Flood Control Plan Feasibility Study

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BYU Storm Water Engineers

Matt Johnson
Donald Anderson
Fabian Zamorano
Mentor: Christian Kesler

Department of Civil and Environmental Engineering
Brigham Young University

Executive Summary

Our project involves the design of a storm water system for the Ridge Lane area in Payson, UT. This area is currently experience flooding during high intensity storm events. To fix this problem, gutters, collection basins, concrete pipes, pretreatment manhole, a sump, and a detention basin will be used. With the use of AutoCAD’s Stormwater Analysis, the sizes needed for the previous stated structures were determined. We are confident that this design will be successful and prevent future flooding from occurring in this area.

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Introduction

The Ridge Lane area of Payson, City currently experiences flooding problems that are due to some faults in the stormwater system. These issues cause flooding in several locations in the area including in a few houses. As a result, the main goal for this project is to improve the stormwater system that will involve installing pipes, gutters, open channels, or drainage basins that will have the capability of handling a 25-year event storm. A detention basin will also be constructed that will have the capability of storing water for a 100-year event storm.

This project involves making several calculations and determining the watershed area that will contribute to the overall storage of the detention basin for the area. Flow rates will be calculated to determine the sizes and dimensions of the pipes, gutters, and open channels that will be installed to improve the stormwater system. The system must be able to handle the flow and the velocity of the stormwater that is contributed to the whole area. The overall volume of water that the area will contribute will also be calculated in order to determine several factors of the system including the required storage volume for the detention basin.

Some of the limitations that will occur during the design process are the current pipes, utilities, and manholes that may affect the path of the new pipes or gutters are designed for the new system. Clogging may occur in the pipes, channels, or grates that may be designed for the system that is caused by sediment or leaves that are in the area.

Due to these limitations, there are several factors must be considered for the design of the system. Like a filtration system that will help minimize issues with clogging. There will be a factor of safety applied to the system to ensure that it will be able to handle a 100-year storm event.

This report will show important aspects of the design. It will include decisions made to why pipes, gutters, open channels, and drainage basins should be installed at certain locations. The report will display the calculations that were required to determine the dimensions used for the design.

This project will help provide much needed improvements to the stormwater system in the Ridge Lane area of Payson, UT. It will help reduce the flooding that may occur while also provide preparation for major storm events. The software programs and methods that were used during the design of this stormwater system will be provided to show how certain issues and obstacles were solves during the design of the project.

Body of Report

The initial weeks of the project were spent mostly doing research in storm water design. We individually studied the theory, the practice, and the given documents in order to get a good grasp for the scope of the project. After we met and discussed some of the theory of storm water design, we visited the site in person. This site visit was an invaluable part of our design, as it completely altered our understanding of the location. Aerial and google map images showed a much flatter slope, rather than the steep and sag ridden area we actually had. Unfortunately, the area was covered in a thick blanket of snow which made it very difficult to see the gutters and current storm water systems. We were able to talk to a neighbor to get a general idea of which houses flooded and why.

The following week, we discussed our initial vision of our design including inlet basin locations, and made plans for the initial design. At this point, we ran into several challenges. The hydrology of the area, the rainfall intensity, time of concentration, and pipe design methods were all up in the air. We initially used AutoDesk Civil 3d to try to get a feel of the hydrology of the area but that did not yield useful results. Then we used WMS watershed modeling program which was more useful. However, WMS calculated watershed based on elevation, and did not take into account any road design, which was the key unknown in this project. We tried to use Civil 3d to design the system but it was a very alien program to us and was not leading us to our desired results.

Fortunately, we were able to find a computer on the BYU campus that had AutoDesk Storm and Sanitary Analysis (SSA) installed. This program simultaneously solved our challenges of hydrology, rainfall intensity, time of concentration, and storm water design. This program was a powerful tool in analyzing stormwater in the area. After spending time to learn the program, we were able to customize the program to give us the design time of concentration and intensity.
With the analysis tool working, we were able to visually calculate the runoff coefficient. We also used Travis's spreadsheet to calculate water flow, detention basin area, and coefficient of discharge.

As we experimented with SSA, we quickly realized several major limitations to a pipe system with inlets. There were existing pipes that were in the way for the optimal piping location. In addition, the problem of flooding, which was our chief concern, was not able to be solved without unreasonably sized inlets. The reason being mainly sag points, clogging, and bypass water. The sag point at house 1 (which floods) quickly ponded, and would still flood the area somewhat. The inlet basin was not capable of intaking all that water. In addition, a lot of the water would run past the inlet basin and into the curbside gutter, flooding house 2. This problem was exasperated by the heavy leaf and sediment clogging problem in the area.

Ironically enough, we found that someone had previously tried to install a stormwater system in exactly the same place we were planning on. However, this system was clogged up with leaves, and would not intake water with led to the flooding. Most grates would quickly lose half of their intake capabilities, not to mention pipes filled with leaves and sediment. For an underground storm water system to be viable, Inlet catch basins would have to be combination curb opening and grated. However, due to the shape of the hill, a curb opening with a grate system would still allow plenty of water to bypass, especially at the corner curb (fire hydrant location). The flooding at house 1 would be mitigated but not for the 2nd house that flooded. The problem of ponding and water bypass was difficult to design around. In addition, the minimum sized pipe would barely be filled with water and would be very inefficient. Ultimately, we decided that a 2nd site visit, after the snow had melted was needed. We went down one more time, talked to the owner of the house that flooded most consistently. It became apparent even before we talked that the problem of flooding for his house would not be adequately fixed with an underground pipe system. The underground system would be expensive, ineffective, and unnecessary.

After that site visit, we had a new idea that we had previously not even considered. Rather than put in a pipe with inlet basins, we decided to take advantage of the water flooded in the area. We decided to work with nature by putting in gutters and opening channels to direct flow downhill into the pretreatment manhole. This way, even any bypass flow would naturally disperse into the open lot, as the house at the bottom of the hill did not have flooding problems due to the existing gutter system and geometry of the driveway. Since the water in the area already flowed to a specific area, we thought it would be more effective to just channel the water down past the flood prone homes. We were not alone in our thinking, as a previous engineering had tried to build an open channel, though on the other side of the street. An open channel would greatly mitigate clogging effects, given the size was sufficient. In addition, it would be very efficient, easy to clean, and inexpensive. The flooding problem would be solved and the leaf and sediment problem would cease to be a major problem. At the bottom of the hill, the open channel would just lead into a pretreatment manhole, which would lead into the detention basin.

Design

The one major problem that was causing flooding to occur was that one resident did not have a curb and gutter. The curb and gutter stopped at the resident's driveway. That driveway is sloped down towards the house. So when there was a large storm event, the water would be channeled by the existing curb and gutter to the driveway and then from the driveway to the home. To fix this problem, we will be extending the existing curb and gutter with a 1.2-foot-wide and 1-foot-deep open channel gutter that will divert stormwater down the street instead of his driveway. The stormwater will continue to a collection basin at the end of the street. The collection basin will consist of a 36-inch curb opening and a 16-inch-wide and 36-inch-long parallel bar P-1-⅞ grate. The proposed gutter is shown as Link-1 and Inlet-2 in the appendix.

There will also be another gutter on the other side of the street. There is an existing channel that diverts the water down to an open lot at the end of the street. We are going to modify this channel to be 1.2-foot-wide and 0.75-foot-deep because the current channel cannot handle the flow from a 25-year storm. There will be a collection basin, Inlet-6 as shown in the appendix. This collection basin will be a 12-inch-wide and 24-inch-long curved vane grate. Both of inlets basins will divert the stormwater to a pre-treatment manhole. The pre-treatment manhole is used to trap unwanted derby so that all that counties is the stormwater down the next pipe. All the pipes used for this project are 15-inch reinforced concrete pipes. There is a third pipe that takes all the water from the pre-treatment manhole to the detention basin. To help drain the water into the ground, there will be a sump at the end of Link-8 as shown in the appendix. A prefabricated concrete sump. There will be drain rock around the sump to help the stormwater drain into the ground. Around the drain rock, there will be a filter fabric that will prevent the surrounding soil from filling the void spaces in the drain rock and allow water to drain out. If the sump cannot handle the incoming flow, then there is a grate at the top of the sump that will allow it to overfill and start filling the detention basin.

Appendix

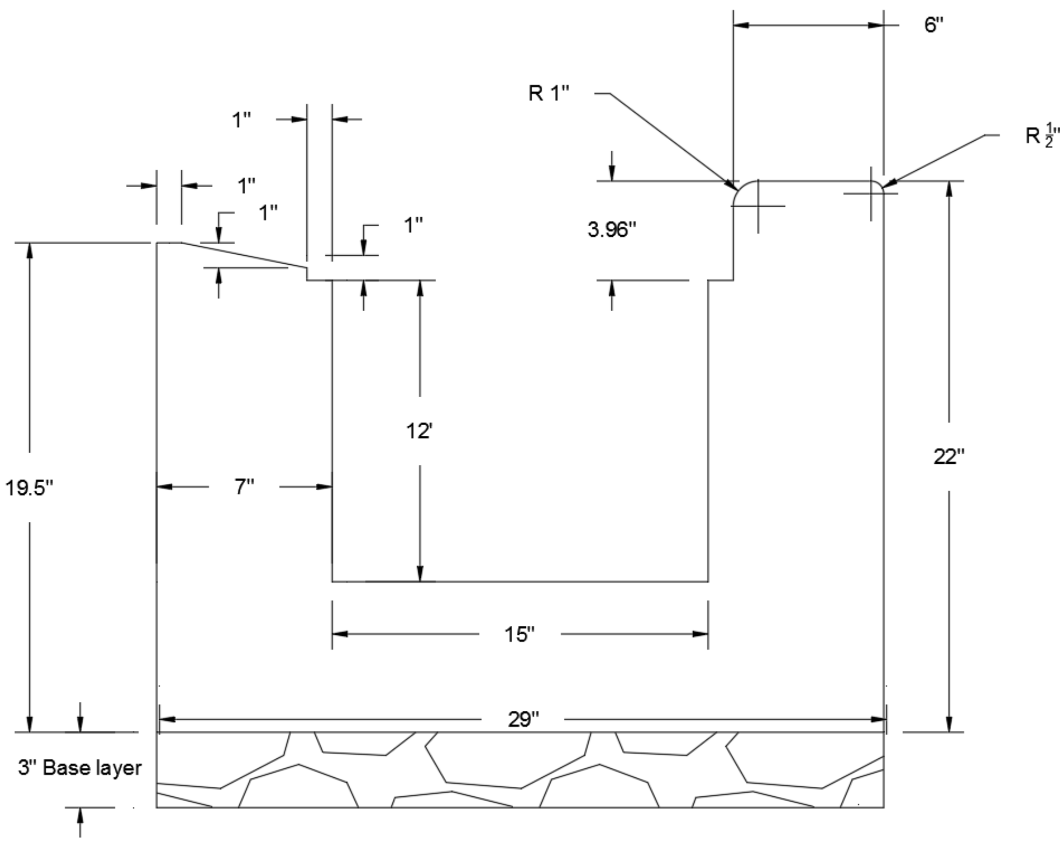


Figure 1. Proposed Open Channel

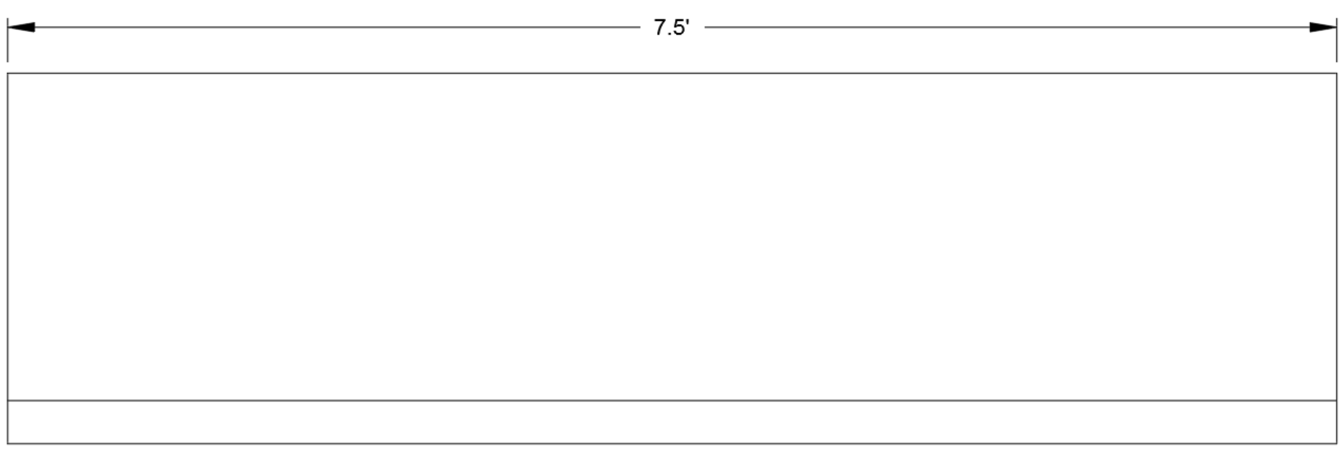


Figure 2. Open Channel Side View

Figure 3. System Aerial View

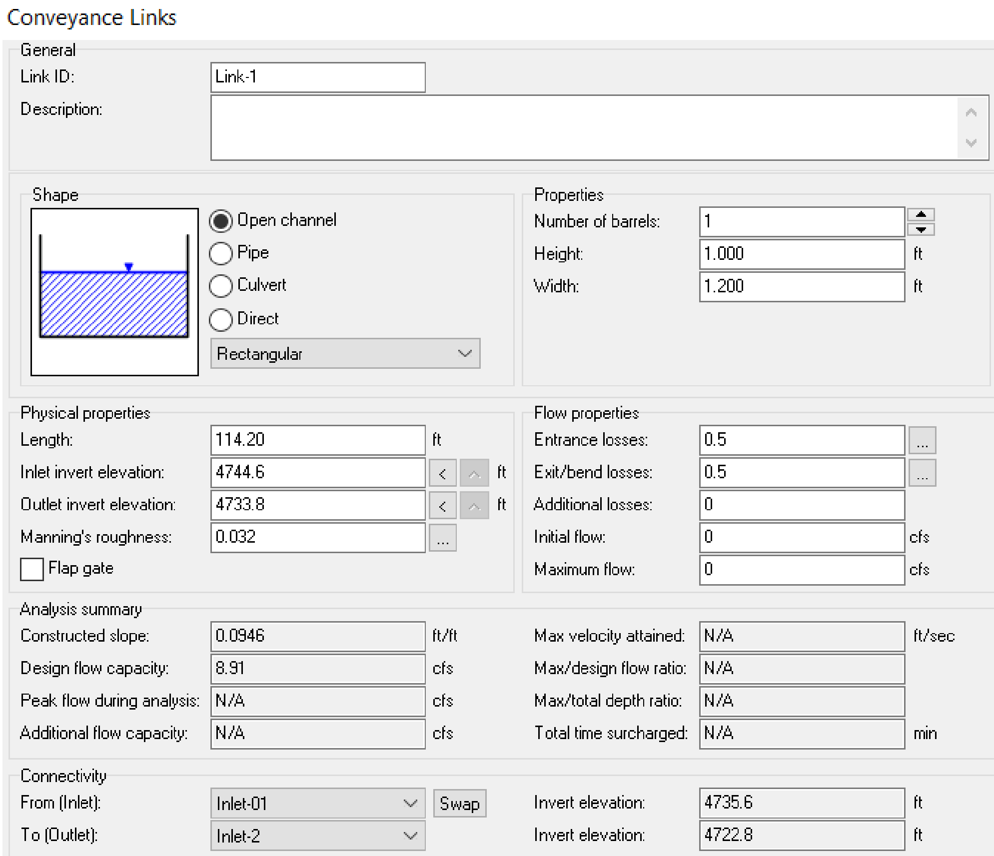


Figure 4. Neighbor Side Channel Feasibility

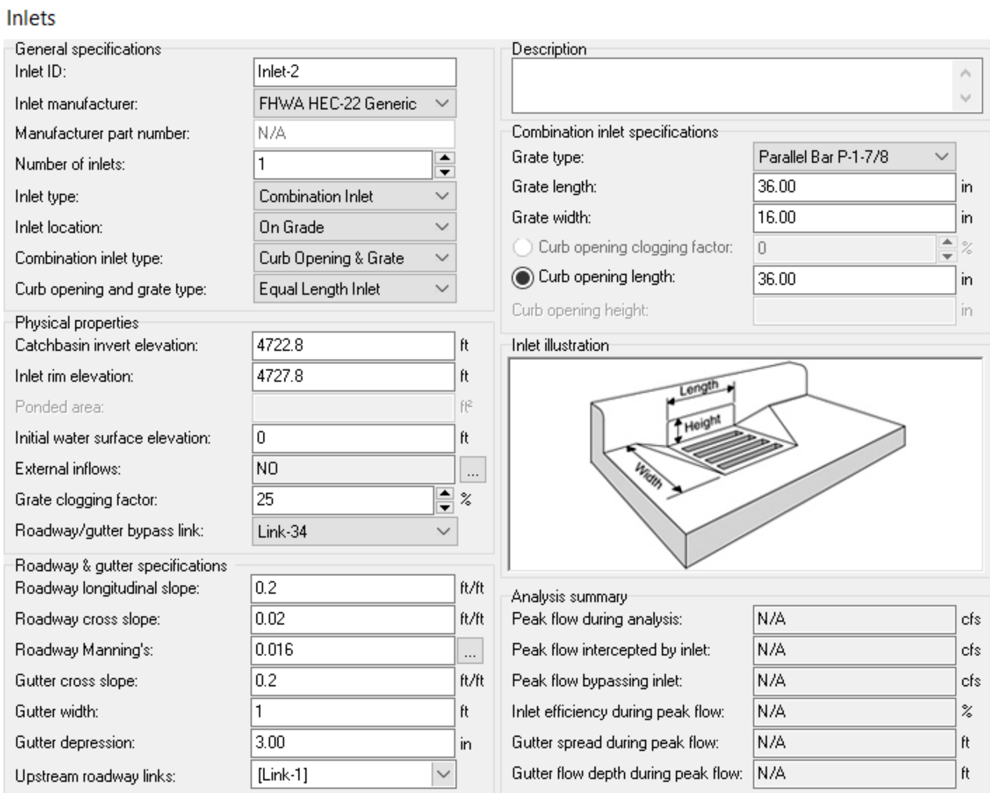


Figure 5. Inlet Grate on Neighbor's Side

Conveyance Links

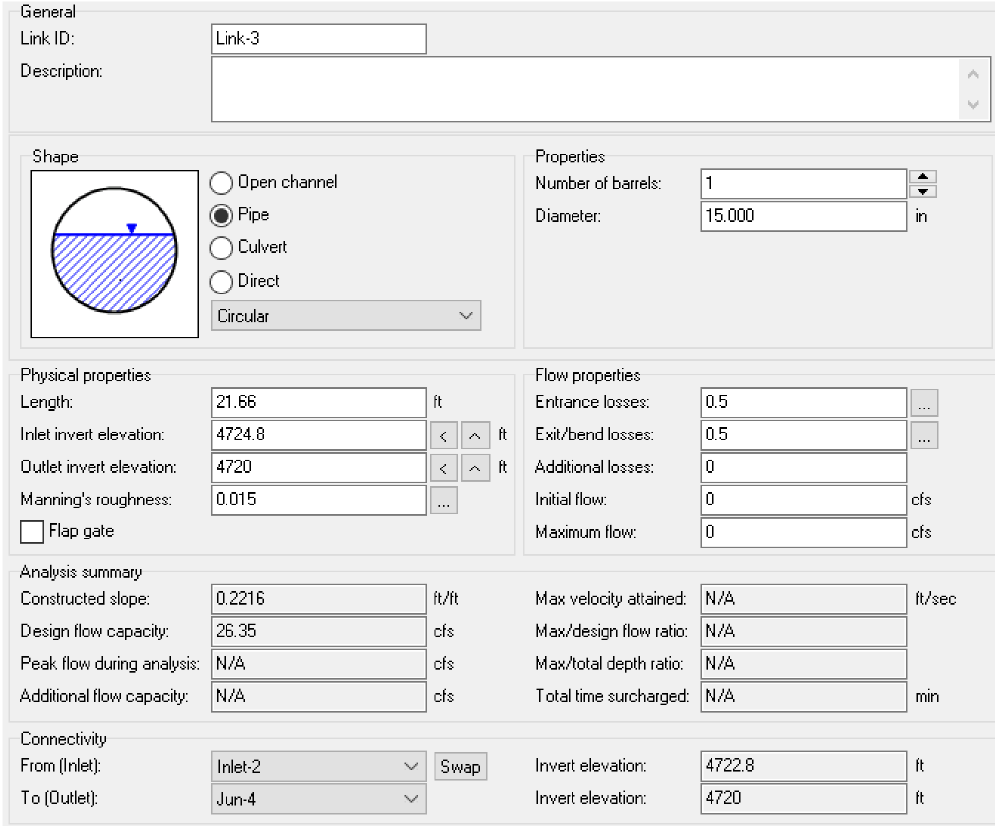


Figure 6. Pipe to Pretreatment, Neighbor's Side

Junctions

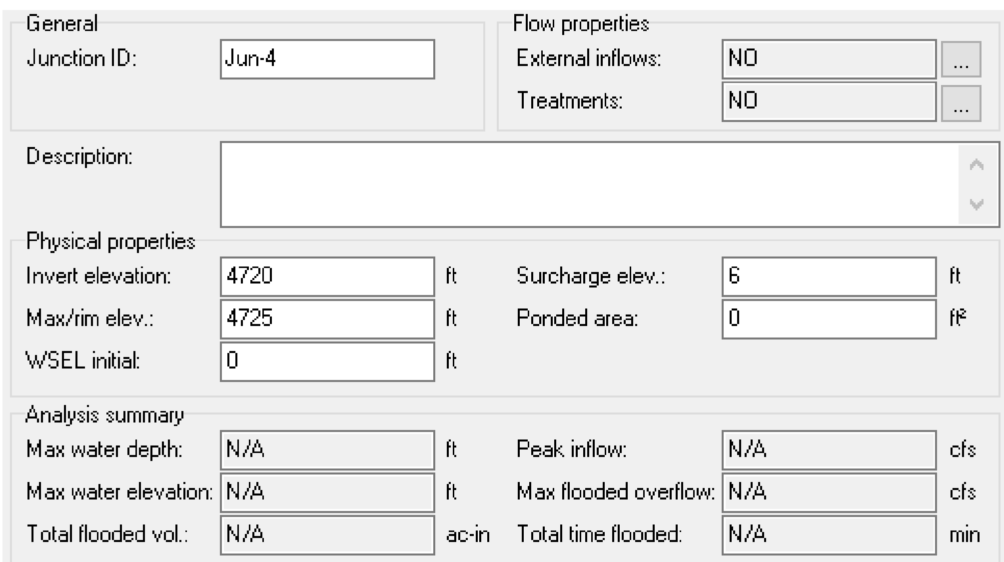


Figure 7. Pretreatment Manhole Analysis

Conveyance Links

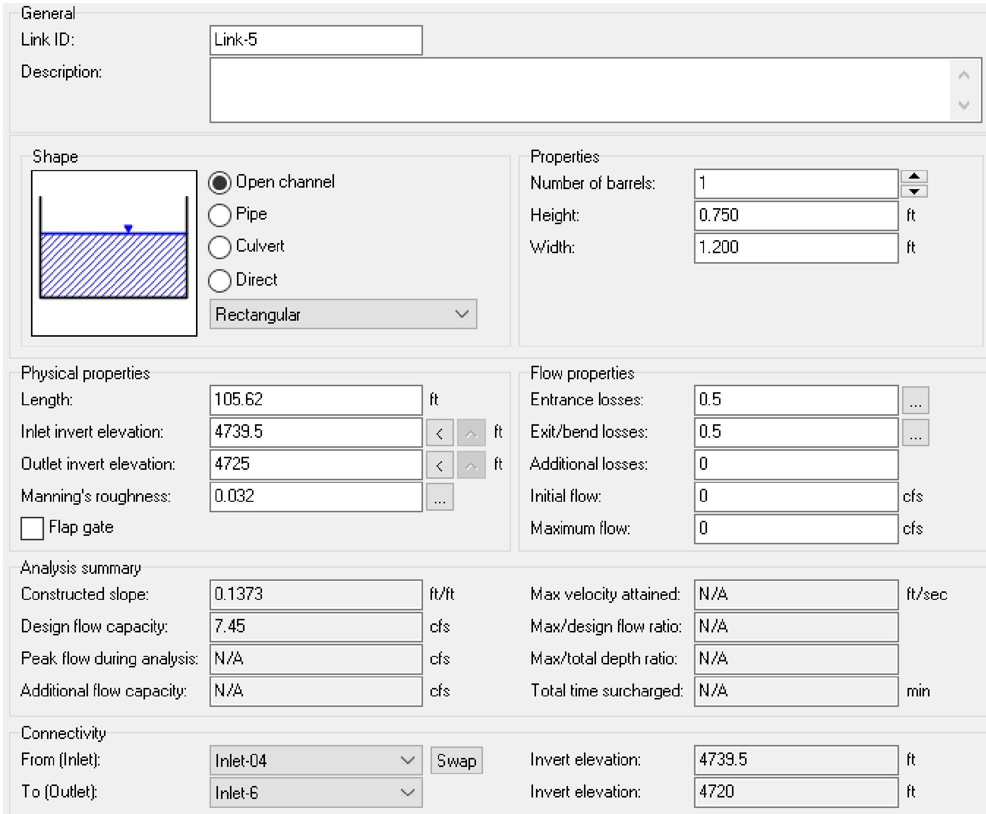
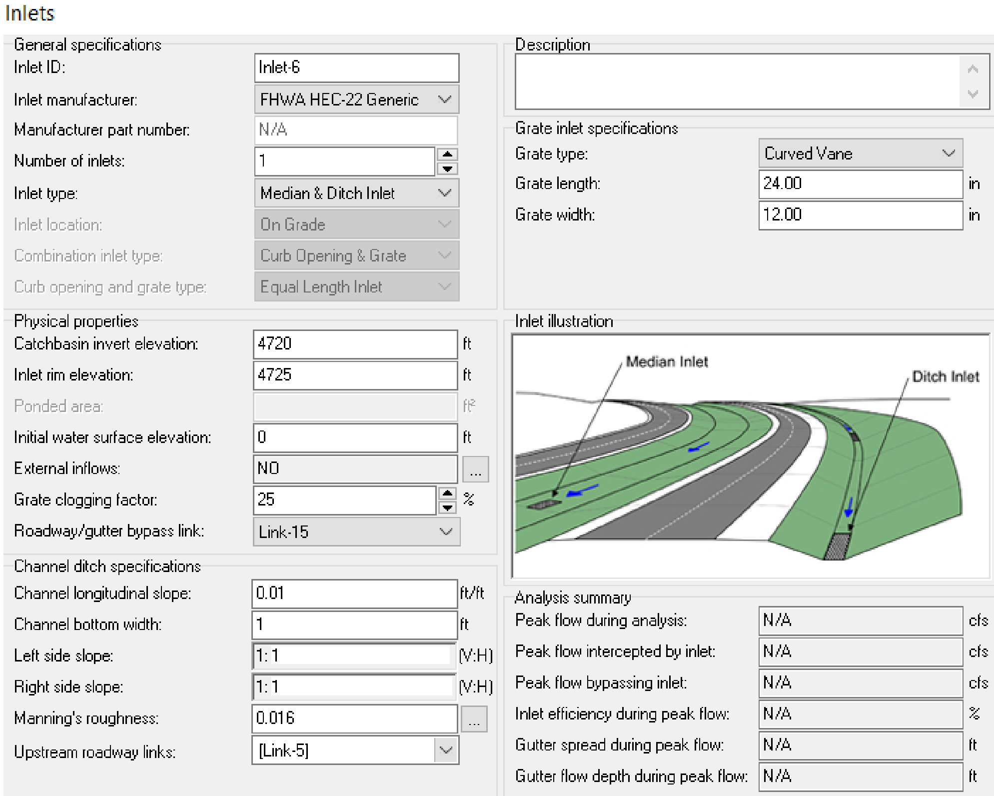


Figure 8. Open Channel, West Side



Inlets

General specifications
Inlet ID: Inlet-6
Inlet manufacturer: FHWA HEC-22 Generic
Manufacturer part number: N/A
Number of inlets: 1
Inlet type: Median & Ditch Inlet
Inlet location: On Grade
Combination inlet type: Curb Opening & Grate
Curb opening and grate type: Equal Length Inlet

Description

Grate inlet specifications
Grate type: Curved Vane
Grate length: 24.00 in
Grate width: 12.00 in

Physical properties
Catchbasin invert elevation: 4720 ft
Inlet rim elevation: 4725 ft
Ponded area: ft²
Initial water surface elevation: 0 ft
External inflows: NO ...
Grate clogging factor: 25 %
Roadway/gutter bypass link: Link-15

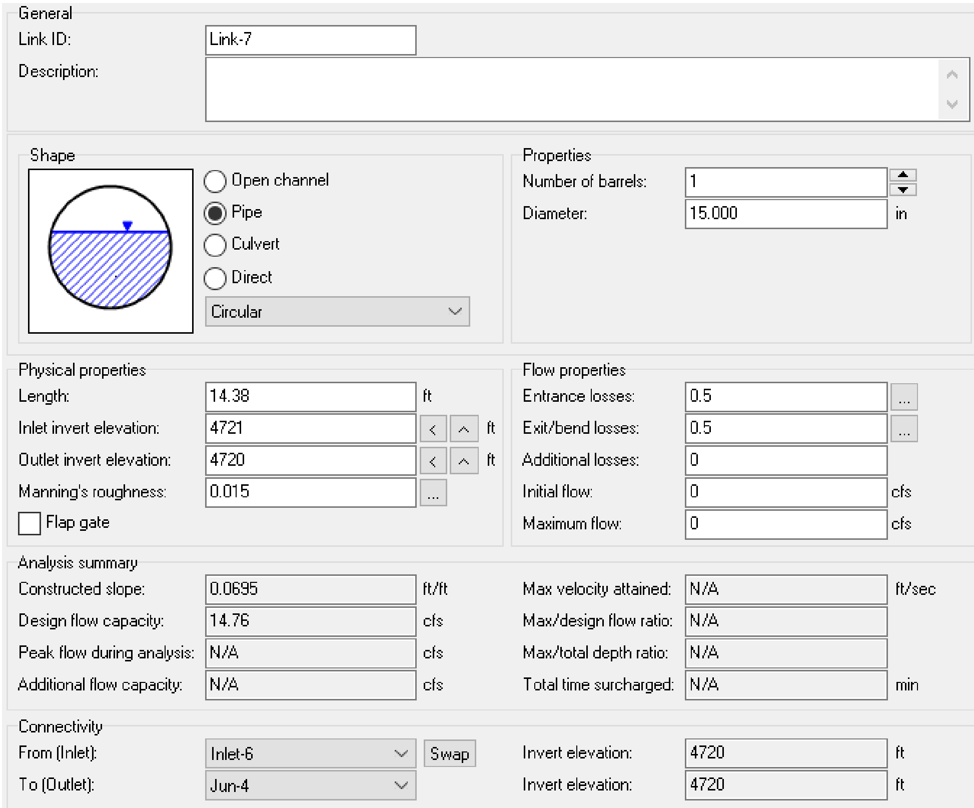
Inlet illustration
Median Inlet
Ditch Inlet

Channel ditch specifications
Channel longitudinal slope: 0.01 ft/ft
Channel bottom width: 1 ft
Left side slope: 1:1 (V:H)
Right side slope: 1:1 (V:H)
Manning's roughness: 0.016 ...
Upstream roadway links: [Link-5]

Analysis summary
Peak flow during analysis: N/A cfs
Peak flow intercepted by inlet: N/A cfs
Peak flow bypassing inlet: N/A cfs
Inlet efficiency during peak flow: N/A %
Gutter spread during peak flow: N/A ft
Gutter flow depth during peak flow: N/A ft

Figure 9. Inlet, West Side

Conveyance Links



General

Link ID: Link-7

Description:

Shape

Open channel

Pipe (selected)

Culvert

Direct

Circular

Properties

Number of barrels: 1

Diameter: 15.000 in

Physical properties

Length:	14.38	ft
Inlet invert elevation:	4721	ft
Outlet invert elevation:	4720	ft
Manning's roughness:	0.015	

Flap gate

Flow properties

Entrance losses:	0.5	
Exit/bend losses:	0.5	
Additional losses:	0	
Initial flow:	0	cfs
Maximum flow:	0	cfs

Analysis summary

Constructed slope:	0.0695	ft/ft	Max velocity attained:	N/A	ft/sec
Design flow capacity:	14.76	cfs	Max/design flow ratio:	N/A	
Peak flow during analysis:	N/A	cfs	Max/total depth ratio:	N/A	
Additional flow capacity:	N/A	cfs	Total time surcharged:	N/A	min

Connectivity

From (Inlet):	Inlet-6	Swap	Invert elevation:	4720	ft
To (Outlet):	Jun-4		Invert elevation:	4720	ft

Figure 10. Pipe to Pretreatment, West Side

Conveyance Links

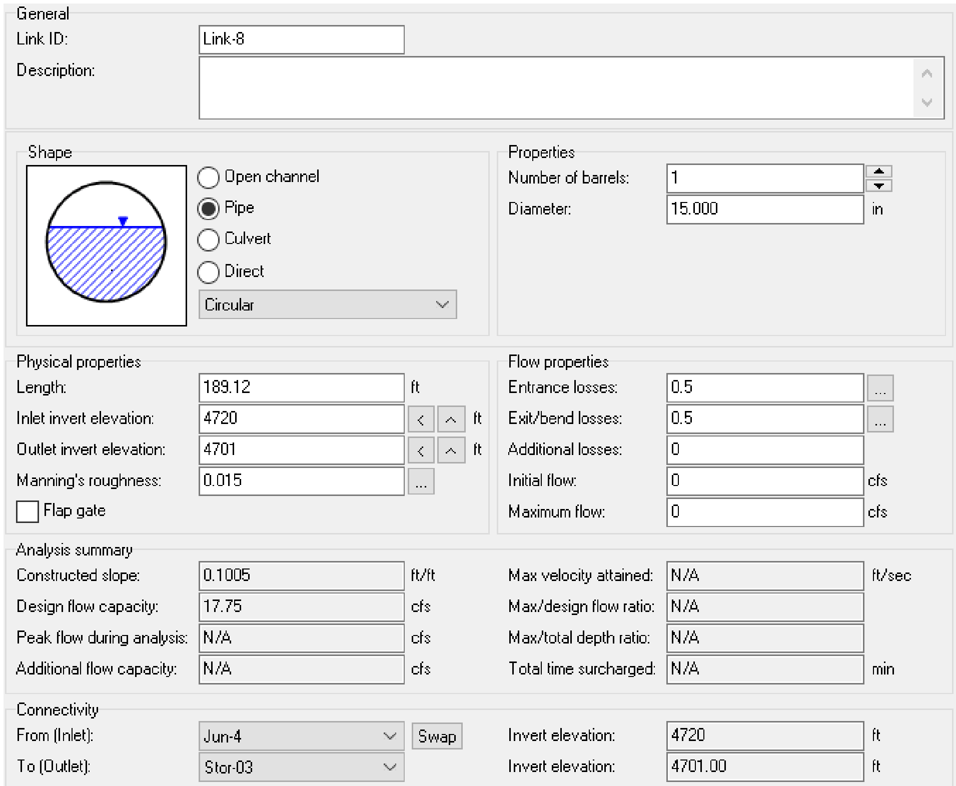


Figure 11. Pipe to Detention Basin

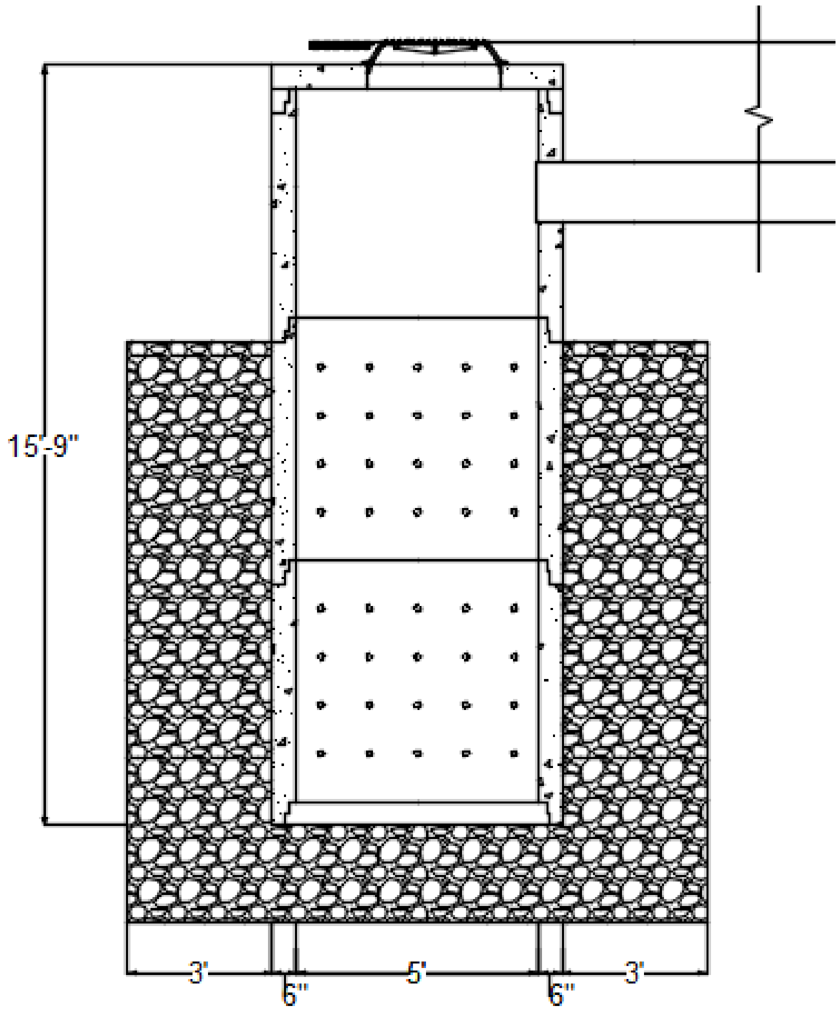


Figure 12. Sump

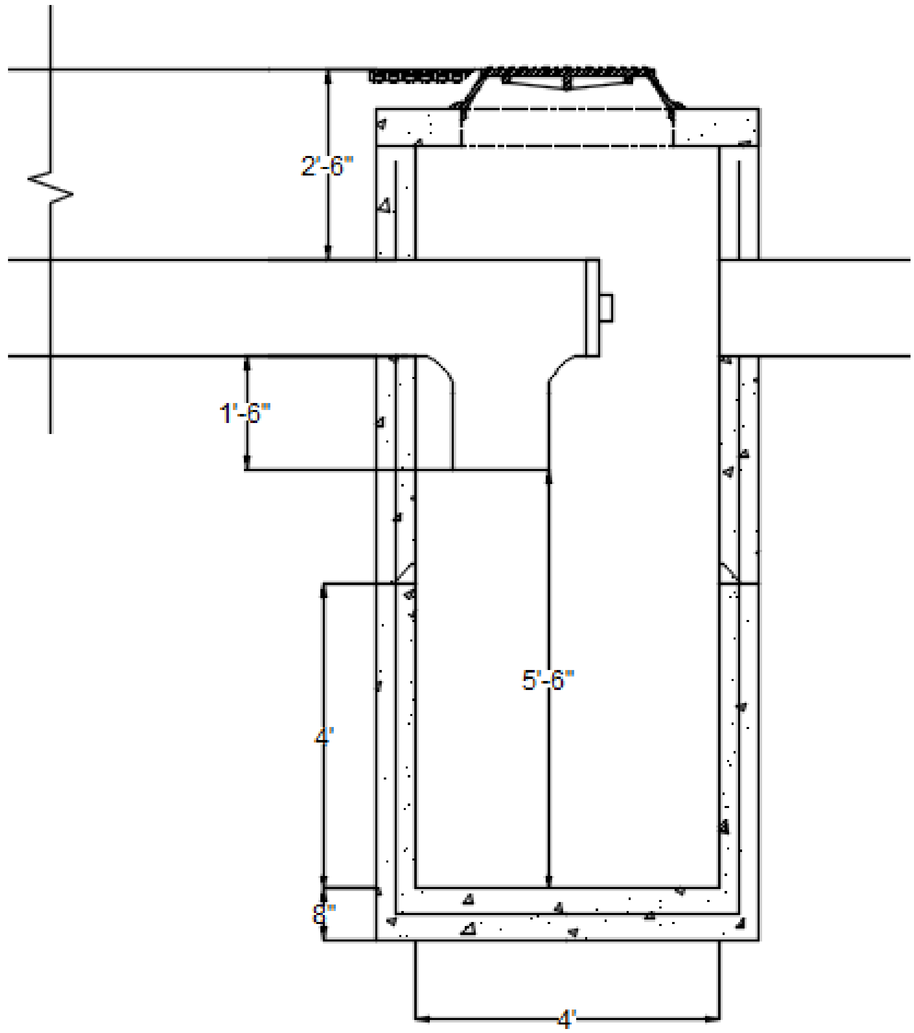


Figure 13. Pretreatment Manhole