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# Boy Scouts of America Concept Site Master Plan and Improvements

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Boy Scouts of America  
Outdoor Education Center  
Concept Site Master Plan and Improvements

An Undergraduate Honors Thesis  
Submitted in Partial fulfillment of  
University Honors Program Requirements  
University of Nebraska-Lincoln

By

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## **Abstract**

Our team, G1 Engineering, has partnered with the Boy Scouts of America to provide an update to their master plan for the Outdoor Education Center site located at 600 S. 120<sup>th</sup> Street, Lincoln, NE. Our work included providing transportation solutions; drainage evaluations; investigation of geotechnical conditions; environmental evaluation and determination of permitting requirements; preparation of concept design plans for bridges, drainage, utilities, and overall site plan; and evaluation of structural elements included in the project.

Two streams cross the property presenting site access issues. Our team provided pedestrian, UTV, and emergency vehicle access bridges to address these issues. With the two streams on the property, a majority of the land is classified as a floodway or a floodplain. As such, there are regulations placed on any structures built in these areas to not raise flood elevations. Recent expanded use of the facility has led to strains on the parking areas and wastewater facilities. Our team has proposed solutions for expanded parking lots and lagoon operations. Finally, our team investigated the geotechnical conditions present on the site to allow for proper construction and placement of foundations of proposed structures.

**Key Words:** Civil Engineering, Boy Scouts, Structural, Water Resources, Transportation, Environmental, Geotechnical

This senior design project included design portions from each of the five subdisciplines of civil engineering. As an honors student, I served as the project manager and the technical expert for the geotechnical subdiscipline. As the project manager I served as the communication link between my team and the client, coordinated design completion stages, and became an expert in all the design recommendations of each subdiscipline. I coordinated and led group meetings and reviewed and compiled design portions. As the geotechnical expert, I researched the existing soil conditions on the property and investigated relevant construction requirements for the placement of design components.

It was challenging to coordinate a group that did not like to complete work until the very last minute. I set due dates early, to allow sufficient time for my review. This allowed members to have a cushion, in case other obligations cropped up with other classes or work. I also learned to provide high-quality quick reviews of our documents for work that was not completed until the last minute. I always organized my work so that I completed my geotechnical portions far before the actual deadlines so that I could dedicate a majority of my time to reviewing and compiling the contributions of my other group members.

It was challenging to encourage group members to take this project seriously in order to provide excellent recommendations to the client. To combat this, I reminded group members that their work could serve as the foundation for actual projects on the site. I worked with many of my group members to write a high-quality report by helping rewrite sections and providing comments. It was challenging to be the technical expert for the geotechnical section with little formal background training in this material, but through dedicated research I was able to come out successful on this task. Upon completion of this project our team was able to provide a high quality product to the client through dedicated research and expert advice.



**G1  
ENGINEERING**



## **Outdoor Education Center Concept Site Master Plan and Improvements**

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May 1, 2019

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**Introduction**

This report contains the final 30% design plans for the Outdoor Education Center (OEC) concept site master plan and improvements. This report was requested by the Cornhusker Council Boy Scouts of America to provide an update to the long-range master plan which was completed in the mid-2000s. The client has requested drainage evaluations; environmental evaluation and determination of permitting requirements; investigation of geotechnical conditions; a traffic study; preparation of concept design plans for bridge, drainage, utility, and site; and evaluation and concept design for structural elements included in the project.

## Water Resources Design

Engineer: William Seeger

### Introduction

The following information provides research and studies of hydraulic features on the OEC property including drainage evaluations, potential constraints and challenges, sizes of proposed hydraulic structures, and streambank stabilization measures.

### Site Information

#### Streams:

Two streams run through the property. Stevens Creek and Scout Creek. Past Federal Emergency Management Agency (FEMA) studies determined the hydrology of each stream. A summary of the hydrology for Stevens Creek and Scout Creek is shown in Tables 1 and 2. Both of the streams on the property flow north to south.

<b>Table 1. Stevens Creek Hydrology</b>	
<i>Storm</i>	<i>Average Peak Flow (CFS)</i>
2-year	3346.32
5-year	5379.64
10-year	6867.30
50-year	9854.30
100-year	11593.84
500-year	15358.42

<b>Table 2. Scout Creek Hydrology</b>	
<i>Storm</i>	<i>Average Peak Flow (CFS)</i>
2-year	751.53
5-year	1276.11
10-year	1759.42
50-year	2701.58
100-year	3248.47
500-year	4532.79

#### Existing Hydraulic Structures:

There are two existing pedestrian bridges along Scout Creek that are shown in Figure 1 and Figure 2. There is also a low-water crossing along Scout Creek that is shown in Figure 3.



*Figure 1: Existing South Scout Creek Pedestrian Bridge Looking East*



*Figure 3: Existing Low-Water Crossing Looking East*



*Figure 2: Existing North Scout Creek Pedestrian Bridge Looking Northeast*



Floodway and Floodplain:

A majority of the property is currently within a floodway or floodplain. As determined by FEMA studies, the floodways and floodplains on the property are shown in Figure 4.

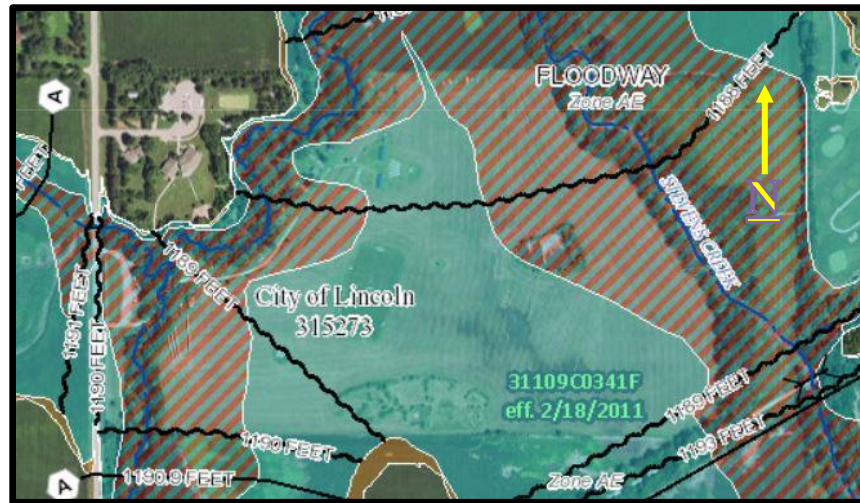


Figure 4. Floodway Map. Source: FEMA

Rainfall Information:

Rainfall information was gathered from the National Oceanic and Atmospheric Administration (NOAA). A summary of the rainfall information for the property’s location is shown in Table 3.

<b>Table 3. Precipitation Data Severe-Based Precipitation Frequency Estimates with 90% Confidence Intervals (inches/hour)</b>							
<b>Duration</b>	<b>Average Recurrence Interval (years)</b>						
	<i>1</i>	<i>2</i>	<i>10</i>	<i>25</i>	<i>50</i>	<i>100</i>	<i>500</i>
<i>5-min</i>	4.64	5.52	8.15	9.79	11.1	12.3	15.4
<i>10-min</i>	3.4	4.04	5.96	7.17	8.1	9.04	11.2
<i>15-min</i>	2.76	3.28	4.85	5.83	6.58	7.34	9.14

General Site Layout:

The client has requested site features including pedestrian bridges over both Stevens Creek and Scout Creek, emergency vehicle access across the creeks during high water events (defined as a 100-year storm), parking lots. These three features will be discussed in the water resources technical memorandum. Other requested general site layout features will be discussed in later technical memorandum sections.

## Challenges

### Scour:

The two existing pedestrian bridges along Scout Creek are susceptible to scour. Scour is the removal and erosion of sediment around bridge foundations, and it is the most common cause of bridge failure. As requested by the client, our team will be designing new pedestrian bridges across Scout Creek and Stevens Creek. Part of the design of the new bridges will include scour countermeasures to protect the foundation of the bridge.

### Overtopping and Pedestrian Bridges:

Our team will be designing a new pedestrian bridge over Scout Creek that will be designed not to experience overtopping up to a 10-year storm event. The location alternatives for the Scout Creek bridge are shown in Figure 5. Our team will also be designing a pedestrian crossing over Stevens Creek that will be designed to not overtop up to a 100-year storm event. The location alternatives for the Stevens Creek bridge are shown in Figure 6.

### Overtopping and Emergency Vehicle Access:

The property currently does not have a high-water access point over Scout Creek for emergency vehicles. Lancaster County does not recognize the current low-water crossing over Scout Creek as an emergency access because it is impassable during high water events. Our team will be designing a new high-water crossing structure. One possible location for this structure is at the current low-water crossing. The second possible location is further south along Scout Creek. Both of these location alternatives can be seen in Figure 7. The new crossing will be designed not to experience overtopping up to a 100-year storm event.

### Floodway Restrictions:

All the proposed water crossing on the property are within floodways as shown in Figure 4. The floodway poses restrictions on the water crossings' designs. All designs in the floodway are limited to no-rise in flood elevations of a 100-year storm. Our team must demonstrate that these proposed designs will not rise flood elevations to obtain the proper "no-rise" certification from FEMA.

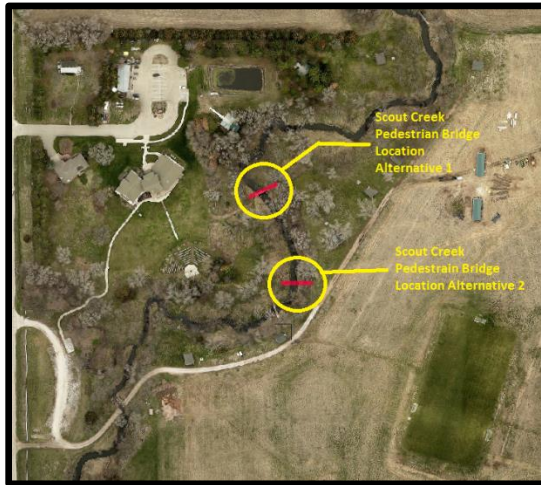
### Future Beltway:

The OEC is located along the proposed Nebraska Department of Transportation (NDOT) East Beltway corridor. This project may not be constructed for several years; however, our team will look at designs that are less likely to be impacted by the construction of the future beltway.

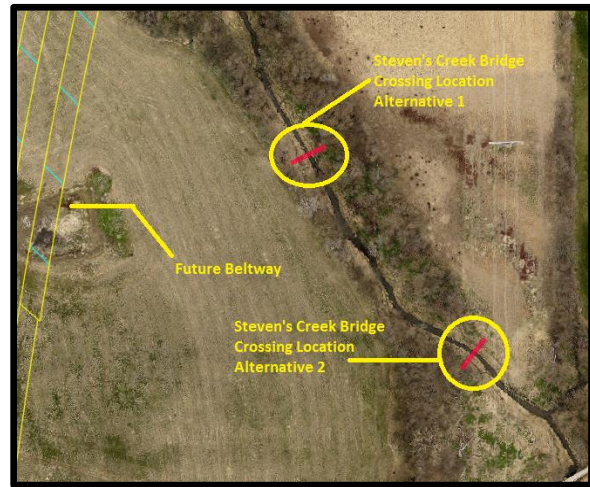
### Drainage:

One of the biggest features that our team is designing is a 300-space parking lot. This parking lot will need proper drainage features so water doesn't stagnate or spread on to the pavement surface. The area of the 300-space parking lot is designed to be 84,150 square feet.

## Alternatives



*Figure 5. Scout Creek Pedestrian Bridge Location Alternatives*



*Figure 6. Stevens Creek Pedestrian Bridge Location Alternatives*



*Figure 7. Emergency Vehicle Access Bridge Location Alternatives*

### Scout Creek and Stevens Creek Pedestrian Bridge Crossings:

Our team has developed two potential locations for the new pedestrian bridge over Scout Creek. The potential locations are shown in Figure 5.

Stevens Creek currently prevents access to the northeast corner of the property. As requested, our team is designing a water crossing that is suitable for pedestrians and UTVs so that the land on the east side of Stevens Creek can be utilized for camping. Our team has developed two potential locations for the new bridge as seen in Figure 6.

Our team ran hydraulic models to determine a location and design where these structures will not rise flood elevations of a 100-year storm event in compliance with FEMA's No-Rise Certification for floodways. To determine the locations of the structures, we also considered its relation to the new beltway that will be built through the property, tentatively in the next decade.

Emergency Vehicle Access Crossing on Scout Creek:

For the newly proposed emergency high-water crossing, our team has two potential locations. These two potential locations can be seen in Figure 7. One location will be over the current low-water crossing while the other is further south at a straighter part of the creek. The location of the new high-water crossing over Scout Creek will be recommended based on where the no-rise requirement can be met at the lowest cost.

Scour Countermeasures:

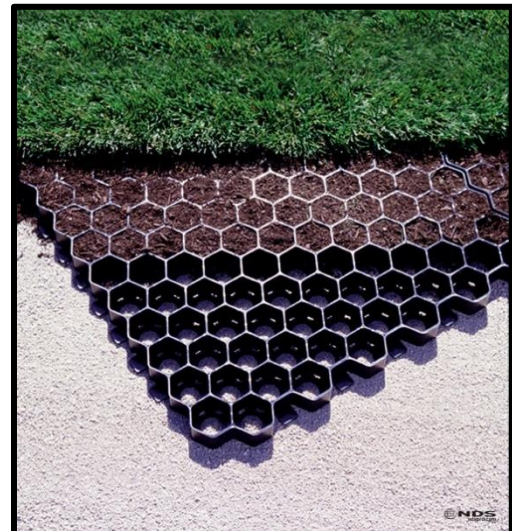
To protect the foundations of the proposed hydraulic structures. We have three different proposed alternatives to prevent scour of the new hydraulic structures: vegetation, tied concrete block mat, and riprap. These alternatives are discussed in more depth in the geotechnical memorandum.

Parking Lot Drainage:

Our team is looking at three alternatives to provide the proper drainage for the proposed parking lot. The first drainage feature alternative our team looked at was a vegetated filter strip. This option includes grading the parking lot so that it drains west towards Scout creek and all water would be filtered through the existing grass before reaching the stream. This alternative is also discussed in the environmental memorandum of this report. The second drainage alternative our team discussed was integrating rain gardens in and around the parking lot. A typical rain garden is shown in Figure 8. This alternative is also discussed in the environmental section of this report. The last alternative our team looked at was a geogrid with a grass cover. Geogrid is shown in Figure 9. Geogrid is also discussed in the transportation section of the report.



*Figure 8. Typical Rain Garden. Source: Butler University*



*Figure 9. Geogrid. Source: NDS Pavers*

**Analysis**

**Scout Creek Pedestrian Crossing:**

The two alternative locations for the Scout Creek crossing are shown in Figure 5. Using a computer software named Hydrologic Engineering Center-River Analysis System (HEC-RAS), our team was able to create hydraulic models to determine how different structure sizes would affect the flood elevations of a 100-year storm event in the floodway and determine proper design elevations so that the structures will not experience over topping up to a 10-year storm. A summary of the data can be seen in Table 4. As shown, a 30-foot span for the pedestrian bridge at each location will be efficient to span the crossing while maintaining a no-rise in the flood elevation of a 100-year storm. As also seen in Table 4, the two alternatives also do not experience overtopping of a design storm of 10-years.

<b>Table 4. Scout Creek Pedestrian Bridge Alternatives Hydraulic Information</b>						
<i>Locations</i>	<i>Length (ft.)</i>	<i>Design to not overtop (storm)</i>	<i>100-year flood elevation before structure (ft.)</i>	<i>100-year flood elevation after to structure (ft.)</i>	<i>Change in elevations (ft.)</i>	<i>Deck to high-water of design overtopping storm (ft.)</i>
Scout Creek Pedestrian Bridge Location Alternative 1	30.0	100-year	1189.6	1189.6	0.0	5.3
Scout Creek Pedestrian Bridge Location Alternative 2	30.0	10-year	1180.0	1180.0	0.0	2.6

Stevens Creek Crossing:

The two alternative locations for the Stevens Creek crossing are shown in Figure 6. Using HEC-RAS, our team was able to model the crossings over the two potential locations. The results from the two alternatives are shown in Table 5. As shown, the two alternatives have significant differences in the length of the bridge as well as how they affect the flood elevations of a 100-year storm event. The shorter spanning bridge at location 1 does not rise flood elevations while the longer spanning bridge at location 2 rises flood elevations by about 3 inches. Both bridge locations do not experience overtopping during a design storm of 100-years.

<b>Table 5. Stevens Creek Access Bridge Alternatives Hydraulic Information</b>								
<i>Locations</i>	<i>Length (ft.)</i>	<i>Design to not overtop (storm)</i>	<i>100-year flood elevation before structure (ft.)</i>	<i>100-year flood elevation after to structure (ft.)</i>	<i>Change in elevations (ft.)</i>	<i>Deck to high-water of design overtopping storm (ft.)</i>	<i>Span No. 1 &amp; No. 3</i>	<i>Span No. 2</i>
Stevens Creek Crossing Location Alternative 1	95.0	100-year	1189.1	1189.1	0.0	5.9	28'-6"	38'-0"
Stevens Creek Crossing Location Alternative 2	120.0	100-year	1189.9	1190.1	0.3	4.8	36'-0"	48'-0"

Emergency Vehicle Access Crossing on Scout Creek:

The two alternative locations for the emergency access crossing are shown in Figure 7. Using the same technique as the Stevens Creek and Scout Creek pedestrian crossing, a hydraulic study was conducted on the alternative locations for the high-water crossing over Scout creek for emergency access. A summary of the data from the hydraulic study is shown in Table 6. As shown, both locations provide a zero rise in the flood elevations of a 100-year storm. There is a significant difference in the length of the bridges. The first alternative over the current low-water crossing would require a shorter span, while alternative two would be longer and would require three spans. Both alternatives do not experience overtopping up to a design storm of 100-years.

<b>Table 6. Emergency Access Bridge Alternatives Hydraulic Information</b>								
<i>Locations</i>	<i>Length (ft.)</i>	<i>Design to not overtop (storm)</i>	<i>100-year flood elevation before structure (ft.)</i>	<i>100-year flood elevation after to structure (ft.)</i>	<i>Change in elevations (ft.)</i>	<i>Deck to high-water of design overtopping storm (ft.)</i>	<i>Span No. 1 &amp; No. 3</i>	<i>Span No. 2</i>
Emergency Access Crossing Location Alternative 1	30.0	100-year	1189.6	1189.6	0.0	5.3	Single Span	Single Span
Emergency Access Crossing Location Alternative 2	65.0	100-year	1190.9	1191.0	0.0	4.0	19'-6"	26'-0

Scour Countermeasures:

Using the HEC-RAS software, scour depth of the piers and abutments for each of the design alternatives were calculated. These scour depths are shown in Table 7. To protect the bridges from scouring there are three different alternatives that our team is considering: vegetation, tied concrete block mat, or riprap.

<b>Table 7. Scour Depths</b>		
<i>Locations</i>	Abutment Scour (ft)	Pier Scour (ft)
Scout Creek Pedestrian Bridge Location Alternative 1	10.0	NA
Scout Creek Pedestrian Bridge Location Alternative 2	10.0	NA
Emergency Access Crossing Location Alternative 1	12.0	NA
Emergency Access Crossing Location Alternative 2	12.0	3.0
Stevens Creek Crossing Location Alternative 1	15.0	10.0
Stevens Creek Crossing Location Alternative 2	15.0	10.0

Parking Lot Drainage:

While analyzing drainage features, it was determined that around 12,000 square feet of rain gardens would be needed to collect and treat the runoff water from the paved parking lot. The benefits of rain gardens include their ability to improve water quality by filtering out pollutants and they are aesthetically pleasing and easy to maintain. More benefits of rain gardens are discussed in the environmental section of the report. While the geogrid alternative will not provide a paved parking lot, it will maintain the property’s current natural drainage and be strong enough to have traffic drive on top of it. The geogrid is a beneficial alternative because the current field can still be utilized when parking is not needed, and it is aesthetically pleasing for the property. More benefits of the geogrid parking lot are discussed in the transportation section of the report.

**Recommendations**

Scout Creek Pedestrian Crossing:

After analyzing the different alternatives for the pedestrian bridge crossings, it was determined that each potential bridge location would need to span the same distance not to rise flood elevations. Our team would recommend using the first alternative location because the bridge will overtop less frequently because the deck can easily be placed at a higher elevation.



#### Stevens Creek Pedestrian Crossing:

After reviewing the hydraulic data for each bridge alternative along Stevens Creek, our team determined that the preferred bridge location would be in location alternative one. This bridge is recommended because it spans a significantly shorter distance which will cost less to construct. This alternative is also the only option that meets the no-rise requirement of a 100-year storm event.

#### Emergency Vehicle Access Crossing on Scout Creek:

From the hydraulic study on the two emergency vehicle access bridge locations, it was determined that both bridges have potential benefits for the client. Designing and constructing the new emergency crossing over the current low-water crossing would require a shorter span while meeting the no-rise requirements; however, constructing the emergency access crossing at location alternative two would give a second access point for the property and may help with traffic congestion during large events.

#### Scour Countermeasures:

From the scour depths calculated by the hydraulic studies, our team determined that using a scour countermeasure is required to protect the bridge's foundations. Our team is recommending the use of riprap and vegetation to help protect the bridges from scour.

#### Parking Lot Drainage:

After estimating the flow that will be running off the parking lot, our team would recommend the use of rain gardens to help collect the water that runs off the parking lot to prevent ponding for the paved parking lot. However, if a paved parking lot is no longer needed, our team would recommend using a geogrid with a grass top to provide parking when needed, but it still allows for full use of the grass area throughout the year when parking is not necessary.

#### Conclusion

In conclusion, the floodplains and floodways of the property create challenges when designing water crossings. The water crossings are limited to locations where a no-rise in flood elevation can be met. Our team believes that the recommended locations discussed in the report are the best options to meet the needs of the property while meeting all regulations and requirements.

## **Environmental Design**

Engineer: Nicholas Cowles

### **Introduction**

This memorandum will include several design concepts for improvement of site features pertaining to environmental engineering, along with their regulations, special permits, and associated details, in order to increase the sustainability and potential use of the site. The OEC site has potential environmental improvements including increased well system sizing, stormwater runoff pollution improvements, and increased wastewater capacity. Any changes to the site must also consider the potential impact on the wetlands and wildlife. Policies of wildlife and endangered species in Nebraska follow the criteria set by the Clean Water Act. G1 Engineering has been working alongside the University of Nebraska–Lincoln to ensure our engineering recommendations are of the utmost quality and provide economic, efficient, and sustainable solutions that have been designed with the client’s vision in mind.

### **Site Information**

By visiting the site and inspecting the issues related to environmental engineering, we were able to gain insight to provide the best solutions regarding the continued use and growth of this site. On-site inspections of the current wastewater pumping station, wastewater lagoon, well system, and current storm water drainage have been conducted. The OEC currently utilizes a wastewater lagoon and wet well to process the wastewater from the site. This lagoon is over 20 years old and has lacked proper maintenance and has incurred increased usage over the past several year. There is also one pump and water system that delivers potable water year round west of Scout Creek and to the east side during adequately warm temperatures via above ground pipes. Another environmental consideration is potential stormwater pollution due to the drainage on the existing paved parking lot near the caretaker residence. Several proposed improvements and alternatives have been considered.

### **Water System Challenges**

A well that supplies drinking water to the entire site is located at the top of a hill north of the OEC. This well was modified in 2002 to its current equipment. The current well pump is a STA-RITE, 5 HP, 50 series pump. This single pump has a maximum capacity of 60 gallons per minute. This pump delivers year-round water to the caretaker residence, soccer field, and OEC building. Due to an increased use of the site, it is important to confirm the adequacy of this pump. Overuse of the current pump from an increase in the peak water demand could cause premature failure. This would not allow for any potable water use on the site and could become a health risk to visitors and staff. The inability to properly clean food, utensils, hands and the constant usage of port-a-potties would increase the chance for disease and illnesses to spread, especially among the children. In order to ensure that the pump can keep up with future site demands, preliminary calculations and design of the current pump capacities have been considered. Another challenge of the current well system are the above-ground water pipes crossing Scout Creek. Currently, the pump cannot provide water

east of Scout Creek during the winter due to freezing and the potential of bursting water lines. Replacing the above-ground lines with lines installed at a proper bury depth would solve this issue and allow for year-round water across Scout Creek.

This site plan has assumed a very conservative growth rate of 100%. With the population of Lincoln growing rapidly, it is likely that this site will be within the city limits within 20 years and would have development nearby. Therefore, not only would there be more people in Lincoln, there would also be people much closer to the site than ever before. This may lead to increased usage of the site due to people not having to drive as far. In addition to population growth and population proximity, the number of girls in the scouts program will most likely increase rapidly over the next 20 years. With this inflation in site usage, our job is to assess if the current pump can and will be adequate in keeping up with the projected water demand.

### **Alternatives**

If the current pumping system is not adequate, a new pumping and water system would have to be designed and constructed. In addition, we have analyzed an alternative design to allow for year-round water on the entire site. To ensure the water does not freeze, the current water lines that run along the southern bridge crossing Scout Creek could be buried below the frost line.

### **Analysis and Findings**

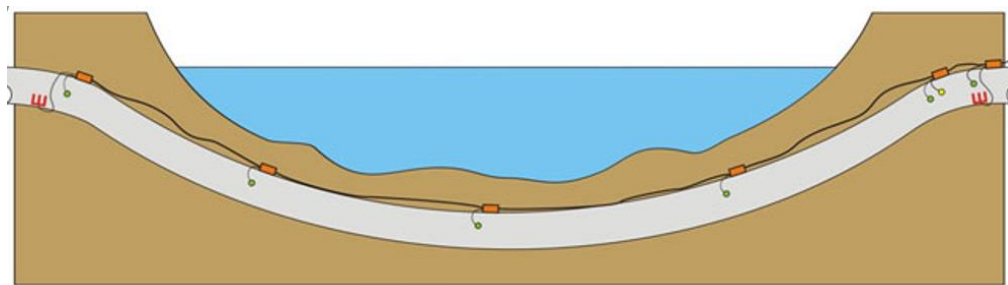
The average daily water demand has been calculated using conservative estimates and data from the on-site inspection. Water demands have been broken down into 6 main categories. The categories, ranked from highest demand to least demand, are as follows: irrigation, kids camps, full time staff, overnight training events, daily visitors and Market to Market Relay demand. Water demand for irrigation was calculated using *Table 2-7: Typical rates of water use for various devices and appliances from Metcalf and Eddy, 3<sup>rd</sup> edition*. Kids camps are assumed to be 6 days long and occur 8 times per year. These camps require overnight stays with shower usage taking up most of the demand at 5 gal/min. Also, overnight training events are assumed to have 50 participants and occur 2 times per month, 12 months per year. We assumed 15 average daily visitors every weekday for 8 months of the year. Finally, the Market to Market Relay demand was calculated by assuming 20% of the 400 visitors at this one-day event would use the restroom 2 times per day. The other 80% of visitors at the market to market event were presumed to use porta potties. *Table 8* below summarizes these calculations of water demand.

**Table 8. Water Demand**

<b>Event Type</b>	<b>Irrigation (1 in./week)</b>	<b>Kids Camps (6 days)</b>	<b>Full-Time staff</b>	<b>Overnight Training Events (3 days)</b>	<b>Daily Visitors (15/day)</b>	<b>Market-to- Market</b>
Events Per year	180 days of watering	8	240	24	160	1
Total Days Per Year	180 days of watering	48	240	72	160	1
Toilet Flushes per capita per day (1.3 gal/flush)	-	4 flushes	3 flushes	4 flushes	2 flushes	2 flushes
Sink Usage Per capita per day (2 gal/min)	-	4 uses	3 uses	4 uses	2 uses	2 uses
Hand washing time	-	20 seconds	20 seconds	20 seconds	20 seconds	20 seconds
Shower per Event	-	3 showers	-	2 showers	-	-
Shower Time (5 gal/min)	-	7 minutes	-	10 minutes	-	-
Gallons per Year	702,000	24,352	16,992	129,440	9,440	314.7
Gallons per Day	1,923	67	47	355	26	1
	<b>Average usage:</b>	2,418 (gal/day)	<b>Assuming 100% growth:</b>	4,836 (gal/day)	<b>Water Demand per Minute:</b>	10 (gal/min)

Assuming the current facilities will be used twice as often (100% growth rate) over the next 20 years, water flow will only reach approximately 10-15 gallons per minutes. Therefore, the current pump is adequate for future demands because it can handle up to 60 gallons per minute. This well system is considered a public water system and must meet Nebraska Department of Health and Human Services (NDHHS) National Advisory Control (NAC) Title 179 requirements due to this site having approximately 12 full time staff and 15 daily visitors over 60 times per year. Title 179 states that a water well must be at least 1000 feet from a source of contamination. Using computer aided design software, the distance between the water well and wastewater lagoon is approximately 300 feet. Therefore, any alterations or additions to the current well system would require additional design characteristics to be met.

The client has requested to have year-round water to the east of Scout Creek. For water to be pumped across Scout Creek, water pipes must be installed underneath Scout Creek. The freeze line in Nebraska is 42 inches deep. Water pipes are usually buried at a depth of 5 feet to ensure they are well below this freeze line. The year-round flow would allow for the use of fixtures inside the Harvey Hunter Lodge during all months of the year. There are currently no fixtures inside of Harvey Hunter Lodge. Buried water pipes would also allow an Iowa hydrant to be usable year-round east of Scout Creek. After the addition of an Iowa hydrant and fixtures in the Harvey Lodge, peak water demand could exceed 45 gallons per minute during heavy site usage. Therefore, the pump is adequate for current and future demand.



*Figure 10: Schematic of Under-Water Piping*

### **Recommendation**

After our water demand calculations, we recommend keeping the current well pumping system. Since this lagoon was constructed before these regulations were put in place, keeping it in its original condition would not require any special regulations or permits. We would also recommend burying the current pipes that run along the pedestrian bridge under Scout Creek. Using the existing pipes would save money and be easier to implement. The calculation of pipe size is not included in this 30% design report and would require further information to be designed.

### **Wastewater Challenge**

This site relies on a wastewater lagoon, located northeast of the OEC building, to process the wastewater. The lagoon is nearing its capacity due to increased use of the site. The dimensions of the current wastewater lagoon are: 24' long along slopes (4:1), 6' deep, 57' wide, and 119' long. The sloped sides are assumed to be along the width and length and can be visualized with *Figure 11* displayed below. The maximum volume has been calculated to be 18,810 cubic feet. However, there only remains approximately 2 feet of unused depth. This means that this wastewater lagoon can only hold up to 10,878 cubic feet more of wastewater before it will begin to overflow. Assuming the average daily wastewater of 460 gallons a day, this wastewater lagoon could fill up in less than 6 months. Overflow of the wastewater lagoon could pose a risk to the nearby wildlife and well system on the site.



*Figure 11: Typical Wastewater Lagoon.*

*Source: Maine Department of Environmental Protection*

### **Alternatives**

One solution to solving our wastewater challenge would be to hire a company to pump the current wastewater out of the lagoon into the nearby trunk sewer via a vacuum truck. The emptied lagoon would then start being filled again as the main wastewater treatment option. This would be the most cost-effective solution; however, it would only be a temporary solution. This process would have to happen on a regular interval to keep the lagoon from overflowing.

A second solution would be to increase the size of the lagoon. First the lagoon would be drained to the trunk sewer via a vacuum truck, then the current wastewater pumping station would be routed to the trunk sewer via a temporary pipe. This would allow for construction of increasing the size of the lagoon. After expansion of the lagoon, the temporary pipe from the wastewater pumping station could be removed and normal operation would resume.

Our third option is our most sustainable, long-term, and permanent solution. This solution would be to remove the wastewater lagoon. However, because the site is outside the city limits, this solution could have restrictions and regulations associated that could delay construction. This solution would require a permanent connection directly from the current wastewater well to the trunk sewer on 120<sup>th</sup> street. A permanent rerouting of the wastewater would require all steps stated in solution one above with an additional step of filling the wastewater lagoon in with fill dirt purchased from a general excavating company at a reduced bulk price. This solution would also provide green space or space for an additional storage facility.

### **Analysis and Findings**

Our first alternative design, to empty the lagoon into the city trunk sewer, is the simplest solution. This solution would not require any environmental permits and could be accomplished as soon as the trunk sewer is installed. The trunk sewer is planned to be completed by the end of June 2019. However, due to weather and other construction conflicts, this could be delayed a few months. The estimation of current inflow of 460 gallons per day into the lagoon shows that there would be adequate storage capacity in the lagoon until the beginning of October 2019. The contribution of

storm water, seepage, and evaporation have been taken into consideration in our first alternative design.

For our second alternative design, to increase the capacity of the lagoon, several regulations and rules apply. Since our average daily flow into the wastewater lagoon is currently at 460 gallons per day, we must make any alteration to the current design in accordance to Nebraska Department of Environmental Quality (NDEQ) Title 124. According to NDEQ Title 124, Chapter 2, we are not subject to the requirements in the Nebraska Administrative Code Title 123 which states “a wastewater treatment system with a design flow greater than 1000 gallons per day...is considered a wastewater works subject to... Title 123.” Our current wastewater lagoon meets all design requirements in NDEQ Title 124, except for maximum depth. Utilizing annual evaporation and precipitation data from Figure 18.1 and 18.2 of NDEQ Title 124, Chapter 18, the maximum water surface area of the new lagoon has been calculated. This design does not consider seepage, as this would require further on-site tests to complete. The maximum surface area of a new wastewater lagoon has been calculated to be 15,000 square feet. The current surface area is only about 7,000 square feet. Therefore, the surface size of the lagoon could be doubled under regulation. The lagoon location is recommended, however not required, to be set back at least 25 feet from neighboring trees and obstructions for better airflow and oxygenation of the lagoon. The maximum depth of the lagoon must be limited to 5 feet as per NDEQ 124.18.010. This would be the second most expensive design as it would require new liner, increased fencing, excavation and hauling of soil.

Our third solution, to permanently remove the current wastewater lagoon, could not be completed until the required permits were obtained. Prior to the removal of the wastewater lagoon, a permanent connection must be routed from the current wastewater pump station wet well to the trunk sewer. Although this site is currently outside of city limits and annex zone, the trunk sewer is owned by the city and in order to use it, permits must be obtained from the city. These permits and payments are beyond the 30% design plan for this project and have not been considered. Once these permits have been obtained, permanent piping construction from the wastewater pumping station to the city trunk sewer could occur. Once this has been completed, removing the wastewater lagoon could begin. Due to the wastewater lagoon being outside of the floodway and flood plain, fill would not increase the flood elevations and would not need special permits. The fill must meet the requirements stated in NDEQ 124.17.003. These requirements state that the lagoon must be drained completely, via a vacuum truck or evaporation, until there is no liquid remaining. Also, the fence and lagoon liner must be removed and properly disposed of and the “lagoon area shall be leveled and filled with clean soil...and the soil shall be mounded over the lagoon area to provide for future settling and to prevent from ponding.”

## **Recommendations**

We recommend emptying the wastewater lagoon via a vacuum truck and then beginning to fill the lagoon once again. This will prevent overflow of the lagoon while permission and permits are obtained from the city to reroute the wastewater pumping station to the trunk sewer. Once the wastewater pumping station has permanently been rerouted to the trunk sewer, removal of the current wastewater lagoon should be done as soon as possible to provide for usable land outside of the floodplain. This solution is the most sustainable and long-term solution and would greatly increase the potential for growth.

## **Stormwater Pollution Challenge**

There is currently only one paved parking lot that utilizes a simple direct-inlet drain that connects to Scout Creek. The current direct-inlet drain design meets NDEQ standards for stormwater drainage. However, a second and third paved parking lot are being designed that would drastically increase the amount of impervious pavement on the site. Our challenge is to filter stormwater runoff before it collects and transports animal waste, salt, pesticides, oil, grease, and fertilizers into Scout Creek as it drains from the two proposed impervious parking lot surfaces. These harmful substances would pose a risk to the wildlife that depend on clean streams to survive. Runoff including high levels of sediment can also increase the effects of streambank erosion over time. A solution that removes sediment and pollution would be desired. Therefore, three potential drainage options to improve stormwater quality have been preliminarily designed.

## **Alternatives**

The first option would be the integration of rain gardens or bioswales in the middle and on each side of the proposed parking lots. These rain gardens can be seen in blue around the main parking lot in concept plan number one in the appendix. Rain gardens are aesthetically pleasing and can filter pollutants carried in stormwater runoff. Tall grasses and deep-rooted perennials act as filters to suck up stormwater and trap pollutants. The gardens require seasonal maintenance that includes replacing dead plants and watering during droughts to keep the plants alive. The plants are designed to survive up to two weeks without rain. If these plants do not receive water for over two weeks, they could die. Therefore, monitoring the plants during dry parts of the year is important.

Our second and most inexpensive solution is the use of a vegetated filter strip. The proposed parking lot east of Scout Creek would be graded to direct all runoff to the west side of the parking lot. This runoff would then pass through a shallow grassy channel that has been designed to accept runoff associated with at least a 10-year storm. The filter strip would allow for the partial filtration of pollutants before entering the stream and would require nearly no maintenance.

Our third option is to implement a gravity-fed rapid sand filter basin for each of the parking lots. This option would be the most expensive and require higher maintenance than the previous two options. Rapid sand filters use coarse sand and gravel to filter the stormwater. Frequent



maintenance during peak site use and periods of heavy rainfall is important to keep the filter working properly.

### **Analysis and Findings**

Stormwater drainage design for the parking lots must meet federal, state and local regulatory requirements including United States Environmental Protection Agency (EPA) and NDEQ. Section 303-d of the Clean Water Act allows for the EPA to assist states in developing total maximum daily loads (TMDL's) for water bodies, such as Scout Creek and Stevens Creek. These TDML's provide the maximum amount of runoff pollution that can be accepted by a water body. These regulations would have to be considered if this 30% design were to be continued.

Rain gardens, our first alternative solution, are very effective filters and can remove up to 90% of pollutants from stormwater. These gardens would be bowl-shaped to catch all initial runoff and would be designed with dimensions deep enough to absorb the runoff of at least a 10-year storm. The calculations of stormwater runoff for a 10-year storm are beyond this 30% design. Each of the three rain gardens along the large parking lot would be approximately 15 feet wide and would run the entire length of the parking lot. Visual representations of what the rain gardens would look like are shown below in *Figure 12* and *Figure 13*.



*Figure 12:* Center of Parking Lot Rain Garden. Source: University of Minnesota



*Figure 13:* Parking Lot Edge Rain Garden. Source: Jensen Sports Park

The vegetated filter strip would be approximately as long as the proposed parking lot east of Scout Creek. This filter strip would be created by allowing native grasses and plants to grow without cutting the grass until they are at least six inches tall. This would allow for dense vegetation that would limit erosion and slow the runoff down to allow for more contaminants to be filtered. The conceptual design and location of the proposed filter strip can be seen in *Figure 14 and 15* below.



Figure 14: Conceptual Design Vegetated Filter Strip. Source: Impact Development Toolbox

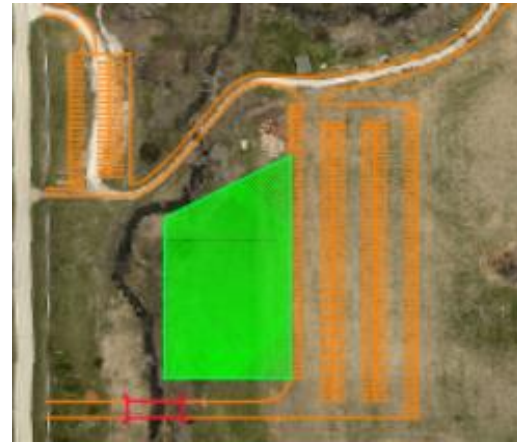


Figure 15: Design of Filter Strip for Parking Lot

A large gravity-fed rapid sand filtration basin would require permits to begin construction. After excavation of a 10' by 10' area on the west of the large parking lot, a wooden form would be set into the hole in preparation for concrete. A truck would then pour the concrete into the mold to create the basin. Then gravel and sand would be poured into this basin. All water draining from the parking lot would travel through this basin to a drain that would lead to Scout Creek.

### **Recommendations**

We recommend the use of rain gardens both inside the large parking lot east of Scout Creek and on either side of the parking lot. This would add beautiful scenery to the parking lot and would be the most practical method of removing the pollutants from stormwater runoff. For the parking lot on the west of Scout Creek, G1 Engineering recommends the use of a direct inlet drain. Due to the small size of this parking lot, stormwater pollution effects would be negligible and there is also inadequate space for a vegetated filter strip. The gravity-fed sand filtration basin design option was not pursued due to high cost and maintenance levels.

### **Conclusion**

Wastewater solutions will ensure the site has adequate capacity to handle the waste produced by an increased usage of the site. Drinking water solutions will provide expanded irrigation east of Scout Creek and provide Iowa Hydrants. Stormwater solutions will ensure clean discharge of runoff into the area streams.

## **Geotechnical Design**

Engineer: Anna Cole

### **Introduction**

The following information provides an investigation of the geotechnical conditions present on the Outdoor Education Center (OEC) property. The soils in the project area were evaluated, and their suitability for placement of utilities, structures, and associated site features in and above these soils was determined. Groundwater table and unstable streambank issues were addressed, and recommendations were made for working around these challenges.

### **Site Information**

#### **Existing Soil Profile:**

Four borings from the Sub-Basin E3 trunk sewer project were taken near the OEC property. They provide information on the existing soil conditions. The location of these borings are shown on the concept plans in the appendix. The existing soil consists of alluvial materials of sand, silt, and clay. The profile has layers of clay that are underlain by layers of sand mixed with clay. This profile is typical of floodplain soils that have stronger layers above weaker layers. The wetting and drying cycles above the groundwater table strengthen the top layers of the soil profile.

#### **Groundwater Table:**

According to these borings, the groundwater table on this property is high. Groundwater levels will be encountered between 6 and 23 feet below ground level.

#### **Unstable Streambanks:**

According to the Sub-Basin E3 Trunk Sewer Geotechnical Report, streams in the area were straightened in the 1920s, which caused a deepening of the stream channels. These deep channels have created unstable bank conditions with soil falling continually into the streams. During the site visit, evidence of scour, which is the removal and erosion of sediment around bridge foundations, under the current bridge abutments was observed. If streambank stabilization measures are not implemented near the bridges, the strength of the bridge abutments will be severely undermined, and failure will be imminent because scour is the most common cause of bridge failure. The stream locations have remained relatively stable for many years, but changing stream geometry should be considered when determining the location and length of the bridges. The bridges should be placed at locations where the stream is straighter because curved stream locations tend to be more unstable and experience channel widening that can undermine bridge abutments.

## **Challenges**

### **Groundwater Table:**

The high groundwater table on this property produces large hydrostatic pressures that cause instability in construction. Dewatering, which is the removal or exclusion of groundwater, will be required for construction purposes.

Piles will be used for bridge foundations on this site, as discussed in the structural technical memorandum. Dewatering techniques should be employed during construction placement of the pile foundations so that the piles will not pop back out of the ground due to the increased pore pressure from pile placement. Dewatering removes the water that causes the high pore pressure. When dewatering is terminated at the end of construction, the water will slowly seep back into the soil, but it will not cause increased pore pressure so the pile foundation will remain in place.

Several proposed projects for this site include pipe placements. These projects are discussed in the environmental technical section. Many of the pipe installations will be installed using the open trenching technique. In this construction technique, large hydrostatic pressures from the high groundwater table can cause instability failure of the trench walls and base. Dewatering of groundwater levels to a few feet below the excavation base will greatly improve the stability of the trench and provide safety for the workers. Additionally, dewatering will allow the pipes to be placed at the correct elevations without rising due to buoyancy forces in seeping water.

### **Unstable Streambanks:**

One technique to counteract the unstable streambanks is to place more fill soil in critical areas such as at bridge abutments. According to the Sub-Basin E3 Trunk Sewer Geotechnical Report, fill soil used in this area is more erodible than the soil currently on the banks. Placing more fill soil is not an adequate solution because high scour forces at bridge abutments will wash the soil downstream. Options for a more permanent solution to the erosion problem are presented in the alternatives section.

### **Water Utilities:**

Current water utilities run under the existing pedestrian bridges on Scout Creek. Since the pipe is located above ground for this portion, the utilities can only be used during months where there is no risk of freezing. As discussed in the environmental technical section, piping for underground utilities must be installed under Scout Creek. These utilities will provide a water supply and bathroom facilities at the Harvey Hunter Lodge year-round and all for the placement of several Iowa Hydrants.

## Alternatives

### Groundwater Table:

The two options to manage high groundwater levels are to remove water or to exclude the water from the construction area. The first option, removal of the water by deep well dewatering, pumps water to lower the groundwater table below the base of the excavation. Sump pumps may be used in open-trenching construction to remove excess seepage water that exists after deep well dewatering.

The second option, exclusion of groundwater is achieved by installing an impermeable layer around the construction area. The impermeable layer could be steel sheet piles, artificial freeze walls, or grout curtains. The area is then excavated, and any water that is trapped within the impermeable layer is pumped out with sump pumps.

For the construction of the emergency vehicle bridges, temporary cofferdams will create a dry area for installation of the piers. A cofferdam is a watertight enclosure that is pumped dry to allow for the construction of bridges. Water inflated tubes could act as the cofferdam walls, and bypass pumping will pump the flow of the creek to the downstream side of the cofferdam. Deep well dewatering or sheet piles should still be used for placement of abutment foundations.

There are two options for disposal of the dewatering flows that are created from the removal option. The first option is to obtain a National Pollutant Discharge Elimination System (NPDES) permit from the Nebraska Department of Environmental Quality (NDEQ) and discharge the flow into the adjacent creeks. The second option is to pump the discharge flows into the pond on the site and discharge into the adjacent creeks when the pond is at capacity. The sediment in the discharge flows will naturally filter out while it is in the pond. The pond disposal option will help prevent long term lowering of the groundwater table because the groundwater will be recharged by seepage through the bottom of the pond.

### Streambank Stabilization:

The following three options will solve the unstable streambank issues discussed in the site information section. These stability measures should be placed at bridge abutment locations shown in the conceptual site plans in the appendix and at any chronically unstable bank locations determined by visual inspection.

The first stabilization option is using a combination of riprap for toe protection along with live stakes, wattles, and seeding above the toe to create a living stabilized bank. A cross section of this stabilization technique is shown in Figure 16. Riprap is placed at the toe of the slope up to four feet along the slope to provide scour protection under normal flow conditions. Live stakes, wattles, and seeding will provide bank stabilization and scour protection under higher flow conditions. Live stakes are dormant cuttings which will sprout once they are planted in the ground. Their roots will bind the soil on the banks together. To install the live stakes, dig one-foot wide and deep trenches every four feet vertically along the slope above the riprap. Plant the live stakes at the bottom of the trenches as shown in Figure 16. Wattles are bundles of branches staked in place along the slope to reduce water velocity and prevent erosion. Branches from the trees removed for construction work could be trimmed and reused for the wattle material. To construct the wattles, trim branches that are approximately one inch in diameter and four to five feet in length from live trees. Tie the branches together with rope to create wattles that are approximately one foot in diameter. Place the wattles above the live stakes in the previously constructed trenches. Secure the wattles with three-foot-long stakes to prevent them from washing downstream during high flow events. Soil backfill should be placed to fill any unoccupied area in the trenches. Seeding should be placed between the live stakes and wattles to provide additional soil binding. To complete the installation, the area above the riprap should be watered for the first week to establish the sprouting. The long-term maintenance necessary for this stabilization option is trimming of any large shrubs, replanting any dead areas, and repairing any scoured areas after large storm events. This maintenance is similar to the maintenance already required for the wooded areas along the creek banks, so it is not excessively burdensome.

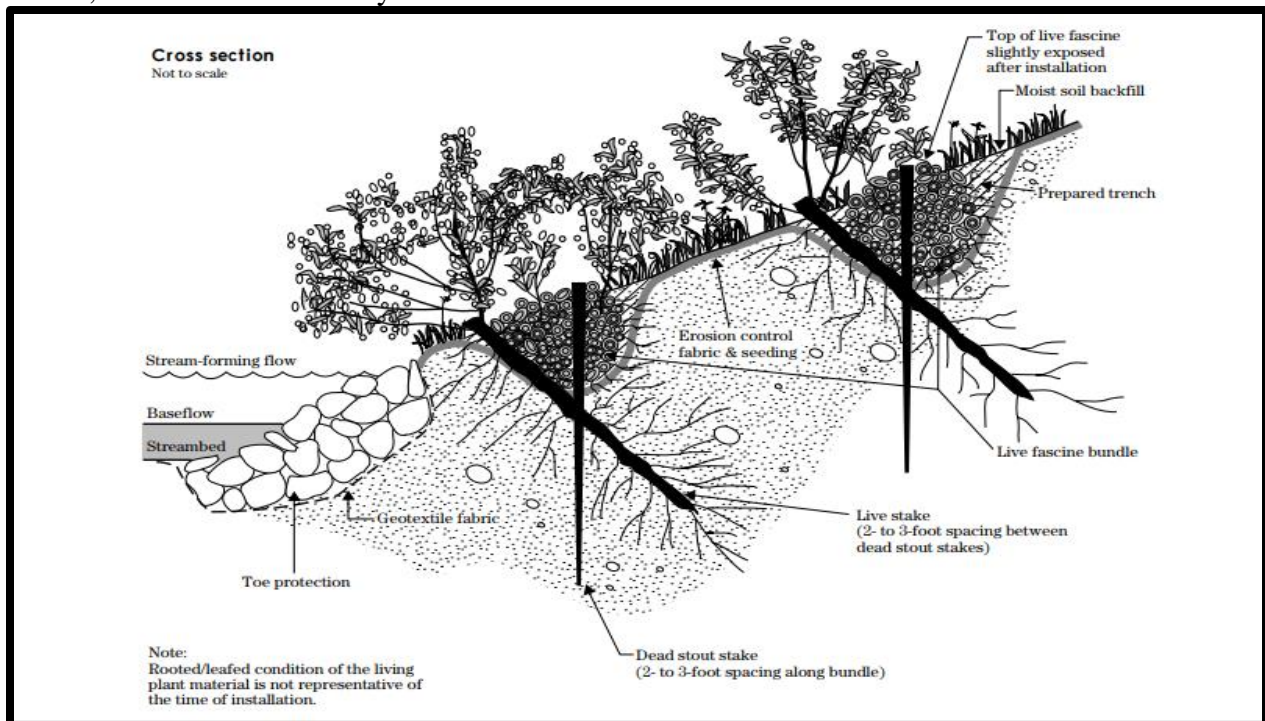


Figure 16: Cross Section of Brush Wattles and Live Staking. Source: United States Department of Agriculture Natural Resources Conservation Service

The second stabilization option is using a tied concrete block mat. This product, as pictured in Figure 17, consists of concrete blocks that are interwoven with a high strength geogrid. The concrete blocks are interlocked with 1.5 inch spacing between them to allow for flexibility and sprouting of vegetation growth that will cover the concrete blocks for a natural look. The banks are seeded with grasses, and then the tied concrete block mat is unrolled over the top. The block mat should be buried for a length of eighteen inches at the toe of the slope, and the geogrid can be staked along the slope to prevent movement of the block mat due to high stream scour forces. Visual inspection maintenance is required after large storm events to confirm the mat has not shifted and to ensure the integrity of the tied concrete block mat.



*Figure 17: Tied Concrete Block Mat. Source: Brock White Manufacturing*

The third stabilization option is the use of rock riprap. This technique, as pictured in Figure 18, places well-graded angular rocks over geotextile fabric along streambank slopes. The riprap acts as an armor between the soil and the water forces. Grasses will grow among the riprap to provide additional bank stabilization in areas where the riprap has migrated. Maintenance includes removal of stream obstructions and inspection for displaced riprap. This maintenance should be performed after any large storm event and is similar to the maintenance already performed on the site.



*Figure 18: Riprap around Bridge Abutments. Source: Wheeler-Con*

## Analyses

### Foundations and Piers:

As discussed in the site information section, the soil on this site consists of stronger layers of clay over weaker layers of sand over bedrock. Bridge abutments and piers will need deep pile foundations to transmit the load to stronger, deeper bedrock stratum. Deep foundations will also prevent erosion failure at pier locations. The new foundation for the Harvey Hunter lodge should be a shallow mat foundation. Borehole locations to test the soil for foundation design are detailed in the recommendations section. Since the existing soil data is preliminary, the design of pile foundations and shallow mat foundations is beyond the scope of the 30% design.

### Groundwater Table:

To use exclusion techniques such as sheet piles or grout curtains discussed in the alternatives section, a low permeability layer must be present at a relatively shallow depth (30 to 40 feet below grade). The exclusion walls must be placed down to the low permeability layer to prevent seepage under the walls. According to the boreholes in the Sub-Basin E3 Trunk Sewer Geotechnical Report, a low permeability layer is not encountered until around a depth of 45 feet at bedrock because permeable mixed clay and sandy soils exist deeper in the soil profile along this site. The exact depth of the bedrock would need to be determined by boreholes at specific construction locations to know how deep to place exclusion walls.

Dewatering by pumping will increase the weight of the soils above the lowered groundwater table. This additional weight will cause consolidation over time. Therefore, in open trenching construction, the dewatering process should only be active for the time necessary to place the structure and replace enough fill to counteract the hydrostatic pressure. Limiting the length of dewatering will prevent consolidation that will cause settlement of pipes.

### Streambank Stability:

Before streambank stabilization measures are placed, the banks should be graded to a stable geometry. According to the Sub-Basin E3 Trunk Sewer Geotechnical Report, the current bank slopes exist at 1-horizontal to 1-vertical, and a slope of 2-horizontal to 1-vertical will produce a more stable slope. Regrading will also allow for placement of armament at a gentler slope so it will remain in place for a longer period because it isn't susceptible to falling into the creek.

### Water Utilities:

A horizontal directional drilling machine will be used to run utilities under Scout Creek as discussed in the challenges section and the environmental technical section. The preliminary soil profile on the OEC site, found from the Sub-Basin E3 Trunk Sewer project boreholes, consists of soft alluvial soils, so high-pressure fluid will be used to remove materials from the borehole. According to the Sub-Basin E3 Trunk Sewer Geotechnical Report, boreholes encountered small grained particles, so larger pieces of rock that slow construction will not likely be encountered.



### Roadway Backfill:

Recommendations for the roadway and parking lot subgrades are in the transportation section. According to the Sub-Basin E3 Trunk Sewer Geotechnical Report, backfill should be placed in level lifts of less than 8-inch loose thickness. The water content of the soils should be  $\pm 4\%$  of optimum water content per ASTM D698-12e1 at the time of compaction. Each lift should be compacted to at least 95% of the maximum dry unit weight determined by ASTM D898-1221, standard Proctor Test.

### Soil Corrosivity:

A boring from the Sub-Basin E3 Trunk Sewer Geotechnical Report on the northwest corner of the property reveals that the soil in the area is corrosive to steel but has little corrosivity to concrete. Steel elements used in this project may include pipes, piers, and pile foundations. To avoid corrosion caused failures of steel elements, the steel should be coated with an anti-corrosion coating before installation.

## **Findings**

### Bedrock

The boreholes from the Sub-Basin E3 Trunk Sewer Geotechnical Report encountered layers of clay and sand. One borehole encountered weathered Dakota Sandstone at a depth of 42 ft below grade. This sandstone is in a medium dense condition and does not require blasting equipment for excavation. All layers can be excavated by backhoes which will help keep construction costs lower.

### Soil Suitability

Based on preliminary soil investigations performed for the Sub-Basin E3 Trunk Sewer project, the soil on the property is suitable and does not need to be replaced or reconditioned. Additional soil investigation suggested in the recommendations section will determine actual soil sufficiency.

## **Recommendations**

### Groundwater Table:

G1 Engineering recommends the use of deep well dewatering to remove groundwater. The depth of water removal can be more carefully controlled by this method. The site has adequate solutions to dispose of the dewatering flows.

Exclusionary dewatering methods such as sheet piles are not recommended by G1 Engineering. The exclusionary methods will need to be placed at a large depth to reach the low permeability bedrock layer. The depth of the bedrock will be determined by future boring investigations detailed later in the recommendations section. This large depth can drive up material and construction costs, but the sheet piles can be reused. Additionally, the depth to the low permeable layer is much deeper than any excavation on this site.

The use of exclusionary cofferdams is recommended for bridge pier installations. Cofferdams will create a dry working environment for proper placement of piers. Deep well dewatering or sheet piles will still be necessary for the installation of pile foundations for bridge abutments. The ultimate decision for dewatering techniques is made by the contractor so these recommendations may be overridden.

#### Streambank Stabilization:

G1 Engineering recommends the use of a combination of riprap, brush wattles, live staking and seeding for streambank stabilization and armament. This option provides instant scour protection from the riprap while the living stabilized bank is being established. This option creates a natural looking streambank that prevents erosion in an ecologically friendly way by providing a habitat for insects and small animals and birds. This solution will be the most cost-effective option because the material for the wattles is already present on the site. This option requires very little additional maintenance to what is already being performed on the site. Since the brush wattles are staked in place and the live stakes are planted, there is little risk of them migrating downstream due to stream scour forces. We recommend this option because it is the most cost effective, aesthetically pleasing, and effective for preventing erosion from scour.

The use of a tied concrete block mat for streambank stabilization could also be used. This option will provide excellent scour protection and will not migrate downstream because it is staked in the ground. This option is higher cost, doesn't provide habitat for wildlife, and does not fit the aesthetics the client desires as well; therefore, it is not the recommended option.

We do not recommend the use of riprap for streambank stabilization. Riprap will help the banks become vegetated, but due to the high stream scour forces it will tend to migrate downstream. This migration leads to excessive maintenance requirements to continually reposition the riprap. Eventually, a large portion of the riprap may wash downstream which would leave bridge abutments vulnerable to scour in areas where the vegetation had not become well established.

#### Future Design Recommendations:

To proceed with the design, additional borings will need to be taken to determine soil properties so foundations can be designed, and settlement can be determined. Information from the borings will also determine actual soil sufficiency as discussed in the findings section. Figure 20 shows the location of the proposed boreholes. The orange circles show boreholes at bridge abutments and piers. These boreholes will need to be 60 feet deep or as deep as the bedrock layer. One borehole should be taken at each bridge abutment and each pier for the bridge locations chosen for the design. The purple circles show boreholes used for the Harvey Hunter Lodge, parking lot design, and roadway design. These boreholes will need to be 35 feet deep.

### General Site Layout:

The client has requested site layout features including lighting, trees, relocation of the Harvey Hunter Lodge, and plans for the pond. Our team proposes placing lighting around the soccer field for increased usage by renting the field and extended usable hours. Additionally, lighting should be installed in the parking lots, RV parking pad locations, and bridge locations. The lighting in these three areas would increase the security and functionality of the site. The design of the lighting features beyond the general site layout is outside the scope of civil engineering. Implementation of trees is included in rain garden locations shown in the green area in Figure 6. The design and use of rain gardens are discussed in the environmental and water resources design sections. Other areas of optimal tree locations will be assessed as locations of activity fields are solidified. A tree barrier along the west and east side of the proposed East Beltway alignment would help reduce noise and provide privacy. The current pond on the site is located directly below the proposed East Beltway. No improvements should be made to the pond, as they will be lost during the implementation of the beltway. Construction crews will bear the cost for filling in the pond for the beltway. The Harvey Hunter Lodge should be moved southeast of its current location, as shown in the conceptual site plans in the appendix. This new location will place the lodge out of the floodway so it can function as an overnight residence. Additionally, the new location will allow the lodge to be used more effectively as a guest check-in point.

### Conclusion

Based upon preliminary investigations performed near the site, the soils in the project area were found suitable for placement of utilities and structures in and above the soils. At this time no soil reconditioning or replacement within the project area has been deemed necessary. Further soil investigations necessary for the continuation of design will determine the validity of these conclusions. Dewatering operations will be necessary for safe open-trenching construction conditions for pipe placement, allow pipes to be placed at correct elevations for proper functioning, and allow placement of foundations that properly support structures. Streambank stabilization measure will prevent excessive erosion and protect streambanks from scour forces.



Figure 19: Boring Locations and Estimated Natural Creek Channel from the Sub-Basin E3 Trunk Sewer Report by Schemmer

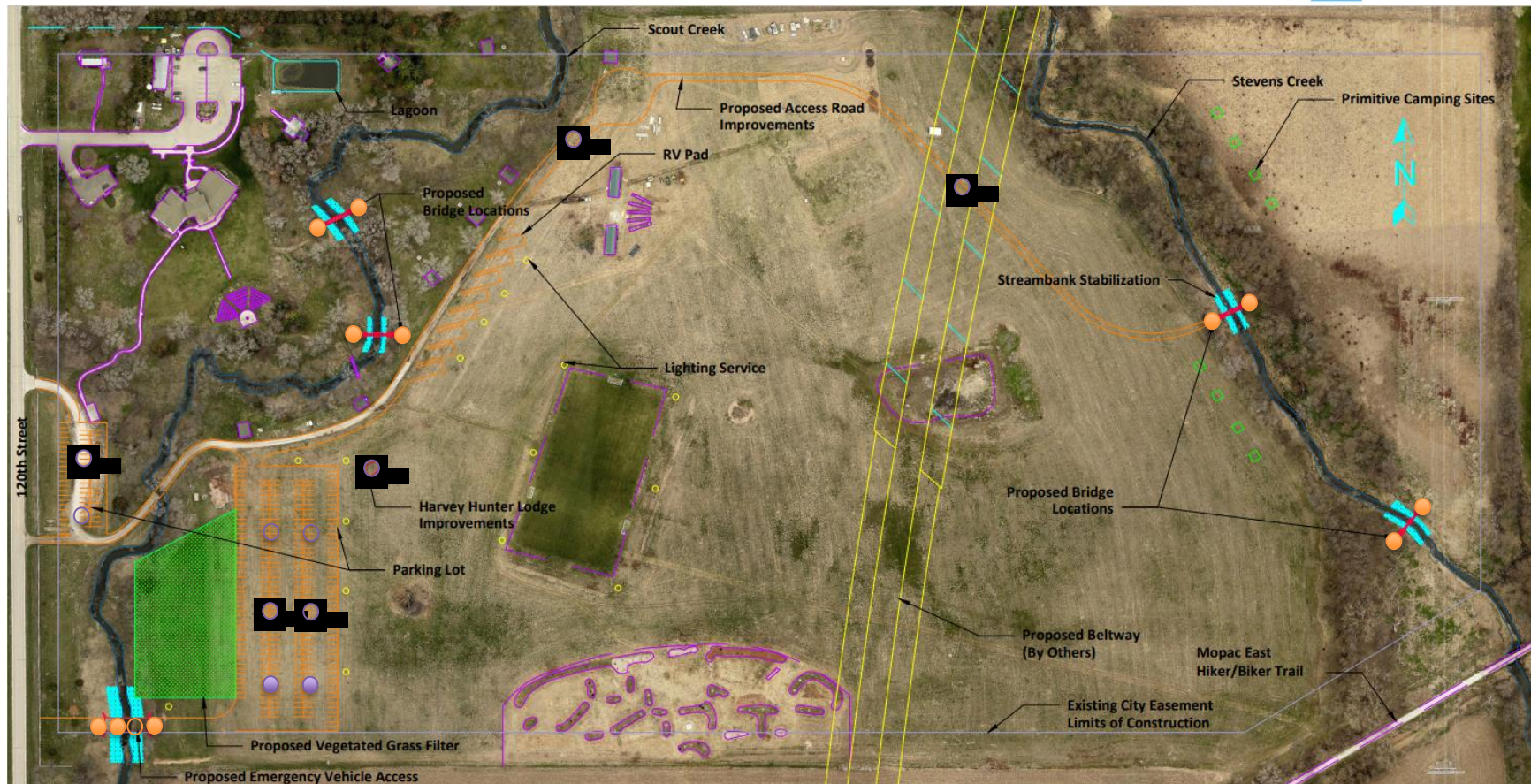


Figure 20: Proposed Boring Locations

## **Transportation Design**

Engineer: Shanon Al-Badry

### **Introduction**

The objective of the transportation technical memorandum is to discuss, analyze, and find solutions to provide site accessibility for the OEC. In this technical memorandum site accessibility refers to vehicles being able to enter and exit the site efficiently. The mission of G1 Engineering is to ensure safe and efficient site accessibility to the OEC which is very crucial due to a large number of guests who are attending events on the property such as the Market to Market Relay, day camps, and recruitment events. The client has requested improvements to provide adequate parking spaces, emergency vehicle access, RV parking pads, and site accessibility with the proposed East beltway.

### **Site Information**

#### **General Site Information:**

The OEC is located in Lincoln, Nebraska on South 120th Street. The OEC serves many guests that have varied lengths of stay on the site. Improving the site's infrastructure is crucial to protect the high volumes of people walking around. The site currently has a sports field, camping shelters, shotgun/archery gun range, challenge courses, and climbing wall. In order for people to be able to access all the activity areas on the site, we will need to provide traffic solutions and make the site safe and accessible.

#### **Parking Lot:**

The site currently has two parking lots, the first one is paved and is located in the northwest corner of the property. The second parking lot is unpaved and is located west of Scout Creek. The unpaved parking lot has a setback from the South 120th street, so the parking lot cannot be extended to the edge of the property. The setback easement is pictured in Figure 20 and 21 by the orange cones. The setback limits the number of parking spaces, so the property cannot be used to its full potential because it cannot accommodate parking for large number of guests.

#### **Emergency Vehicle Access:**

The current low-water crossing is not recognized as an emergency vehicle crossing by Lancaster County. The low-water crossing is overtopped during high flow conditions making it impassable due to the water levels. Emergency vehicle access over Scout Creek must be provided by a high-water crossing to accommodate overnight camping east of Scout Creek. The current low-water crossing can only accommodate one-way traffic causing congestion problems if this continues to be the only access east of Scout Creek as the use of the property expands.

### Access Road:

The proposed NDOT East Beltway runs through the center of the property thus dividing the east portion from the western portion. Site accessibility will become extremely limited after the construction of the beltway.

### RV Pads:

The client has requested provision of RV parking pads in the new site master plan. Since the site lacks RV pads, not many RV's are able to recharge, park, and access the site adequately. The provision of RV parking pads would allow for expanded use of the facility.

### Challenges

#### Parking Lot:

Due to increased usage of the site, guests have trouble finding parking in the limited parking areas. The first challenge is providing a sufficient number of vehicle parking spaces. In order for the OEC to have more guests, the site must be able to accommodate the high volumes of visitors. The client has requested a parking lot design to accommodate 300 parking spots for events that have high volumes of guests. The current, unpaved parking lot, located west of Scout Creek, provides a limited number of parking spaces due to inefficient design and portions of it extending into the city setback. Currently there are cones placed in the unpaved parking lot to prevent guests from parking in the setback area as shown in Figure 21. The dimensions for this existing parking lot made it challenging to provide enough space for vehicles to enter and exit parking spaces and limit congestion in the aisles. We were able to place 63 parking spaces in the unpaved parking lot that are 8.5 feet wide and 18 feet long. Another challenge with the existing, unpaved parking lot is providing enough space for emergency vehicles to maneuver without congestion. The paved parking lot on the northwest corner of the property serves the staff and day visitors for the site, but generally is not big enough to handle the large volumes of guests visiting the site. Setback constraints and existing property features do not allow the northwest parking lot to be expanded.

#### Emergency Vehicle Access:

Currently, the OEC lacks emergency vehicle access on the site over the low-water crossing. It is important to have an emergency entry/exit if any accidents occur on site. G1 Engineering initially recommended replacing the current low-water crossing with a high-water crossing to function as the emergency vehicle access point. However, after a traffic study was performed, we decided a better location for the emergency vehicle access was further south on Scout Creek. This would provide another entrance and exit to the site and allow the low-water crossing to still be used when flow conditions permitted. If we placed the emergency exit at the current low-water crossing location, traffic congestion would still exist. With the emergency vehicle access placed further south on Scout Creek, a challenge would be having the emergency vehicles enter and exit through the 300-space parking lot.

### Access Road:

The site is located along the proposed NDOT East Beltway corridor, which means the beltway will run through the center of the property, effectively cutting off access between the eastern and western side of the property. G1 Engineering initially planned to place an unpaved road that would run below the beltway bridge that crosses over Stevens Creek on the northern border of the property as stated in the structural design memorandum. The unpaved road would have consisted of dirt, gravel, and fine-sized particles. Gravel is a mixture of sand, fines, and stones. After discussion with the client about their preference of the road's design, we then decided to pave the road with asphalt. One problem with asphalt is that it does not function well with weathering, for instance, during cold temperatures it is more complicated to attain optimum density during construction.

### RV Pads:

The OEC currently lacks RV pads, so guests cannot stay in RV's on the site. The client has requested provision of RV pads for expanded camping facilities on the site. The RV's will need to be able to access the camping pads safely and efficiently. The RV pads will be located on the east side of the access road. One challenge associated with designing the RV pads was creating the optimal balance of parking pad size and angle to accommodate the largest number of RV's while also providing them with a nicely sized and easily accessible camping site. It is important for the RV drivers to have adequate space for the RV to park safely, and for families to have enough room to maneuver.

### Alternatives

#### Parking Lot:

There are several material alternatives for the 300-space parking lot located east of Scout Creek and the currently unpaved parking lot located west of Scout Creek. Material alternatives include paving the parking spaces with concrete or asphalt. The parking lot located west of Scout Creek will encounter congestion problems unless proper solutions are implemented. G1 Engineering proposes two alternatives to reduce traffic congestion in this parking lot. The first option is to have a one-way entrance and a one-way exit. The entrance will be placed on the north end of the parking lot, and the exit will be located on the south end of the parking lot at an existing gate. The second option is to make the parking lot entrance and exit two-way and provide proper signs such as one-way signs and stop signs for vehicles to enter and exit accordingly.

#### Emergency Vehicle Access:

One design option will be to have an emergency access road located in the southwest corner of the property. This road will have two-way traffic, and each lane will be 11 feet wide. This option will retain the low-water crossing for use when water elevations are low. The second option for the emergency vehicle access road is to place a high-water crossing at the current low-water crossing



location and make it two-way traffic with 11 feet wide lanes, for a total of 22 feet plus an additional one foot shoulder on each side for a total of 24 feet. The local lane widths were determined from NDOT specifications as shown in Figure 23.

#### Access Road:

Since the proposed East Beltway will divide the property in the future, we will need to provide site accessibility with the proposed beltway. Our team has implemented an access road that will extend from the RV turnaround to the bridge over Stevens Creek. This access road will extend under the East Beltway bridge over Stevens Creek and will continue to provide the access link to the eastern portion of the property. We provided two material options for the access road. The first option is to pave the road with asphalt. Asphalt can be repaired and constructed whenever needed and in a timely manner which is beneficial for the site. The second option would have the proposed access road consist of dirt, gravel, and fine-sized particles.

#### RV Pads:

G1 Engineering will implement RV parking pads per the client's request. The RV pads will be placed east of the access road. The first option, as shown in concept plan one shown in the appendix, is to have 8 RV pads. The second option will be placing 10 RV pads rather than 8. Providing 8 RV pads will provide RV's and their users plenty of space to park. The materials used for paving the RV pads will be concrete, due to the heavy weight vehicles, and the durability of concrete. The concrete pavement will be 6 inches deep as shown in Figure 25.

#### Analysis

If the emergency vehicle access is placed at the southern location on Scout Creek, one-way signage will need to be provided in the western parking lot and along portions of the access road. The current low-water crossing is one-way so the access road will be one-way from west to east from the 120<sup>th</sup> street parking lot to the main parking lot. All traffic that traverses to the east side of Scout Creek will need to exit the property from the southern bridge location. This traffic analysis was done to provide safe traffic flow on the site.

#### Findings

G1 Engineering has found several aspects that will make transportation on the site more safe and efficient. We need to consider the existing challenges in order to improve the site. We provided multiple options for the clients to decide from. These findings to improve the site are detailed in the recommendations section.

#### Recommendations

##### Parking Lot:

To maximize the number of parking spaces, our team recommends revamping the existing parking lot located on South 120th Street that is west of Scout Creek. That parking lot will hold up to 63

parking spaces. We calculated 63 parking spaces by placing 8.5 feet wide and 18 feet long parking spaces to fit in the site constraints of the setback and natural tree areas. We will leave the existing disabled access parking spaces. Our recommended option for the southwest parking lot will have a one-way entrance and a one-way exit to reduce congestion by placing one way signs and stop signs for vehicle to enter accordingly and stop when needed. Our goal is to not have cars traveling two-way in the parking lot when the width of lane is only approximately 19 feet, when a minimum of 22 feet is necessary for adequate two-way travel. The entrance will be placed on the north end of the parking lot, and the exit will be located on the south end of the parking lot. We will place a new parking lot located east of Scout Creek that will provide 300 parking spaces to accommodate high volumes of guests during the Market to Market Relay, day camps, and recruitment events. The total amount of parking spaces on the site will be 363. The parking lot located east of Scout Creek will have dimensions of 180 feet by 467.5 feet for a total area of 84,150 ft<sup>2</sup>. The existing unpaved parking lot dimensions will be 85.5 feet by 190.50 feet for a total area of 16,715 ft<sup>2</sup>. According to The University of Houston Parking Lot Design Standards, an acceptable parking stall design is 8.5 feet wide and 18 feet long as shown in Figure 23. The pavement of the parking lots will be constructed of concrete. Proper concrete maintenance will allow for a parking lot life of approximately 20-30 years. The concrete parking lot pavement design shall be 6 inches deep to accommodate heavyweight vehicles such as RV's and emergency vehicles as shown in Figure 25.

#### Emergency Vehicle Access:

Our recommended design option is to have an emergency access road located in the southwest corner of the property. This road will have two-way traffic, and each lane will be 11 feet wide following the specifications of The Nebraska Administrative Code (NAC) Title 428 for a local road as shown in Figure 23. This access point will allow guest vehicles, emergency vehicles, and RV's to enter and exit the site safely and efficiently. RV's and emergency vehicles will be able to exit safely because the exit has a 40° turn radius. This option will retain the low-water crossing for use when water elevations are low.

#### Access Road:

G1 Engineering proposes revamping the current access road. The entrance of the access road will be one-way with traffic traveling east until it reaches the east parking lot with the emergency vehicle access located in the southwest corner of the property. At the north end of the access road, we will have a turnaround that will allow RV's or other vehicles to turn around and use the southwest corner to exit. With the proposed East Beltway, we recommend adding an access road that will connect to the RV turnaround and follow the northern property line east to connect to the proposed pedestrian bridges over Stevens Creek which are further detailed in the structural design technical memorandum. This proposed access road will run under the anticipated beltway bridge that traverses Stevens Creek at the northern boundary of the property. The proposed access road will consist of asphalt.

### RV Pads:

Since the client has requested RV pads to be included in the master plan, our recommended design will consist of 8 RV parking pads. This number of RV pads will provide the optimum balance of expanded camping provisions without crowding the shooting range on the site. The pads will be located on the east side of the access road before the RV turnaround. The proposed location of the RV pads can be seen in the conceptual site plans in the Appendix. According to the Recreational Vehicle Parks, the standard RV dimensions are 20 feet wide by 40 feet long. Since the RV's dimensions are large, when they exit the RV Pads they will need plenty of space. If the pads were placed at 90° from the access road, their exit would push them to be on both sides of the road. However, if we angle the pads at 45° the RV's will not have to be on both side of the access road to exit. Each pad will be angled at 45° from the access road to allow for easy RV maneuvering. The dimensions of each pad are 20 feet wide and 40 feet long with a 5-foot setback from the access road. Our second option for the RV pads would be adding two additional parking spaces for a total of 10 RV pads.

### Conclusion

G1 Engineering's goal is to make the site as accessible as possible by revamping the current unpaved parking lot, designing a newly paved parking lot located east of Scout Creek, providing RV pads for guests, and accessibility to the divided site with the proposed beltway. The structural design section will detail the proposed emergency access crossings.



Figure 21: Existing parking lot located southwest of Scout Creek. View from north looking to south.



Figure 22: Existing southwest unpaved parking lot, the orange cones represent the setback from the county's easement. View from south looking north.

**MINIMUM DESIGN STANDARDS - PART TWO  
LOCAL ROADS AND STREETS**

001.15 MINIMUM DESIGN STANDARDS — MUNICIPAL STREETS (1)

(2) State Functional Classification	(3) Design Year Traffic	(4) Design Speed (mph)	(5) Maximum Horizontal Curve (Degree)	Maximum Grade (Percent)	(6) Number of Lanes	(7) Lane Width (Feet)	Median Width (Feet)	Non-Curbed Section Shoulder Width (Feet)	(8) Fixed Obstacle Clearance (Feet)	Lighting	New and Reconstructed Bridge Design Loading
Other Arterial	-	30	15	8	2	11	0 - As Required	8	-	Full	HL93
Collector	-	25	20	10	2	11	None	6	-	Desirable	HL93
Local	-	25	30*	10	2	11	None	6	-	Desirable	HL93

Figure 23: Minimum Road Design Standards. Source: Nebraska Department of Transportation Administrative Code (NAC) Title 428.

**ACCEPTIBLE PARKING DESIGNS**

Angle Parking Angle	Dimensions				One Way Traffic		Two Way Traffic	
	Stall Width (ft)	Curb Length (ft)	Stall Depth (ft)	Stripe Length (ft)	Aisle Width (ft)	Section Width (ft)	Aisle Width (ft)	Section Width (ft)
<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>G</b>	<b>E</b>	<b>F</b>	<b>E</b>	<b>F</b>
30°	8.5	17	16.4	32.7	12	44.7	24	56.7
45°	8.5	12	18.7	26.5	14	51.4	24	61.4
60°	8.5	9.8	19.8	22.9	16	55.6	24	63.6
90°	8.5	8.5	18	18	22	58	24	60

Figure 23: Minimum Acceptable Parking Space Design. Source: University of Houston Parking Lot Design Standards.

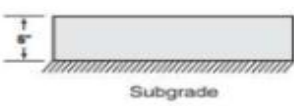
**Residential**

**Design variables:**  $k = 100$ ,  $ADTT = 5$ , Light axle load category, 30 year design life, unreinforced, 600 psi concrete flexural strength

**Concrete:** Design thickness = 6.0 inches ( $SN_{ESTIMATE} = 6 \times 0.50 = 3.0$ )


**Asphalt:** 1.5 inches of high stability asphalt on a coarse-graded bituminous base of 7.0 inches ( $SN = 1.5 \times 0.44 + 7.0 \times 0.34 = 3.0$ )

**Concrete**



Subgrade

**Asphalt**



Subgrade

---


**Collector**

**Design variables:**  $k = 100$ ,  $ADTT = 50$ , Medium axle load category, 30 year design life, unreinforced, 600 psi concrete flexural strength

**Concrete:** Design thickness = 7.0 inches ( $SN_{ESTIMATE} = 7 \times 0.50 = 3.5$ )


**Asphalt:** 1.5 inches high stability asphalt on a coarse-graded bituminous base of 8.4 inches ( $SN = 1.5 \times 0.44 + 8.4 \times 0.34 = 3.5$ )

**Concrete**




Subgrade

**Asphalt**



Subgrade



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Fax: 202.842.2022  
Web: www.pavement.com

Figure 25: Concrete Pavement Design. Source: American Concrete Pavement Association

## **Structural Design**

Engineer: Jacob Chekal

### **Introduction**

This technical memorandum discusses the results of the preliminary structural designs and studies in accordance with the hydraulic studies discussed in the water resources technical memorandum. It also details the structural components for the emergency vehicle access discussed in the transportation technical memorandum. It is important to note that at this stage of the design process, preliminary structural designs are performed to determine accurate estimations of quantities and to provide general concepts regarding the structural elements of the project.

### **Site Information**

#### **General:**

The existing structural site conditions are composed of a low-water crossing and two timber pedestrian bridges. All three crossings allow access over Scout Creek during low water events. There are currently no crossings over Stevens Creek on the client's property.

#### **Pedestrian Bridges:**

The existing pedestrian bridges were constructed using timber power poles as girders, wooden planks as the deck, and wooden safety rails. During the site visit, it was determined that the two pedestrian bridges were not designed according to the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Standards based upon a preliminary visual inspection of the safety rail. According to AASHTO Bridge Design Standards, pedestrian safety railings must be at least forty-two inches in height with only six-inch openings for the lower twenty-seven inches of height. Above the lower twenty-seven inches of rail height, an eight-inch opening can be used. The current pedestrian rails have vertical gaps that are much larger than six inches, meaning they do not meet the necessary design standards.

#### **Low-Water Crossing:**

According to the client, the current vehicular crossing used over Scout Creek is defined as a low-water crossing. This classification was confirmed by a hydraulic study conducted by our team. This hydraulic study, discussed in the water resources technical memorandum, determined that the channel would need to be significantly widened to accommodate the client's request for an emergency vehicle route over Scout Creek. The findings regarding the necessary type of structure from the results of the hydraulic study will be discussed in the next section of this memorandum.

## Challenges

### General:

One of the challenges on the site was that all of the existing and proposed structures lie in the floodway of either Scout Creek or Stevens Creek. This floodway designation means that our team must be able to demonstrate that the proposed construction will not raise the current flood elevations.

### Pedestrian Bridges:

One of the challenges that our team faced was the potential reuse of some of the existing timber bridge components. Our team had initially proposed to do a study of the reuse of the existing power pole girders for the new pedestrian girders. One problem found during the study was the length of the power poles, with the existing poles being 30 feet long. The hydraulic study, discussed in the water resources technical memorandum determined the required lengths of the pedestrian bridges over Scout Creek to be 30 feet. The girders of a bridge typically must extend a few inches past the bridge length to obtain a proper bearing on the abutments. This abutment bearing is crucial for structural stability. Also, if the channel would need to be widened at any point during the design process, the existing timber girders would be too short. Additionally, the existing timber poles have a large amount of section loss from the safety railing and wooden planks that have been bolted and nailed into them. This section loss reduces the strength and serviceability of the girders. Another issue found by the study was that long term deflection, or creep, has occurred. Creep occurs with materials that have moisture inside them such as concrete or wood. This creep decreases serviceability and adds additional stress on the girder. Another issue that arose from the study of the existing timber girders was that the wood species of the power poles is unknown. The unknown wood species makes it difficult to run an analysis of the girder. Due to these issues, our team decided to abandon the suggestion to reuse existing bridge components and has provided an alternative pedestrian bridge design option that will be discussed in the alternatives section of this memorandum.

### Emergency Vehicle Access:

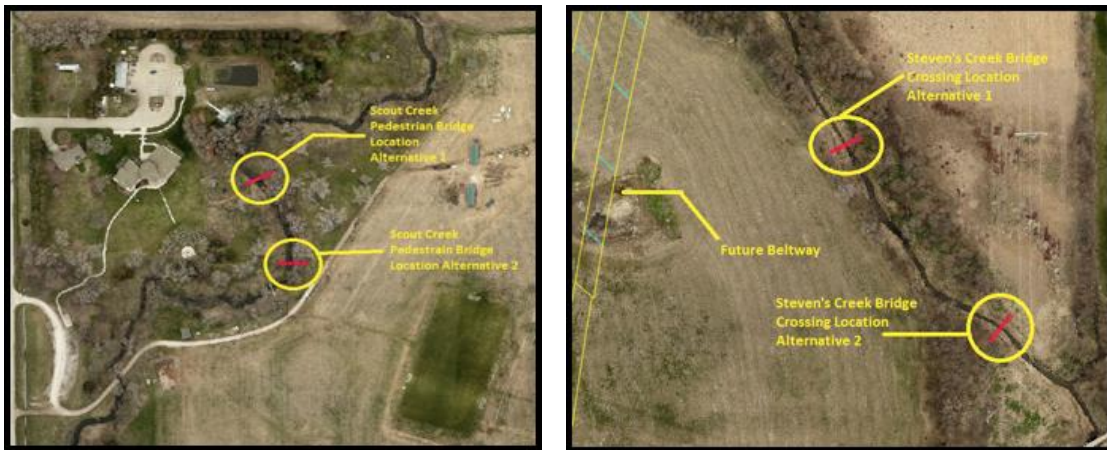
A challenge that our team faced was the selection of the best design alternative for the emergency vehicle access. Our team started this project planning to use a concrete box culvert or a corrugated metal pipe (CMP) culvert for the emergency vehicle access over Scout Creek. However, this plan was based on preliminary assumptions made before our team was provided with the resources to perform a hydraulic study. Two alternative locations were chosen for the emergency vehicle access. The first location would be at the existing low-water crossing. This structure would need to be thirty feet long. The second location would be on the southwest part of the property. This structure would be sixty-five feet long. Due to the lengths of the required structures and the requirement to prevent flood elevation increase, it was determined that a bridge would be a better option than a culvert for the emergency vehicle access. One of the main

considerations for the selection of a bridge is that this type of structure allows for less effect to the flood elevations.

**Alternatives**

**General:**

The locations of all proposed bridges are shown below in Figures 26-28. The reasoning behind the selection of these locations is discussed later in this section.



*Figures 26-27. Proposed Pedestrian Bridge Locations Over Scout and Stevens Creek*



*Figure 28. Proposed Emergency Vehicle Access Bridge over Scout Creek*

**Pedestrian Bridges:**

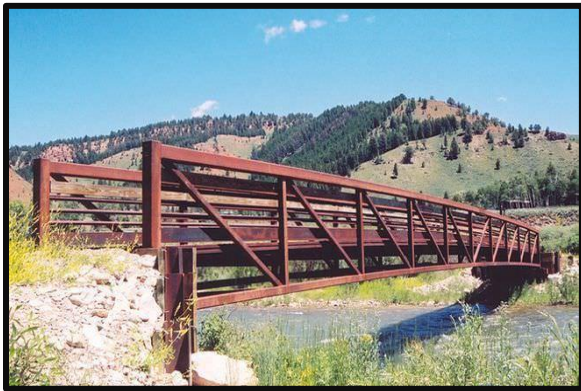
The design options discussed below are based on the clients desire to have bridges over both Scout and Stevens Creek that allow for pedestrian and maintenance vehicle traffic.

The first design option that our team is proposing for the pedestrian bridges is a prefabricated truss bridge with a steel sheet pile and steel bearing pile abutment. Abutments with sheet pile are efficient when there is a high possibility of scour, as is present in both Scout and Stevens Creek.



The second design option that our team is proposing for the pedestrian bridges is a steel twin girder bridge with a composite concrete deck. The abutment for this design option would be a steel sheet pile and steel bearing pile abutment. This design option works best for the shorter bridges since girder size and weight increases significantly at longer lengths such as lengths for the pedestrian bridges over Stevens Creek.

Figure 29 shown below on the left shows an example of a prefabricated truss bridge, and Figure 30 on the right shows an example of a twin girder bridge.



*Figure 29. Prefabricated Truss Bridge with Steel Sheet Pile Abutment (left) Source: Wheeler-Con  
Figure 30. Steel Twin Girder Bridge (right) Source: Wheeler-Con*

A third design option is being proposed if the client wants roadway vehicle access over Scout Creek. This design option will require a three-span concrete slab bridge with a steel sheet pile and steel bearing pile abutment.

#### Emergency Vehicle Access Bridge:

The first design option our team is proposing for the emergency vehicle access is a concrete slab bridge in the location of the existing low-water crossing. This location is not ideal for traffic purposes; however, it offers a smaller span length of thirty feet. Due to this smaller span, it is more cost effective. Additionally, the proposed bridge would be twenty-eight feet wide to allow for two way traffic to help alleviate some of the previous traffic issues addressed by the client.

The second design option our team is proposing for the emergency vehicle access is a three-span concrete slab bridge to the south of the existing low-water crossing. This bridge location is proposed because it allows the client to continue using the low-water crossing when flow conditions allow it. Additionally, the client has stated that the location of the low-water crossing creates large amounts of traffic, so the decision to offer a different location was made. The hydraulic study conducted by our team determined that the length of this structure would need to be sixty-five feet long.

## Analysis

### General:

At this stage in the design process, the structural analysis is limited to determining the feasibility of selected bridge design options and to determine an estimate of quantities for a preliminary cost estimate.

### Pedestrian Bridges:

The design of the prefabricated truss bridge is generally performed by the manufacturer of the bridge, so the design of the structural engineer of record is limited to the design of the abutments in coordination with the geotechnical engineer.

The design of the twin steel girder bridge with a composite concrete slab includes the design of the slab, girders, and abutment. The concrete slab must be designed to carry the load from the concrete deck to the girders. The deck system is composite which means that the concrete deck and the girders work together to resist load and deflection. This style of design requires the girders to be designed to withstand all loads before the concrete cures. This loading includes the self-weight of the girders, the weight of the wet concrete, and a construction load of twenty pounds per square foot. The girders should be designed to prevent plasticity as much as possible while the concrete cures. This allows for proper structural behavior after the deck is placed. Additionally, the bridge must be designed for the worst case between a ninety pounds per square foot live pedestrian load and the loading of an HS5 design truck. The HS5 design truck is a theoretical truck defined by AASHTO which is meant to simulate utility vehicles. To simplify the design for the preliminary design, the engineer has chosen to adopt Iowa Department of Transportation (IDOT) Specification Section 2429 which replaces the HS5 design truck with a ten thousand pound load at midspan increased for impact. The IDOT specification was used due to a lack of Nebraska specifications regarding pedestrian bridges. Additionally, this specification allows for simplified analysis that is ideal for thirty percent concept plans. This specification typically applies to truss bridges; however, it will be a reasonably close and simplified estimate to the HS5 truck due to the similarity of the loading. An example strength envelope is shown below in Figure 31 and Figure 32. These figures show the force effects that the designer must take into account in the design of the structures. The larger the force effects are, the larger the structure needs to be, and the more material the structure needs to use. The blue lines refer to the load effects experienced by pedestrian foot traffic, and the red lines refer to the load effects experienced by a utility truck. The values of the shear demand envelope show approximate end bearings for the pedestrian bridges. This value of the end bearings is used by the geotechnical engineer to determine the required size and depth of the foundations.

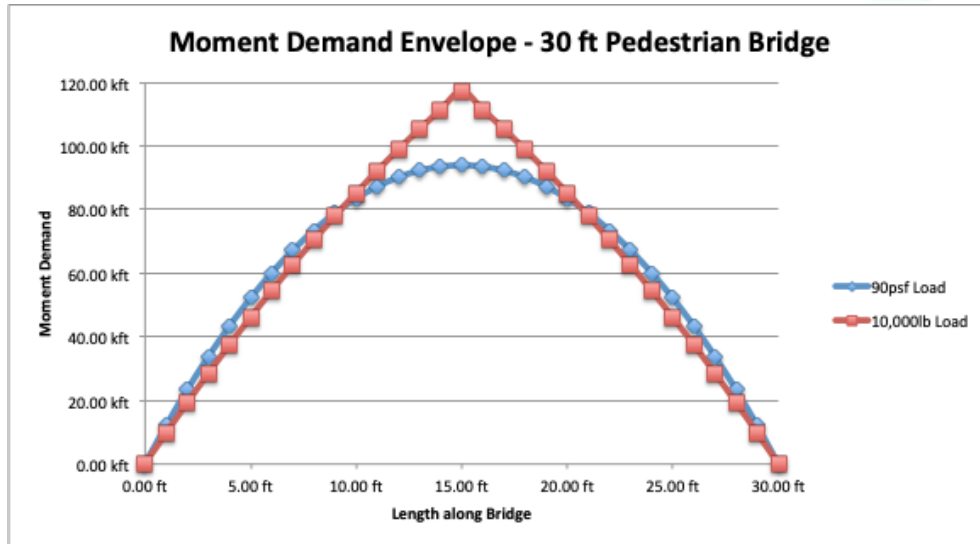


Figure 31. Moment Demand Envelope

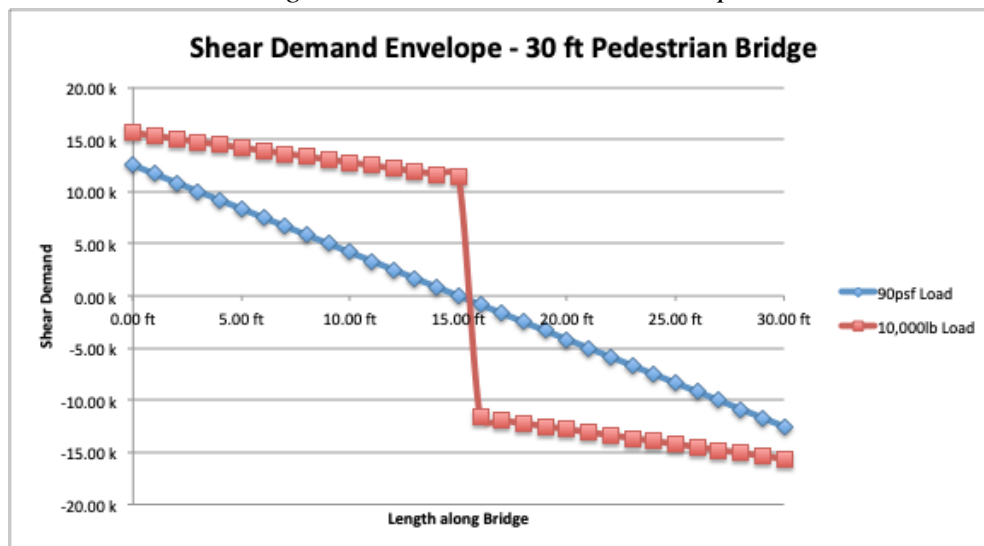


Figure 32. Shear Demand Envelope

### Roadway Bridges:

The roadway bridges are to be designed in accordance with the design tables in the Nebraska Department of Transportation (NDOT) Bridge Office Policies and Procedures (BOPP). This means that these structures are partially pre-designed, and that the designs are pre-approved by NDOT. The abutments will use steel sheet pile to hold back soil, and the abutments and piers shall use steel bearing piles for their vertical load resistance systems.

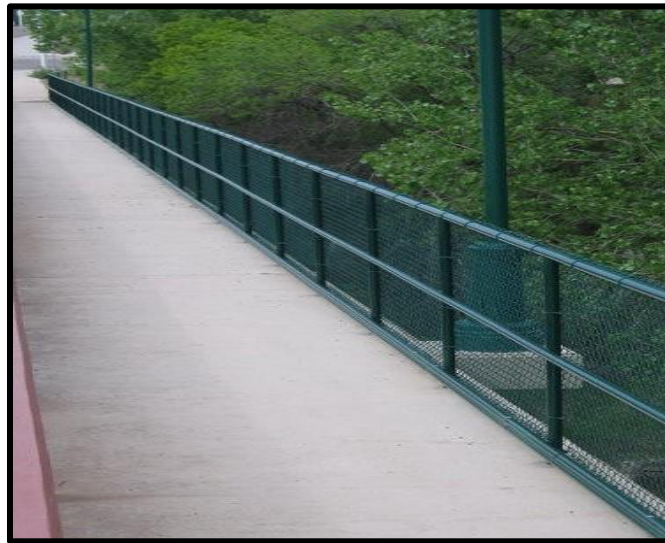
### Findings

#### Pedestrian Bridges:

As stated previously, the prefabricated truss bridges are designed by the manufacturer leaving only abutment and approach roadway design to be done by the structural engineer of record.

A reinforced concrete slab with a 28-day compressive 4000 psi shall be used for the deck of the steel twin girder bridge. This concrete strength was selected because it is the standard bridge deck concrete. The bridges shall be the appropriate length as specified in the water resources technical memorandum. These lengths are 30 feet for both crossings over Scout Creek and 95 or 120 feet for the crossings over Stevens Creek. The size of the steel girders will be different for the different bridge lengths, with lighter girders being used for the shorter spans. Additionally, the twin girder bridges will require intermediate steel channel stiffeners to provide lateral stability and strength.

The pedestrian bridges shall all use a double steel channel cap with two HP12x53 bearing pile. Steel sheet pile will be used at each abutment to hold back channel soil. Each pedestrian bridge will also be seven feet wide to allow for two way pedestrian traffic and to allow for one way maintenance vehicle traffic. A steel or wooden safety fence will be used for the steel twin girder bridges in order to meet the requirements of a pedestrian rail specified earlier in this memo. The prefabricated truss bridges use the truss with intermediate horizontal rails spaced at 4 inches on center to act as a safety rail. Figure 33 shows an example of the safety fence for the pedestrian bridges.



*Figure 33. Typical Safety Rail for Bridge. Source: Pascetti Steel*

#### Roadway Vehicle Access Bridges:

The roadway vehicle bridges shall be 28 feet wide to allow two-way traffic. The emergency vehicle access bridges are predesigned according to the NDOT BOPP documentation. The design criteria for these bridges can be found on page 3.21-3.23 of the BOPP. Slab bridge designs shall use 4000 psi concrete with 60 ksi reinforcing. Figure 34 below shows additional design information for slab bridges such as thicknesses and reinforcing layouts.

Slab Bridge Design Table									
Design Criteria					Edge Beam				
Bridge Length feet	Span No. 1 & No. 3	Span No. 2	Slab Thickness "T"	"X"	Haunch J10 (long.)	Bar Size	Span 1 & 3	Span 2	NEG
					Bar		J8 bars Length	J9 bars Length	J11 bars Length
40	12'-0"	16'-0"	9½"	5'-0"	6	6	10'-8"	11'-9"	36'-0"
45	13'-6"	18'-0"	10"	5'-0"	6	7	12'-0"	13'-0"	40'-0"
50	15'-0"	20'-0"	10½"	5'-5"	6	7	13'-10"	15'-0"	42'-0"
55	16'-6"	22'-0"	11"	5'-10"	6	7	15'-0"	19'-0"	45'-8"
60	18'-0"	24'-0"	11½"	6'-3"	6	7	16'-6"	19'-3"	50'-0"
65	19'-6"	26'-0"	11½"	6'-8"	6	8	17'-9"	21'-8"	28'-0"
70	21'-0"	28'-0"	12"	7'-1"	6	8	18'-10"	22'-0"	27'-3"
75	22'-6"	30'-0"	12½"	7'-6"	6	8	19'-10"	23'-0"	29'-3"
80	24'-0"	32'-0"	13"	7'-11"	6	8	22'-8"	25'-0"	31'-3"
85	25'-6"	34'-0"	13½"	8'-3"	6	8	23'-3"	27'-6"	33'-0"
90	27'-0"	36'-0"	14"	8'-8"	6	8	25'-0"	28'-0"	35'-8"
95	28'-6"	38'-0"	14½"	9'-6"	6	8	25'-0"	28'-0"	37'-11"
100	30'-0"	40'-0"	15"	10'-0"	7	9	27'-3"	29'-10"	40'-6"
105	31'-6"	42'-0"	15½"	10'-4"	7	9	28'-0"	32'-2"	41'-9"
110	33'-0"	44'-0"	16"	11'-0"	7	9	29'-0"	32'-6"	42'-6"
115	34'-6"	46'-0"	16½"	11'-4"	7	9	31'-0"	34'-0"	44'-7"
120	36'-0"	48'-0"	17"	11'-9"	7	9	31'-3"	38'-0"	44'-9"
125	37'-6"	50'-0"	17½"	12'-2"	7	9	31'-6"	39'-0"	46'-3"
**130	39'-0"	52'-0"	18"	12'-6"	7	9	33'-9"	41'-0"	45'-4"
**135	40'-6"	54'-0"	19"	12'-10"	7	9	35'-3"	42'-6"	44'-4"
**140	42'-0"	56'-0"	19½"	13'-2"	7	9	36'-10"	44'-0"	45'-0"

Figure 34. Slab Bridge Design Table from NDOT BOPP

The design option for the emergency vehicle access in the location of the existing low-water crossing, which requires a 30-foot bridge, does not have a design length stated in the BOPP tables. This means that the structural engineer will have to adjust span lengths and slab thicknesses accordingly, however, the 40-foot bridge length from the design tables will be used to come up with a reasonably accurate estimation of the quantities to be used.

The abutments and piers for the slab bridges will be composed of a double steel channel cap with six HP12x53 bearing pile. These piles were selected based on typical pile requirements specified in the BOPP. The steel sheet pile at the abutments would not typically be designed until later in the design process; however, a depth of 25 feet will be used for a preliminary estimate for the sheet pile. The abutment sheet pile can be reasonably approximated to be a foot wider than the deck width on each side (30-foot length), and the wings can be estimated to be 10 feet long each.

## **Recommendations**

### **Pedestrian Bridges:**

G1 Engineering is recommending the steel twin girder bridges for the proposed pedestrian bridges over Scout Creek due to efficient use of material for short spans. We recommend the prefabricated truss bridge for the crossings over Stevens Creek since these structures are a more efficient use of material for long spans.

### **Roadway Vehicle Access Bridges:**

G1 Engineering recommends the placement of a three-span slab bridge to the south of the existing low-water crossing to allow for emergency vehicle access. This option allows traffic to use both the emergency vehicle access and the low-water crossing in times of high traffic. If the client wishes to reduce the cost of the structure, the client can select the second proposed location over Scout Creek in the same location as the current low-water crossing.

## **Conclusion**

In conclusion, the structural aspects of this project are crucial to meeting the client's needs. The desired expansion to the east of Scout Creek can only be achieved if the emergency vehicle access is constructed. All the structural components will help add safety and beauty to the property.

## Cost Estimates

The following information provides preliminary opinions of cost for the proposed features detailed in the technical memorandums.

The first option includes paving the west parking lot with concrete to provide 63 spaces. A 300-space concrete parking lot located west of Scout Creek. An asphalt access road traverses the site. Rain garden stormwater filtration around the 300-space parking lot. Temporarily emptying the lagoon via vacuum truck. Vegetation streambank stabilization that includes riprap, live stakes, and brush wattles. A 65 feet length emergency vehicle slab bridge in the southwestern corner of the property. A 30 feet length pedestrian twin girder bridge over Scout Creek and a 95 feet length pedestrian truss bridge over Stevens Creek. Lighting around the parking lot, RV pads, and soccer field. Relocation of the Harvey Hunter Lodge out of the floodway.

<b>Option 1</b>				
Item	Quantity	Unit	Unit Cost	Total Cost
Transportation	1	LS	\$1,022,000.00	\$1,022,000.00
Environmental	1	LS	\$237,000.00	\$237,000.00
Water Resources	1	LS	\$46,000.00	\$46,000.00
<b>Structural</b>				
Emergency Vehicle Access at South Location (65ft Slab Bridge)	1	LS	\$353,000.00	\$353,000.00
Pedestrian Twin Girder Bridge on Scout Creek (South Location, 30ft Length)	1	LS	\$136,000.00	\$136,000.00
Pedestrian Truss Bridge on Stevens Creek (North Location, 95ft Length)	1	LS	\$231,000.00	\$231,000.00
<b>Geotechnical</b>				
	1	LS	\$138,000.00	\$138,000.00
<b>Total For Option 1</b>				<b>\$2,163,000.00</b>
Mobilization/Demobilization (10% of total)				\$2,380,000.00
<b>Total For Option 1 with 40% Contingency</b>				<b>\$3,332,000.00</b>

The second option includes paving the west parking lot with concrete to provide 63 spaces. A 300-space concrete parking lot is located west of Scout Creek. An asphalt access road traverses the site. A vegetated strip filter provides stormwater filtration to the west of the 300-space parking lot. The lagoon will be temporarily emptied via vacuum truck and then the lagoon will be expanded. A tied concrete block mat provides streambank stabilization. A 30 feet length emergency vehicle slab bridge is located at the current low-water crossing. A 30 feet length pedestrian truss bridge will be located on Scout Creek. A 95 feet length pedestrian twin girder will be located on Stevens Creek. Lighting should be placed around the parking lot, RV pads, and soccer field. The Harvey Hunter Lodge is relocated out of the floodway.

<b>Option 2</b>				
Item	Quantity	Unit	Unit Cost	Total Cost
Transportation	1	LS	\$1,002,000.00	\$1,002,000.00
Environmental	1	LS	\$25,000.00	\$25,000.00
Water Resources	1	LS	\$46,000.00	\$46,000.00
<b>Structural</b>				
Emergency Vehicle Access at Current Low-Water Crossing Location (30ft Slab Bridge)	1	LS	\$329,000.00	\$329,000.00
Pedestrian Truss Bridge on Scout Creek (North Location, 30ft Length)	1	LS	\$148,000.00	\$148,000.00
Pedestrian Twin Girder Bridge on Stevens Creek (North Location, 95ft Length)	1	LS	\$573,000.00	\$573,000.00
<b>Geotechnical</b>				
	1	LS	\$272,000.00	\$272,000.00
<b>Total for Option 2</b>				<b>\$2,395,000.00</b>
Mobilization/Demobilization (10% of total)				\$2,635,000.00
<b>Total for Option 2 with 40% Contingency</b>				<b>\$3,689,000.00</b>

The third option includes paving the parking lot west of Scout Creek. Geogrid improvements are provided to accommodate 300 vehicles. The geogrid negates the need for stormwater pollution solutions. An asphalt access road traverses the site. The lagoon will be emptied via vacuum truck, a permanent connection to the trunk sewer installed, and the lagoon filled in. Riprap will provide the streambank stabilization. A 30 feet length emergency vehicle slab bridge will be placed at the current low-water crossing location. A 30 feet length pedestrian truss bridge will be provided over Scout Creek. A 95 feet length pedestrian twin girder bridge will be provided over Stevens Creek. Lighting should be placed around the parking lot, RV pads, and soccer field. The Harvey Hunter Lodge is relocated out of the floodway.

<b>Option 3</b>				
Item	Quantity	Unit	Unit Cost	Total Cost
<b>Transportation</b>	1	LS	\$454,000.00	\$454,000.00
<b>Environmental</b>	1	LS	\$71,000.00	\$71,000.00
<b>Water Resources</b>	1	LS	\$46,000.00	\$46,000.00
<b>Structural</b>				
Emergency Vehicle Access at Current Low-Water Crossing Location (30ft Slab Bridge)	1	LS	\$329,000.00	\$329,000.00
Pedestrian Truss Bridge on Scout Creek (South Location, 30ft Length)	1	LS	\$148,000.00	\$148,000.00
Pedestrian Twin Girder Bridge on Stevens Creek (North Location, 95ft Length)	1	LS	\$573,000.00	\$573,000.00
<b>Geotechnical</b>	1	LS	\$127,000.00	\$127,000.00
<b>Total for Option 3</b>				<b>\$1,748,000.00</b>
Mobilization/Demobilization (10% of total)				\$1,923,000.00
<b>Total for Option 3 with 40% Contingency</b>				<b>\$2,693,000.00</b>

## Conclusion

The drainage evaluation yielded recommendations of regrading, implementation of rain gardens, or placement of a geogrid. The water resources evaluation of the creeks on the property found that bridges would be necessary to handle high flow volumes. The environmental evaluation found that the current lagoon is near its capacity. Several solutions for preventing overtopping were proposed and included expanding the lagoon, emptying the lagoon and continuing to refill it, and connecting the waste wet well to the city trunk sewer and filling in the lagoon. The investigation of geotechnical conditions found that dewatering will be necessary for safe and effective construction, streambank stabilization measure will provide proper support for banks, and the soil on the site is sufficient for construction. The transportation study provided RV parking spots, eased traffic congestion on the site, and provided adequate parking for large events. The structural evaluation of the property found that bridges would be necessary to provide site access across the property. The following appendix includes the updated site plans for OEC that support the technical memorandums included in the report.



## References

- Klostermann, Loras A. P.E. Schemmer (2017). Preliminary Report of Geotechnical Exploration. Stevens Creek Phase V and Sub-Basin E3 Sanitary Sewer Project (City Project #701863. Schemmer Project #06913.001). Lincoln, NE.
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- FEMA. (2019). UNIT 5: THE NFIP FLOODPLAIN MANAGEMENT REQUIREMENTS, 1–59.
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- Nebraska Department of Health and Human Services - Title 179. (2007, May 2). Retrieved April 25, 2019, from <https://www.nebraska.gov/nesos/rules-and-regs/regtrack/proposals/00000000000000432.pdf>
- Rules and Regulations for the Design, Operation and Maintenance of On-site Wastewater Treatment Systems. Title 124. (2012, August 11). Retrieved April 25, 2019, from [http://deq.ne.gov/RuleAndR.nsf/Title\\_124.xsp](http://deq.ne.gov/RuleAndR.nsf/Title_124.xsp)
- Wastewater Engineering by Metcalf and Eddy, 3rd edition

## **Appendix A**

### CAD Plans

# Outdoor Education Center Concept Site Master Plan and Improvements Project # CIVE 489-002

Boy Scouts of America  
Cornhusker Council

## G1 Engineering Design Team

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Scale 1:1

PROJ: Outdoor Education Center  
PEN: \$PENBLA\$  
USER: \$--USER--\$\$  
DATE: 4/5/2019  
DGN: \$--DESIGN-FILE-NAME--\$\$

PROJ: Outdoor Education Center  
REV: SPENBILAS  
USER: JAC  
DATE: 4/5/19  
DGN: JAC



489-007	2
Date: 4/5/2019	Drawn: JAC
Horz. Scale 1 : NTS	Checked: JAC
	Approved: JAC

### Legend

-  Vegetated Grass Filter
-  Rain Garden
-  Geogrid
-  Lagoon Removal
-  East Beltway Bridge
-  Proposed Lighting (Typ)
-  Proposed Roadway
-  Lagoon
-  Proposed Wastewater Pipes
-  Proposed Bridge
-  Existing Site Features
-  East Beltway Alignment
-  Existing Creek
-  Existing Easement, Limit of Construction

### Sources of Data

Nebraska Department of Transportation (NDOT) Standard Plans  
NDOT Bridge Office Policies and Procedures (BOPP)  
A Policy on Geometric Design of Highways and Streets

Vertical Information: NTS  
Horizontal Information: NTS

### Typical Notes

- #### Truss Bridge
- Prefabricated truss bridge shall be designed by the bridge fabricator.
  - Structural steel for substructure shall meet the requirements of ASTM A709 Grade 36.
  - Concrete for deadman shall be class "47B" with a minimum 28-day strength of 3000 psi.
- #### Twin Girder Bridge
- Structural steel for rolled beam girders, stiffener plates, and separators shall meet the requirements of ASTM A709 Grade 50 weathering steel.
  - Structural steel for substructure shall meet the requirements of ASTM A709 Grade 36.
  - Concrete for deadman shall be class "47B" with a minimum 28-day strength of 3000 psi.
  - Concrete for deck shall be class "47BD" with a minimum 28-day strength of 4000 psi.
  - Steel reinforcing shall have a minimum tensile yield strength of 60 ksi.
  - Steel reinforcing bars shall have a minimum tensile yield strength of 60 ksi.
  - Girder design was performed using the worst case between a 90 psf pedestrian live load and a 10,000 pound point load at midspan increased for impact by 30%. These loads were not applied simultaneously.
- #### Slab Bridge:
- Concrete for deadman shall be class "47B" with a minimum 28-day strength of 3000 psi.
  - Concrete for deck shall be class "47BD" with a minimum 28-day strength of 4000 psi.
  - Steel reinforcing bars shall have a minimum tensile yield strength of 60 ksi.
  - Typical top reinforcement shall be #4 bars at 12 inches on center.
  - Negative moment haunch height and reinforcing varies depending on bridge length.
  - Slab bridge design as specified by the design tables in the NDOT BOPP.

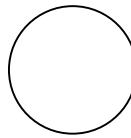
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 General Notes  
Scale: NTS

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Quantity Table		
Item No.	Item	Unit
Truss Bridge		
1	Structural Steel for Substructure	LB
2	HP12x53 Bearing Pile	LF
3	Steel Sheet Piling	SF
4	Class "47B" Concrete for Deadman	CY
5	Reinforcing Steel for Deadman	LB
6	Slope Protection	TON
Twin Girder Bridge		
7	Structural Steel for Superstructure	LB
8	Structural Steel for Substructure	LB
9	HP12x53 Bearing Pile	LF
10	Steel Sheet Piling	SF
11	Class "47B-3000" Concrete for Deadman	CY
12	Class "47BD-4000" Concrete for Deck	CY
13	Pedestrian Safety Rail	LF
14	Reinforcing Steel for Deadman	LB
15	Reinforcing Steel for Deck	LB
16	Slope Protection	TON
Slab Bridge		
17	Structural Steel for Substructure	LB
18	HP12x53 Bearing Pile	LF
19	Steel Sheet Piling	SF
20	Class "47B-3000" Concrete for Deadman	CY
21	Class "47BD-4000" Concrete for Deck	CY
22	Class "47BD-4000" Concrete for Rail	CY
23	Reinforcing Steel for Deadman	LB
24	Reinforcing Steel for Deck	LB
25	Slope Protection	TON

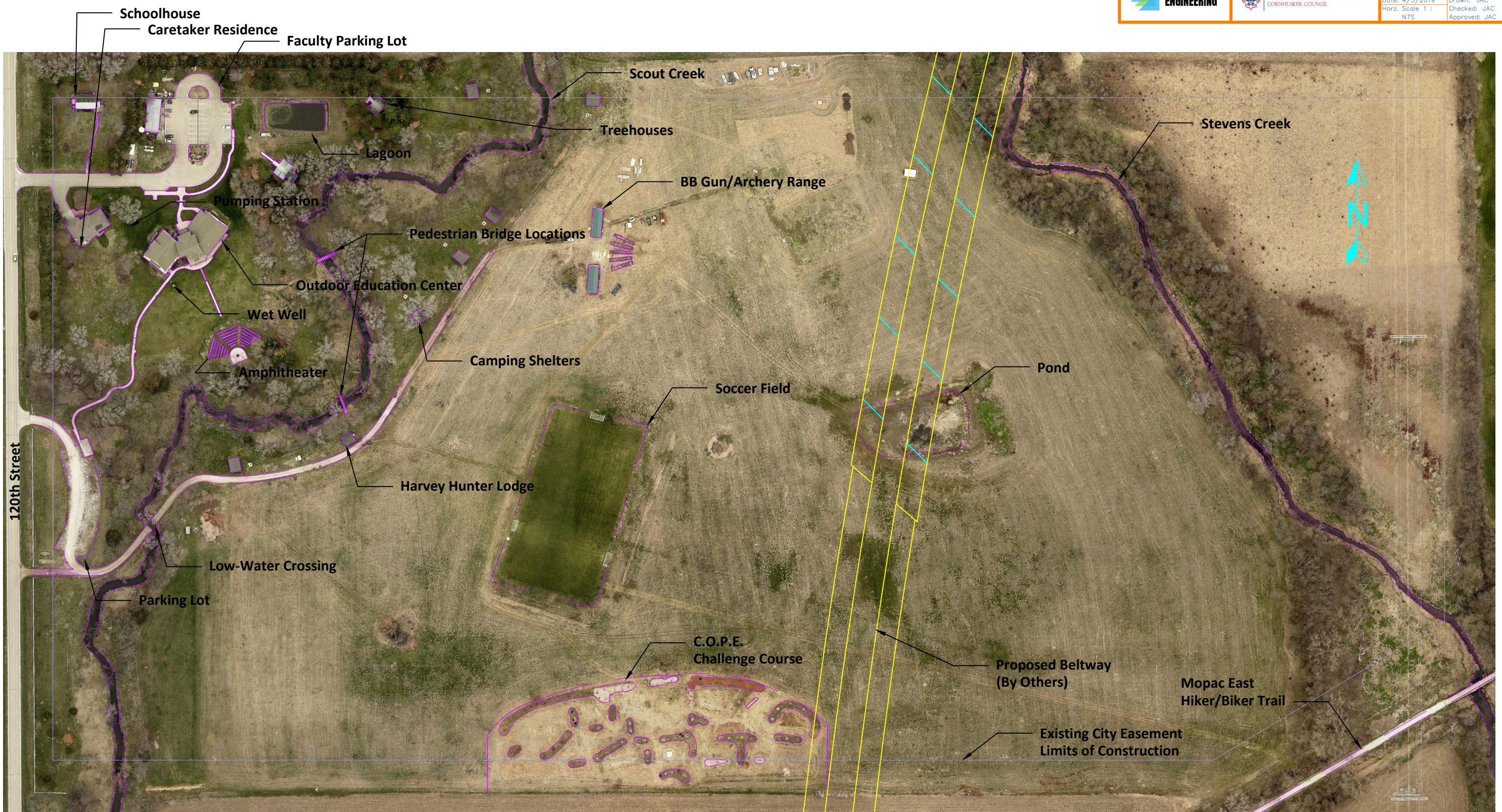
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 DGN: JAC



## General Notes

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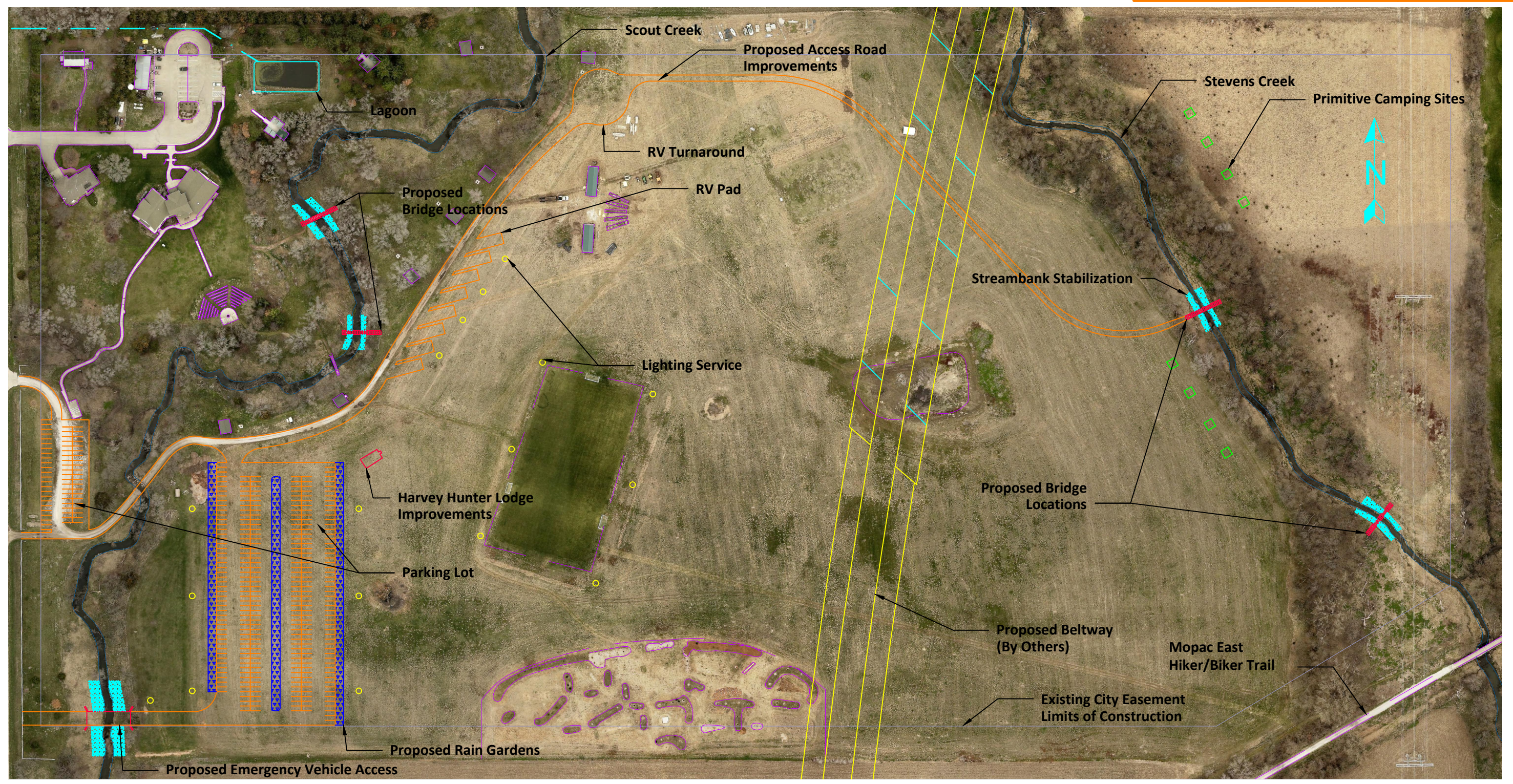
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 USER: JAC  
 DATE: 4/5/19  
 DGN: \$\$\$--DESIGN-FILE-NAME--\$\$



**Existing Site Layout**  
 Scale: NTS

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 USER: JAC  
 DATE: 4/5/19  
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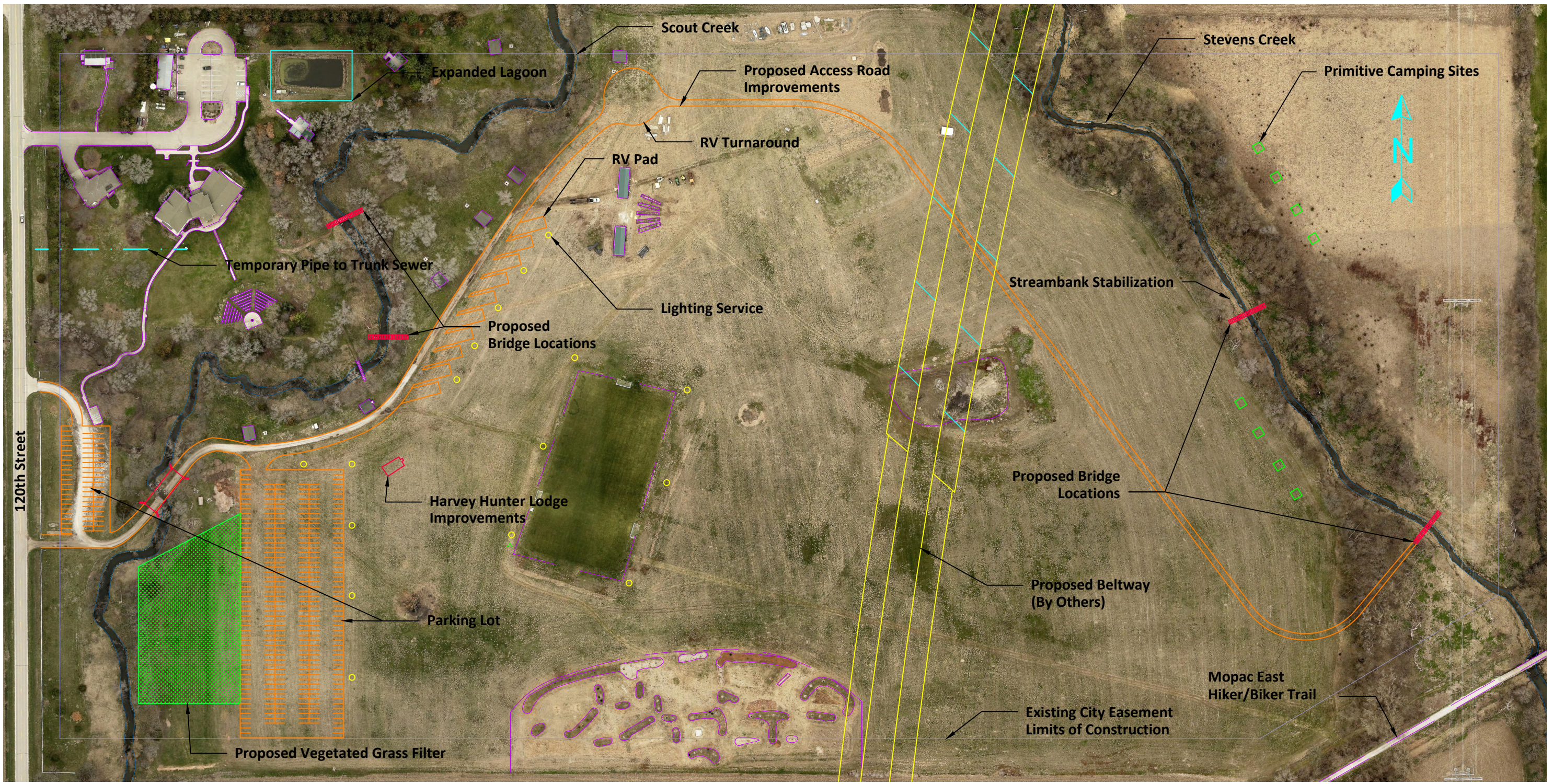
# CONCEPTUAL SITE PLAN OPTION 1

Scale: NTS

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This option has a southwest emergency vehicle access location with the entrance leading into a concrete paved 300 space parking lot. The existing gravel parking lot is upgraded to concrete and can accommodate 63 cars. Eight RV parking pads are located on the east side of the access road. The access road is concrete and one-way west to east from the 120th street parking lot. This road becomes two way after the main parking lot until the RV turnaround at the northern edge of the property. The access road returns to one lane asphalt after the RV turnaround leading to the Stevens Creek bridge. Pedestrian bridge location options over Scout and Stevens are shown. The wastewater lagoon should be emptied via vacuum truck and then normal lagoon operation should continue. Rain gardens are implemented for treatment of stormwater. Lighting is placed around the main parking lot, soccer field, and at RV parking pads. Eight primitive camping sites are located by Stevens Creek with four on each side.

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 PEN: SPENBLAS  
 USER: JAC  
 DATE: 4/5/2019  
 DGN: \$\$\$--DESIGN-FILE-NAME-\$\$\$



# CONCEPTUAL SITE PLAN OPTION 2

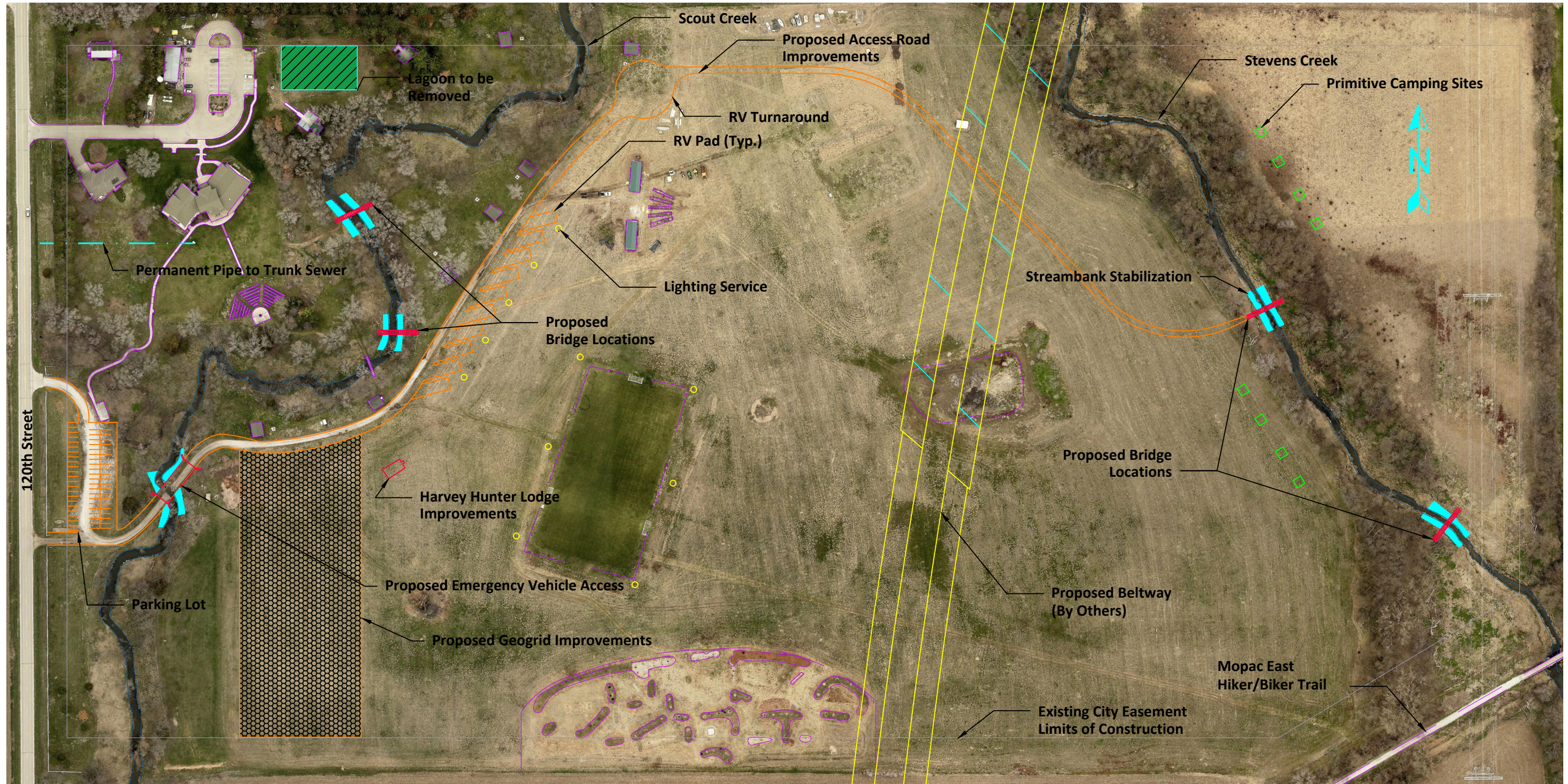
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**NOT FOR CONSTRUCTION  
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This option has the emergency vehicle access at the current low-water crossing location. The existing gravel parking lot is upgraded to concrete and can accommodate 63 cars and a 300 space concrete parking lot is implemented. Ten RV parking pads are located on the east side of the access road. The access road is concrete and two-way until the RV turnaround at the northern edge of the property. The access road returns to one lane asphalt after the RV turnaround leading to the Stevens Creek bridge. Pedestrian bridge location options over Scout and Stevens are shown. The wastewater lagoon should be emptied via vacuum truck and then expanded. A vegetative filter strip is implemented for stormwater runoff filtration. Lighting is placed around the main parking lot, soccer field, and at RV parking pads. Eight primitive camping sites are located by Stevens Creek with four on each side.



PROJ: Outdoor Education Center  
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# CONCEPTUAL SITE PLAN OPTION 3

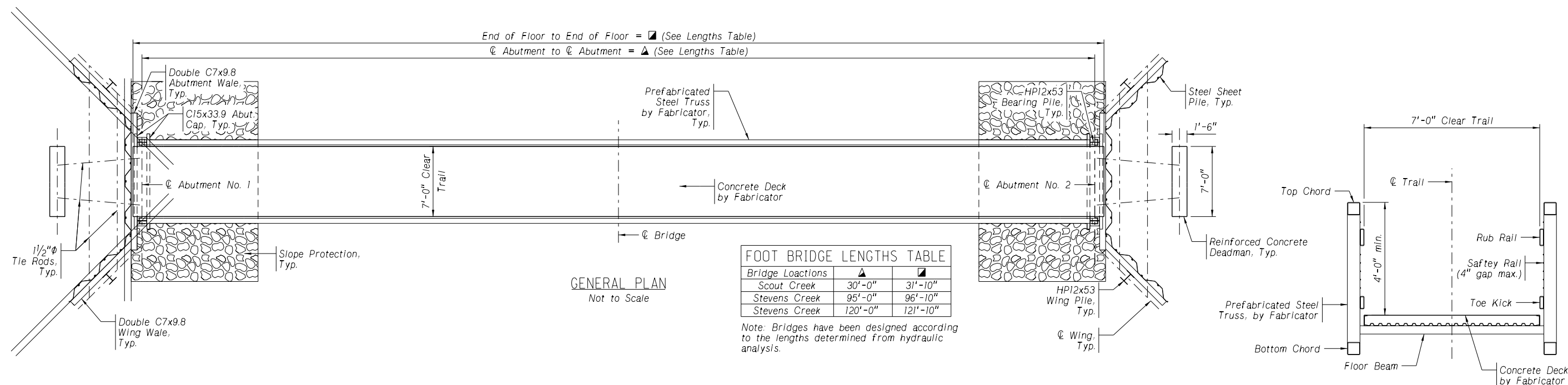
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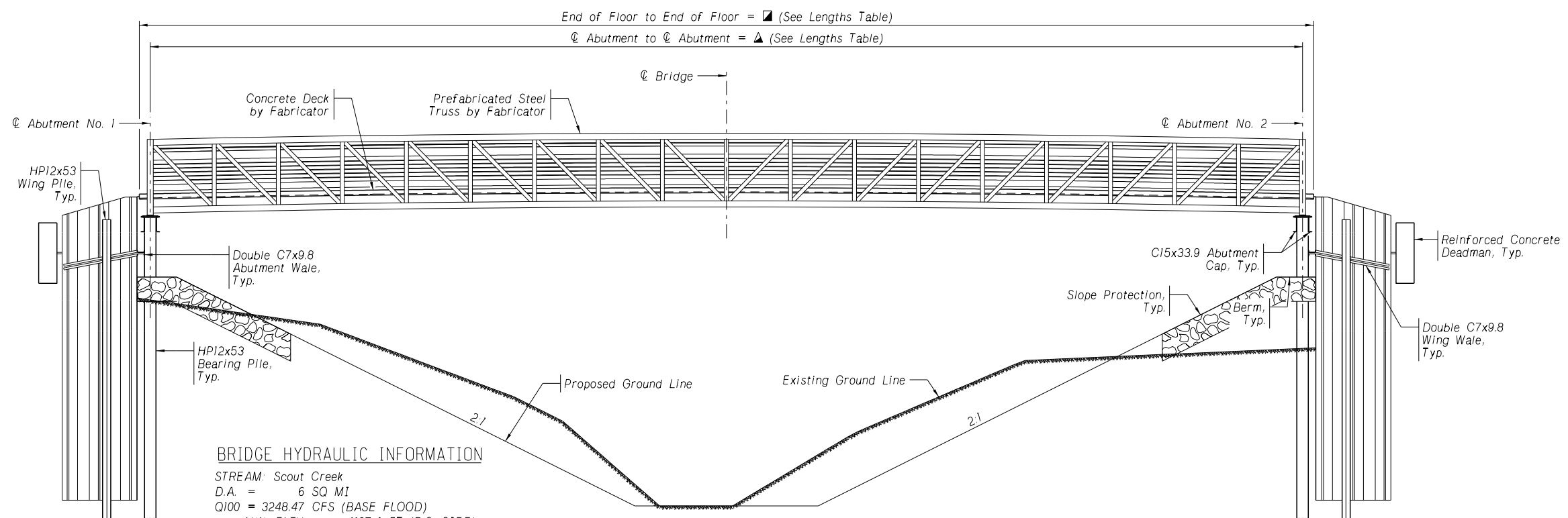
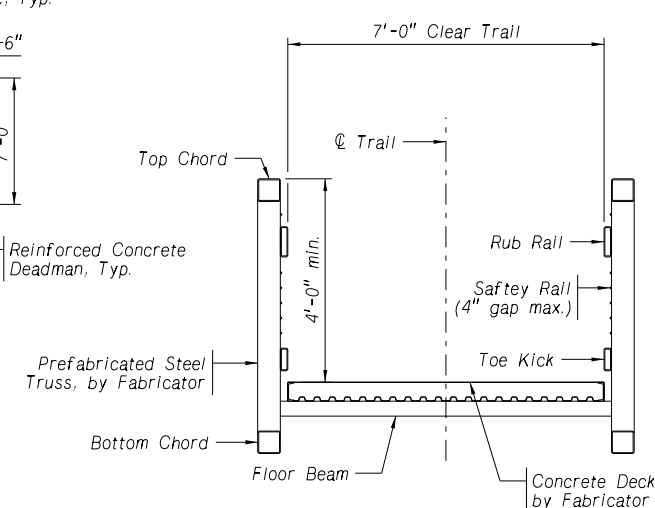
This option has the emergency vehicle access at the current low-water crossing location. The existing gravel parking lot is upgraded to concrete and can accommodate 63 cars. Geogrid improvements allow for vehicle parking and retention of the field and require no stormwater filtration systems. Ten RV parking pads are located on the east side of the access road. The access road is concrete and two-way until the RV turnaround at the northern edge of the property. The access road returns to one lane asphalt after the RV turnaround leading to the Stevens Creek bridge. Pedestrian bridge location options over Scout and Stevens are shown. The wastewater lagoon should be emptied via vacuum truck, a permanent connection to the trunk sewer installed, and lagoon filled in. Lighting is placed around the main parking lot, soccer field, and at RV parking pads. Eight primitive camping sites are located by Stevens Creek with four on each side.

# - PEDESTRIAN TRUSS BRIDGE OPTION -

**PRELIMINARY PLAN**  
NOT FINAL - SUBJECT TO CHANGE



Bridge Locations	▲	■
Scout Creek	30'-0"	31'-10"
Stevens Creek	95'-0"	96'-10"
Stevens Creek	120'-0"	121'-10"



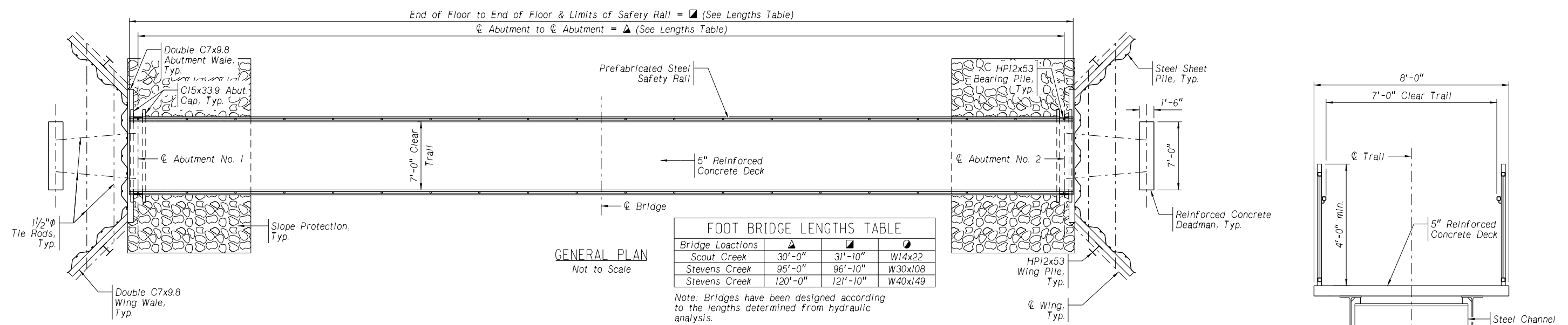
**BRIDGE HYDRAULIC INFORMATION**  
 STREAM: Scout Creek  
 D.A. = 6 SQ MI  
 Q100 = 3248.47 CFS (BASE FLOOD)  
 H.W. ELEV. = 1187.4 FT (D.S. SIDE)  
 Q100 LOCAL SCOUR = 5 FT

**BRIDGE HYDRAULIC INFORMATION**  
 STREAM: Stevens Creek  
 D.A. = 30 SQ MI  
 Q100 = 11,593.84 CFS (BASE FLOOD)  
 H.W. ELEV. = 1189.0 FT (D.S. SIDE)  
 Q100 LOCAL SCOUR = 10 FT

Note: Bridge elevations vary depending on location and length.

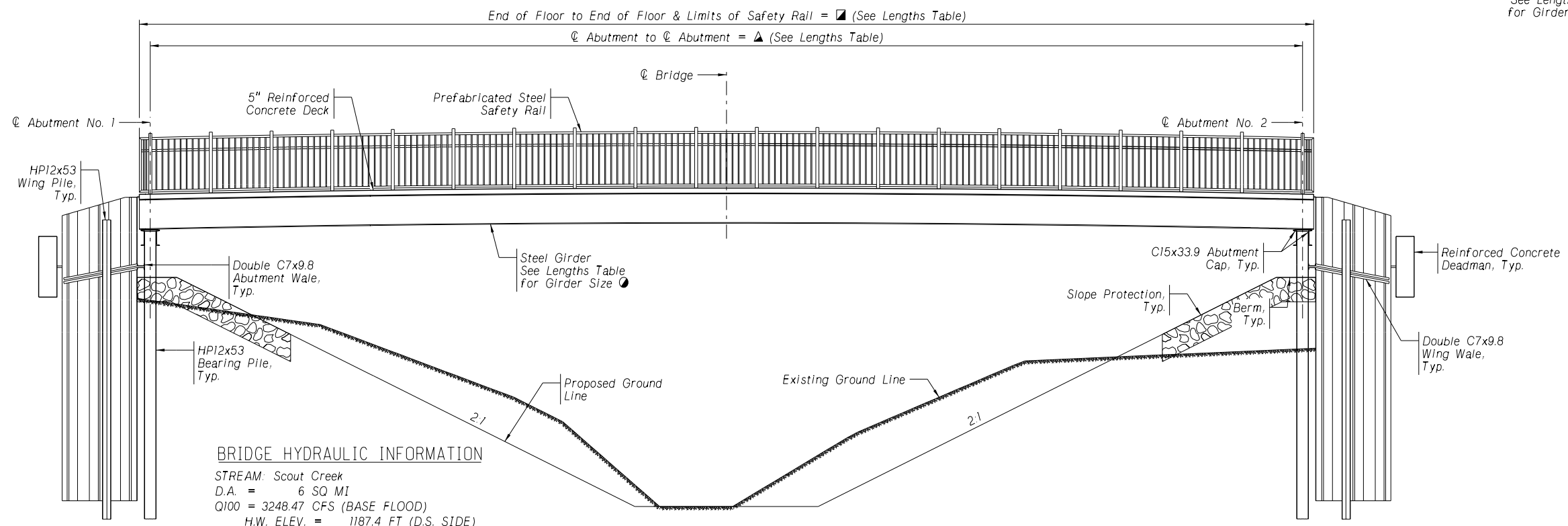
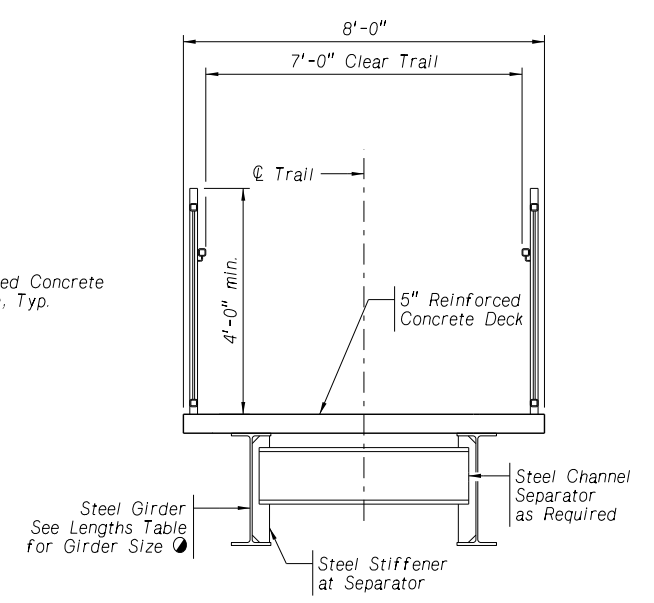
# - PEDESTRIAN TWIN GIRDER BRIDGE OPTION -

**PRELIMINARY PLAN**  
NOT FINAL - SUBJECT TO CHANGE



Bridge Locations	▲	■	●
Scout Creek	30'-0"	31'-10"	W14x22
Stevens Creek	95'-0"	96'-10"	W30x108
Stevens Creek	120'-0"	121'-10"	W40x149

Note: Bridges have been designed according to the lengths determined from hydraulic analysis.



**BRIDGE HYDRAULIC INFORMATION**  
 STREAM: Scout Creek  
 D.A. = 6 SQ MI  
 Q100 = 3248.47 CFS (BASE FLOOD)  
 H.W. ELEV. = 1187.4 FT (D.S. SIDE)  
 Q100 LOCAL SCOUR = 5 FT

**BRIDGE HYDRAULIC INFORMATION**  
 STREAM: Stevens Creek  
 D.A. = 30 SQ MI  
 Q100 = 11,593.84 CFS (BASE FLOOD)  
 H.W. ELEV. = 1189.0 FT (D.S. SIDE)  
 Q100 LOCAL SCOUR = 10 FT

Note: Bridge elevations vary depending on location and length.

# SLAB BRIDGE OPTION

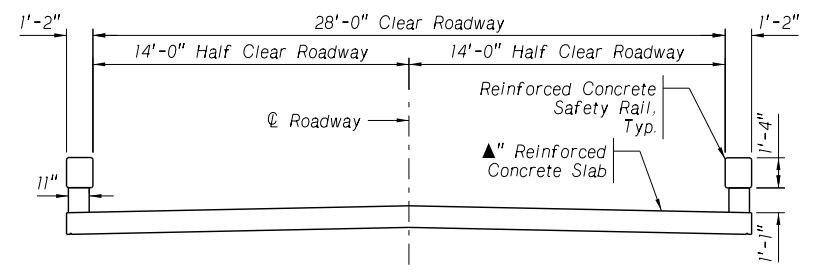
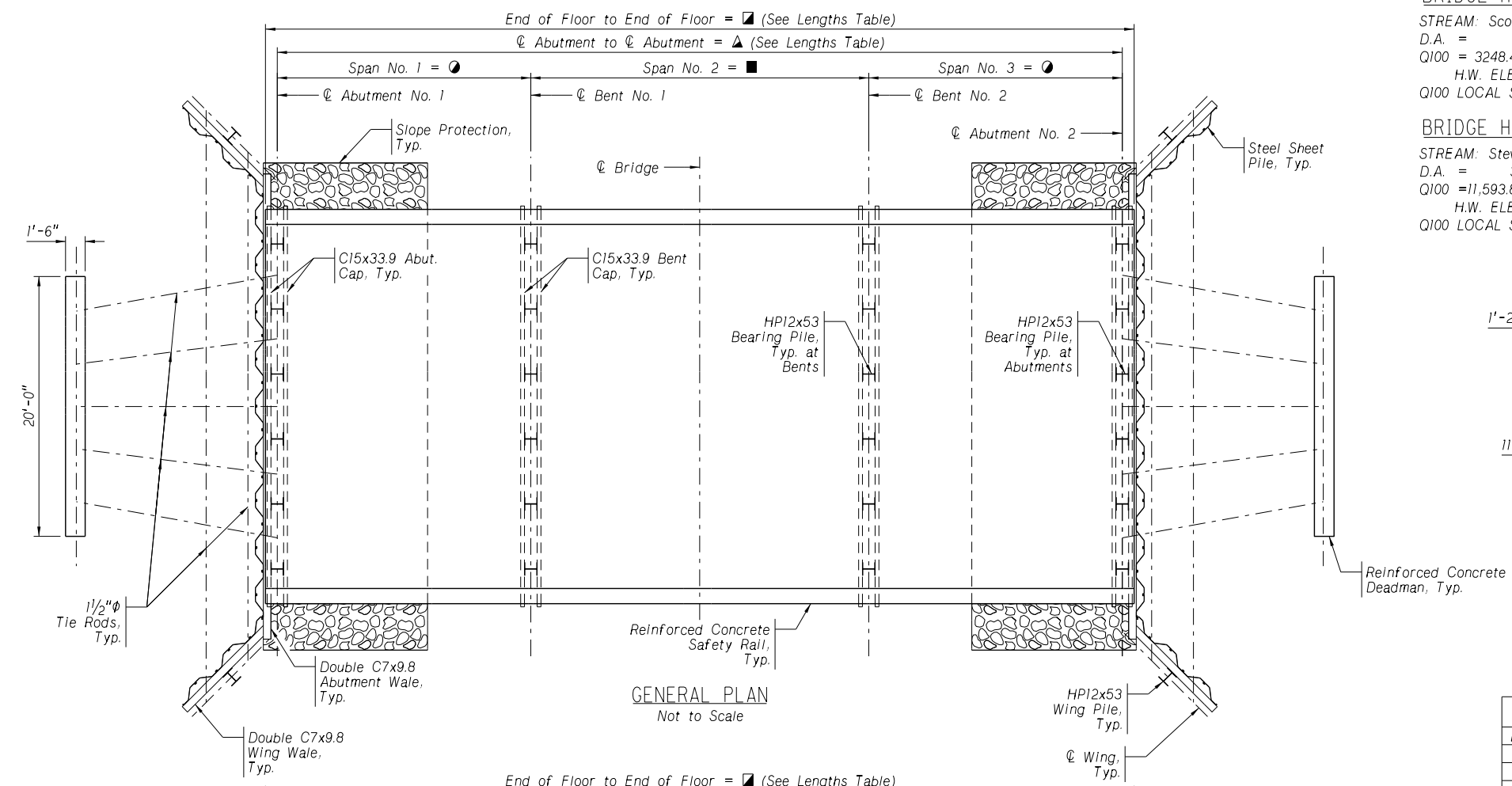
**PRELIMINARY PLAN**  
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### BRIDGE HYDRAULIC INFORMATION

STREAM: Scout Creek  
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Q100 = 3248.47 CFS (BASE FLOOD)  
H.W. ELEV. = 1187.4 FT (D.S. SIDE)  
Q100 LOCAL SCOUR = 5 FT

### BRIDGE HYDRAULIC INFORMATION

STREAM: Stevens Creek  
D.A. = 30 SQ MI  
Q100 = 11,593.84 CFS (BASE FLOOD)  
H.W. ELEV. = 1189.0 FT (D.S. SIDE)  
Q100 LOCAL SCOUR = 10 FT



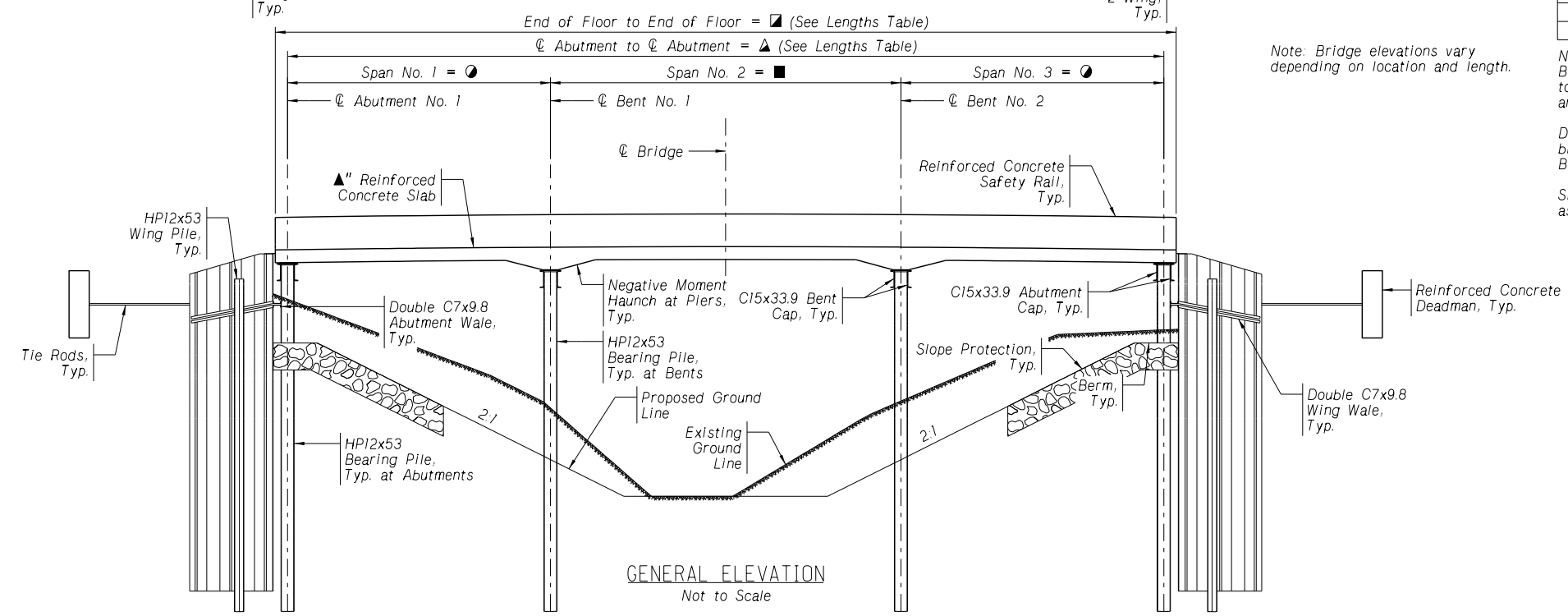
Note: Rail dimensions measured at the front face of rail

Bridge Locations	▲	▣	◌	■	▲
Scout Creek	65'-0"	66'-10"	19'-6"	26'-0"	11 1/2"
Stevens Creek	95'-0"	96'-10"	28'-6"	38'-0"	14 1/2"
Stevens Creek	120'-0"	121'-10"	36'-0"	48'-0"	17"

Note: Bridges have been designed according to the lengths determined from hydraulic analysis.

Design values and lengths for the slab bridges have been pulled from the NDOT BOPP documentation.

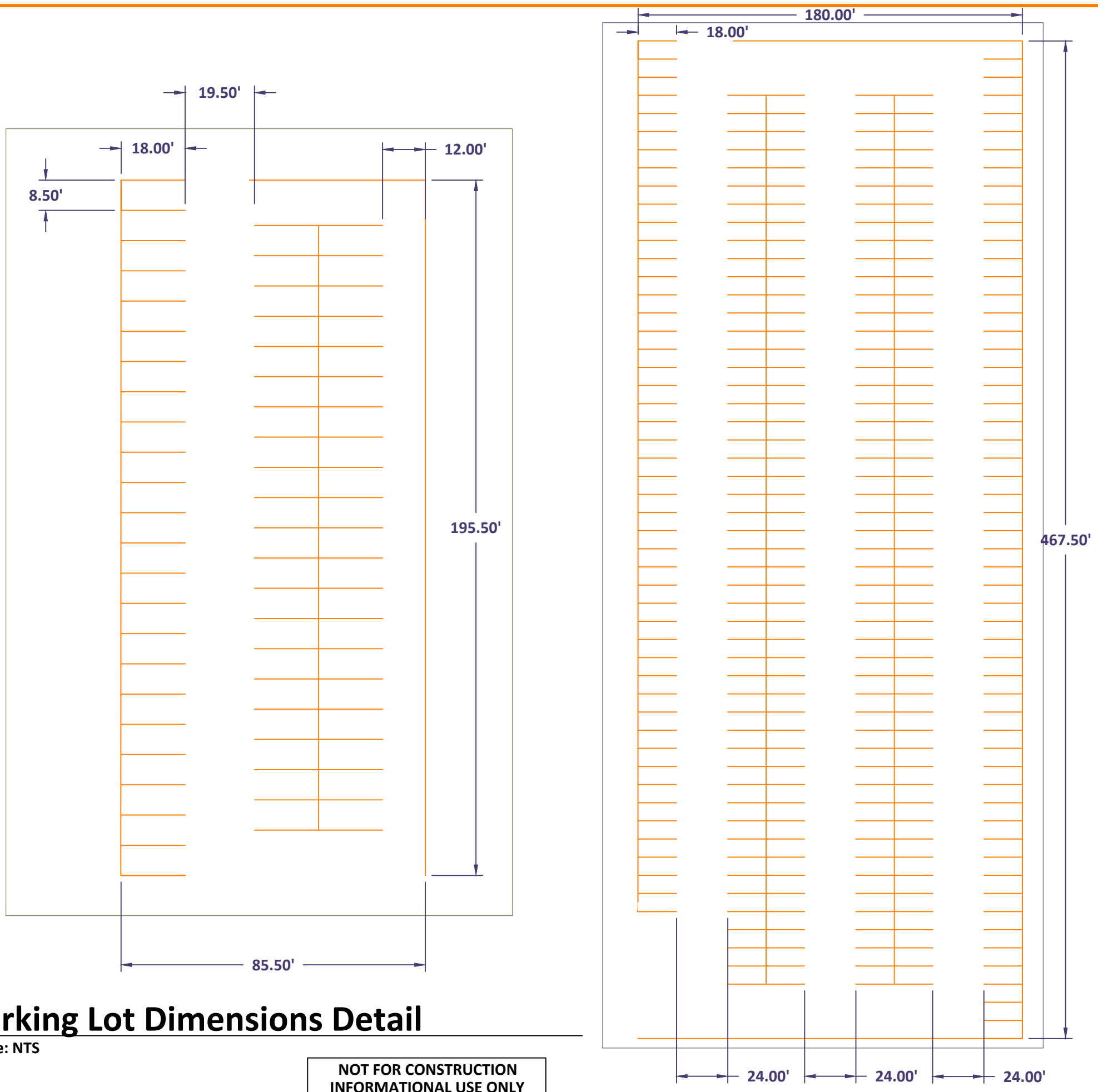
Slab bridges under 40 feet can be designed as a single span with no bents or piers.



Note: Bridge elevations vary depending on location and length.



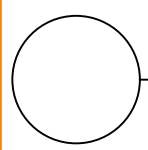
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 PEN: SPEN/BLA  
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PRODUCED BY AN AUTODESK STUDENT VERSION

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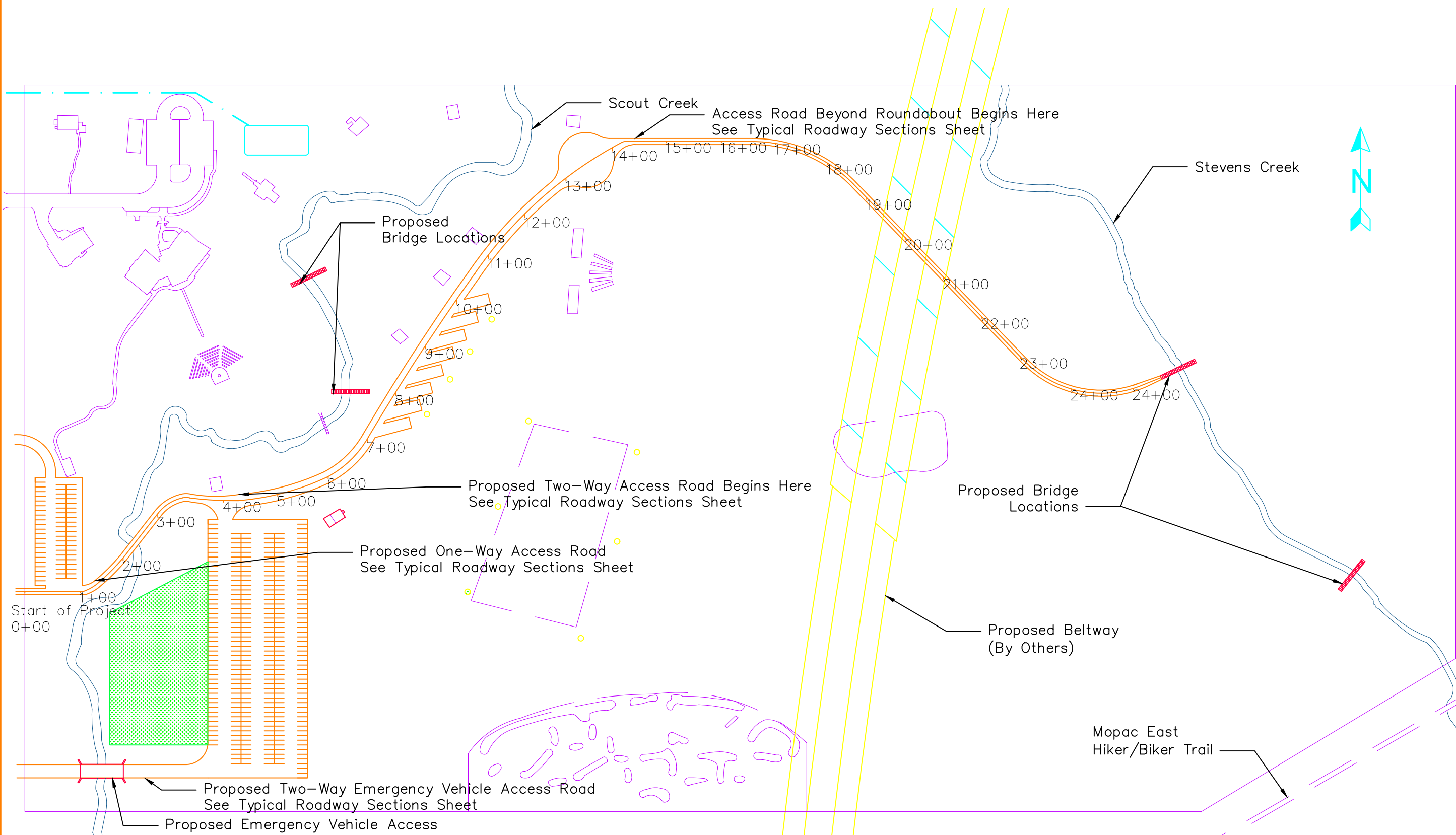


# Parking Lot Dimensions Detail

Scale: NTS

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 INFORMATIONAL USE ONLY

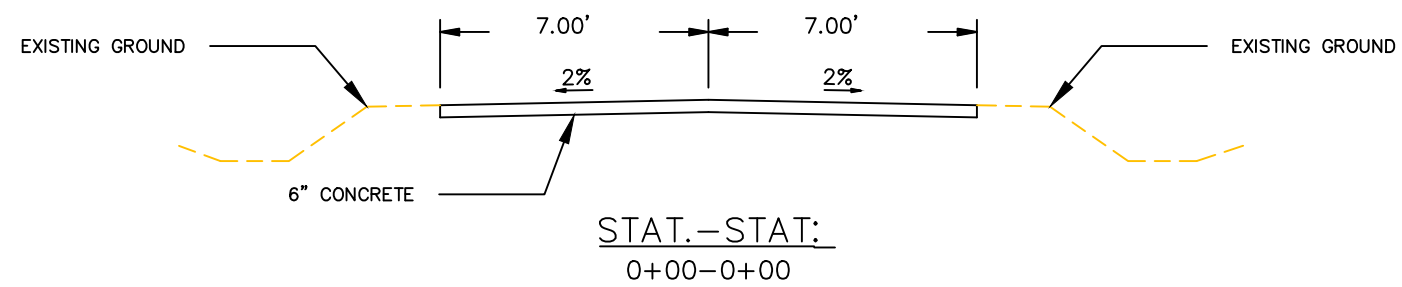
PROJ: Outdoor Education Center  
 REV: \$PENUSL\$  
 USER: \$USER\$  
 DATE: 4/5/19  
 DGN: \$DESIGN-FILE-NAME-\$\$



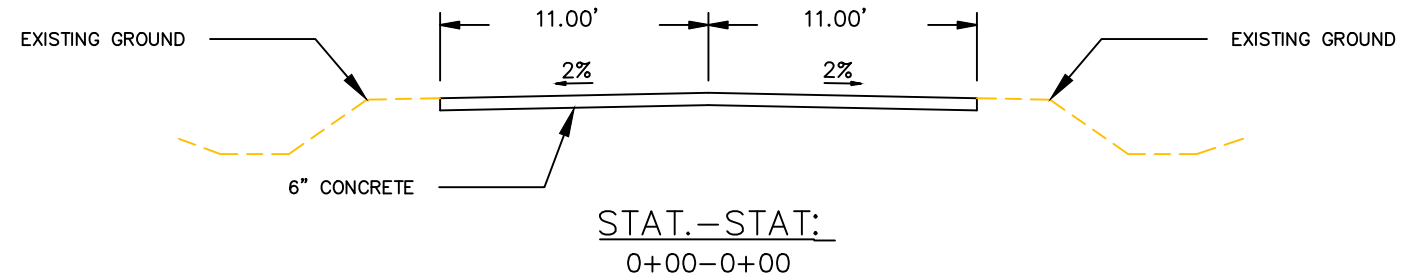
Horizontal Alignment Stationing  
 Scale: NTS

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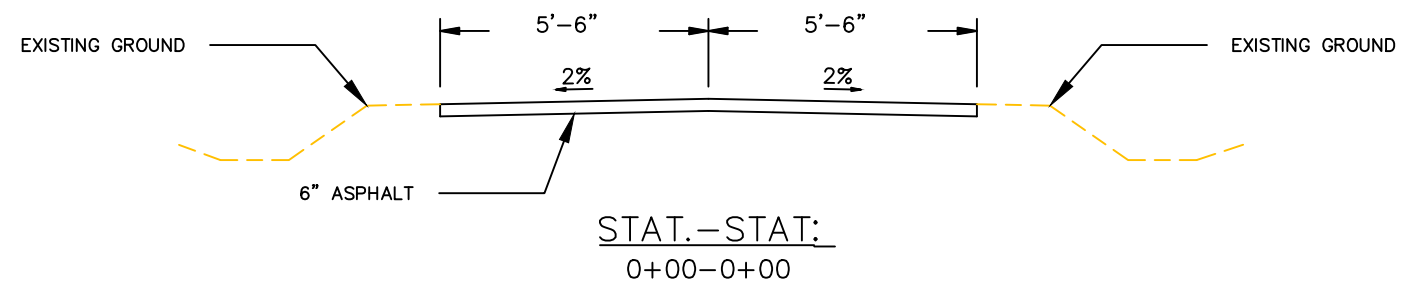
PROJ: Outdoor Education Center  
 REV: SPENJLJ  
 USER: JAC  
 DATE: 4/5/19  
 DGN: JAC



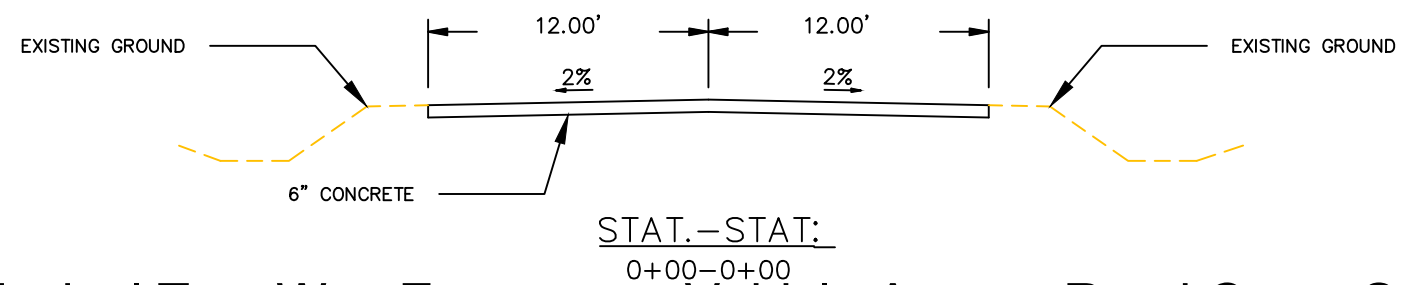
Typical One-Way Access Road Cross Section



Typical Two-Way Access Road Cross Section



Typical Access Road Beyond Roundabout Cross Section



Typical Two-Way Emergency Vehicle Access Road Cross Section

○ Typical Roadway Cross Sections  
Scale: NTS

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