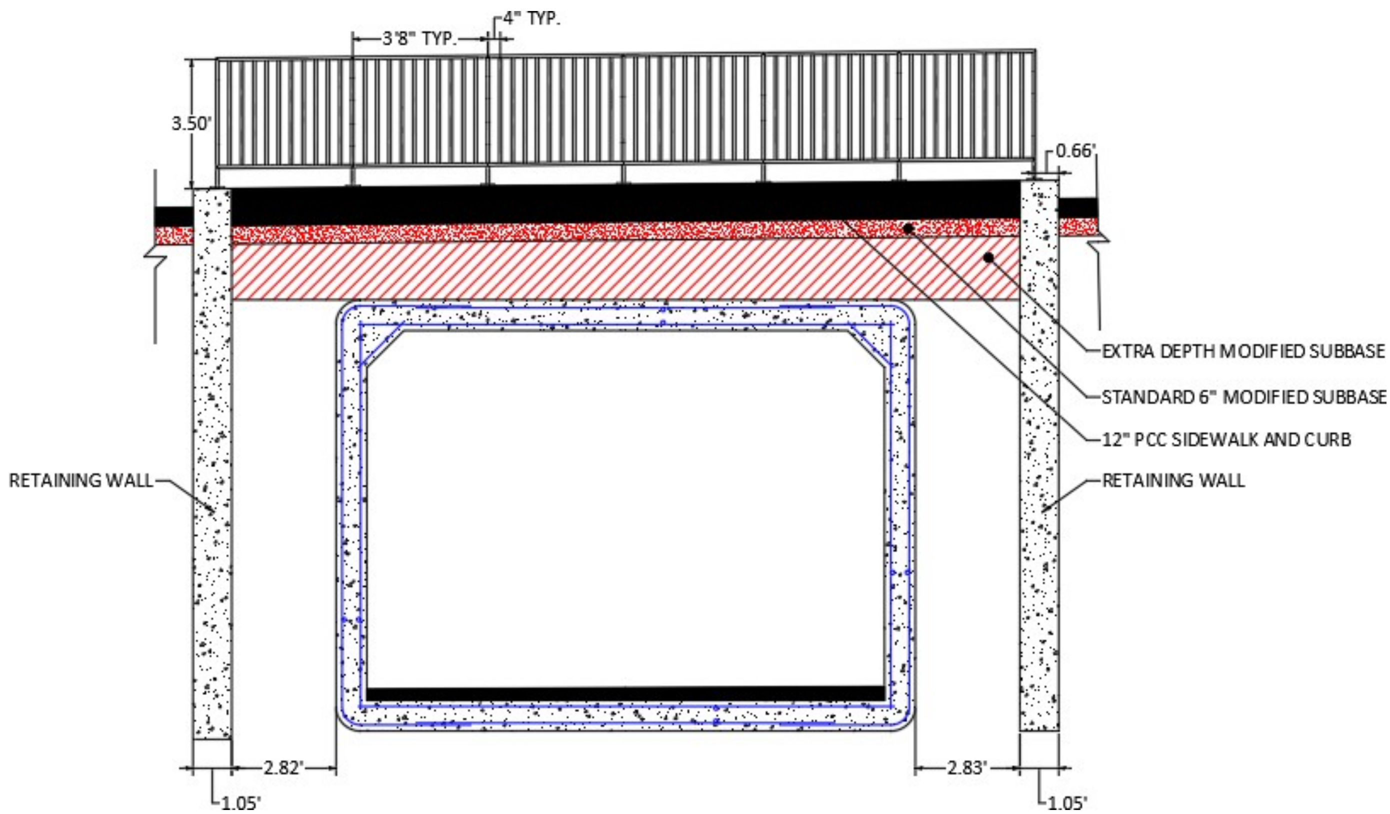


Figure 2: Tunnel Cross Section at Opening

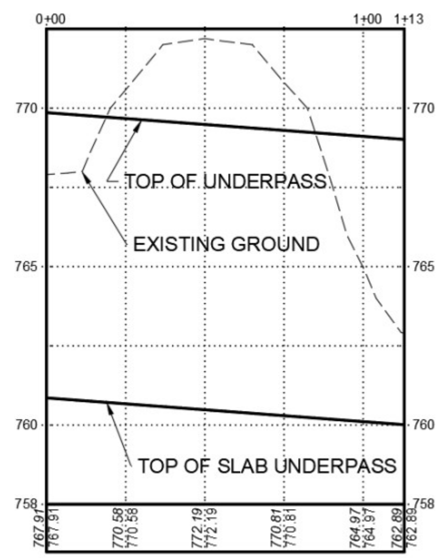


Figure 3: Underpass Vertical Alignment

Appendix C: Retaining Walls

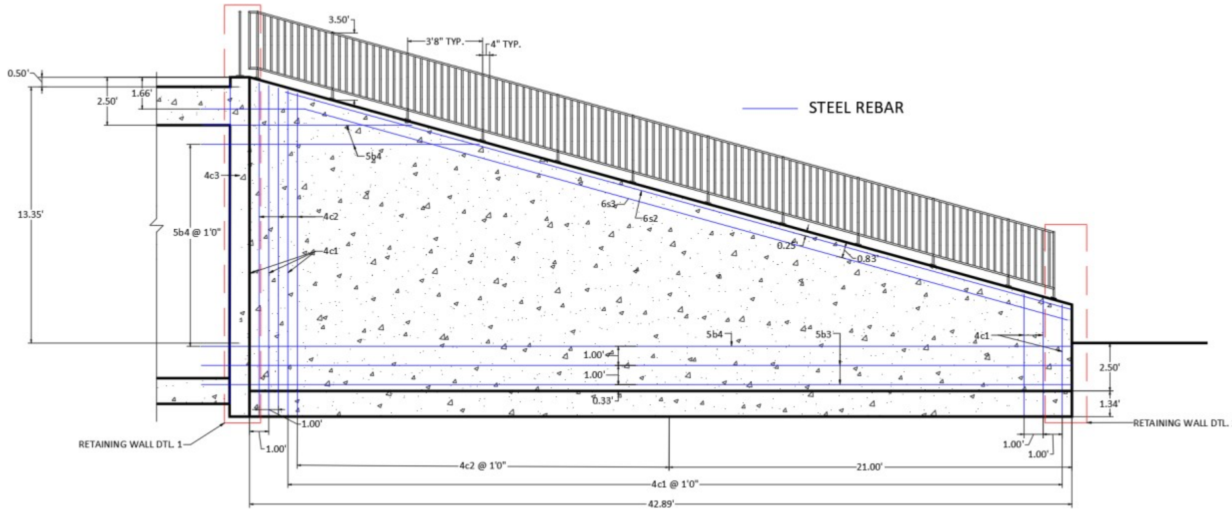


Figure 1: Elevation View of Wingwall

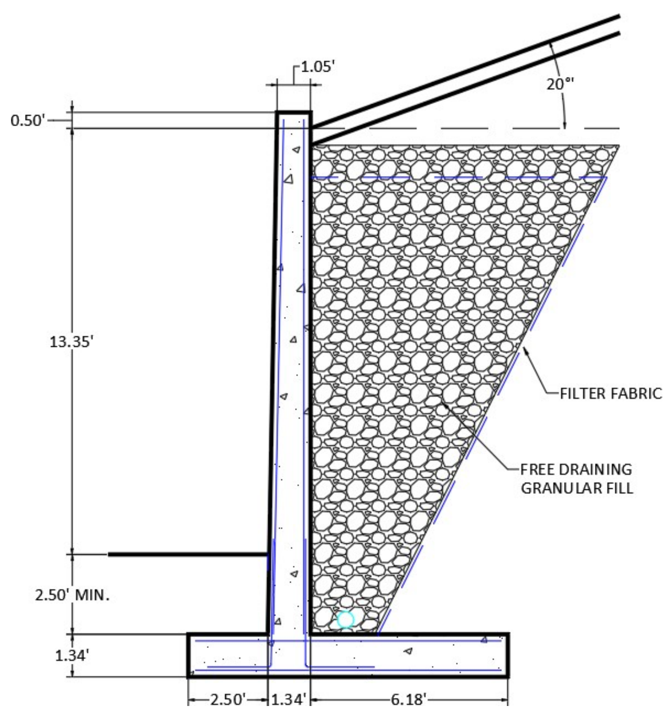


Figure 2: Retaining Wall Detail 1

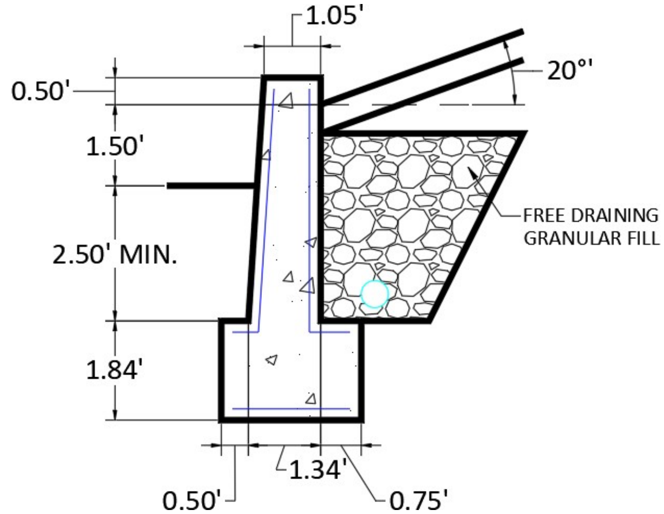


Figure 3: Retaining Wall Detail 2

Appendix D: Stormwater Management

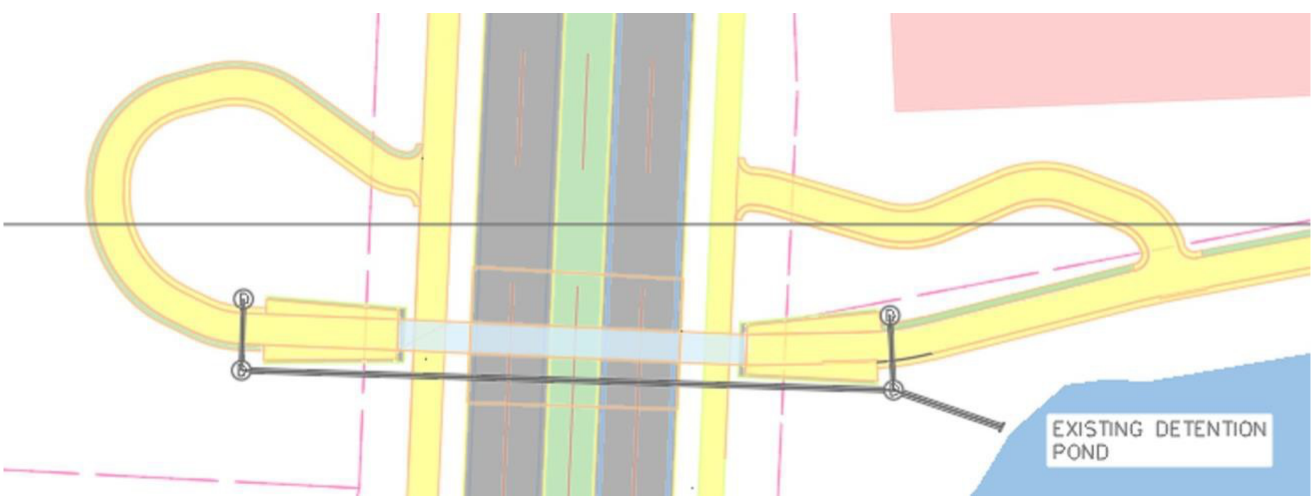


Figure 1: Storm Sewer Plan View

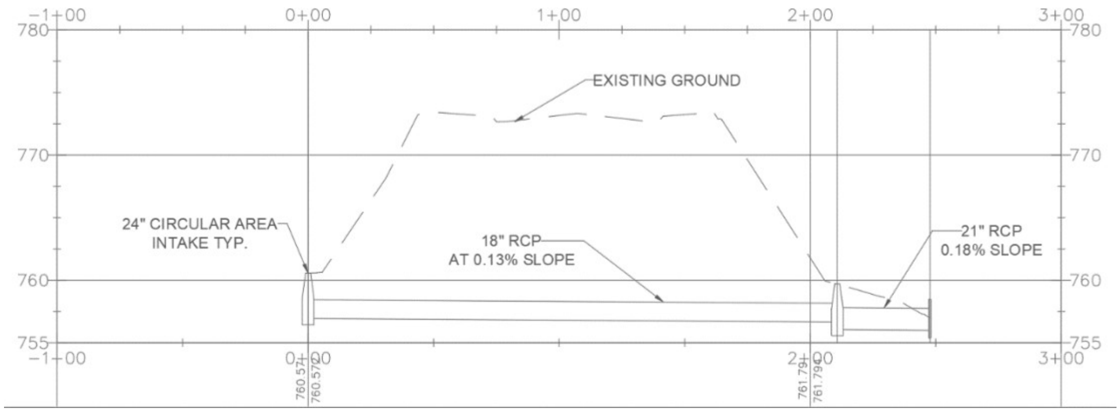
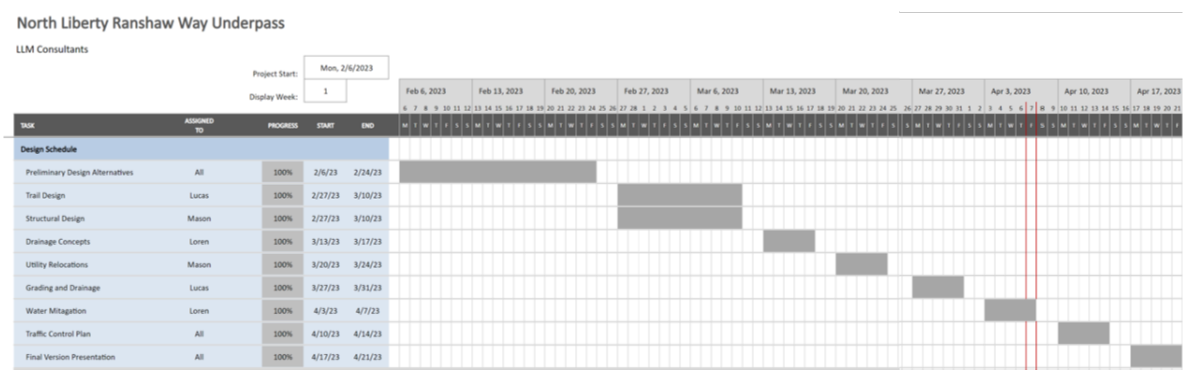


Figure 2: Storm Sewer Profile View

Appendix E: Other



TASK	ASSIGNED TO	PROGRESS	START	END
Design Schedule				
Preliminary Design Alternatives	All	100%	2/6/23	2/24/23
Trail Design	Lucas	100%	2/27/23	3/10/23
Structural Design	Mason	100%	2/27/23	3/10/23
Drainage Concepts	Loren	100%	3/13/23	3/17/23
Utility Relocations	Mason	100%	3/20/23	3/24/23
Grading and Drainage	Lucas	100%	3/27/23	3/31/23
Water Mitagation	Loren	100%	4/3/23	4/7/23
Traffic Control Plan	All	100%	4/10/23	4/14/23
Final Version Presentation	All	100%	4/17/23	4/21/23

Figure 1: Design Schedule

Table 1: Design Cost Estimate

North Liberty Ranshaw Way Underpass Estimate

Item Number	Description	Quantity	Unit	Unit Price	Extended Amount
2102-0425046	SELECTED BACKFILL (SOIL)	1715	CY	$ 15.00	$ 25,725.00
2102-2710070	EXCAVATION, CLASS 10, ROADWAY AND BORROW	2201	CY	$ 27.00	$ 59,427.00
2111-8174100	GRANULAR SUBBASE 6"	1237	SY	$ 60.00	$ 74,220.00
2402-0425030	GRANULAR BACKFILL	1388	CY	$ 35.00	$ 48,580.00
2414-6444100	STEEL PIPE PEDESTRIAN HAND RAILING	988	LF	$ 113.00	$ 111,644.00
2415-2111409	PRECAST CONCRETE BOX CULVERT, 14 FT. X 9 FT.	113	LF	$ 1,800.00	$ 203,400.00
2435-0140148	CASTING FOR AREA INTAKE, TYPE 3B	4	EACH	$ 400.00	$ 1,600.00
2435-0140150	CIRCULAR AREA INTAKE, SW-512	4	EACH	$ 750.00	$ 3,000.00
2435-0140188	CONCRETE RECTANGULAR HEADWALL, 21" OUTLET	1	EACH	$ 500.00	$ 500.00
2503-0114215	STORM SEWER GRAVITY MAIN, TRENCHED, REINFORCED CONCRETE PIPE (RCP), 2000D (CLASS III), 15 IN.	50	LF	$ 85.00	$ 4,250.00
2503-0114218	STORM SEWER GRAVITY MAIN, TRENCHED, REINFORCED CONCRETE PIPE (RCP), 2000D (CLASS III), 18 IN.	211	LF	$ 95.00	$ 20,045.00
2503-0114221	STORM SEWER GRAVITY MAIN, TRENCHED, REINFORCED CONCRETE PIPE (RCP), 2000D (CLASS III), 21 IN.	38	LF	$ 105.00	$ 3,990.00
2511-0302400	RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 4 IN.	126	SY	$ 55.00	$ 6,930.00
2511-0302600	RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 6 IN.	1111	SY	$ 65.00	$ 72,215.00
2516-8725000	P.C. CONCRETE RETAINING WALL	202	CY	$ 1,000.00	$ 202,000.00
2526-8285000	CONSTRUCTION SURVEY	1	LS	$12,000.00	$ 12,000.00
2533-4980005	MOBILIZATION	1	LS	$50,000.00	$ 50,000.00
2601-2636070	HYDRAULIC SEEDING	0.3	ACRE	$ 5,000.00	$ 1,500.00
		Sub Total			$ 900,000.00
		Contingency		20.00%	$ 200,000.00
		Total			$ 1,100,000.00

Design Renderings

All renderings and modeling completed in 3ds Max software.