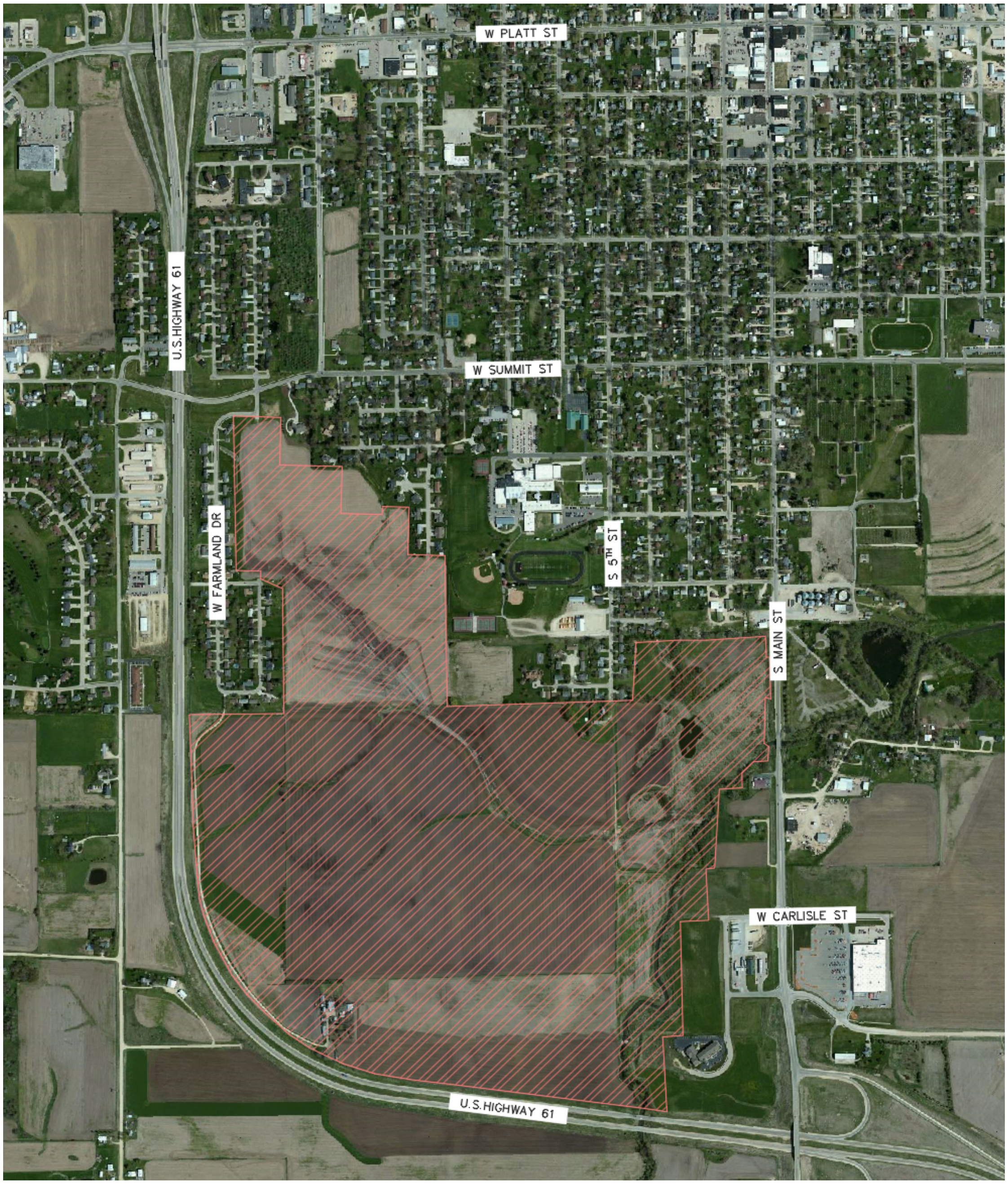

SW Maquoketa Land Use Plan for the City of Maquoketa, Iowa

CITY OF MAQUOKETA
ONE OF A KIND

May 13th, 2022

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Section I Executive Summary

In the Spring of 222, a team of civil engineering students (Project Team) at the University of Iowa prepared a land use plan for the city of Maquoketa, Iowa. This team has experience in transportation and water resource engineering as well as site design through courses and professional engineering experience through internships. This land use plan was created for the 335 acres of undeveloped land bounded by Highway 61 (west and south), S Main Street (east), and W Summit Street (north) that is adjacent to the City of Maquoketa, Iowa to the South.

The Project Team has prepared a set of design drawings, cost estimates, and this design report for the development of the region. The design drawings include a street network layout that contains street classifications with right-of-way width, right-of-way cross-sections depicting the typical street corridor from doorstep to doorstep, a stormwater management system containing significant drainage ways and culverts, a water main and sanitary sewer network, green space, and trail network. The City of Maquoketa Code and the Iowa Statewide Urban Design and Specifications (SUDAS) governed this design.

The land use plan provides the Maquoketa with 490 new single-family lots, averaging 0.3 acres, 7.28 acres of duplex and multifamily housing and 14.95 acres of commercial zoning, allowing the community to grow by over 20%. Upon full development of the site, it is estimated that the single-family, multifamily, and commercial tax base will increase by $134.3 million. A summary of the tax base increase is in Table 1. Figure 1 below shows the proposed zoning and land use for the project site. The commercial area can support the development by targeting businesses that will provide services to the neighborhood such as daycare, church, and dining facilities.

Table 1 Estimated Tax Base Increase

ESTIMATED TAX BASE INCREASE		
SINGLE-FAMILY TAX BASE INCREASE	$	122,500,000.00
MULTIFAMILY TAX BASE INCREASE	$	6,976,000.00
COMMERCIAL TAX BASE INCREASE	$	4,817,000.00
TOTAL TAX BASE INCREASE	$	134,293,000.00

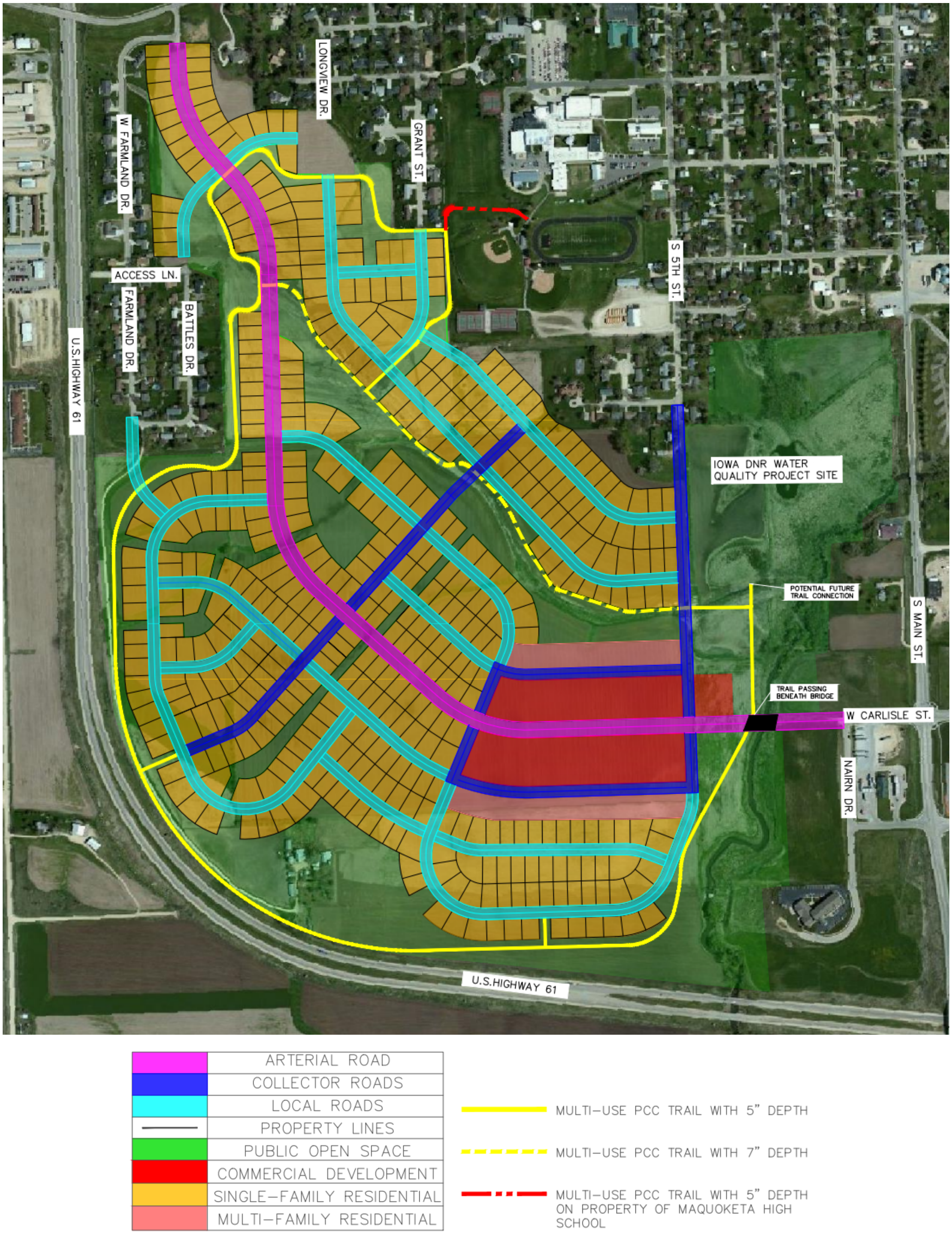


Figure 1 Land Use Plan Overview

The land use plan utilizes a modified grid street network to connect to existing roads and provide connectivity to the site while coinciding with the existing topography. This plan increases the total road paved miles in the City of Maquoketa by 6.6 miles and utilizes three main street types which are arterial (90-foot ROW), collector (65-foot ROW), and local (65-foot ROW). The cross-section of each road corridor can be seen in Figure 2 which depicts the geometry of each road type. The pavement design for the arterial road was determined using the SUDAS pavement thickness design procedure in SUDAS Chapter 5 and a pavement design of 6-inch base with 9-inch PCC. The longitudinal joints should be every 10-12 feet and the transverse joints should be 15 feet. SUDAS transverse joint type CD Doweled Contraction Joint should be used with 1 ¼ inch dowels. The collector and local roads have a 10-inch base with 3-inch HMA layer which is standard for the City of Maquoketa. All pavement design thicknesses are summarized in Table 2.

Table 2 Pavement Thickness Design Summary

PAVMENT DESIGN			
ROAD CLASSIFICATION	PAVEMENT TYPE	PAVEMENT THICKNESS (IN)	BASE THICKNESS (IN)
ARTERIAL	PCC	9	6
COLLECTOR	HMA	3	10
LOCAL	HMA	3	10

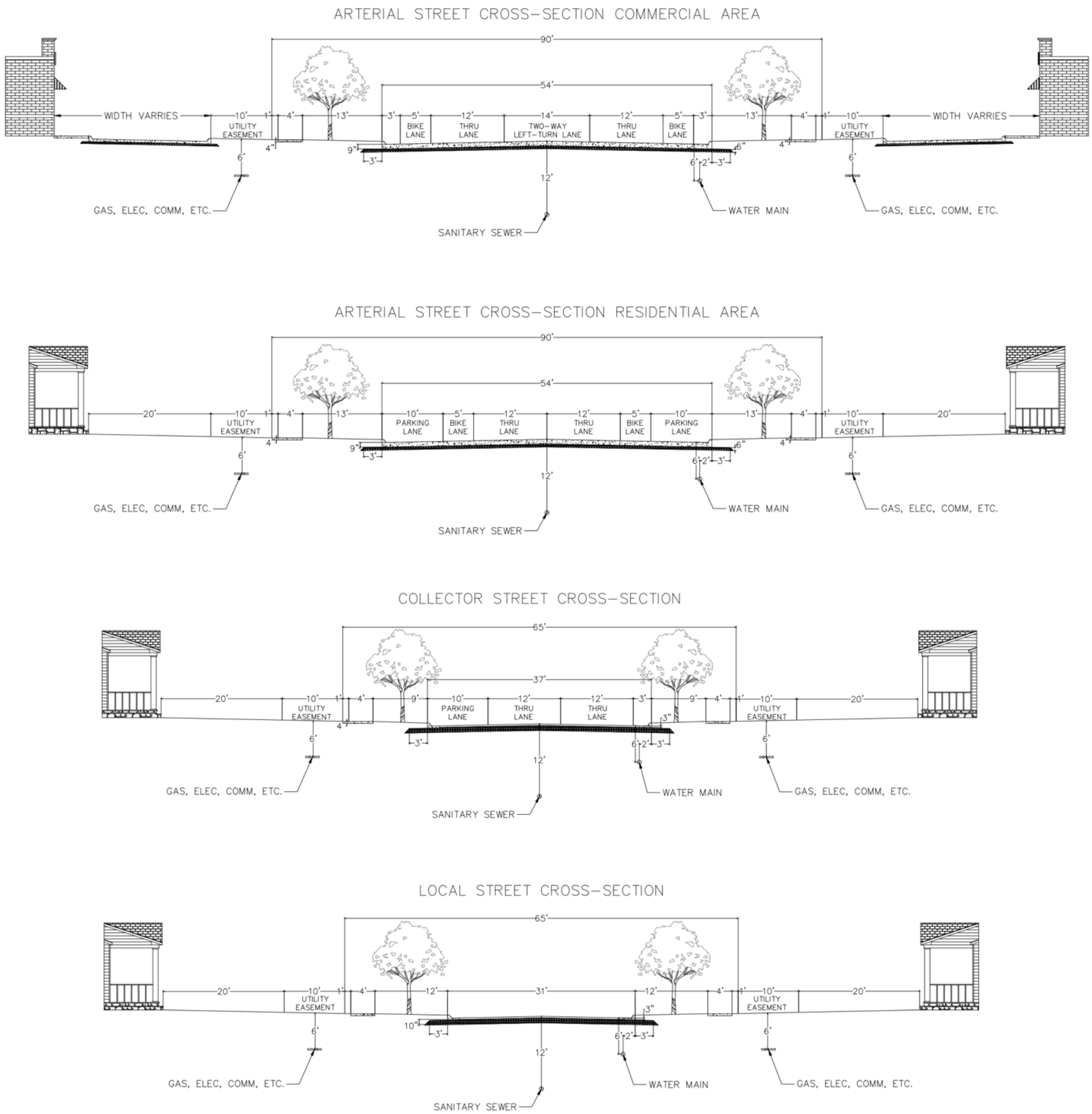


Figure 2 Road Corridor Cross-Sections

Stormwater calculations were designed based on SUDAS Chapter 2 and the Iowa Stormwater Management Manual (ISWMM). All culverts and drainage channels were designed to provide the city of Maquoketa with general estimates of cost for materials. This information also shows water level elevations for different storm events to help with planning for flooding and reducing the risk to private property and the city. A bridge was determined to be needed across Prairie Creek connecting the proposed arterial to W Carlisle St on the east side of the development. Existing flood data was pulled from FEMA flood maps as well as StreamStats to determine a bridge length of 160 feet. This bridge will be three spans with vertical abutments to reduce cost due to the high-water levels. This bridge will have sidewalks on both sides to connect the new development to the commercial areas east of Prairie Creek along Main St. The bridge will also allow the proposed trail to travel underneath it and connect to the stormwater management site to the north. This bridge will provide an opportunity to create a sense of place in the community through thoughtful aesthetic features. A side view of the proposed bridge is shown in Figure 3.

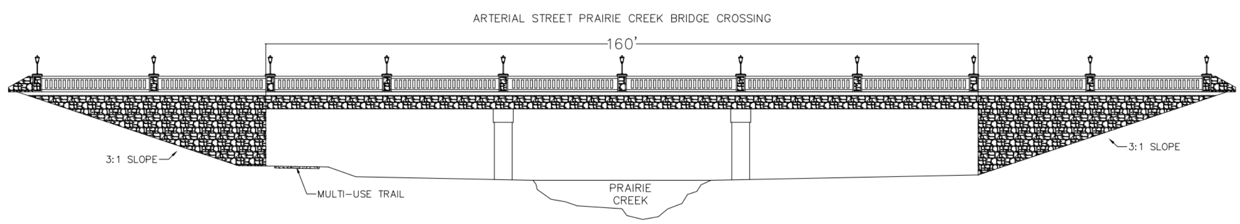


Figure 3 Proposed Bridge

Development within the city of Maquoketa requires stormwater management. A regional stormwater management option was determined to fit well with the site at a location predetermined for an Iowa DNR water quality project site in the northeast portion of the property. A wet pond is recommended due to an assumed high-water table as well as the recreation and aesthetics it can create for the community. Storage volume was calculated to be 9.38 ac-ft. Allowable release rate for proposed development is specified as the existing 5-year rate. Pass through from off site, which occurs on this project, allows the release rate to increase, and undetained runoff from onsite restricts the release rate and makes it decrease. The allowable release rate was calculated to be 646 cfs while the inflow was 2256 cfs for the fully developed condition.

Water main design was based on SUDAS Chapter 4. Following full development of the project site the City of Maquoketa should expect an increase of 0.15 MGD of demand to their water system. All water mains are to be located under the roadway 2 feet from the back of curb which is standard in the City of Maquoketa. Table 3 summarizes the specific offset from center of right-of-way that water main should be placed based on the associated road classification.

Table 3 Water Main Offset from Center Line

ROAD CLASSIFICATION	OFFSET FROM CENTER LINE	
ARTERIAL	25	FT
COLLECTOR	16.5	FT
LOCAL	13.5	FT

All water mains should be 8” diameter PVC except for the watermain that runs the length of the arterial roadway connecting W Carlisle St. And W Farmland Dr. which should be a 12” diameter PVC pipe. Throughout the site, valves have been specified at intersections as well as every 800 feet for single family housing areas and every 400 feet for all other non-single-family areas. When placing valves at intersections, a valve is required on all but one of the pipe legs connecting to the intersection. In addition to valve locations, the design includes locations for hydrants. Hydrants are to be placed 25 feet away from all intersections as well as every 450 feet in single family areas and every 300 feet in multi-family and commercial areas. Hydrants have also been located at high points to allow air to be bled from the system. The water main network and valve and hydrant quantities and locations are shown in Table 4 and Figure 4 respectively.

Table 4 Water Main, Valve, and Hydrant Quantities

WATER MAIN QUANTITIES	
NUMBER OF HYDRANTS	101
NUMBER OF VALVES	199
LENGTH OF 12" PIPE (LF)	6597
LENGTH OF 8" PIPE (LF)	28422

Figure 4 Water Main Network and Valve and Hydrant Locations

Sanitary sewer designs were conducted using SUDAS Chapter 3. The existing 12” sanitary sewer line running along the main drainage channel that has been proposed was analyzed for future development capacity before a proposed sanitary sewer network was designed. Based on SUDAS Chapter 3, the peak daily flow for the entire drainage area was determined to be 2.34 cfs. After tabulating the peak flow for the entire drainage area, including existing and proposed development, the 12” line was deemed to be of a sufficient size for full build out of the site. The peak daily flow per lot was used to design all proposed sanitary sewer pipelines that feed into the 12” existing line. All pipes were designed with an 8” diameter based on the peak daily flows. While the existing 12” sanitary line running through the project site is sufficient for the proposed demand, it is important to note that the Project Team was not able to access information concerning the existing lift station to the south of S 5th St. so we are unable to verify whether the lift station has enough capacity to convey the amount of flow that this site will produce. The Project Team recommends that the lift station be analyzed so that it will be known if it will need to be upgraded before the full build out of this development. Following full development of the site the City of Maquoketa should expect an increase of 0.24 MGD of demand to their sanitary sewer system.

While 8” diameter PVC piping is sufficient to convey the flow rates produced by the existing and proposed development, three pipe runs are specified as 10” diameter PVC and are shown in *Figure 1*. The goal of these three areas is to provide a buffer for future development that the Project Team has not specified. These 10” lines convey sanitary sewage from the commercial area just west of the proposed bridge as well as from the area where the farmstead has currently been preserved to the south of the project site. These 10” lines are a precautionary measure in case there is an abnormal sanitary discharge produced in these three areas that our design group has not specifically designed for.

Table 5 Sanitary Sewer Quantities

SANITARY SEWER QUANTITIES	
LENGTH OF 8" PIPE (LF)	29813
LENGTH OF 12" PIPE (LF)	3202
NUMBER OF MANHOLES	140

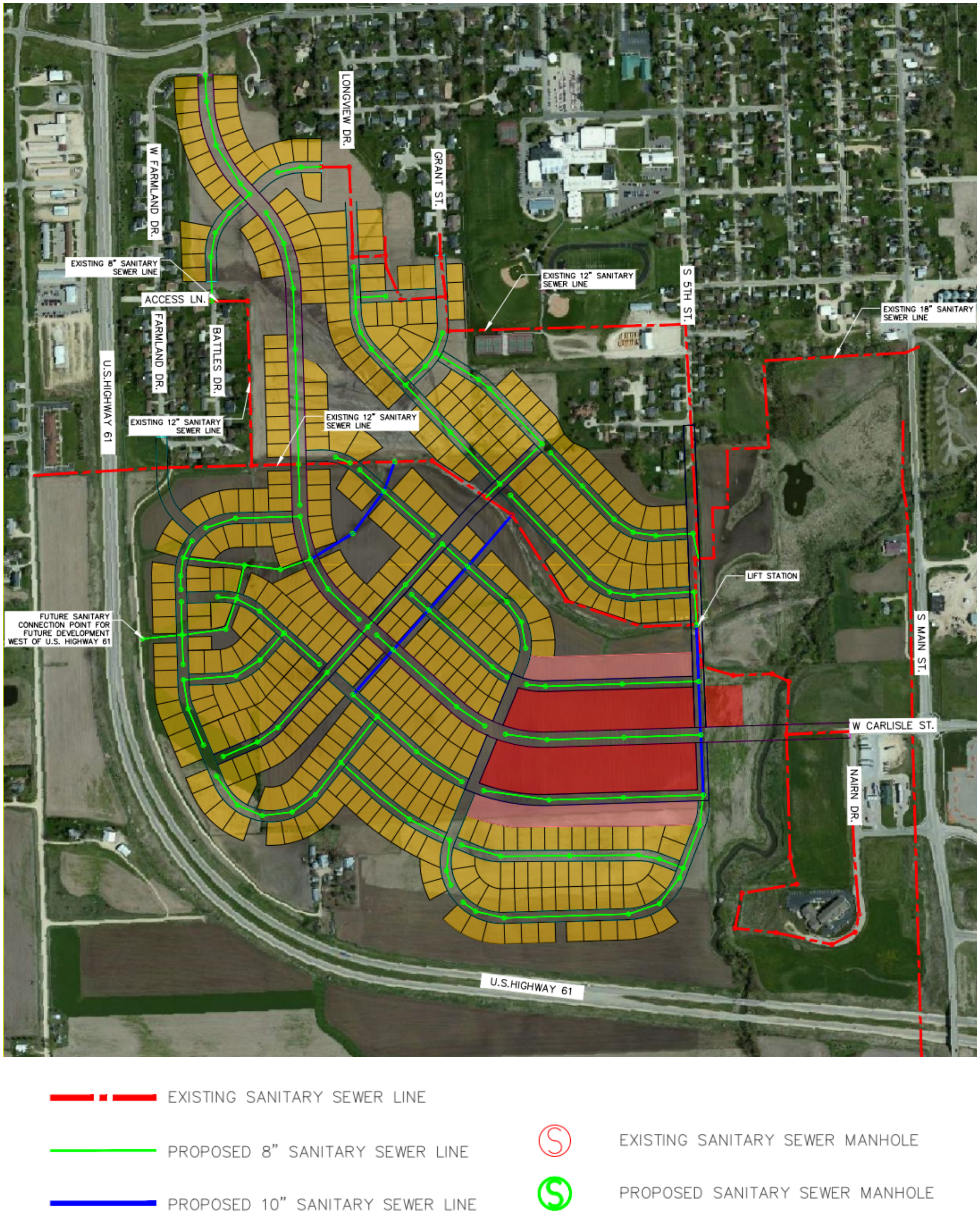


Figure 5 Sanitary Sewer Network

Trail design was based on SUDAS Chapter 12. The trail was designed for a shared use designation to provide access to both bicyclists and pedestrians. Based on these desired uses, the trail was designed as Type 3 Shared Use Path. A pavement width of 10 feet with a 2-foot grass buffer on either side of the pavement for the safety of users was designed using SUDAS 12B. The proposed trail was designed with a minimum right-of-way width of 20 feet with most of the trail network located in public green space where right-of-way is not of concern. As the client has specified a preference for the trail to be constructed with PCC, the Project Team designed the trail to be PCC pavement with a thickness of 5” on top of a compacted subgrade. This thickness is uniform throughout the site except the section specified in *Figure 7*. This section of trail along the existing sanitary sewer main is specified as 7” thick PCC pavement on top of compacted subgrade to provide a viable route for service vehicles using the trail to access sanitary sewer manholes along the edge of the trail right-of-way. In addition to the portion of trail proposed on the project site, the Project Team has proposed a 585-foot length trail extending onto property of Maquoketa High School.

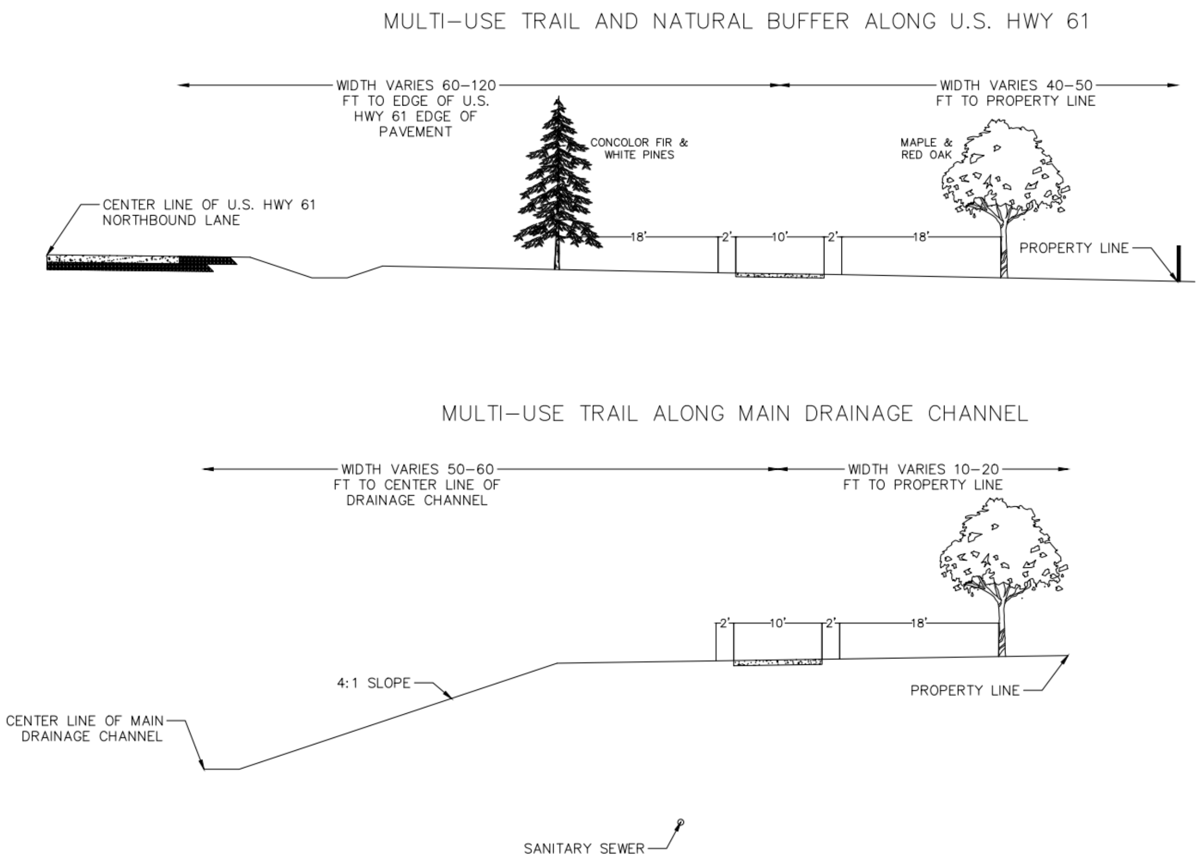


Figure 6 Multi-Use Trail Cross Sections

While outside of the scope of this project, the trail design we have provided allows a connection to the school property to provide a safe route for kids travelling to school from the proposed development as well as community members who would like to attend events at the high school. Another aspect of the proposed trail layout is having the trail come all the way to the existing lift station to the south of S 5th St. The goal of this is to provide the opportunity for a potential trail connection coming from the Iowa DNR Water Quality Project site.

In addition to the design layout for the trail, the Project Team proposes that Concolor Firs, White Pines, Maples, and Red Oaks be planted along the trail section that runs parallel to U.S. Highway 61 at the south side of the project site. Overall, the goal of these trees is to provide a natural sound buffer from the noise produced by vehicles on U.S. Highway 61 as well as provide some visual privacy to residents of the proposed site. The goal of Concolor Firs and White Pines specifically is to provide coniferous plants that will retain their needles year-round to maintain the privacy buffer during all seasons, and the goal of planting Red Oaks and Maple trees is to provide vibrant colors that are aesthetically pleasing as well as shade to individuals using the trail. All these tree species are very hardy and do well in the Midwestern United States. It is important that the client utilize multiple varieties of tree species to provide biodiversity and resiliency to the tree ecosystem on site. A variety of trees are much more resistant to insects and fungi on a large scale. Additionally, the Project Team recommends that trees be planted 20 feet from the trail edge and maintained regularly to prevent branches from obstructing the 2-foot grass buffer on either side of the trail pavement.

Figure 7 Trail Network and Green Space

The overall cost to fully develop this site is $27.9 million. This estimate does not include the cost associated with acquiring the land. This development will add an additional $20.9 million worth of infrastructure value to the City of Maquoketa. As with most development master plans, market conditions and developers' willingness to move forward with subdivisions dictate the construction schedule. Cities can make developable areas more attractive to developers and investors with incentives and/or investments in key infrastructure elements. The City of Maquoketa has already made strategic investments in the water and sanitary sewer utilities in this area that will be helpful. Another investment to consider is the bridge over Prairie Creek as it requires significant capital that is too large for any single development. The Project Team recommends that the City of Maquoketa investigate a grant from Iowa's RISE program to fund the bridge as a catalyst to development. In addition to the existing utilities and bridge investment, using the future Iowa DNR Water Quality Site as regional stormwater management area would be a significant incentive for developers and investors.

Table 6 Full Build Out Statistics

SINGLE-FAMILY RESIDENTIAL DEVELOPMENT	126.66	ACRES
	490	LOTS
MULTI-FAMILY RESIDENTIAL DEVELOPMENT	7.28	ACRES
COMERCIAL AREA DEVELOPMENT	14.95	ACRES
PUBLIC OPEN GREEN SPACE	132.9	ACRES
ARTERIAL ROAD	1.2	MILES
COLLECTOR AND LOCAL ROAD	5.4	MILES
WATER MAIN	35019	LF
INCREASE DEMAND ON WATER SYSTEM	0.15	MGD
SANITARY SEWER	32779	LF
INCREASE DEMAND ON WASTE WATER SYSTEM	0.24	MGD
MULTI-USE TRAIL NETWORK	3.2	MILES

Section II Organization Qualifications and Experience

Contact Information

The Project Team operated out of the University of Iowa's College of Engineering Civil and Environmental Engineering department. The main point of contact for this project wass Nick Radcliffe.

Organization and Design Team Description

The Project Team is a team of civil engineering students in their senior capstone design course at the University of Iowa. The design team is composed of Thomas Dau, Nick Radcliffe, Shane Hochstetler, and Matthew Huinker. Thomas Dau and Matthew Huinker specialize in transportation and Shane Hochstetler and Nick Radcliffe specialize in water resources and transportation.

Section III Design Services

Project Scope

The scope of this project was to provide the City of Maquoketa with a land use plan for the undeveloped land to the south of the city that is bounded by Highway 61 to the west and south, 200th Street to the east, and West Summit Street to the north. The land use plan developed consists of a street network layout, lot layout, sanitary sewer and water main networks, road corridor cross-sections for arterial, collector, and local roadways, as well as a green space and trail network plan. This plan also quantifies the value of the proposed infrastructure, as well as impacts on the existing water and wastewater utilizes. We have also estimated the projected residential and commercial growth that can be accommodated and associated growth in tax base.

Work Plan

The schedule in which this project was completed is summarized in Figure 8 below.

Task	Week 1 1/24/22	Week 2 1/31/22	Week 3 2/7/22	Week 4 2/14/22	Week 5 2/21/22	Week 6 2/28/22	Week 7 3/7/22	Week 8 3/14/22	Week 9 3/21/22	Week 10 3/28/22	Week 11 4/4/22	Week 12 4/11/22	Week 13 4/18/22	Week 14 4/25/22	Week 15 5/2/22	Week 16 5/9/22
Initial Data Collection	■	■														
Site Visit		■														
Draft Prelimianry Design Options			■	■	■											
Present Preliminary Design Options to Client						■										
Draft Final Design							■	■	■	■	■					
Prepare Draft Documents											■					
Revise and Finalize Plans/Documents												■	■	■	■	
Prepare Final Documents															■	
Present Project to Client																■

Figure 8 Project Schedule

Section IV Constraints, Challenges, and Impacts

Constraints

One constraint for this project was time. The accelerated schedule needed to complete this project did not allow for a grading plan to be developed for the site. With no final grading plan high points and slopes used in design were based off the existing topography as it will remain close to existing.

Several other constraints were dictated by existing conditions. Due to Highway 61 running along the south and west sides of the site the need for a natural buffer zone was determined to be needed between the highway and residential area. The City of Maquoketa's existing sanitary sewer line that runs through the middle of the site-controlled lot layout as adequate space was kept for sanitary sewer operation and repair. All these existing conditions reduced the amount of buildable area. Another constraint that controlled the design of this project is the farmstead located at the southwest corner of the site. It was determined that this property should be left in the overall land use plan but be provided adequate access to allow it to be developed in the future.

Challenges

This site also experiences significant storm water runoff from both onsite and offsite. The large amounts of storm water runoff created the need for numerous drainage ways to ensure proper capacity within the drainage system.

One challenge with this project was the large flow running through the existing waterway directly through the middle of the site. Most of this runoff comes from offsite to the west of U.S. Highway 61 and from the adjacent neighborhoods to the north. Development alone increases runoff by increasing the number of impervious areas. Large culverts were needed to remedy these flows along with tall embankment slopes. These culverts create backwater and low openings of homes should be kept at the same level or above the embankment height.

Streams and wetlands are protected by law in the state of Iowa. Any change to streams and wetlands require permitting and needs to follow strict standards. Impacts to these areas are to be avoided on this project through an assumed floodway width. Using the U.S. Fish and Wildlife Services National Wetland Inventory it was determined that no wetlands exist on the site.

Societal Impact within the Community

The area contained in this study can accommodate more than a 20% growth in population as well as additional commercial development. The proposed zoning allows for single family and multi-family housing to accommodate a wide range of incomes. The completed development of the site will add 490 single-family dwellings to the city of Maquoketa. Along with the addition of single-family housing, 7.28 acres of duplex and multi-family housing and 14.95 acres of commercial development exist on this site. The additional commercial area was placed adjacent to the existing commercial development along South Main Street to reduce the effects on the existing residential areas that surround the site to the north and west.

The existing residential development to the north and west will be impacted by this development as many residents will no longer have a farm field adjacent to their back yard. In addition to the reduction of farmland adjacent to the existing city limits, this development plan connects into the dead ends of existing streets. This will increase the traffic flow on these streets, which may concern existing residents.

This 335-acre development will increase the runoff from the site as the area of impervious surfaces will increase significantly. 10% of the area will be impervious, excluding roof and driveway area, which requires stormwater management measures to offset. The Iowa DNR Water Quality Project site will be used as a regional stormwater management site to accomplish this. The flood plain of Prairie Creek will be reduced to increase the developable area but will still have its adequate floodway width to accommodate large storms and not cause flooding.

Section V Alternative Solutions that Were Considered

Design Alternative 1

Prior to the final land use plan three alternative plans were considered. Each plan that was considered was unique and focused on providing the undeveloped land with specific purposes.

The first alternative that was considered focused on maximizing the amount of residential area available for development. This alternative provided medium density housing with lots averaging 0.3 acres. Connectivity was provided between W Farmland Dr. and W Carlisle St with access to a proposed arterial street. This alternative specifically provides commercial development along the southern side of the property where it abuts to U.S. Highway 61 allowing for easy view from passing vehicles. Additionally, the plan provides additional green space along a proposed drainage swale running from the northwest to the southeast. This additional green space would allow for recreational

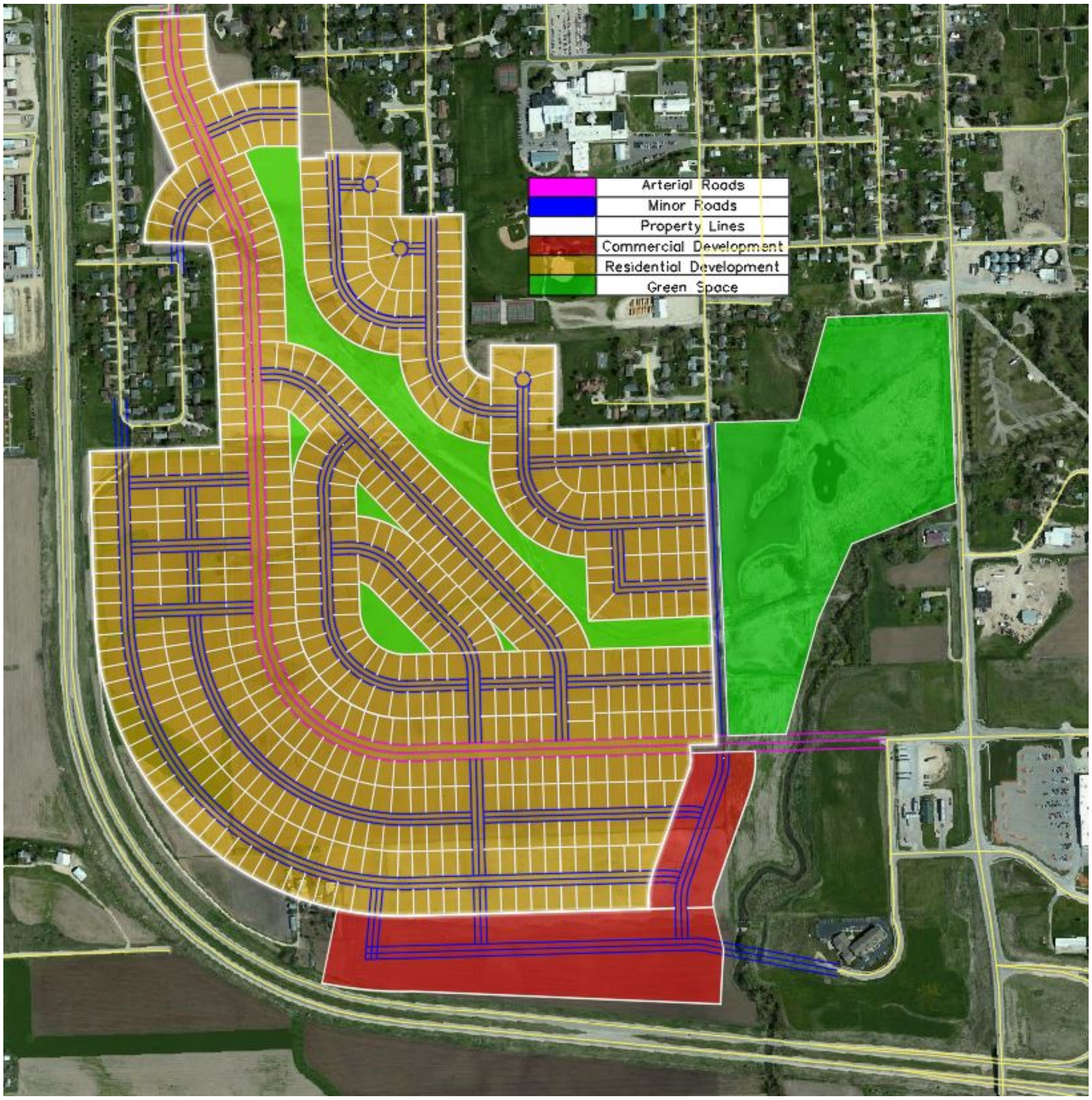


Figure 9 Considered Alternative Design Option 1

trail that would also provide access to an existing sanitary sewer line and connect to a trail network in the Iowa DNR Water Quality Project to the northeast of the site. This option routes streets away from the drainage swale to avoid the need for numerous culverts at crossings. This alternative uses the land of the farmstead that is located at the southwest corner of the site which allows for a uniform street network.

Some negative aspects of this alternative are limited trail network opportunities to the south of the site. Along the south side of the site the blocks become long reducing the efficiency of vehicle traffic as the distance to reach the proposed arterial road is long.

This large block system also makes walking a challenging task as the distance to get from mid-block on one street to mid-block on the next street is significantly larger. This alternative also does not provide much connectivity between the north and south side of the site due to the limited drainage swale crossings. Although this will be a negative for those living in the new development it may be a positive for the existing residents to the north of the site as additional traffic will be limited in their area.

Design Alternative 2

The second alternative that was considered focused on providing all residential housing with a natural buffer from U.S. Highway 61 and keeping the commercial development adjacent to the existing commercial space along South Main Street. This alternative provides medium density with average lot sizes of 0.3 acres with larger lots abutting the green space. The street network provided with this alternative provides connectivity to all existing roadways except for Nairn Drive due to the need for an additional bridge. The green space along the west and southern border of the site provides 100-foot-wide green space for a natural noise buffer from U.S. Highway 61 as well as room for a recreational trail. The trail running withing the natural buffer along U.S. Highway 61 would be extended north along Prairie Creek and the follow the drainage swale to the northwest where it would ultimately connect to high school adjacent to the site on the north.

A negative aspect of this alternative is limited commercial space as well as several locations of additional green space where lots could not be made. This alternative's road network strategically offsets residential and collector streets to reduce the likely hood of these roads turning into another arterial road. This may also be seen as a negative aspect as it reduces interconnectivity. Additionally, this alternative allows for progressive development if land from the farmstead to the southwest is acquired, allowing for new driveway access within development.

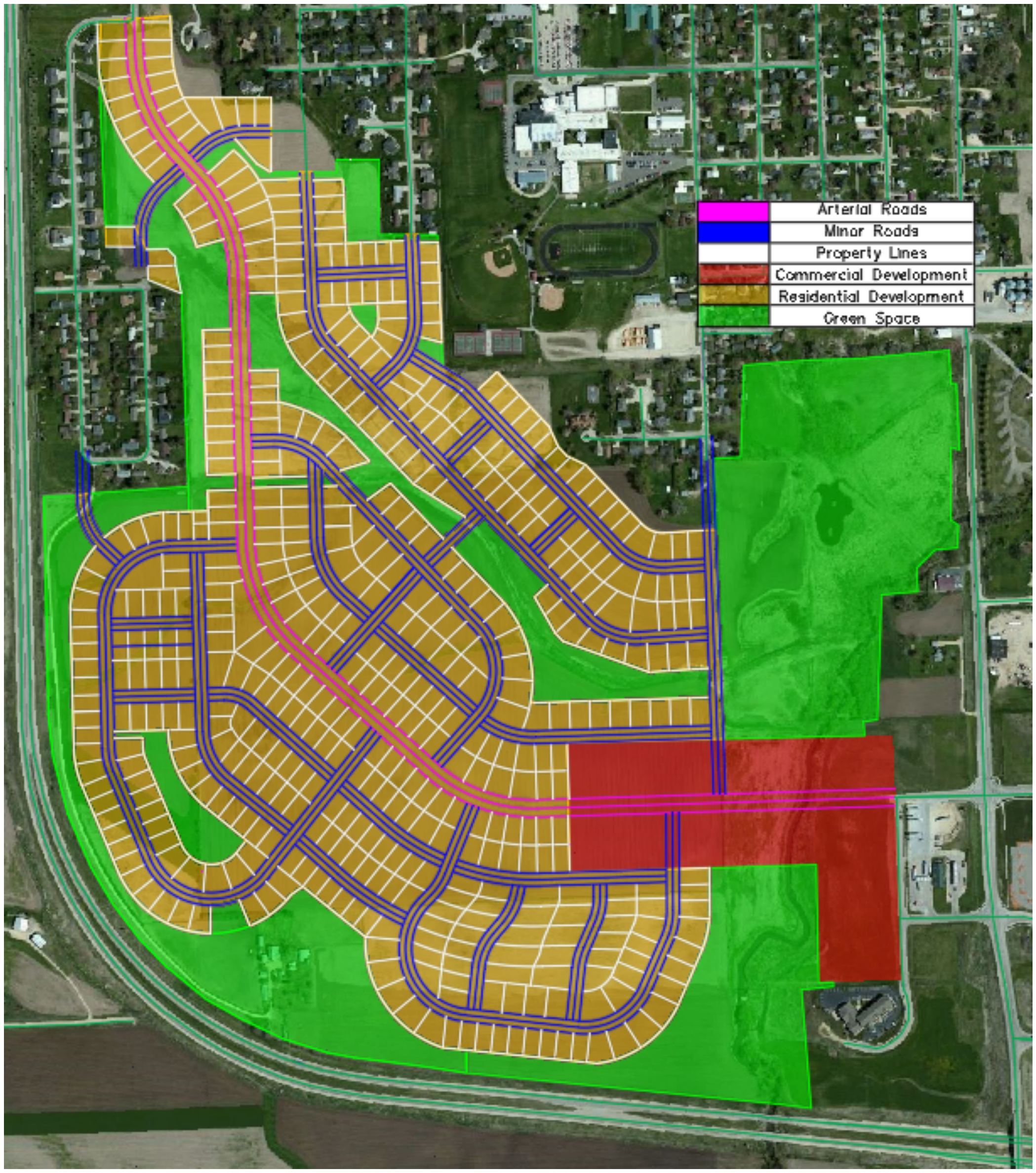


Figure 10 Considered Alternative Design Option 2

Design Alternative 3

The third alternative design option that was considered focused on providing a park like setting with large quantities of green space and extending commercial development along an arterial route. This alternative consists of medium density housing with the average lot sizing 0.3 acres with corner lots being larger. Additionally, this alternative provides vast amounts of area for stormwater management and recreational purposes including trails and parks. The green spaces could be used for playgrounds in addition to a trail system.

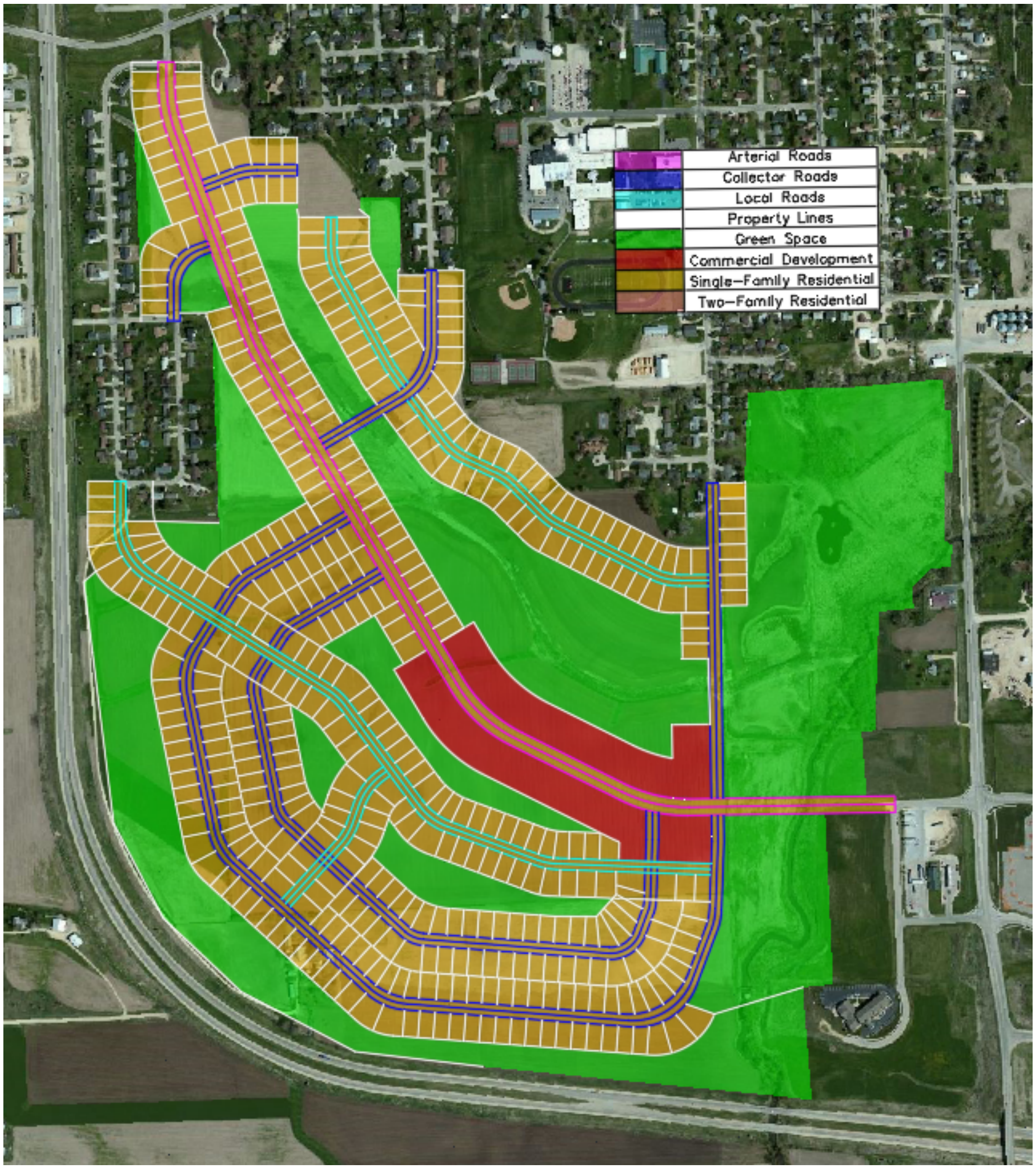


Figure 11 Considered Alternative Design Option 3

Some negative aspects of this alternative are both the excess amount of green space and the lack of phasing plausibility. The amount of green space within this layout limits the amount of developable area and ultimately is a larger financial burden when for utility installation as the same length of utility services are required but there are significantly less services on them compared to the other options. The large green spaces also burden the city with additional upkeep. The street network that this alternative offers has limited interconnectivity reducing the resilience of the neighborhood as traffic and utility services cannot be easily rerouted.

Design Alternative Conclusion

After considering all three design alternatives it was concluded that design alternative 2 provided the best basis for final design. This alternative was determined to align the closest with the community's vision as it provides a moderate amount of green space and medium density housing along with a modified grid street network that connects to the areas existing roads while also utilizing the existing lay of the land. This design alternative was mildly altered to reflect the needs of the community and taken to finer detail.

Section VI Final Design Details

Overview of the Site and Zoning

This land use plan focuses on providing medium density residential housing across most of the site with lots averaging 0.3 acres. Lot sizes were determined by following Maquoketa City's Code for R1-Residential Zoning and the average lot sizes in the community. The City of Maquoketa's R1-Residential Zoning code that was referenced is in Appendix A Figure A1. Commercial space is allocated along an arterial route that connects West Carlisle Street and West Farmland Drive. This is an expansion of the commercial zone that already exists along South Main Street. Adjacent to the commercial zone there is multifamily space which will provide a buffer between the commercial zone and the single-family residential areas. Along the southern side of the site is a 100-foot-wide natural buffer that provides noise reduction from U.S. Highway 61 as well as space for a recreational trail. Another main characteristic of the plan is a large drainage swale that runs from the northwest to the southeast of the site. This serves as an existing drainage way and was utilized to provide drainage as well as a recreational trail space for the area.

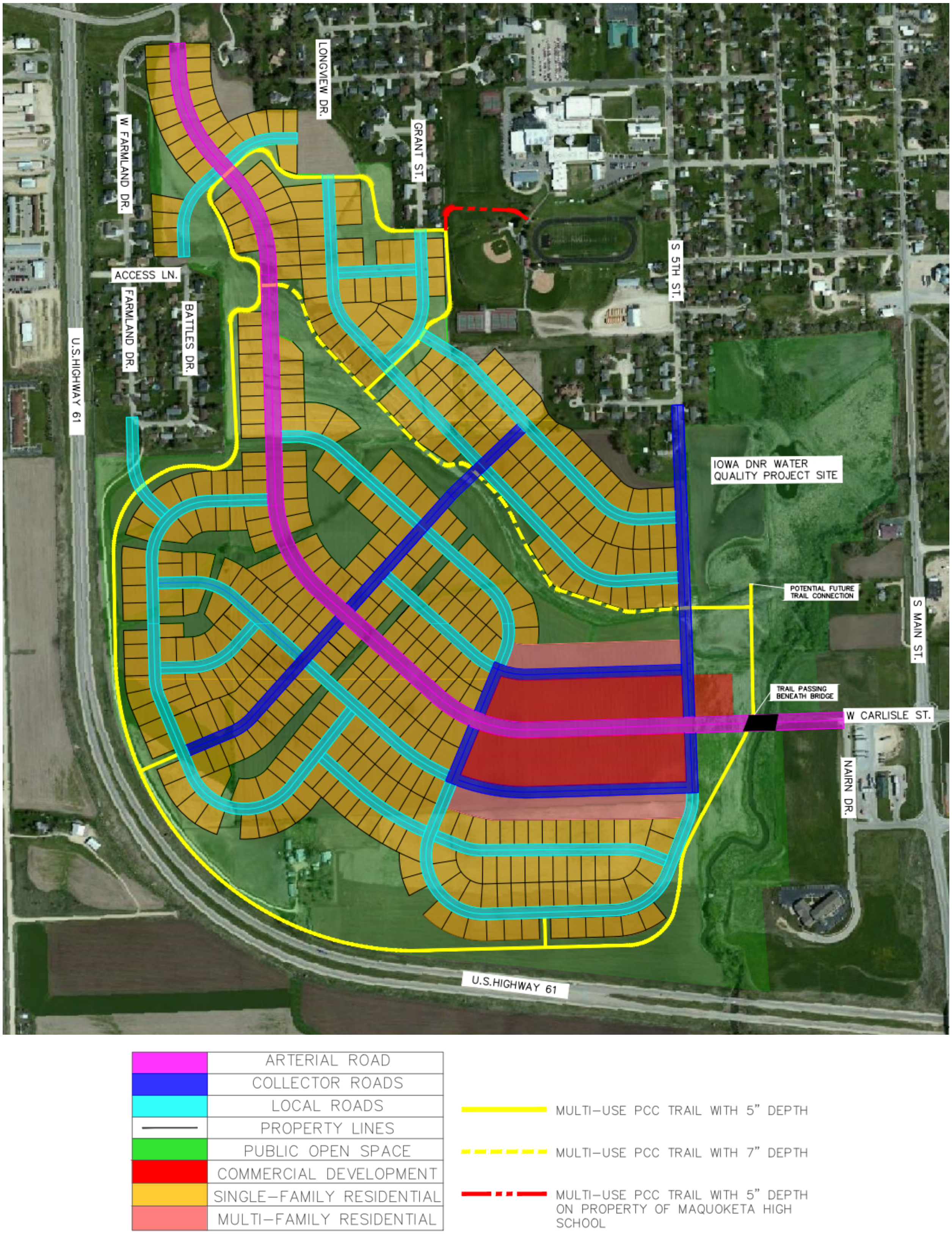


Figure 12 Land Use Plan Overview

This plan will increase the number of single-family dwellings in the City of Maquoketa by 490 single family homes, the acres of duplex and multifamily housing by 7.28 acres, and the acres of commercial development by 14.95 acres. The increase in tax base for the area was estimated to be $134.3 million. The increase in tax base for single-family, multifamily, and commercial areas is summarized in Table 7. The increase in single-family tax base was estimated by taking the average assessed value of existing single-family properties in the area and multiplying by the number of lots resulting from full development. The tax base increase for multifamily and commercial property was estimated by locating existing properties in the area and determining their assessed value per acre. The increase in tax base calculations is summarized in Appendix B Table B1.

Table 7 Tax Base Increase Summary

ESTIMATED TAX BASE INCREASE		
SINGLE-FAMILY TAX BASE INCREASE	$	122,500,000.00
MULTIFAMILY TAX BASE INCREASE	$	6,976,000.00
COMMERCIAL TAX BASE INCREASE	$	4,817,000.00
TOTAL TAX BASE INCREASE	$	134,293,000.00

Street Layout and Designations

The overall street configuration was influenced by the existing street network within the City of Maquoketa as well as the topography of the site. Continuing the grid street network of the existing street network was determined to be vital to the community to ensure resilient infrastructure, improved maintenance accessibility, and interconnectivity throughout the community. A traditional grid was not able to be accomplished due to large quantities of stormwater running through the center of the site and the need for large drainage areas. Therefore, the street network resulted in a modified grid that provides connectivity while also providing adequate room for stormwater.

Three main road classifications are provided within the road network to serve specific purposes and traffic volumes. The three road classifications are arterial, collector, and local roads. There is an arterial road running through the site that connects to West Carlisle Street and West Farmland Drive. These connections ultimately connect the site to two existing arterial roads, West Summit Street and South Main Street. These connections for the arterial road were determined to provide the best access to the site for both construction purposes and future residents due to their proximity to existing arterial roads. These access points limit the impact on existing residential dwellings as the connection to West Carlisle Street is in a commercial area and the connection to West Farmland Drive will only impact one home. The collector roads are positioned to collect traffic and direct it to the arterial road and away from local roads whose primary purpose is to serve a limited amount of property.

The width of each road right-of-way were determined using SUDAS Chapter 5C-1. All widths for roadway and right-of-way aspects were taken from SUDAS Table 5C-1.01 and Table 5C-2.02. Both tables are included in Appendix B Table B1 and Table B2. All widths were from the SUDAS preferred roadway elements table and altered where necessary to best serve the community's needs. Some common attributes to all roadway classifications are a 10-foot utility easement that extends beyond the right-of way line on each side as the city of Maquoketa has its private utilities located outside of the right-of-way on their existing and new construction. In addition to a utility easement, there are 4-foot sidewalks on both sides of the road that are offset from the right-of-way line by 1 foot.

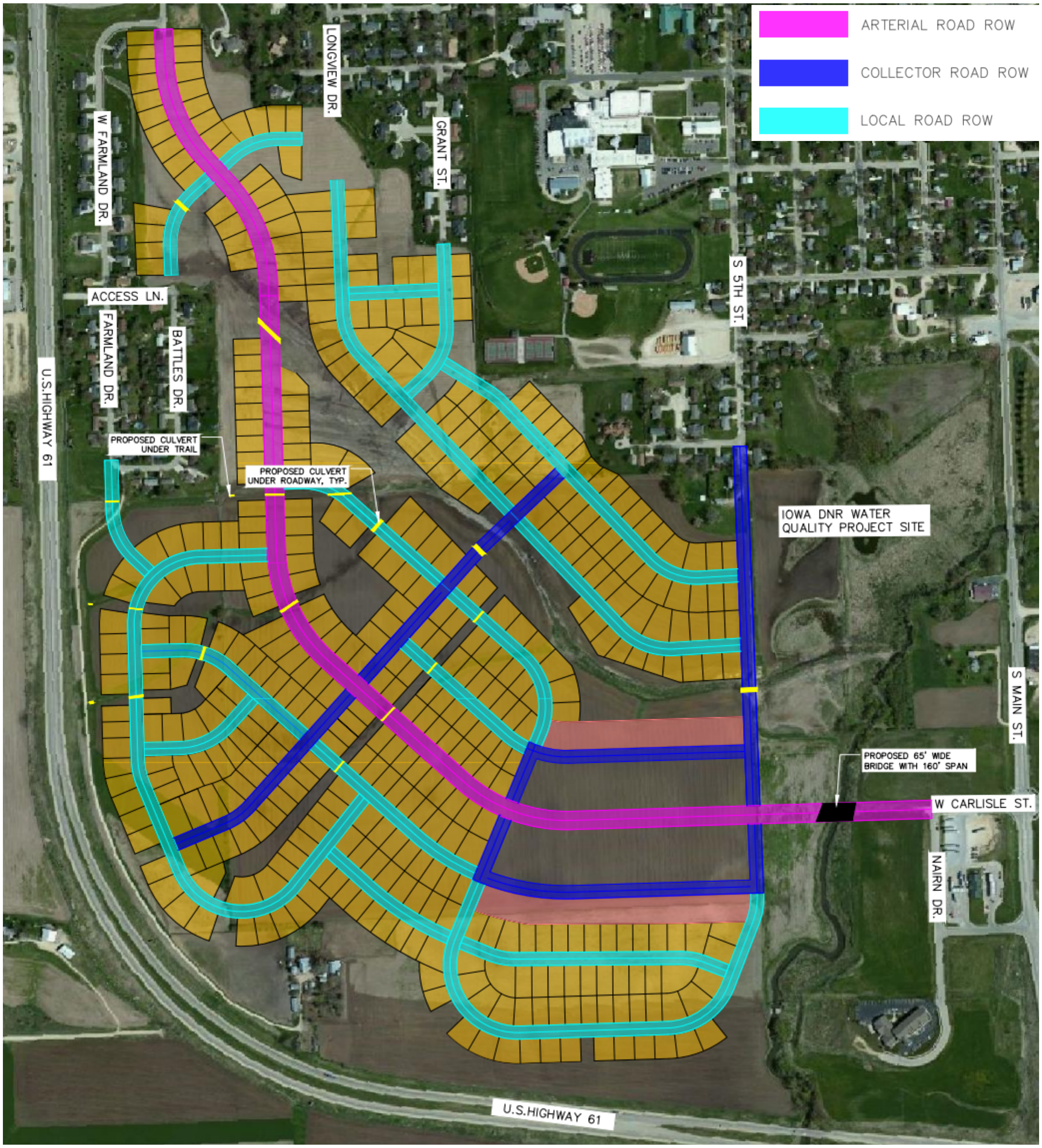


Figure 13 Road Network

The arterial road has a total right-of-way width of 90 feet and pavement width 54 feet. The arterial road layout varies between the commercial area and the residential area. Where the arterial is along commercial space the paved surface consists of a 12-foot vehicle lane and 5-foot bike lane in each direction, a center 14-foot two-way left-turn lane, and a curb offset of 3 feet. The curb is offset 3 feet from the bike lane to provide adequate gutter capacity while also keeping the curb and gutter joint out of the bike lane which can cause safety issues. Along the residential area the paved surface consists of a 12-foot vehicle lane and 5-foot bike lane in each direction with a 10-foot parking lane on the outside of each bike lane. Along both the commercial space and residential housing there is an additional 18 feet of right-of way on each side to allow for trees, sidewalk, and adequate snow storage. The width of paved surface allows for two lanes of travel in each direction if the need arises as well as the conversion to parking along one or both sides with the removal of the center two-way left-turn lane in the commercial area.

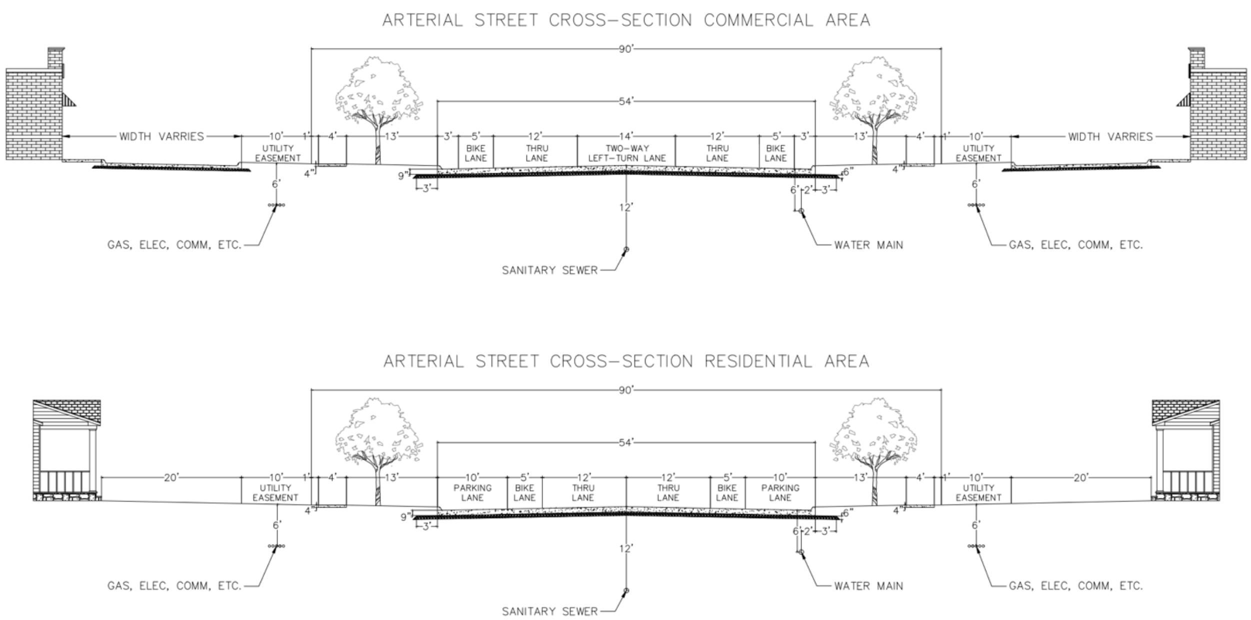


Figure 14 Arterial Road Right-of-Way Cross-Sections

The collector roads have a total right-of-way width of 65 feet and a pavement width of 37 feet. The paved surface consists of a 12-foot lane of travel in each direction, a 10-foot parking lane on one side, a 3-foot curb offset, and an additional 14 feet of right-of way on each side to allow for trees, sidewalk, and adequate snow storage. Although SUDAS recommends a 2-foot curb offset for a collector road the City of Maquoketa prefers curb offsets of 30 inches or more. Therefore, a 3-foot offset was used to accommodate the communities needs as well as be uniform with the arterial road.

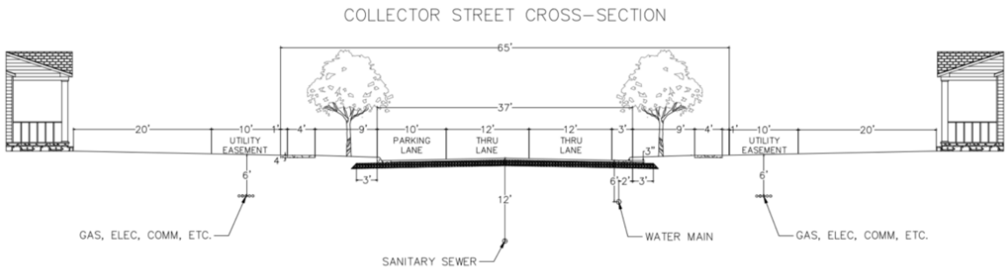


Figure 15 Collector Road Right-of-Way Cross-Section

The local roads have a total right-of-way width of 65-feet and a pavement width of 31 feet. The 31-foot pavement width allows for parking on both sides with a shared travel lane in the center. There is an additional 17 feet of right-of way on each side of the road to allow for trees, sidewalk, and adequate snow storage. SUDAS recommends the additional right-of-way beyond the back of curb to be 14 feet however this would narrow the right-of-way to 59 feet which the City of Maquoketa felt was to narrow. Therefore, 17 feet was used to increase the right-of-way to 65 feet which allows the opportunity for local roads to be upgraded to a collector road format is the need arises.

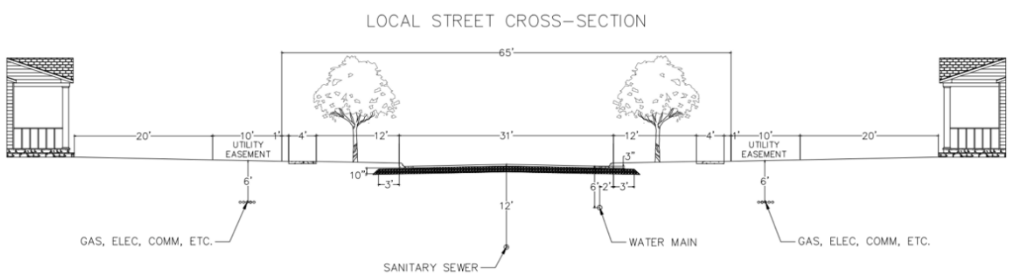


Figure 16 Local Road Right-of-Way Cross-Section

6.6 miles of new roads will result from this development and the additional length of each street classification is summarized in Table 8. The pavement design for the arterial road varies from the pavement design that both the collector and local roads will follow. The City of Maquoketa's standard for collector and local road pavement consist of 10-inch aggregate base with a 3-inch hot mix asphalt (HMA) surface. The collector and local road's 3-foot curb and gutter on both sides of the street will be Portland cement concrete (PCC). The pavement design of the arterial road was determined to be 6 inches of base with 9 inches of PCC. The Project Team recommends that longitudinal joints should be placed every 10-12 feet and the transverse joints should be placed every 15 feet (Appendix B Figure B6). SUDAS transverse joint type CD Doweled Contraction Joint should be used with 1 ¼ inch dowels as specified in SUDAS Table 5G-2.03 (Appendix B Table B9).

Table 8 Road Classification Quantities

ROAD CLASSIFICATION	LENGTH (MILE)
ARTERIAL	1.2
COLLECTOR	1.5
LOACAL	3.9
TOTAL CENERLINE MILES	6.6

Table 9 Pavement Thickness Design

PAVMENT DESIGN			
ROAD CLASSIFICATION	PAVEMENT TYPE	PAVEMENT THICKNESS (IN)	BASE THICKNESS (IN)
ARTERIAL	PCC	9	6
COLLECTOR	HMA	3	10
LOCAL	HMA	3	10

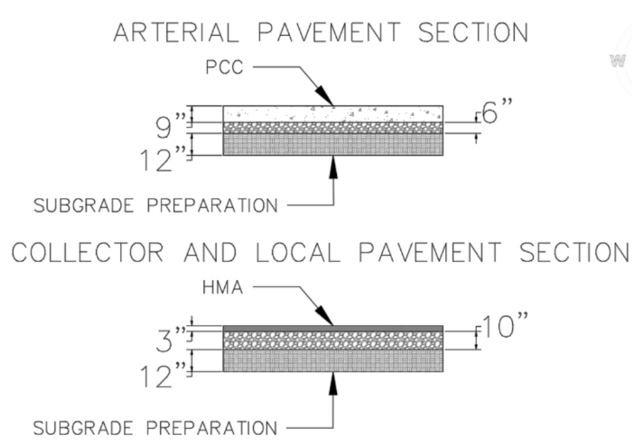


Figure 17 Pavement Sections

To determine the pavement design for the arterial road the traffic demand for the road was estimated. The traffic demand was estimated using the Institute of Transportation Engineer’s Trip Generation Manual, 6th Edition. For the estimated trips generated from the residential zone the single-family detached housing section of the Trip Generation Manual was used (Appendix B Figure B1), and the trips generated were based off the total number of single-family dwellings. It was assumed that 90% of the total trips from the single-family residential area would result in using the arterial road and therefore a total of 4203 trips are expected daily from this zone. For the two-family housing daily trips, the residential condominiums/townhouse section of the Trip Generation Manual was used (Appendix B Figure B2), and the trips generated were based off the total number of two-family dwellings. The total number of two-family dwellings was determined by taking the gross area for two-family housing and dividing the minimum lot area acceptable for two-family units in the City of Maquoketa's City Code chapter 5 subchapter 1D (Appendix A Figure A1) which is 9000 square feet. It was assumed that only 90% of the total trips from the two-family residential area would result in using the arterial road and therefore a total of 186 trips are expected daily from this zone. For the commercial zone daily trips, the shopping center section of the Trip Generation Manual was used (Appendix B Figure B3). Although no planned shopping center is planned for this area this section of the manual is the most generic for commercial space and accounts for a wide variety of commercial spaces in a proximity, therefore this model was used. For commercial space the trips generated are based off each 1000 square feet of leasable area. It was assumed that only 50% of the total commercial zone will be leasable, the other 50% being taken up by parking, stormwater management, and building structure. With this reduction in total commercial zone and assuming 95% of the trips generated will use the arterial the total trips generated for the commercial area is 12222 trips daily. The total daily trips generated along the arterial road is therefore expected to be 16611. The calculation table for trip generation for all zones is in Appendix B Figure B4 and reflects the total trips following full development. The capacity of a three-lane road is roughly 16,000 vehicles per day which is why the arterial is specified as 56-ft wide. A 56-foot-wide road allows for the pavement to be restriped to four lanes.

With the build out year average annual daily traffic (AADT) estimated for the arterial road the pavement thickness design procedure for a two-lane ridged pavement outlined in SUDAS Chapter 5 was used. Assumptions made in the procedure were 7% of the traffic on the arterial will be truck traffic and SUDAS truck type mix A. 7% trucks was assumed to account for truck traffic from the commercial zone and routine garbage truck us and the assumed truck type was assumed to represent the traffic as the area is mostly residential with some. The SUDAS truck type A mix description is in SUDAS Table 5F-1.06 and is in Appendix B Table B3. Since the AADT calculated was for the fully built out year the growth rate was assumed to be zero. SUDAS table 5F-1.07 and Table 5F-

1.11 (Appendix B Table B4 and Table B5) was used to determine the base year design ESAL of 117,000 and growth factor of 50 respectively. The design ESAL was determined to be 5,850,000 and rounded up to 7,500,000 for use in SUDAS Table 5F-1.15 (Appendix B Table B7). SUDAS states that CBR values of 1-3 are common in Iowa without a full soil report of the project site it was assumed that a CBR of 3 could be achieved for this project.

Stormwater

Runoff was calculated based on the NRCS method using WinTR-55 to simulate conditions. 24-hour rainfall depths were found from SUDAS table 2B-2.07 for zone 6 (east central Iowa) which is included in Appendix C. Time of concentration was calculated based on the NRCS velocity method. SUDAS table and figure 2B-3.01 aided in time of concentrations as well as the Iowa Stormwater Management Manual (ISWMM) table C3-S3-2. Drainage areas were determined based on existing lidar, and a drainage area map is included in Figure C1 in Appendix D. Proposed grading was to follow existing ground as much as possible with some exceptions. Drainage delineations occurred mostly at culverts. Curve numbers for each drainage area were calculated using an area weighted average of values from SUDAS tables 2B-4.03 and 2B-2.04 and are included in Appendix C along with the calculations of area weighted average CN for each drainage area. Future conditions for the areas west of Highway 61 were assumed in calculating CN values and were determined based on the city's comprehensive plan. The area is planned for mostly low density residential with some high density residential and commercial. It was determined based on Web Soil Survey that the predominant soil type on site consisted of hydrologic soil group C.

Culverts were designed based on SUDAS section 2E-2. The assumed culvert type for this project was SUDAS type 2.01C and is shown in Appendix C. This type of culvert contains a submerged entrance with a critical flow through the culvert which is what the Iowa DOT recommends when designing culverts. Flows found from the runoff calculations were used with Hydraflow Express within Civil3d to determine sizes of culverts and depths. An example of Hydraflow Express for culverts is shown in Appendix

C Figure D2. SUDAS recommends designing culverts to pass the 10-year flow within itself, to pass the 50-year flow without exceeding a depth of 1 foot above the culvert top, and to pass the 100-year flow with 1 foot of freeboard on the embankment. All culverts were designed to these standards except for the main drainage channel running through These culverts (1, 2, 3, and 4) were designed to a more conservative standard where the culvert was to pass the 50-year flow within itself, to pass the 100-year flow without exceeding 1 foot above the culvert top, and to pass the 500-year flow with 1 foot of freeboard to the embankment crest. All culverts create backwater due to this design, and low opening information for houses near this backwater are included on the plans and in the Table C11 in Appendix C. Low opening for houses upstream should correspond to one foot above the embankment height above culvert invert in the table.

Channels to each culvert were designed based on the largest storm the culvert was designed to. All channels were V ditch channels with 3:1 side slope except for the main drainage channel that was a trapezoidal channel with an 8-foot bottom width and 4:1 side slope. Channel depths were determined based on 1 foot of freeboard within the channel and assuming normal depth in the channel. Channel dimensions correspond to the channel just upstream from the culvert (Channel 1 corresponds to the channel just upstream from culvert 1). Culvert and channel calculation information is included in Table C10 in Appendix C. Table C11 in Appendix C is a summary table of culverts and channels.

Regional stormwater detention was used for this development with the location at the Iowa DNR water quality project location. The required storage volume for the development was calculated using the difference in runoff volumes for existing and proposed. Runoff volume depends only on the weighted CN values, and these were inputted into WinTR-55 to get a runoff depth that was then multiplied by the project area of 330.9 acres to get a volume. The required storage volume is 9.38 ac-ft for the site. The allowable release rate for the site recommended by SUDAS was calculated as the 5-year existing flow rate. Some runoff from offsite passes through the detention structure which allows the allowable release rate to increase by the amount of flow passing through. However, some runoff from onsite does not pass through the detention structure and this flow was subtracted from the allowable release rate. A summary of these flows is included in Table C12 in Appendix C. The allowable release rate was calculated as 646 cfs and the inflow to the detention site was calculated as 2256 cfs.

A bridge is proposed connecting the proposed arterial across Prairie Creek and connecting to W Carlisle St. The 100-year flood elevation level for Prairie Creek was gathered from FEMA floodplain mapping shown in Figure C3 in Appendix C. This existing flood elevation was about 14 feet above the channel bottom. FEMA allows fill up to where the floodway begins, and to maximize development to the west of the creek it was proposed to fill at a 3 to 1 slope from the floodway. Floodway data was unavailable, but the commercial area to the east of prairie creek has already been developed and filled. This fill stopped about 80 feet from the centerline of the creek, so a floodway width of 160 feet was assumed. Filling to the floodway allows for a maximum rise in water elevation of 1 foot for the 100-year event, so the assumed proposed water elevation was 15 feet above the channel bottom. Assuming a 3-foot low hang elevation on the bridge and 1 foot of freeboard, the deck elevation was determined to be 19 feet above the existing channel bottom. Vertical abutments were assumed rather than sloping to account for this large height difference and cut down on bridge cost due to a large increase in length with sloping abutments, so with vertical abutments, the bridge length was the length of the floodway which was 160 feet. This was comparable to the bridge just upstream crossing Highway 61 with a length of 160 feet. A side view and plan view or the proposed bridge are in Appendix C Figure C4 and Figure C5.

Water Main

The average daily demand minimum was calculated for single family residential and multifamily residential densities with SUDAS Equations 4B-1.01 and 4B-1.02 shown in Figure D1 in Appendix D of this report. The unit density and rate of flow were given from SUDAS Table 4B-1.01 shown in Table D1 in Appendix D of this report. The average daily demand minimum was found to be 104 gpm as shown in Table D2 in Appendix D. This is much lower than the required amount for fire flow, given the spacing between the buildings on the lots. The required average daily flow will need to be 1000 gpm to be sufficient for fire flow.

As a standard for the City of Maquoketa, the water main is offset by two feet from the back of curb. The exact offset from the centerline of the road types is summarized in Table 10. The fire hydrants are spaced 25 ft back from each intersection and spaced 450 ft apart along the roadways where there are single family properties. In all other districts the fire hydrants are spaced 300 ft apart. There is a valve located at every fire hydrant. Necessary fire hydrant spacing is given SUDAS 4C-1E shown in Table D3 in Appendix D of this report. There are two valves at each "T" intersection and three valves at each "four –way" intersection. According to SUDAS 4C-1D there should always be one un-valved pipe existing at the intersection. At each intersection the valves are spaced less than 25 ft back from each intersection. There are additional valves spaced 800 ft apart along the water mains going through single family districts, 400 ft in all other districts.

Table 10 Water Main Offset from Center Line

ROAD CLASSIFICATION	OFFSET FROM CENTER LINE	
ARTERIAL	25	FT
COLLECTOR	16.5	FT
LOCAL	13.5	FT

The water main pipes should also be sized in accordance with their classification. The arterial water main should have a minimum pipe diameter of 12 inches. The distribution mains should be sized as 8-inch diameter. This is in accordance with SUDAS 4B-1D. Per the client's preference and due to the soil condition at the site, the water main piping should be DR18PVC. A summary of valve, hydrant, and pipe quantities is shown in Table 11.

Table 11 Water Main, Valve, and Hydrant Quantities

WATER MAIN QUANTITIES	
NUMBER OF HYDRANTS	101
NUMBER OF VALVES	199
LENGTH OF 12" PIPE (LF)	6597
LENGTH OF 8" PIPE (LF)	28422

There are existing water mains next to the project site. The water mains will be connected to the existing water mains where applicable. At each connection point between the new and existing water main a valve needs to be installed. This is in accordance with SUDAS 4C-1D. The water main layout can be found in Figure 18.

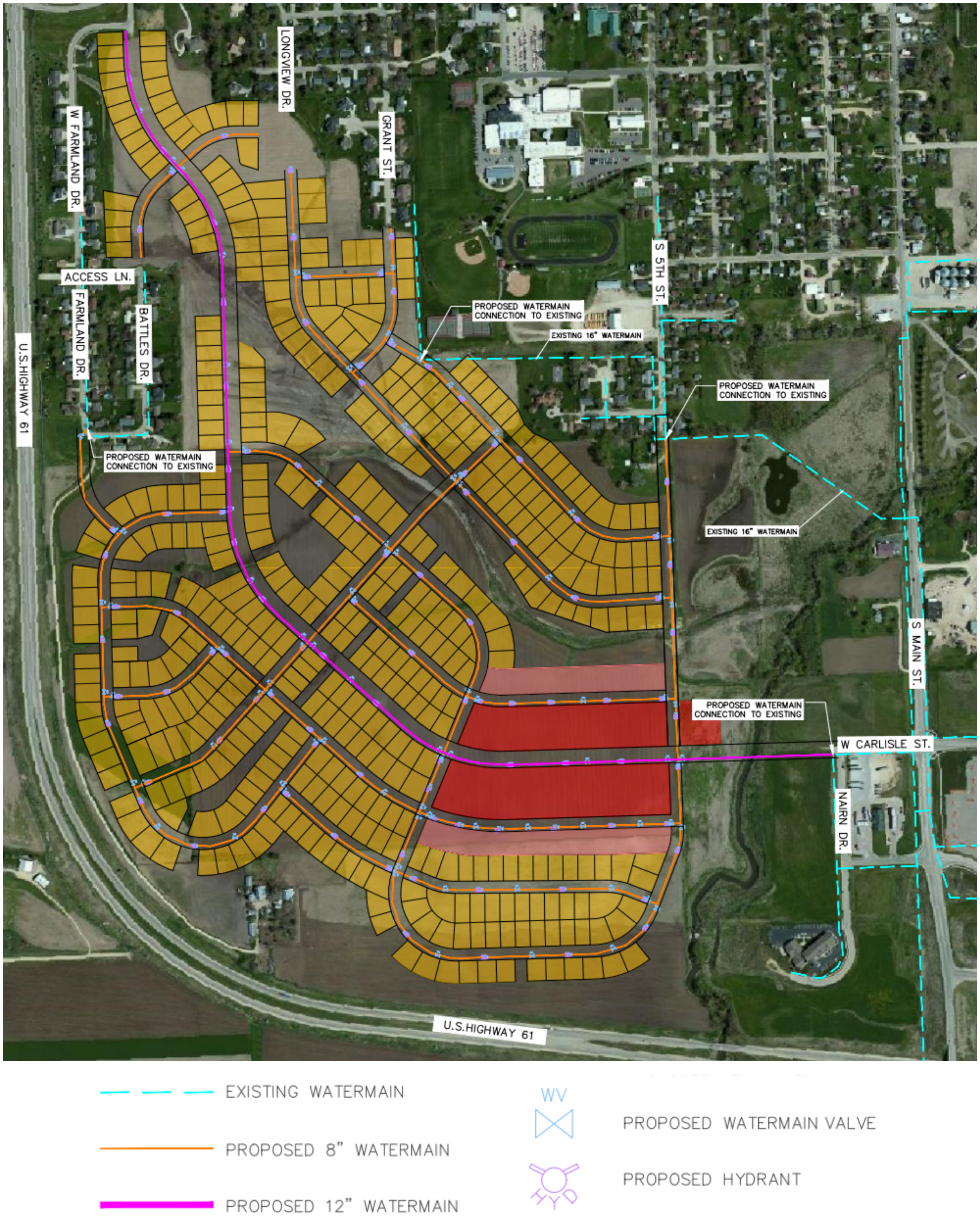


Figure 18 Water Main Network

Sanitary Sewer

The sanitary sewer design was highly dependent on the existing sanitary sewer lines on the site. Before a sanitary system could be proposed for the site, the existing infrastructure had to be analyzed to verify that it had enough capacity to convey the increased flow produced by the proposed development. To analyze the current capacity of the system, the flow was determined using the method described in SUDAS 3B-1. This method required finding the average daily flow rate two different ways and then using the minimum of the two. These two methods are from SUDAS Equation 3B-1.01 and Equation 3B-1.02 which are shown in Figure E1 in Appendix E. SUDAS Equation 3B-1.01 is based on the drainage area and Equation 3B-1.02 is based on the number of units within the drainage basin. Using the drainage areas found within the Stormwater design section above, an average daily flow rate was found by multiplying the drainage area by the area density and then multiplying again by the flow rate for the respective zoning. All area densities and flow rates were found in SUDAS Table 3B-1.01 which is shown Table E1 in Appendix E. The flow rate was then calculated based on SUDAS Equation 3B-1.02 focusing on the number of units within the site. After tabulating the number of units in the respective drainage area, the number of units was multiplied by the unit density and flow rate for the respective land use found in SUDAS Table 3B-1.01. After taking the minimum value from the two methods for each land use type, an overall daily average flow of 0.78 cfs was determined. Once the entire project area had a tabulated average daily flow rate, population was calculated based on the number of dwelling units and the persons per acre for each respective land use of single-family, multi-family, and commercial and light industrial. After finding the population in thousands of persons, the population was inputted into the Curve Equation corresponding to SUDAS Figure 3B-1.01 shown in Figure E2 in Appendix E to find the peak factor for daily sewer flow. The entire project site had an overall peak ratio of 3.49. The total peak daily flow was then tabulated by multiplying the average daily flow rate by the peak factor of 3.49. An overall peak flow rate of 2.08 cfs was found for the entire site. To evaluate the slope of existing 12" sanitary sewer line running from the south end of Battles Dr. to the lift station south of S 5th St. Our group consulted the City of Maquoketa Rosemere to South

Slope Sanitary Sewer Project plans from 1991 designed by Missman, Stanley & Associates, P.C. A total slope of 0.35 ft/100 ft was determined for the 12" pipe. Using SUDAS Figure 3C-1.01 shown in Figure E3 in Appendix E of this report, it was determined that a 12" diameter pipe was sufficient for the proposed increase in daily flow as the velocity of the flow within the pipe was 2.7 ft/s while flowing full. This flow velocity is sufficient according to SUDAS 3C-1B. All calculated flows are shown in Tables E2 through E4 in Appendix E. It is important to note that the Project Team has not received information concerning the capacity of the existing lift station to the south of S 5th St., so all designs are contingent upon a sufficient lift station capacity. The Project Team strongly recommends analysis of the capacity of the existing lift station before any designs are pursued.

After determining that the existing sanitary sewer network was sufficient, the proposed network was designed. This design was started by determining the high-points and low-points on the site to design an effective gravity flow network. Using the drainage paths produced by the proposed site design, the design of all pipes was done using the same method used to determine the suitability of the existing system; following the method outlined in SUDAS 3B-1. By determining the number of units draining to each proposed sanitary pipeline as well as the respective drainage area, minimum average daily flows were found and then multiplied by the peak factor of 3.49. An 8" pipe was determined to be suitable for all areas, however, our group recommends installing a 10" pipeline in three locations specified on the sanitary sewer layout shown in. The reason for an increased pipe size in these areas is to provide a safe buffer from abnormal outputs of sanitary sewage flow from both the commercial district just west of the proposed bridge as well as the potential future development of the current family farm located at the south of the site. If this current farmstead is developed as a commercial area, an increased pipeline diameter will be needed.

Table 12 Sanitary Sewer Quantities

SANITARY SEWER QUANTITIES	
LENGTH OF 8" PIPE (LF)	29813
LENGTH OF 12" PIPE (LF)	3202
NUMBER OF MANHOLES	140

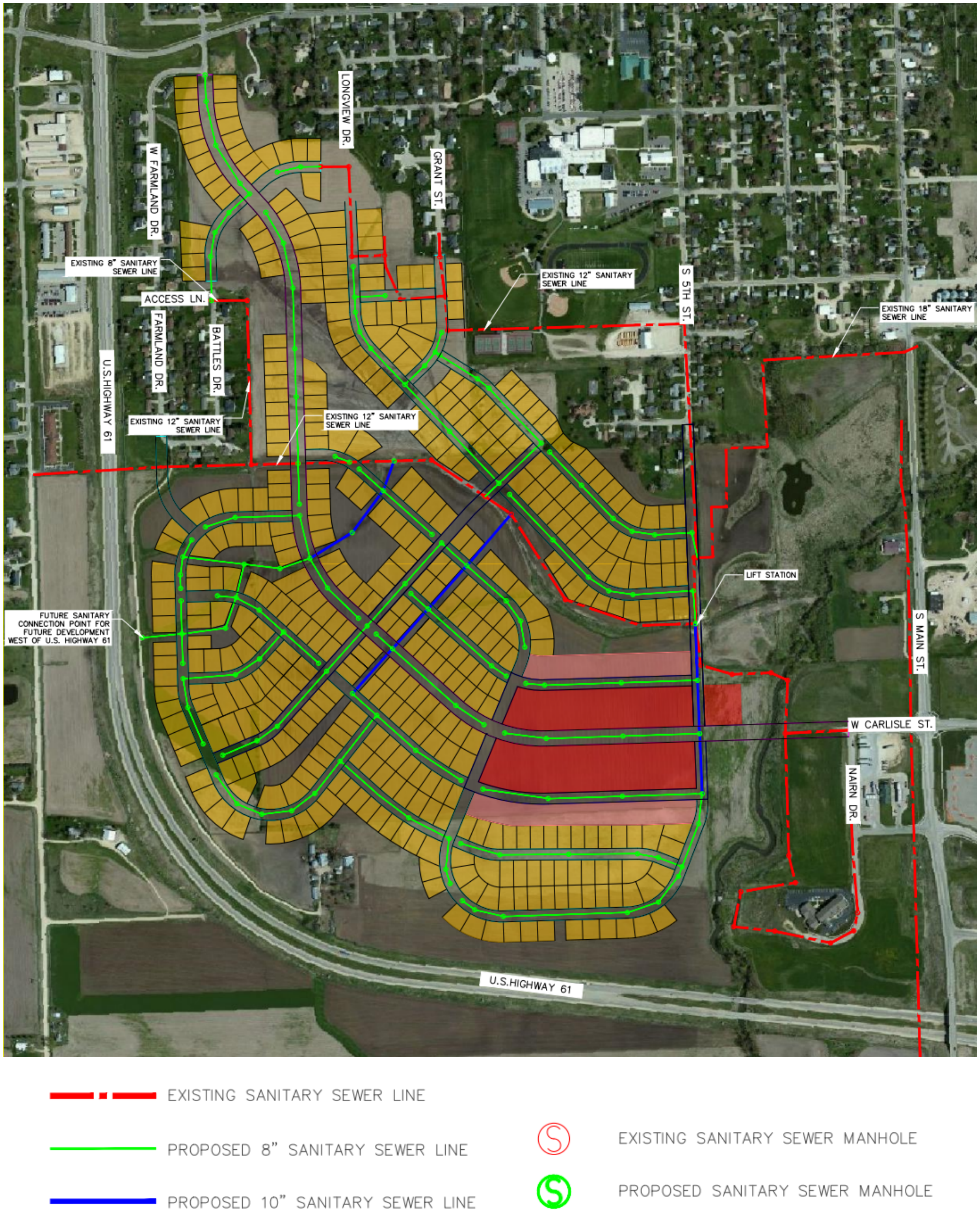


Figure 19 Sanitary Sewer Network

Green Space and Trail

Design of the trail system running throughout the site was conducted based on design standards specified in SUDAS 12B-2 and the final design layout is shown in *Figure 20*.

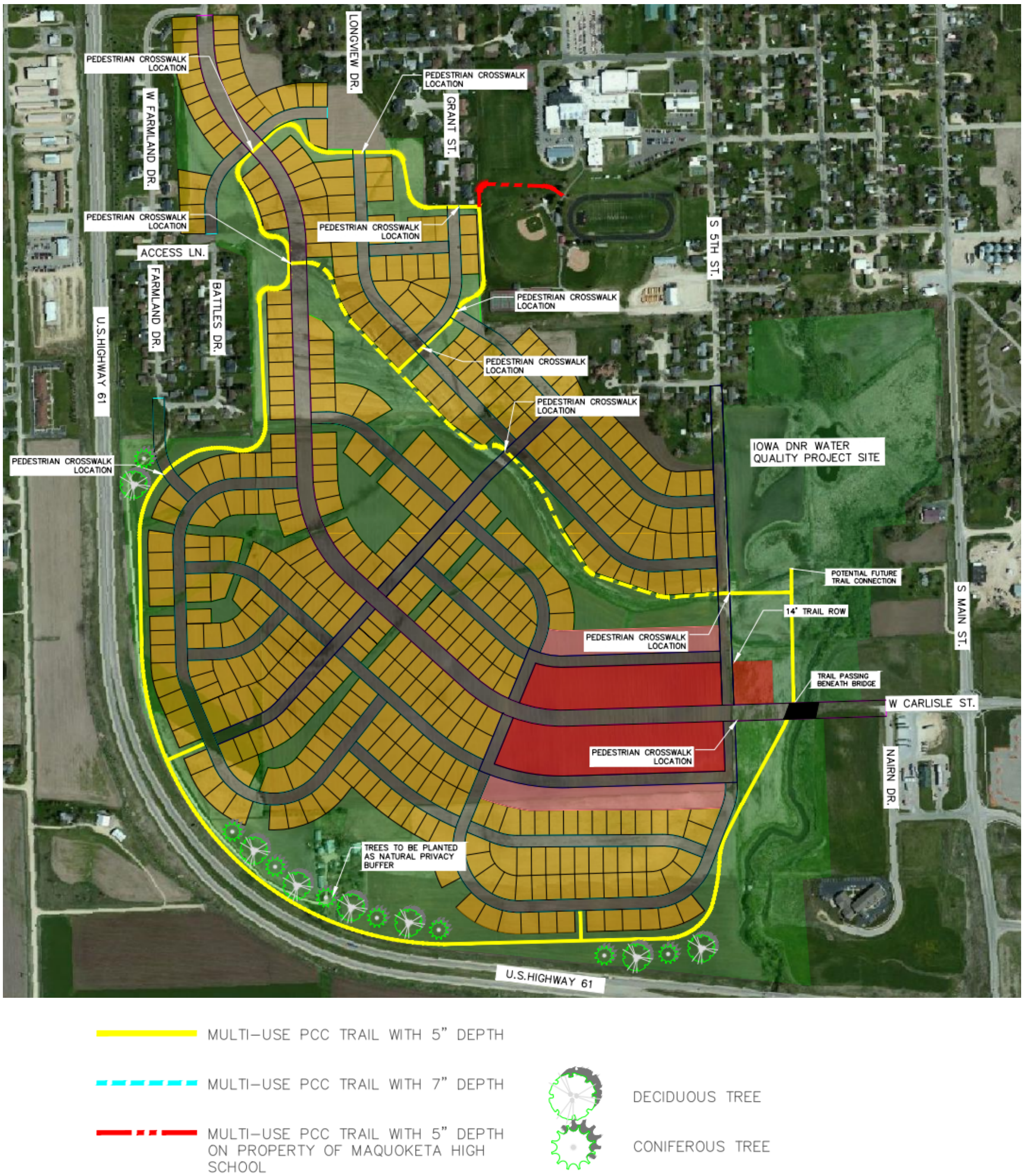


Figure 20 Green Space and Trail Network

The trail system was designed to accommodate both bicycles and pedestrians and was designed as a Type 3 Shared Use Path from SUDAS 12B-2B. A path width of 10 feet was used per SUDAS 12B-2C as well as a 2-foot grass buffer on either side as specified by SUDAS Figure 12B-2.01 shown in Figure F1 in Appendix F of this report. With a 10-foot-wide paved trail and a 2-foot buffer on either side, the space reserved for the trail needs to be at least 20 feet wide. However, with most of the trail located in public green space this is not of concern. The trail pavement is primarily designed as 5 inches of PCC on top of a compacted subgrade as designed per SUDAS 12B-2C. The portion of trail that runs along the main drainage way and the existing 12" sanitary sewer pipeline was designed as being PCC with a thickness of 7 inches on top of compacted subgrade to accommodate service vehicles having access to the sanitary sewer manholes running along the trail right of way. The main loop of the trail network is 2.35 miles which will provide the community with a fitness asset. As part of the trail network design, there is a proposed 585-foot-long section of paved trail on the existing high school property. While not within the scope of this project, the trail design presented by the Project Team provides the potential for connecting the high school to the proposed development. The goal of this additional connectivity has two parts, the first of which is providing students with a safe walking route to school. The second part is providing the community with walking access to sporting events held at the high school. This will hopefully provide an enjoyable route for community members who attend events at the high school, as well as increase attendance at school events.

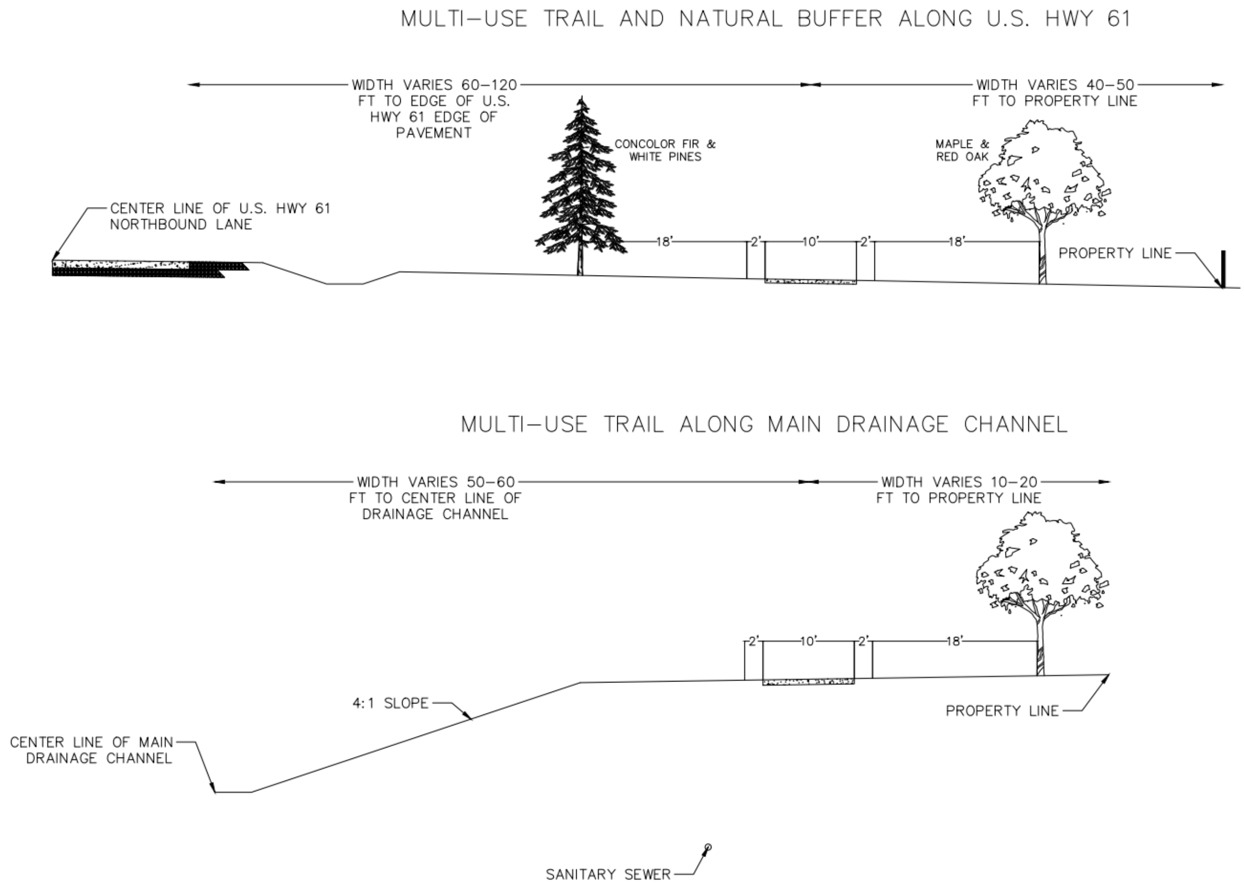


Figure 21 Multi-Use Trail Cross Sections

The Project Team also designed the trail to have ample greenspace on either side of the trail right of way as the trail runs along U.S. Highway 61. The goal of this green space is to provide an area for tree planting. Not only are trees aesthetically pleasing to trail users, but the trees can also provide a natural buffer for the sound coming from U.S. Highway 61 as well as provide visual privacy to the residents residing within the proposed development. The trees recommended to be planted are a mixture of Concolor Firs, Maple, White Pine, and Red Oaks. All these trees are hardy and can be found within the Midwest, but each has its own purpose. The first piece of this recommendation of trees to plant has the goal of providing biodiversity that can withstand many natural onslaughts like insects or fungi. Two of these proposed tree species, both Concolor Firs and White Pines are coniferous trees that will retain their needles throughout the winter season. This will ensure that privacy is maintained year-round. Maple and Red Oak trees are proposed as well, not only because they are hardy Midwest species, but also because they will provide a colorful aesthetic in the fall and provide a fair amount of shade on the trail depending on how close they are planted to the trail. It is recommended that the trees are planted at least 20 feet from the trail edge and be maintained enough to prevent the limbs from obstructing the 2-foot clearance along the trail.

While a trail design has not been proposed for the Iowa DNR Water Quality Project area, our design as provided trail access close to the existing lift station to the south of S 5th St. The goal of this design consideration was to provide a potential future trail connection to any future trail designs proposed by the Iowa DNR Water Quality Project.

Section VII Engineer's Cost Estimate

The total estimated cost to fully develop this site is $27.9 million. This estimate does not include the cost associated with property acquisition. The development of this site will increase the City of Maquoketa's infrastructure value by $20.9 million. The itemized development cost and infrastructure value is summarized in Table 13. All unit prices were obtained from the Iowa DOT's Bid Express Lettings page and adjusted to reflect an urban setting as most of the DOT's work is in rural areas. Awarded contract unit prices were used from the March 15th, 2022, and April 19th, 2022, letting releases. The calculation of quantities of non-direct measurable items can be found in Appendix G. The 25% earthwork and contingencies were estimated by assuming there was an average of 6-inches of topsoil over the site that would need to be a striped, salvaged, and spread as well as a average 2-feet of cut/fill across the site. The earthwork estimate is summarized in Figure G4 located in Appendix G. Rounding standards were used from RSMeans Cost Handbook and the rounding standards are provided in Appendix G. The estimated cost to develop the area is not the total cost to the city, it is the value of the additional infrastructure that city will have following full development of the site.

As with most development master plans, market conditions and the developers' willingness to move forward with subdivisions dictate the construction schedule and phasing. Cities can make developable areas more attractive to developers and investors with incentives and/or investments in key infrastructure elements. The City of Maquoketa has already made strategic investments in the water and sanitary sewer utilities in this area that will be enticing to developers. Another investment to consider is the bridge over Prairie Creek as it requires significant capital that is too large for any single development. The Project Team recommends that the City of Maquoketa investigate a grant from Iowa's RISE program to fund the bridge as a catalyst to development. In addition to the existing utilities and bridge investment, using the future Iowa DNR Water Quality Site as regional stormwater management area would be a significant incentive for developers and investors.

Table 13 Site Development Cost Estimate

ENGINEER'S COST ESTIMATE

STORM COST ESTIMATE				
ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
INTAKE, SW-505	224	EACH	$ 2,550.00	$ 571,506.98
STORM SEWER GRAVITY MAIN, TRENCHED, 18 IN.	31899.8	LF	$ 84.59	$ 2,698,324.44
CULVERT, CONCRETE ROADWAY PIPE, 30 IN. DIA.	85	LF	$ 134.96	$ 11,471.81
CULVERT, CONCRETE ROADWAY PIPE, 54 IN. DIA.	65	LF	$ 226.66	$ 14,733.06
CULVERT, CONCRETE ROADWAY PIPE, 60 IN. DIA.	155	LF	$ 492.35	$ 76,314.25
CULVERT, CONCRETE ROADWAY PIPE, 66 IN. DIA.	110	LF	$ 562.50	$ 61,875.00
PRECAST CONCRETE BOX CULVERT, 5.5 FT. X 5 FT.	70	LF	$ 2,620.18	$ 183,412.25
PRECAST CONCRETE BOX CULVERT, 6 FT. X 5 FT.	65	LF	$ 2,096.14	$ 136,249.10
PRECAST CONCRETE BOX CULVERT,	70	LF	$ 2,620.18	$ 183,412.25
DOUBLE, 5 FT. X 6 FT.	160	LF	$ 2,096.14	$ 335,382.40
PRECAST CONCRETE BOX CULVERT,	65	LF	$ 1,315.49	$ 85,506.69
DOUBLE 8 FT. X 5 FT.	65	LF	$ 2,630.98	$ 171,013.38
DOUBLE 8 FT. X 5.5 FT.	145	LF	$ 3,157.17	$ 457,789.65
PRECAST CONCRETE BOX CULVERT, DOUBLE 10 FT. X 10 FT.	150	LF	$ 2,850.45	$ 427,567.50
			TOTAL COST	$ 5,414,558.76

WATER MAIN COST ESTIMATE				
ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
WATER MAIN, TRENCHED, POLYVINYL CHLORIDE PIPE (PVC), 8 IN.	28421.9	LF	$ 45.00	$ 1,278,984.15
WATER MAIN, TRENCHED, POLYVINYL CHLORIDE PIPE (PVC), 12 IN.	6596.9	LF	$ 60.00	$ 395,816.40
VALVE, BUTTERFLY, DIP	199	EACH	$ 3,000.00	$ 597,000.00
FIRE HYDRANT ASSEMBLY, WM-201	101	EACH	$ 3,500.00	$ 353,500.00
			TOTAL COST	$ 2,625,300.55

SANITARY SEWER COST ESTIMATE				
ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
SANITARY SEWER GRAVITY MAIN, TRENCHED, POLYVINYL CHLORIDE PIPE (PVC), 8 IN.	29577.4	LF	$ 52.00	$ 1,538,023.76
SANITARY SEWER GRAVITY MAIN, TRENCHED, POLYVINYL CHLORIDE PIPE (PVC), 10 IN.	3201.2	LF	$ 75.00	$ 240,093.00
MANHOLE, SANITARY SEWER, SW-301, 48 IN.	139.0	EACH	$ 3,850.00	$ 535,150.00
			TOTAL COST	$ 2,313,266.76

ROAD NETWORK COST ESTIMATE				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
MODIFIED SUBBASE	41443.5	CY	$ 88.88	$ 3,683,288.26
STANDARD OR SLIP FORM PORTLAND CEMENT CONCRETE	17591.8	SY	$ 65.65	$ 1,154,904.30
HOT MIX ASPHALT MIXTURE, COMMERCIAL MIX (INCLUDES	13712.4515	TON	$ 55.00	$ 754,184.83
CURB AND GUTTER, P.C. CONCRETE 3.0 FT	70037.6	LF	$ 48.38	$ 3,388,069.87
THREE SPAN BRIDGE	1.0	EACH	$1,149,068.00	$ 1,149,068.00
			TOTAL COST	$ 10,129,515.26

RECREATIONAL TRAIL COST ESTIMATE				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 5 IN.	7605.0	SY	$ 45.71	$ 347,643.56
RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 7 IN.	1771.0	SY	$ 69.00	$ 122,196.32
			TOTAL COST	$ 469,839.88

TOTAL PROJECT COST	
CONSTRUCTION SUBTOTAL	$ 20,952,481.21
25% TOPSOIL, EXCAVATION, SEEDING/FERTILIZING, AND	$ 5,238,120.30
8% ENGINEERING AND ADMINISTRA	$ 1,676,198.50
TOTAL PROJECT COST	$ 27,867,000.00

Section VII Appendices

Appendix A: Overview of the Site

TITLE V LAND USE REGULATIONS

SUBCHAPTER 1D "R-1" RESIDENTIAL DISTRICT

5-1D-1 "R-1" DISTRICT REGULATIONS:

1. The regulations set forth in this Chapter or set forth elsewhere in this Title, when referred to in this Chapter, are the regulations in the "R-1" Residential District.

5-1D-2 USE REGULATIONS:

1. A building or premises shall be used only for the following purposes:

a. Single family dwellings.

b. Two (2) family dwellings.

c. Churches.

d. Public buildings, parks, playgrounds, community center, and recreational vehicle campsites in City Parks as designated by Council Resolution.

(Ord. 773, 1-6-92)

e. Public schools, elementary and high, and private education institutions having a curriculum the same as ordinarily given in public schools, and having no rooms regularly used for housing and sleeping rooms.

f. Home occupations.

g. Golf courses, except miniature courses or practice driving tees operated for commercial purposes.

h. Temporary buildings, the uses of which are incidental to the construction operations or sale of lots during development being conducted on the same or adjoining tract or subdivision and which shall be removed upon completion or abandonment of such construction, or upon the

Figure A1: The City of Maquoketa R1-Residential Zoning expiration of a period of two (2) years from the time of erection of such temporary buildings, whichever is sooner.

i. Cemetery or mausoleum on sites not less than twenty (20) acres.

j. Signs: Refer to the Subchapter 1O, Signs.

k. Accessory buildings and uses including, but not limited to, accessory private garages, swimming pools, home barbecue grills, accessory storage, and accessory off street parking and loading space.

5-1D-3 PARKING REGULATIONS:

1. Off street parking spaces shall be provided in accordance with the requirements for specific uses set forth in Subchapter 1L.

5-1D-4 HEIGHT REGULATIONS:

1. No building shall exceed two and one-half (2 1/2) stories nor shall it exceed thirty-five (35') feet except as provided in Subchapter 1K.

5-1D-5 AREA REGULATIONS:

1. Yard Regulations. Subject to the modifications set out in Subchapter 1K, the regulations are as follows:

a. Front Yard. There shall be a front yard of not less than thirty (30') feet.

b. Side Yard. There shall be a side yard on each side of a lot of not less than seven feet (7').

c. Rear Yard. There shall be a rear yard of not less than thirty feet (30').

d. Front Porch Reconstruction.

e. If a residence was constructed prior to January 1, 1964, with a front porch that does not comply with the front yard or side yard setback requirements, then the front porch may be rebuilt provided that the overall square footage of the porch is not increased and the existing nonconforming front and side yard setbacks are not decreased.

2.. Minimum Lot Area.

a. A lot occupied by a single family dwelling shall contain not less than seven thousand two hundred (7,200) square feet and shall not be less than sixty feet (60') in width.

b. A lot occupied by a two (2) family dwelling shall contain not less than nine thousand (9,000) square feet and shall not be less than seventy-five feet (75') in width.

Figure A1 (Continued): The City of Maquoketa R1-Residential Zoning

Table A1: Increase in Tax Base Following Full Development

SINGLE-FAMILY TAX BASE INCREASE		
NUMBER OF DWELLINGS		490
ESTIMATED AVERAGE DWELLING VALUE	$	250,000.00
ESTIMATED SINGLE -FAMILY TAX BASE INCREAS	$	122,500,000.00

*** THE ESTIMATED AVERAGE DWELLING VALUE IS AN ASSUMED VALUE BASED OFF OF CURRENT MARKET CONDITIONS.

COMMERCIAL SPACE TAX BASE INCREASE		
AREA OF COMMERCIAL SPACE (SQ FT)		651424.00
AREA OF COMMERCIAL SPACE (ACRE)		14.95
ASSESSED VALUE OF STUDY PROPERTY	$	1,337,000.00
SIZE OF STUDY PROPERTY (ACRE)		4.15
ESTIMATED COMMERCIAL VALUE PER ACRE	$	322,168.67
ESTIMATED COMMERCIAL TAX BASE INCREASE	$	4,817,000.00

*** THE STUDY PROPERTY USED FOR COMMERCIAL SPACE TAX RATE IS 102 DAVID STREET MAQUOKETA, IA (QUICK STAR LOCATED OFF OF SOUTH MAIN STREET IN MAQUOKETA, IA)

*** COMMERCIAL AREA VALUE PER ACRE WAS OBTAINED BY DIVIDING THE ASSESSED VALUE BY THE PROPERTY SIZE.

MULTI-FAMILY TAX BASE INCREASE		
AREA OF MULTIFAMILY HOUSING (SQ FT)		316988.29
AREA OF MULTIFAMILY HOUSING (ACRE)		7.28
ASSESSED VALUE OF STUDY PROPERTY	$	1,332,500.00
SIZE OF STUDY PROPERTY (ACRE)		1.39
ESTIMATED MULTIFAMILY VALUE PER ACRE	$	958,633.09
ESTIMATED MULTIFAMILY TAX BASE INCREASE	$	6,976,000.00

*** THE STUDY PROPERTY USED FOR MULTIFAMILY HOUSING IS LOCATED AT 401 ARCADE STREET MAQUOKETA, IA (APARTMENT COMPLEX ON THE NORTH SIDE OF THE CITY).

*** MULTIFAMILY HOUSING VALUE PER ACRE WAS OBTAINED BY DIVIDING THE ASSESSED VALUE BY THE PROPERTY SIZE.

TOTAL TAX REVENUE INCREASE FOLLOWING FULL DEVELOPMENT		
ESTIMATED TOTAL TAX BASE INCREASE	$	134,293,000.00

*** THE TOTAL TAX BASE INCREASE WAS FOUND BY SUMMING THE INDIVIDUAL BASE INCREASES FROM SINGLE-FAMILY, COMMERCIAL, AND MULTIFAMILY DEVELOPMENT.

Appendix B: Street Layout and Designation

Table B1: SUDAS Table 5C-1.01: Preferred Roadway Elements

Table 5C-1.01: Preferred Roadway Elements

Elements Related to Functional Classification

Design Element	Local		Collector		Arterial	
	Res.	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*
General						
Design level of service[1]	D	D	C/D	C/D	C/D	C/D
Lane width (single lane) (ft)[2]	10.5	12	12	12	12	12
Two-way left-turn lanes (TWLTL) (ft)	N/A	N/A	14	14	14	14
Width of new bridges (ft)[3]	See Footnote 3					
Width of bridges to remain in place (ft)[4]	----------	----------	----------	----------	----------	----------
Vertical clearance (ft)[5]	14.5	14.5	14.5	14.5	16.5	16.5
Object setback (ft)[6]	3	3	3	3	3	3
Clear zone (ft)	Refer to Table 5C-1.03, Table 5C-1.04, and 5C-1, C, 1					
Urban						
Curb offset (ft)[7]	2	2	2	3	3	3
Parking lane width (ft)	8	8	8	10	N/A	N/A
Roadway width with parking on one side[8]	26/27/31[9]	34	34	37	N/A	N/A
Roadway width without parking[10]	26	31	31	31	31	31
Raised median with left-turn lane (ft)[11]	N/A	N/A	19.5	20.5	20.5	20.5
Cul-de-sac radius (ft)	45/48[12]	45/48[12]	N/A	N/A	N/A	N/A
Rural Sections in Urban Areas						
Shoulder width (ft)						
ADT: under 400	4	4	6	6	10	10
ADT: 400 to 1,500	6	6	6	6	10	10
ADT: 1,500 to 2000	8	8	8	8	10	10
ADT: above 2,000	8	8	8	8	10	10
Foreslope (H:V)	4:1	4:1	4:1	4:1	6:1	6:1
Backslope (H:V)	4:1	4:1	4:1	4:1	4:1	4:1

Res. = Residential, C/I = Commercial/Industrial

Elements Related to Design Speed

Design Element	Design Speed, mph[13]							
	25	*30*	*35*	*40*	*45*	*50*	*55*	*60*
Stopping sight distance (ft)	155	200	250	305	360	425	495	570
Passing sight distance (ft)	900	1090	1,280	1,470	1,625	1,835	1,985	2,135
Min. horizontal curve radius (ft)[14]	198	333	510	762	1,039	926	1,190	1,500
Min. vertical curve length (ft)	50	75	105	120	135	150	165	180
Min. rate of vertical curvature, Crest (K)[15]	18	30	47	71	98	136	185	245
Min. rate of vertical curvature, Sag (K)	26	37	49	64	79	96	115	136
Minimum gradient (percent)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Maximum gradient (percent)	5	5	5	5	5	5	5	5

Table B2: SUDAS Table 5C-2.02: Preferred Border Area

Table 5C-2.02: Preferred Border Area

Street Classification	Border Area Width (feet)
Major/minor arterial	16
Collector	14.5
Local streets	14

Single-Family Detached Housing
(210)

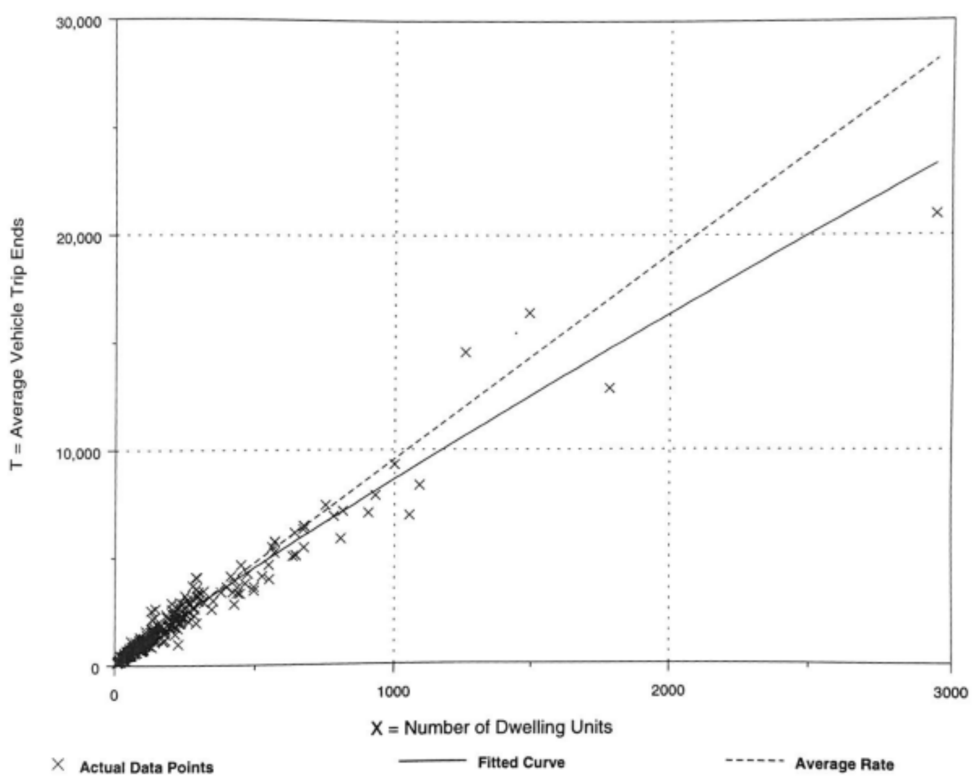
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 348
Avg. Number of Dwelling Units: 198
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.57	4.31 - 21.85	3.69

Data Plot and Equation



Fitted Curve Equation: $Ln(T) = 0.920\ Ln(X) + 2.707$ $R^2 = 0.96$

Trip Generation, 6th Edition 263 Institute of Transportation Engineers

Figure B1: Institute of Transportation Engineers Trip Generation Manual for Single-Family Dethatched Housing.

Residential Condominium/Townhouse
(230)

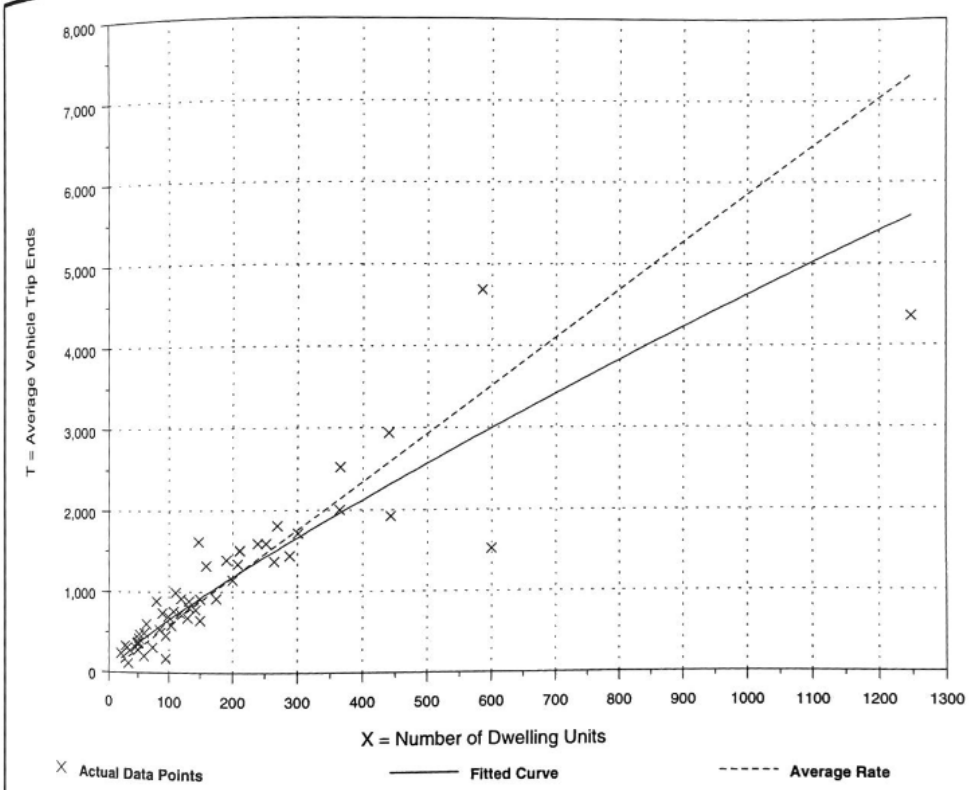
Average Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Number of Studies: 53
Avg. Number of Dwelling Units: 185
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
5.86	1.83 - 11.79	3.09

Data Plot and Equation



Fitted Curve Equation: $Ln(T) = 0.850\ Ln(X) + 2.564$ $R^2 = 0.83$

Trip Generation, 6th Edition   361   Institute of Transportation Engineers

Figure B2: Institute of Transportation Engineers Trip Generation Manual for Residential Condominium/Townhouse.

Shopping Center
(820)

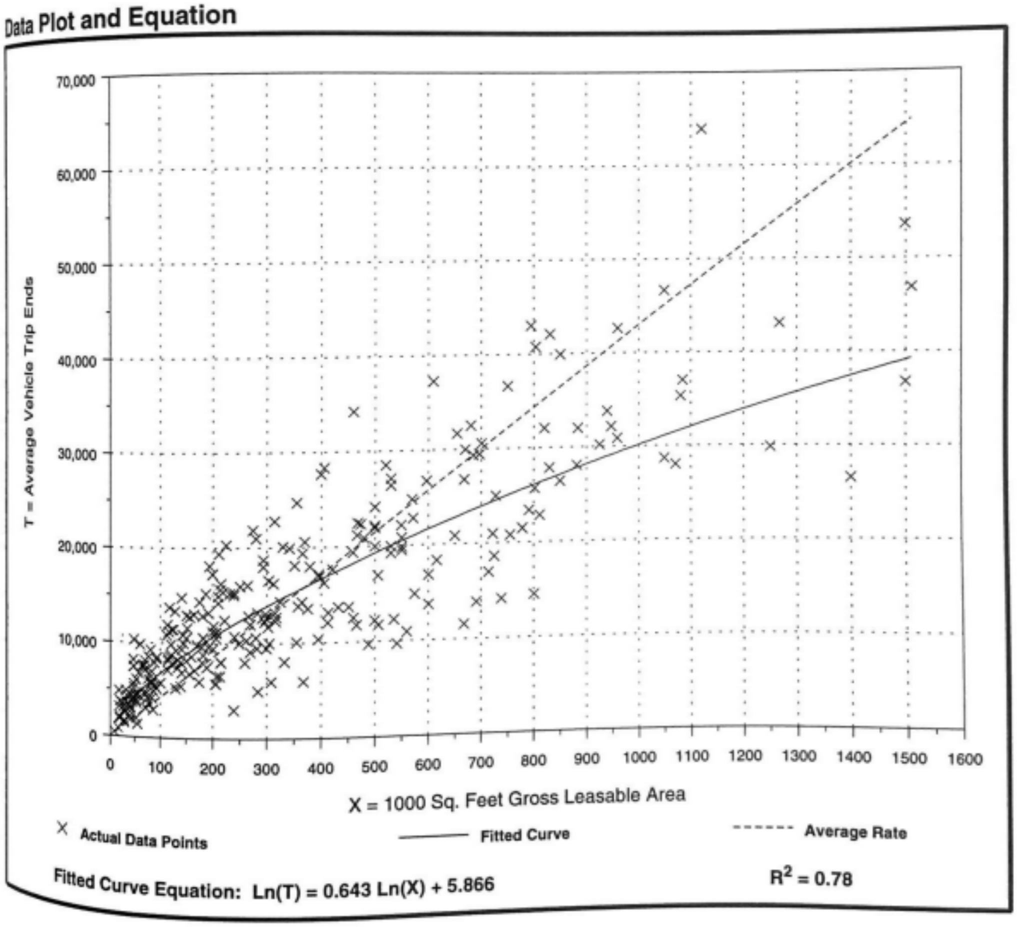
Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Leasable Area
On a: Weekday

Number of Studies: 299
Average 1000 Sq. Feet GLA: 331
Directional Distribution: 50% entering, 50% exiting

Trip Generation per 1000 Sq. Feet Gross Leasable Area

Average Rate	Range of Rates	Standard Deviation
42.92	12.50 - 270.89	21.39

Data Plot and Equation



Trip Generation, 6th Edition 1337 Institute of Transportation Engineers

Figure B3: Institute of Transportation Engineers Trip Generation Manual for Shopping Center

SINGLE-FAMILY RESIDENTIAL	
NUMBER OF SINGLE-FAMILY DWELLING UNITS	488
TRIP GENERATION PER DWELLING UNIT	9.57
TOTAL TRIPS GENERATED	4670
PERCENT TRIPS ASSUMED TO ROUTE TO ARTERIAL	90%
TOTAL TRIPS TO ARTERIAL ROAD	4203

*** 90% OF ALL TRIPS ARE ASSUMED TO UTILIZE THE ARTERIAL ROAD AS IT IS THE MOST DIRRECT CONNECTION TO EXISTING ARTERIAL ROADS

MULTIFAMILY RESIDENTIAL	
AREA OF MULTIFAMILY RESIDENTIAL HOUSING (SQ FT)	316988.29
MINIMUM LOT AREA PER TWO DWELLINGS (SQ FT)	9000
NUMBER OF MULTIFAMILY DWELLING UNITS	35
TRIP GENERATION PER DWELLING UNIT	5.86
TOTAL TRIPS GENERATED	206
PERCENT TRIPS ASSUMED TO ROUTE TO ARTERIAL	90%
TOTAL TRIPS TO ARTERIAL ROAD	186

*** 90% OF ALL TRIPS ARE ASSUMED TO UTILIZE THE ARTERIAL ROAD AS IT IS THE MOST DIRRECT CONNECTION TO EXISTING ARTERIAL ROADS

*** MINIMUM LOT AREA PER TWO DWELLINGS IS FROM THE CITY OF MAQUOKETA'S CITY CODE CHAPTER 5 SUBCHAPTER 1D.

COMMERCIAL	
AREA OF COMMERCIAL AREA (SQ FT)	599489.09
PERCENT OF LEASABLE AREA	50%
TRIP GENERATION PER 1000 SQ FT LEASABLE AREA	42.92
TOTAL TRIPS GENERATED	12865
PERCENT TRIPS ASSUMED TO ROUTE TO ARTERIAL	95%
TOTAL TRIPS TO ARTERIAL ROAD	12222

*** 95% OF ALL TRIPS ARE ASSUMED TO UTILIZE THE ARTERIAL ROAD AS IT IS THE MOST DIRRECT CONNECTION TO EXISTING ARTERIAL ROADS

*** FOLLOWING FULL BUILD OUT OF THE COMMERCIAL AREA IT IS ASSUMED THAT 50% OF THE GROSS AREA WILL BE LEASALBE AND THE OTHER 50% DETICATED TO GREENSPACE, PARKING, AND BUILDING STRUCTURE.

TOTAL BUILD OUT YEAR AADT	
TOTAL BUILD OUT YEAR AADT	16600

*** TRIP GENERATION RATES ARE FROM THE INSTITUTE OF TRANSPORTATION ENGINEERS TRIP GENERATION MANNUAL, 6TH EDITION.

Figure B4: Full Development Arterial Road Estimated AADT

Table B3: SUDAS Table 5F-1.06: Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor.

Table 5F-1.06: Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor

Type A Truck Mix: Primarily buses and single axle trucks often found on low volume streets

Truck Class	(Vehicle Description)	Percent of Total Trucks	Loading	Percent of Truck Class	Vehicle Weight (lbs)	Axle Type S-Single TA-Tandem	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
	Class 4 (2-axle busses, BUS)	10%	Partial Load (80% capacity)	100%	25000	Front-S	9000	0.053	0.066		
						Rear-S	16000	0.607	0.631	0.660	0.697
	Class 5 (2-axle, 6-tire trucks & busses, SU-2)	75%	Partial Load (50% capacity)	100%	20000	Front-S	6500	0.014	0.018		
						Rear-S	13500	0.294	0.326	0.308	0.344
	Class 6 (3-axle trucks, SU-3)	5%	Empty	50%	22000	Front-S	7000	0.019	0.024		
						Rear-TA	15000	0.064	0.044	0.041	0.034
			Fully Loaded	50%	46000	Front-S	12000	0.178	0.206		
						Rear-TA	34000	1.900	1.099	1.039	0.653
	Class 8 (4-axle (or less) single trailer truck, Comb-4)	5%	Empty	20%	24000	Front-S	9000	0.053	0.066		
						Rear-TA	9000	0.009	0.006		
						Trailer-S	6000	0.010	0.013	0.014	0.017
			Partial Load (50% capacity)	40%	44000	Front-S	9500	0.067	0.082		
						Rear-TA	22000	0.310	0.202		
						Trailer-S	12500	0.212	0.242	0.236	0.210
			Fully Loaded	40%	64000	Front-S	10000	0.083	0.101		
						Rear-TA	34000	1.900	1.099		
						Trailer-S	20000	1.558	1.520	1.416	1.088
	Class 9 (5-axle single trailer truck, Comb-5)	5%	Empty	20%	36000	Front-S	11000	0.124	0.147		
						Rear-TA	14000	0.048	0.033		
						Trailer-TA	11000	0.019	0.013	0.038	0.039
			Partial Load (50% capacity)	40%	58000	Front-S	11500	0.149	0.175		
						Rear-TA	24000	0.447	0.284		
						Trailer-TA	22500	0.341	0.220	0.375	0.272
			Fully Loaded	40%	80000	Front-S	12000	0.178	0.206		
						Rear-TA	34000	1.900	1.099		
						Trailer-TA	34000	1.900	1.099	1.592	0.962
									Composite LEF for Type A Truck Mix =	**0.535**	**0.492**

Table B4: SUDAS Table 5F-1.07: Base Year Design ESALs for Two Lane Ridged Pavement

Table 5F-1.07: Base Year Design ESALs for Two Lane *Rigid Pavement*

% Trucks	Truck Mix Type	Two-Way Base Year AADT							
		1,000	**2,000**	**3,000**	**4,000**	**5,000**	**10,000**	**15,000**	**20,000**
1	A	1,000	2,000	3,000	4,000	5,000	10,000	14,500	19,500
	B	1,500	3,500	5,000	6,500	8,000	16,500	24,500	32,500
	C	2,500	5,000	7,000	9,500	12,000	24,000	35,500	47,500
2	A	2,000	4,000	6,000	8,000	10,000	19,500	29,500	39,000
	B	3,500	6,500	10,000	13,000	16,500	32,500	49,000	65,500
	C	5,000	9,500	14,500	19,000	24,000	47,500	71,500	95,000
3	A	3,000	6,000	9,000	11,500	14,500	29,500	44,000	58,500
	B	5,000	10,000	14,500	19,500	24,500	49,000	73,500	98,000
	C	7,000	14,500	21,500	28,500	35,500	71,500	107,000	142,500
4	A	4,000	8,000	11,500	15,500	19,500	39,000	58,500	78,000
	B	6,500	13,000	19,500	26,000	32,500	65,500	98,000	130,500
	C	9,500	19,000	28,500	38,000	47,500	95,000	142,500	190,000
5	A	5,000	10,000	14,500	19,500	24,500	49,000	73,000	97,500
	B	8,000	16,500	24,500	32,500	41,000	81,500	122,500	163,500
	C	12,000	24,000	35,500	47,500	59,500	119,000	178,000	237,500
6	A	6,000	11,500	17,500	23,500	29,500	58,500	88,000	117,000
	B	10,000	19,500	29,500	39,000	49,000	98,000	147,000	196,000
	C	14,500	28,500	43,000	57,000	71,500	142,500	214,000	285,000
7	A	7,000	13,500	20,500	27,500	34,000	68,500	102,500	136,500
	B	11,500	23,000	34,500	45,500	57,000	114,500	171,500	228,500
	C	16,500	33,500	50,000	66,500	83,000	166,500	249,500	332,500
8	A	8,000	15,500	23,500	31,000	39,000	78,000	117,000	156,000
	B	13,000	26,000	39,000	52,500	65,500	130,500	196,000	261,500
	C	19,000	38,000	57,000	76,000	95,000	190,000	285,000	380,000
9	A	9,000	17,500	26,500	35,000	44,000	88,000	132,000	175,500
	B	14,500	29,500	44,000	59,000	73,500	147,000	220,500	294,000
	C	21,500	43,000	64,000	85,500	107,000	214,000	321,000	427,500
10	A	10,000	19,500	29,500	39,000	49,000	97,500	146,500	195,000
	B	16,500	32,500	49,000	65,500	81,500	163,500	245,000	326,500
	C	24,000	47,500	71,500	95,000	119,000	237,500	356,500	475,000
12	A	11,500	23,500	35,000	47,000	58,500	117,000	175,500	234,000
	B	19,500	39,000	59,000	78,500	98,000	196,000	294,000	392,000
	C	28,500	57,000	85,500	114,000	142,500	285,000	427,500	570,500
14	A	13,500	27,500	41,000	54,500	68,500	136,500	205,000	273,500
	B	23,000	45,500	68,500	91,500	114,500	228,500	343,000	457,500
	C	33,500	66,500	100,000	133,000	166,500	332,500	499,000	665,500
16	A	15,500	31,000	47,000	62,500	78,000	156,000	234,000	312,500
	B	26,000	52,500	78,500	104,500	130,500	261,500	392,000	522,500
	C	38,000	76,000	114,000	152,000	190,000	380,000	570,500	760,500
18	A	17,500	35,000	52,500	70,500	88,000	175,500	263,500	351,500
	B	29,500	59,000	88,000	117,500	147,000	294,000	441,000	588,000
	C	43,000	85,500	128,500	171,000	214,000	427,500	641,500	855,500
20	A	19,500	39,000	58,500	78,000	97,500	195,000	293,000	390,500
	B	32,500	65,500	98,000	130,500	163,500	326,500	490,000	653,500
	C	47,500	95,000	142,500	190,000	237,500	475,000	713,000	950,500

Assumes two lane roadway with 50/50 directional split of base year AADT

Table B5: SUDAS Table 5F-1.11: Growth Factor

Table 5F-1.11: Growth Factor

Design Period Years (n)	Average Annual Traffic Growth Rate, Percent					
	No Growth	1%	2%	3%	4%	5%
1	1.0	1.0	1.0	1.0	1.0	1.0
2	2.0	2.0	2.0	2.0	2.0	2.1
3	3.0	3.0	3.1	3.1	3.1	3.2
4	4.0	4.1	4.1	4.2	4.2	4.3
5	5.0	5.1	5.2	5.3	5.4	5.5
6	6.0	6.2	6.3	6.5	6.6	6.8
7	7.0	7.2	7.4	7.7	7.9	8.1
8	8.0	8.3	8.6	8.9	9.2	9.5
9	9.0	9.4	9.8	10.2	10.6	11.0
10	10.0	10.5	10.9	11.5	12.0	12.6
11	11.0	11.6	12.2	12.8	13.5	14.2
12	12.0	12.7	13.4	14.2	15.0	15.9
13	13.0	13.8	14.7	15.6	16.6	17.7
14	14.0	14.9	16.0	17.1	18.3	19.6
15	15.0	16.1	17.3	18.6	20.0	21.6
16	16.0	17.3	18.6	20.2	21.8	23.7
17	17.0	18.4	20.0	21.8	23.7	25.8
18	18.0	19.6	21.4	23.4	25.6	28.1
19	19.0	20.8	22.8	25.1	27.7	30.5
20	20.0	22.0	24.3	26.9	29.8	33.1
21	21.0	23.2	25.8	28.7	32.0	35.7
22	22.0	24.5	27.3	30.5	34.2	38.5
23	23.0	25.7	28.8	32.5	36.6	41.4
24	24.0	27.0	30.4	34.4	39.1	44.5
25	25.0	28.2	32.0	36.5	41.6	47.7
26	26.0	29.5	33.7	38.6	44.3	51.1
27	27.0	30.8	35.3	40.7	47.1	54.7
28	28.0	32.1	37.1	42.9	50.0	58.4
29	29.0	33.5	38.8	45.2	53.0	62.3
30	30.0	34.8	40.6	47.6	56.1	66.4
31	31.0	36.1	42.4	50.0	59.3	70.8
32	32.0	37.5	44.2	52.5	62.7	75.3
33	33.0	38.9	46.1	55.1	66.2	80.1
34	34.0	40.3	48.0	57.7	69.9	85.1
35	35.0	41.7	50.0	60.5	73.7	90.3
36	36.0	43.1	52.0	63.3	77.6	95.8
37	37.0	44.5	54.0	66.2	81.7	101.6
38	38.0	46.0	56.1	69.2	86.0	107.7
39	39.0	47.4	58.2	72.2	90.4	114.1
40	40.0	48.9	60.4	75.4	95.0	120.8
41	41.0	50.4	62.6	78.7	99.8	127.8
42	42.0	51.9	64.9	82.0	104.8	135.2
43	43.0	53.4	67.2	85.5	110.0	143.0
44	44.0	54.9	69.5	89.0	115.4	151.1
45	45.0	56.5	71.9	92.7	121.0	159.7
46	46.0	58.0	74.3	96.5	126.9	168.7
47	47.0	59.6	76.8	100.4	132.9	178.1
48	48.0	61.2	79.4	104.4	139.3	188.0
49	49.0	62.8	81.9	108.5	145.8	198.4
50	50.0	64.5	84.6	112.8	152.7	209.3

Table B6: SUDAS Table 5F-1.12: Parameter Assumptions Used for Pavement Thickness Design Tables.

Table 5F-1.12: Parameter Assumptions Used for Pavement Thickness Design Tables

Subbase:	**Natural**		**4" Subbase**		**6" Subbase**		**8" Subbase**		**10" Subbase**		**12" Subbase**	
CBR Value:	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**
Rigid Pavement Parameters												
Initial Serviceability Index, P_o	4.5											
Terminal Serviceability Index, P_t	Local Roads = 2.00 Collector Roads = 2.25 Arterials = 2.50											
Reliability, R	Local Roads = 80% Collector Roads = 88% Arterials = 95%											
Overall Standard Deviation, S_o	0.35											
Loss of Support, LS	0											
Soil Resilient Modulus, M_R 1500 x CBR	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500
Subbase Resilient Modulus, E_{SB} *Assumed	Not Applicable		30,000*									
Modulus of Subgrade Reaction k, and Composite Modulus of Subgrade Reaction, k_c Use AASHTO Chapter 3, Table 3.2 and Figures 3.3 - 3.6 to determine	105	148	228	342	239	359	254	380	269	404	285	428
Coefficient of Drainage, C_d	1.00		1.10									
Modulus of Rupture, S'_c $S'_c = 2.3 \times f_c^{0.667}$ *Assumed 4,000 psi concrete	580											
Modulus of Elasticity, E_c $E_c = 6{,}750 \times S'_c$ *Assumed 4,000 psi concrete	3,915,000											
Load Transfer, J	J = 3.1 (Pavement Thickness <8") J = 2.7 (Pavement Thickness ≥ 8")											
Flexible Pavement Parameters												
Initial Serviceability Index, P_o	4.2											
Terminal Serviceability Index, P_t	Local Roads = 2.00 Collector Roads = 2.25 Arterials = 2.50											
Reliability, R	Local Roads = 80% Collector Roads = 88% Arterials = 95%											
Overall Standard Deviation, S_o	0.45											
Layer Coefficients	Surface / Intermediate = 0.44 Base = 0.44 Granular Subbase = 0.14											
Soil Resilient Modulus, M_R 1500 x CBR	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500
Effective Soil Resilient Modulus, MR Use AASHTO Chapter 2, Figure 2.3 to determine	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520
Coefficient of Drainage, C_d	1.00		1.15									

Table B7: SUDAS Table 5F-1.15: Recommended Thickness for Ridged Pavement – Arterial Roads.

Table 5F-1.15: Recommended Thickness for Rigid Pavement - *Arterial Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
1,000,000	7.5	7	7	7	7	6.5	7.5	6.5	6.5	6.5	6.5	6.5
1,500,000	8	7.5	7.5	7.5	7.5	7	8	7	7	7	7	7
2,000,000	8	8	7.5	7.5	7.5	7.5	8	7.5	7.5	7.5	7.5	7.5
3,000,000	8.5	8	8	8	8	8	8.5	8	8	8	8	8
4,000,000	9	8	8	8	8	8	8.5	8	8	8	8	8
5,000,000	9	8.5	8.5	8.5	8	8	9	8	8	8	8	8
7,500,000	10	9	9	9	9	9	9.5	8.5	8.5	8.5	8.5	8.5
10,000,000	10	9.5	9.5	9.5	9	9	10	9	9	9	9	9
12,500,000	10.5	9.5	9.5	9.5	9.5	9.5	10.5	9.5	9.5	9.5	9.5	9
15,000,000	11	10	10	10	10	10	10.5	9.5	9.5	9.5	9.5	9.5
17,500,000	11	10	10	10	10	10	11	10	10	10	10	10
20,000,000	11.5	10.5	10.5	10.5	10.5	10.5	11	10	10	10	10	10

TOTAL BUILD OUT AADT	16611	
PERCENT TRUCKS	7%	ASSUMED VALUE
TRUCK TYPE MIX	A	SUDAS TABLE 5F-1.06
ANNUAL GROWTH RATE	NO GROWTH	(ASSUMED SINCE BUILD OUT AADT USED)
DESIGN PERIOD (YEARS)	50	ASSUMED VALUE
BASE YEAR DESIGN ESALS	117000	SUDAS TABLE 5F-1.07
GROWTH FACTOR	50	SUDAS TABLE 5F-1.11
DESIGN ESALS	5850000	(BASE YEAR DESIGN ESALS X GROWTH FACTOR)
BASE THICKNESS (IN)	6	SUDAS TABLE 5F-1.15
PAVEMENT THICKNESS (IN)	9	SUDAS TABLE 5F-1.15

MOST SOILS IN IOWA HAVE CBR OF 1-3. SUDAS USES 3 AS IT CAN BE ACHIEVED BY COMPACTING TOP 12 INCHES OF SOIL TO 95% STANDARD PROCTOR DENSITY

Figure B5: Pavement Thickness Design Calculations/Procedure Based Off of SUDAS Chapter 5.

Table B8: SUDAS Table 5G-2.01

Table 5G-2.01: Transverse Joint Requirements

Pavement Thickness	Transverse Joint Type	Transverse Joint Spacing
6”	C	12’
7”	C	15’
8”	CD[1]	15’
9”	CD[1]	15’
≥ 10”	CD[1]	17’

[1] No dowels within 24” of the back of curb

Table B9: SUDAS Table 5G-2.03

Table 5G-2.03: Dowel Bar Size and Length

Pavement Thickness (inches)	Dowel Size (diameter in inches)	Dowel Length (inches)
8	1 1/4	18
9	1 1/4	18
10	1 1/2	18
11	1 1/2	18
12	1 1/2	18

B. Joint Spacing

Joint spacing for unreinforced concrete pavements depends on slab thickness, concrete aggregate, subgrade/subbase support, and environmental conditions. Transverse joint spacing should be limited to 24T (T is slab thickness) for pavements on subgrades and granular subbases or 21T if the pavement is placed on stabilized subbases, existing concrete, or asphalt. Transverse joint spacing is12 feet for pavements 6 inches thick, 15 feet for pavements 7 to 9 inches thick, and 17 feet for pavements over 9 inches thick. Longitudinal joint spacing for two lane streets, where lane delineation is not necessary, should be limited to a maximum of 10 feet. For multi-lane streets, where lane delineation is desired, longitudinal joint spacing is typically 10 to 12 feet. Generally, transverse joint spacing should not exceed 150% of the longitudinal joint spacing. Table 5G-2.01 provides transverse joint spacings for standard two lane streets.

Figure B6: SUDAS Chapter 5G-B

b. Doweled Contraction Joints: Dowel bars are used to supplement the load transfer produced by aggregate interlock. The joints are sawed to a depth of T/3 and are spaced at 15 foot intervals for slab thickness of 9 inches or less and 17 feet for slabs greater than 9 inches thick. The dowels are placed at the mid-depth in the slab so they can resist shear forces as traffic loads cross the joint; thus helping reduce deflection and stress of the joint. The need for doweled contraction joints depends on subgrade/subbase support and the truck traffic loadings the roadway is to provide. They are usually used on streets or roadways where the pavement thickness is 8 inches or greater and where the pavement is subject to heavier truck traffic, generally more than 100 trucks per lane per day. Early entry concrete sawing can be used for 'CD' joints.

Dowels should not be placed closer than 24 inches from the back of the curb on streets with quarter point or third point jointing. If gutterline jointing is used, place the first dowel in the traffic lane 6 inches from the joint.

Figure 5G-2.02: 'CD' Doweled Contraction Joint

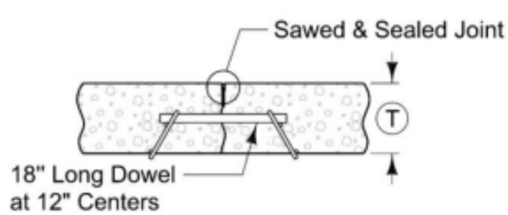
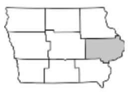


Figure B7: SUDAS Chapter 5G-2-C-1b Doweled Contraction Joint

Appendix C: Stormwater

Runoff

Table 2B-2.07: Section 6 - East Central Iowa
Rainfall Depth and Intensity for Various Return Periods

	Return Period															
	1 year		*2 year*		*5 year*		*10 year*		*25 year*		*50 year*		*100 year*		*500 year*	
Duration	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***	***D***	***I***
5 min	0.38	4.56	0.44	5.30	0.54	6.56	0.63	7.65	0.76	9.18	0.86	10.3	0.97	11.6	1.23	14.8
10 min	0.55	3.33	0.64	3.87	0.8	4.8	0.93	5.58	1.11	6.70	1.26	7.60	1.42	8.54	1.80	10.8
15 min	0.67	2.70	0.78	3.14	0.97	3.88	1.13	4.53	1.36	5.45	1.54	6.18	1.73	6.94	2.20	8.81
30 min	0.95	1.90	1.11	2.22	1.38	2.76	1.61	3.22	1.94	3.88	2.20	4.40	2.47	4.95	3.14	6.29
1 hr	1.23	1.23	1.44	1.44	1.80	1.80	2.11	2.11	2.58	2.58	2.96	2.96	3.36	3.36	4.37	4.37
2 hr	1.51	0.75	1.77	0.88	2.22	1.11	2.62	1.31	3.22	1.61	3.71	1.85	4.24	2.12	5.60	2.80
3 hr	1.68	0.56	1.96	0.65	2.47	0.82	2.93	0.97	3.63	1.21	4.22	1.40	4.85	1.61	6.50	2.16
6 hr	1.97	0.32	2.30	0.38	2.89	0.48	3.45	0.57	4.3	0.71	5.02	0.83	5.8	0.96	7.87	1.31
12 hr	2.28	0.19	2.65	0.22	3.31	0.27	3.93	0.32	4.88	0.40	5.68	0.47	6.56	0.54	8.87	0.73
24 hr	2.60	0.10	3.01	0.12	3.75	0.15	4.42	0.18	5.44	0.22	6.29	0.26	7.22	0.30	9.64	0.40
48 hr	2.98	0.06	3.43	0.07	4.22	0.08	4.93	0.10	6.01	0.12	6.90	0.14	7.86	0.16	10.3	0.21
3 day	3.28	0.04	3.72	0.05	4.51	0.06	5.24	0.07	6.32	0.08	7.22	0.10	8.19	0.11	10.7	0.14
4 day	3.53	0.03	3.98	0.04	4.78	0.04	5.50	0.05	6.58	0.06	7.49	0.07	8.46	0.08	10.9	0.11
7 day	4.17	0.02	4.67	0.02	5.53	0.03	6.29	0.03	7.39	0.04	8.30	0.04	9.25	0.05	11.6	0.06
10 day	4.75	0.01	5.30	0.02	6.24	0.02	7.04	0.02	8.20	0.03	9.12	0.03	10.0	0.04	12.4	0.05

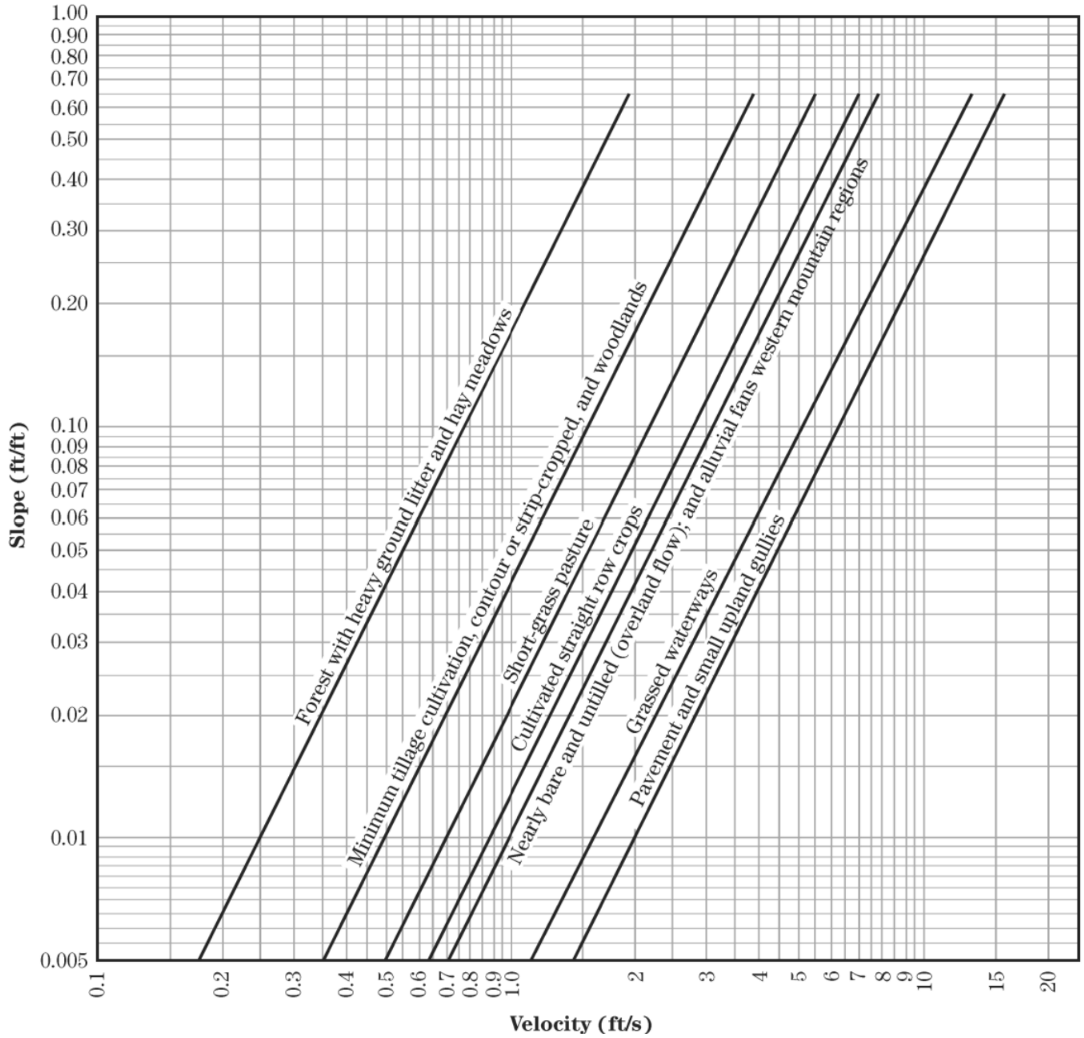
D = Total depth of rainfall for given storm duration (inches)
I = Rainfall intensity for given storm duration (inches/hour)

Table 2B-3.01: Manning's Roughness Coefficient for Sheet Flow

Surface Description	***n***
Smooth Surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated Soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[1]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[2]	
Light underbrush	0.40
Dense underbrush	0.80

[1] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[2] When selecting n, consider cover to a height of about 0.1 foot. This is the only part of the plant cover that will obstruct sheet flow.

Figure 2B-3.01: Velocity Versus Slope for Shallow Concentrated Flow



Source: NRCS National Engineerining Handbook, Part 630, Chapter 15

Table C3-S3- 2: Manning roughness coefficients, n

	Manning's *n* range
I. Closed conduits:	
A. Concrete pipe	0.011-0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2 by ½-in. corrugation (riveted pipe):	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50% of circumference paved):	
1) Flow full depth	0.021-0.018
2) Flow 0.8 depth	0.021-0.016
3) Flow 0.6 depth	0.019-0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012-0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009-0.011
F. Brick	0.014-0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015-0.017
2. Wood forms, smooth	0.012-0.014
3. Steel forms	0.012-0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017-0.022
2. Natural floor	0.019-0.025
I. Laminated treated wood	0.015-0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined (straight alignment):	
A. Concrete with surfaces as indicated:	
1. Formed, no finish	0.013-0.017
2. Trowel finish	0.012-0.014
3. Float finish	0.013-0.015
4. Float finish, some gravel on bottom	0.015-0.017
5. Gunite, good section	0.016-0.019
6. Gunite, wavy section	0.018-0.022
B. Concrete, bottom float finish, sides as indicated:	
1. Dressed stone in mortar	0.015-0.017
2. Random stone in mortar	0.017-0.020
3. Cement rubble masonry	0.020-0.025
4. Cement rubble masonry, plastered	0.016-0.020
5. Dry rubble (riprap)	0.020-0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017-0.020
2. Random stone in mortar	0.020-0.023
3. Dry rubble (riprap)	0.023-0.033
D. Brick	0.014-0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011-0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017-0.020
2. Irregular section	0.022-0.027
III. pen channels, excavated (straight alignment, natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016-0.018
2. Clean, after weathering	0.018-0.020
3. With short grass, few weeds	0.022-0.027
4. In gravelly soil, uniform section, clean	0.022-0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022-0.025
2. Grass, some weeds	0.025-0.030
3. Dense weeds or aquatic plants in deep channels	0.030-0.035
4. Sides clean, gravel bottom	0.025-0.030
5. Sides clean, cobble bottom	0.030-0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028-0.033
2. Light brush on banks	0.035-0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035-0.040
b. Jagged and irregular	0.040-0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08-0.12
2. Clean bottom, brush on sides	0.05-0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07-0.11
4. Dense brush, high stage	0.10-0.14
IV. Highway channels and swales with maintained vegetation (values shown are for velocities of 2 and 6 fps):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, Buffalograss:	
a. Mowed to 2 inches	0.07-0.045
b. Length 4-6 inches	0.09-0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18-0.09
b. Length about 24 inches	0.30-0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14-0.08
b. length about 24 inches	0.25-0.13
B. Depth of flow 0.7-1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, Buffalograss:	
a. Mowed to 2 inches	0.05-0.035
b. Length 4-6 inches	0.06-0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12-0.07
b. Length about 24 inches	0.20-0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10-0.06
b. Length about 24 inches	0.17-0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of *n* by	*0.002*
VI. Natural stream channels:	
A. Minor streams (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030-0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035-0.05
c. Some weeds, light brush on banks	0.035-0.05
d. Some weeds, heavy brush on banks	0.05-0.07
e. Some weeds, dense willows on banks	0.06-0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	0.01-0.02
2. Irregular sections, with pools, slight channel meander; increase values given in la-e about	*0.01-0.02*
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04-0.05
b. Bottom of cobbles, with large boulders	0.05-0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030-0.035
b. High grass	0.035-0.05
2. Cultivated areas:	
a. No crop	0.03-0.04
b. Mature row crops	0.035-0.045
c. Mature field crops	0.04-0.05
3. Heavy weeds, scattered brush	0.05-0.07
4. Light brush and trees:	
a. Winter	0.05-0.06
b. Summer	0.06-0.08
5. Medium to dense brush:	
a. Winter	0.07-0.11
b. Summer	0.10-0.16
6. Dense willows, summer, not bent over by current	0.15-0.20
7. Cleared land with tree stumps, 100-150 per acre:	
a. No sprouts	0.04-0.05
b. With heavy growth of sprouts	0.06-0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10-0.12
b. Flood depth reaches branches	0.12-0.16
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks of vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited, if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of 0.028-0.033.	

Table C1: Time of Concentration Worksheet Culverts 1-4 and to Detention

Sheet Flow	Segment	Ridge											
Surface Description		Grass											
Manning's roughness coefficient, n (Table C3-S3-1)		0.24											
Flow Length, L (ft)		100											
Two-year 24-hour rainfall P_2 (in)		3.01											
Land slope, s (ft/ft)		0.0515											
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$ (hr)		0.167981											
Shallow concentrated flow	Segment	Ridge to street	Street	from street	from 60" culv								
Surface description		Unpaved	Paved	Unpaved	Unpaved								
Flow Length, L (ft)		1037	200	429	169								
Watercourse slope, s (ft/ft)		0.0328	0.008	0.01015	0.0237								
Average velocity, V (ft/s) (Figure C3-S3-1)		2.9	1.8	1.6	2.5								
$T_t = \frac{L}{3600V}$ (hr)		0.09933	0.030864	0.074479	0.018778								
Open channel flow	Segment	Ex 30" Culv	Ditch	Ex 60" Culv	Ex 8x5' box	Bioswale to culv 1	Culv 1	Bioswale to culv 2	Culv 2	Bioswale to culv 3	Culv 3	Bioswale to Culv 4	Culv 4
Cross sectional flow area, a (ft2)		4.91	4	19.63	40	270.2	51	297.4	60.72	572	136.6	625	114.4
Wetted perimeter, Pw (ft)		7.85	8.25	15.71	26	68.03	20.2	71.33	22.04	98.71	33.66	103.16	31.44
Hydraulic radius, $r = \frac{a}{P_w}$ (ft)		0.625478	0.484848	1.249523	1.538462	3.971777	2.524752	4.169354	2.754991	5.794752	4.058229	6.05855	3.638677
Channel slope, s (ft/ft)		0.0141	0.0339	0.0118	0.01439	0.007	0.0092	0.007	0.0056	0.007	0.007	0.007	0.0323
Manning's roughness coefficient, n (Table C3-S3-2)		0.013	0.05	0.013	0.013	0.1	0.013	0.1	0.013	0.1	0.013	0.1	0.013
$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n}$ (ft/s)		9.95391	3.386259	14.44375	18.32305	3.126501	20.38369	3.229345	16.85584	4.021844	24.39774	4.142995	48.73113
Flow length, L (ft)		142	118	340	139	715	65	680	125	1400	65	1574	65
$T_t = \frac{L}{3600V}$ (hr)		0.003963	0.00968	0.006539	0.002107	0.063525	0.000886	0.058491	0.00206	0.096694	0.00074	0.105533	0.000371
		Culvert 1	Culvert 2	Culvert 3	Culvert 4		To detention						
		0.477245	0.536623	0.635377	0.74165		0.74202	hrs					

Table C2: Time of Concentration Worksheet Culverts 5 & 6

Sheet Flow		Segment	ridge			
Surface Description			grass			
Manning's roughness coefficient, n (Table C3-S3-1)			0.24			
Flow Length, L (ft)			100			
Two-year 24-hour rainfall P_2 (in)			3.01			
Land slope, s (ft/ft)			0.0145			
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$	(hr)		0.278892			
Shallow concentrated flow		Segment	unpaved	paved	from paved to ex culv	
Surface description			Unpaved	Paved	Unpaved	
Flow Length, L (ft)			559	1111	162	
Watercourse slope, s (ft/ft)			0.0372	0.0128	0.0414	
Average velocity, V (ft/s) (Figure C3-S3-1)			3.1	2.2	3.3	
$T_t = \frac{L}{3600V}$	(hr)		0.05009	0.140278	0.013636	
Open channel flow		Segment	Ex 36" culv	Channel	Culv 5	Channel
Cross sectional flow area, a (ft2)			7.07	44	16.1	43.8
Wetted perimeter, Pw (ft)			9.42	24	10.7	24.2
Hydraulic radius, $r = \frac{a}{P_e}$	(ft)		0.750531	1.833333	1.504673	1.809917
Channel slope, s (ft/ft)			0.005	0.0088	0.0167	0.0152
Manning's roughness coefficient, n (Table C3-S3-2)			0.013	0.05	0.013	0.05
$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n}$	(ft/s)		6.6933	4.187472	19.44894	5.456455
Flow length, L (ft)			192	375	60	726
$T_t = \frac{L}{3600V}$	(hr)		0.007968	0.024876	0.000857	0.036959
			Culvert 5	Culvert 6		
			0.502104	0.53992	hrs	

Table C3: Time of Concentration Worksheet Culvert 7

Sheet Flow Segment	Parkinglot		
Surface Description	Paved		
Manning's roughness coefficient, n (Table C3-S3-1)	0.011		
Flow Length, L (ft)	100		
Two-year 24-hour rainfall P_2 (in)	3.01		
Land slope, s (ft/ft)	0.0012		
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$ (hr)	0.0641588		
Shallow concentrated flow Segment	Parkinglot	To culvert	
Surface description	Paved	unpaved	
Flow Length, L (ft)	181	58	
Watercourse slope, s (ft/ft)	0.0411	0.206	
Average velocity, V (ft/s) (Figure C3-S3-1)	4.1	6.5	
$T_t = \frac{L}{3600V}$ (hr)	0.0122629	0.002479	
Open channel flow Segment	Ex 24" Culv	Channel	
Cross sectional flow area, a (ft2)	3.14	3.3	
Wetted perimeter, Pw (ft)	6.28	6.6	
Hydraulic radius, $r = \frac{a}{P_w}$ (ft)	0.5	0.5	
Channel slope, s (ft/ft)	0.0035	0.048	
Manning's roughness coefficient, n (Table C3-S3-2)	0.013	0.05	
$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n}$ (ft/s)	4.271597	4.11292	
Flow length, L (ft)	144	326	
$T_t = \frac{L}{3600V}$ (hr)	0.0093642	0.022017	
	Culvert 7		
	0.1102819	hrs	

Table C4: Time of Concentration Worksheet Culverts 10, 11, 8, and 9

Sheet Flow	Segment	Ridge							
Surface Description		Grass							
Manning's roughness coefficient, n (Table C3-S3-1)		0.24							
Flow Length, L (ft)		100							
Two-year 24-hour rainfall P_2 (in)		3.01							
Land slope, s (ft/ft)		0.052							
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2} s^{0.4}}$ (hr)		0.167333							
Shallow concentrated flow	Segment	Ridge to hwy							
Surface description		Unpaved							
Flow Length, L (ft)		1767							
Watercourse slope, s (ft/ft)		0.0466							
Average velocity, V (ft/s) (Figure C3-S3-1)		2.7							
$T_t = \frac{L}{3600V}$ (hr)		0.18179							
Open channel flow	Segment	Ex 42" culv	channel	10x5.5 cul	channel	10x6 culv	channel	10x6 culv	channel
Cross sectional flow area, a (ft2)		9.62	66	39	45.7	38.4	87.5	42.5	138.3
Wetted perimeter, Pw (ft)		11	29.7	17.8	24.7	17.7	34.2	18.5	42.94
Hydraulic radius, $r = \frac{a}{P_e}$ (ft)		0.874545	2.222222	2.191011	1.850202	2.169492	2.55848	2.297297	3.220773
Channel slope, s (ft/ft)		0.0354	0.0171	0.002	0.0135	0.0077	0.0143	0.0074	0.0087
Manning's roughness coefficient, n (Table C3-S3-2)		0.013	0.05	0.013	0.05	0.013	0.05	0.013	0.05
$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n}$ (ft/s)		19.72118	6.635994	8.646778	5.218303	16.85493	6.666106	17.16604	6.062001
Flow length, L (ft)		226	263	65	399	65	505	95	505
$T_t = \frac{L}{3600V}$ (hr)		0.003183	0.011009	0.002088	0.021239	0.001071	0.021043	0.001537	0.023141
		Culvert 10	Culvert 11	Culvert 8	Culvert 9				
		0.363316	0.386643	0.408758	0.433436	hrs			

Table C5: Time of Concentration Worksheet Culverts 12, 13, 14, and 15

Sheet Flow	Segment	Grass						
Surface Description		Grass						
Manning's roughness coefficient, n (Table C3-S3-1)		0.24						
Flow Length, L (ft)		100						
Two-year 24-hour rainfall P_2 (in)		3.01						
Land slope, s (ft/ft)		0.012						
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$ (hr)		0.300823						
Shallow concentrated flow	Segment	grass						
Surface description		unpaved						
Flow Length, L (ft)		518						
Watercourse slope, s (ft/ft)		0.038						
Average velocity, V (ft/s) (Figure C3-S3-1)		3.1						
$T_t = \frac{L}{3600V}$ (hr)		0.046416						
Open channel flow	Segment	channel	54" culv	channel	60" culv	channel	5x5.5 culv	channel
Cross sectional flow area, a (ft2)		19.8	13.24	39.1	16.34	45.55	19.47	47.04
Wetted perimeter, Pw (ft)		16.3	9.7	22.83	10.78	24.1	12.58	25.05
Hydraulic radius, $r = \frac{a}{P_e}$ (ft)		1.214724	1.364948	1.712659	1.51577	1.890041	1.547695	1.877844
Channel slope, s (ft/ft)		0.043	0.0092	0.0123	0.0042	0.0077	0.0029	0.0018
Manning's roughness coefficient, n (Table C3-S3-2)		0.05	0.013	0.05	0.013	0.05	0.013	0.05
$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n}$ (ft/s)		7.035077	13.5274	4.730961	9.801437	3.997384	8.258455	1.924386
Flow length, L (ft)		626	65	277	95	235	70	276
$T_t = \frac{L}{3600V}$ (hr)		0.024717	0.001335	0.016264	0.002692	0.01633	0.002354	0.03984
		Culvert 12	Culvert 13	Culvert 14	Culvert 15			
		0.371956	0.389555	0.408578	0.450772	hrs		

Table C6: Time of Concentration Worksheet SE Undetained

Sheet Flow			Segment	Grass		
Surface Description				Grass		
Manning's roughness coefficient, n (Table C3-S3-1)				0.24		
Flow Length, L (ft)				100		
Two-year 24-hour rainfall P_2 (in)				3.01		
Land slope, s (ft/ft)				0.03		
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$	(hr)			0.208514		
Shallow concentrated flow			Segment	Grass		
Surface description				unpaved		
Flow Length, L (ft)				2772		
Watercourse slope, s (ft/ft)				0.0202		
Average velocity, V (ft/s) (Figure C3-S3-1)				2.25		
$T_t = \frac{L}{3600V}$	(hr)			0.342222		
Open channel flow			Segment	Creek		
Cross sectional flow area, a (ft2)				288		
Wetted perimeter, Pw (ft)				55.8		
Hydraulic radius, $r = \frac{a}{P_e}$	(ft)			5.16129		
Channel slope, s (ft/ft)				0.0007		
Manning's roughness coefficient, n (Table C3-S3-2)				0.035		
$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n}$	(ft/s)			3.363872		
Flow length, L (ft)				3395		
$T_t = \frac{L}{3600V}$	(hr)			0.280348		
				Total		
				0.831084	hrs	

Table C7: Time of Concentration Worksheet NE Passthrough

Sheet Flow		Segment	Grass	
Surface Description			Grass	
Manning's roughness coefficient, n (Table C3-S3-1)			0.24	
Flow Length, L (ft)			100	
Two-year 24-hour rainfall P_2 (in)			3.01	
Land slope, s (ft/ft)			0.035	
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2}s^{0.4}}$	(hr)		0.196045	
Shallow concentrated flow		Segment	Rest	
Surface description			unpaved	
Flow Length, L (ft)			3413	
Watercourse slope, s (ft/ft)			0.0227	
Average velocity, V (ft/s) (Figure C3-S3-1)			2.4	
$T_t = \frac{L}{3600V}$	(hr)		0.395023	
Open channel flow		Segment	Creek	
Cross sectional flow area, a (ft2)			806.4	
Wetted perimeter, Pw (ft)			106.78	
Hydraulic radius, $r = \frac{a}{P_e}$	(ft)		7.551976	
Channel slope, s (ft/ft)			0.0023	
Manning's roughness coefficient, n (Table C3-S3-2)			0.05	
$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n}$	(ft/s)		5.501155	
Flow length, L (ft)			3421	
$T_t = \frac{L}{3600V}$	(hr)		0.172741	
			Total	
			0.76381	hrs

Table C8: Time of Concentration Worksheet Existing to Detainment

Sheet Flow	Segment	Ridge				
Surface Description		Grass				
Manning's roughness coefficient, n (Table C3-S3-1)		0.24				
Flow Length, L (ft)		100				
Two-year 24-hour rainfall P_2 (in)		3.01				
Land slope, s (ft/ft)		0.0515				
$T_t = \frac{0.007[(n)(L)]^{0.8}}{\sqrt{P_2} s^{0.4}}$ (hr)		0.167981				
Shallow concentrated flow	Segment	Ridge to street	Street	from street	from 60" culv	From Ex 8x5 box
Surface description		Unpaved	Paved	Unpaved	Unpaved	unpaved
Flow Length, L (ft)		1037	200	429	169	5316
Watercourse slope, s (ft/ft)		0.0328	0.008	0.01015	0.0237	0.0083
Average velocity, V (ft/s) (Figure C3-S3-1)		2.9	1.8	1.6	2.5	1.45
$T_t = \frac{L}{3600V}$ (hr)		0.09933	0.030864	0.074479	0.018778	1.018391
Open channel flow	Segment	Ex 30" Culv	Ditch	Ex 60" Culv	Ex 8x5' box	
Cross sectional flow area, a (ft2)		4.91	4	19.63	40	
Wetted perimeter, Pw (ft)		7.85	8.25	15.71	26	
Hydraulic radius, $r = \frac{a}{P_e}$ (ft)		0.625478	0.484848	1.249523	1.538462	
Channel slope, s (ft/ft)		0.0141	0.0339	0.0118	0.01439	
Manning's roughness coefficient, n (Table C3-S3-2)		0.013	0.05	0.013	0.013	
$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n}$ (ft/s)		9.95391	3.386259	14.44375	18.32305	
Flow length, L (ft)		142	118	340	139	
$T_t = \frac{L}{3600V}$ (hr)		0.003963	0.00968	0.006539	0.002107	
		Total				
		1.432111	hrs			

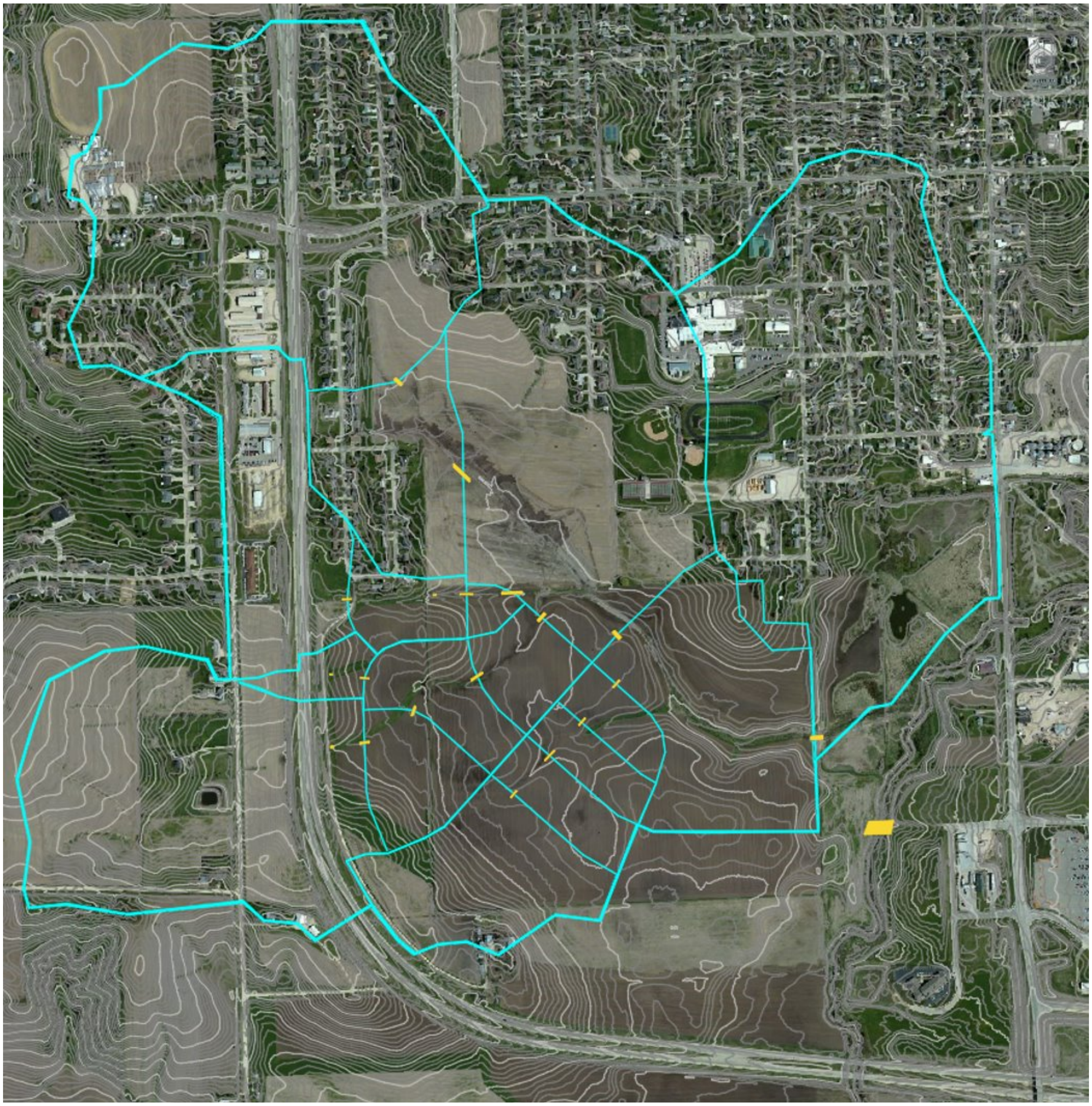


Figure C1: Drainage Area Delineations

Table 2B-4.03: Runoff Curve Numbers for Urban Areas[1]

Cover Type and Hydrologic Condition	Average Percent Impervious Area[2]	CN's for Hydrologic Soil Group			
		A	***B***	***C***	***D***
Fully Developed Urban Areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.):[3]					
Poor condition (grass cover < 50%)	--------------	68	79	86	89
Fair condition (grass cover 50% to 75%)	--------------	49	69	79	84
Good condition (grass cover >75%)	--------------	39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)	--------------	98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)	--------------	98	98	98	98
Paved; open ditches (including right-of-way)	--------------	83	89	92	93
Gravel (including right-of-way)	--------------	76	85	89	91
Dirt (including right-of-way)	--------------	72	82	87	89
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town homes)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing Urban Areas					
Newly graded areas (pervious areas only, no vegetation)[4]	--------------	77	86	91	94
Idle lands (CN's are determined using cover types similar to those in Table 2B-4.01)					

[1] Average runoff condition and I_a=0.2S

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figures 2B-4.01 or 2B-4.02.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figures 2B-4.01 or 2B-4.02 based upon the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Source: NRCS National Engineering Handbook, Part 630, Chapter 9

Table C9: Area Tables

CULVERT 1

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	560985	12.87844
Residential 0.3 ac	82	3609323	82.85865
Commercial	94	1062061	24.38157
Open Space	74	69206	1.588751
Total	86.0	5301575	121.71

CULVERT 2

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	751401	17.24979
Residential 0.3 ac	82	4686221	107.5808
Commercial	94	1062061	24.38157
Open Space	74	299395	6.873163
Total	85.8	6499683	149.21

CULVERT 3

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	1800503	41.33386
Residential 0.3 ac	82	11112887	255.1168
Commercial	94	1446588	33.20909
Open Space	74	2772579	63.64966
Industrial	91	306681	7.040427
Residential 1/8 ac	90	571848	13.12782
Total	83.7	18011086	413.48

CULVERT 4

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	1997564	45.85776
Residential 0.3 ac	82	14056839	322.7006
Commercial	94	1707388	39.19624
Open Space	74	3139652	72.07649
Industrial	91	306681	7.040427
Residential 1/8 ac	90	711109	16.32482
Total	83.6	21919233	503.20

CULVERT 5

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	228052	5.235354
Residential 0.3 ac	82	813781	18.68184
Commercial	94	206189	4.733448
Industrial	91	306681	7.040427
Open Space	74	56990	1.30831
Total	87.2	1611693	37.00

CULVERT 6

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	268546	6.164968
Residential 0.3 ac	82	1045341	23.99773
Commercial	94	206189	4.733448
Industrial	91	306681	7.040427
Open Space	74	159365	3.658517
Total	86.2	1986122	45.60

CULVERT 7

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	28800	0.661157
Residential 0.3 ac	82	68864	1.5809
Residential 1/8 ac	90	39249	0.901033
Open Space	74	82047	1.88354
Total	82.5	218960	5.03

CULVERT 8

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	382846	8.788935
Residential 0.3 ac	82	2788376	64.0123
Residential 1/8 ac	90	571848	13.12782
Open Space	74	1167924	26.81185
Total	82.3	4910994	112.74

CULVERT 9

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	688237	15.79975
Residential 0.3 ac	82	2759239	63.34341
Residential 1/8 ac	90	571848	13.12782
Open Space	74	1293408	29.69256
Total	83.0	5312732	121.96

CULVERT 10

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	228016	5.234527
Residential 0.3 ac	82	1911316	43.87778
Residential 1/8 ac	90	532599	12.22679
Open Space	74	977668	22.44417
Total	82.0	3649599	83.78

CULVERT 11

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	290760	6.674931
Residential 0.3 ac	82	2356514	54.09812
Residential 1/8 ac	90	532599	12.22679
Open Space	74	1007126	23.12043
Total	82.2	4186999	96.12

CULVERT 12

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	99464	2.283379
Residential 0.3 ac	82	778927	17.8817
Open Space	74	312738	7.179477
Total	81.2	1191129	27.34

CULVERT 13

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	159087	3.652135
Residential 0.3 ac	82	1070757	24.5812
Open Space	74	327791	7.525046
Total	82.0	1557635	35.76

CULVERT 14

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	213688	4.905601
Residential 0.3 ac	82	1287254	29.55129
Open Space	74	341026	7.82888
Total	82.4	1841968	42.29

CULVERT 15

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	248145	5.696625
Residential 0.3 ac	82	1508807	34.63744
Open Space	74	356457	8.183127
Total	82.5	2113409	48.52

CULVERT 19

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	28686	0.65854
Residential 0.3 ac	82	1090619	25.03717
Commercial	94	206189	4.733448
Industrial	91	306681	7.040427
Open Space	74	182722	4.19472
Total	73.3	2088684	47.95

Existing property only

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	107282	2.462856
Straight row crop	81	11444103	262.7205
Open Space	74	2863177	65.7295
Total	79.7	14414562	330.91
Pe =	4.9	in	

Proposed property only

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	2620095	60.1491
Residential 0.3 ac	82	5517215	126.6578
Open Space	74	5054169	116.0278
Commercial	94	906095	20.80108
Residential 1/8 ac	90	316988	7.277043
Total	83.0	14414562	330.91
Pe =	5.24	in	
Storage	9.38	ac-ft	

SE undetained

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	277525	6.371097
Residential 0.3 ac	82	944605	21.68515
Open Space	74	2262755	51.94571
Commercial	94	649012	14.89927
Residential 1/8 ac	90	180391	4.141208
Total	81.0	4314288	99.04

NE Passthrough

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	375441	8.618939
Residential 0.3 ac	82	2889740	66.3393
Open Space	74	1718688	39.45565
Commercial	94	714345	16.3991
Total	82.1	5698214	130.81

Existing to detainment

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	1661559	38.14415
Residential 0.3 ac	82	12373969	284.0672
Open Space	74	2478414	56.89656
Commercial	94	2160933	49.6082
Industrial	91	306681	7.040427
Residential 1/8 ac	90	571848	13.12782
Straight row crop	81	8064043	185.125
Total	83.2	27617447	634.01

Proposed to detainment

Description	CN	Area	Area
		(sf)	(ac)
Impervious	98	2373005	54.4767
Residential 0.3 ac	82	16946579	389.0399
Open Space	74	4858340	111.5321
Commercial	94	2421733	55.59534
Industrial	91	306681	7.040427
Residential 1/8 ac	90	711109	16.32482
Total	83.3	27617447	634.01

Table 2B-4.04: Runoff Curve Numbers for Cultivated Agricultural Lands[1]

Cover Description			CN's for Hydrologic Soil Group			
Cover Type	***Treatment***[2]	***Hydrologic Condition***[3]	***A***	***B***	***C***	***D***
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	Straight Row (SR)	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	Contoured (C)	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	Contoured & terraced (C&T)	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition and I_a=0.2S
[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good $\geq$20%), and (e) degree of surface roughness.

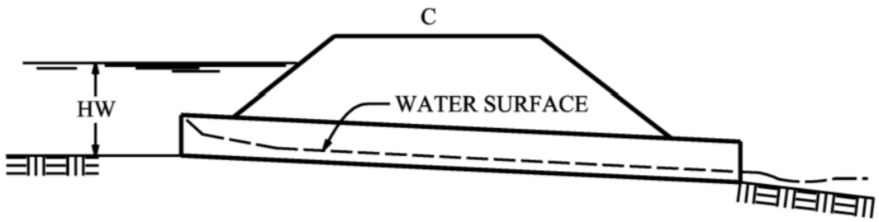
Poor: Factors impair infiltration and tend to increase runoff

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Source: NRCS National Engineering Handbook, Part 630, Chapter 9

Culverts and Channels

Figure 2E-2.01C: Inlet Submerged



Source: *Hydraulic Design of Highway Culverts*, FHWA

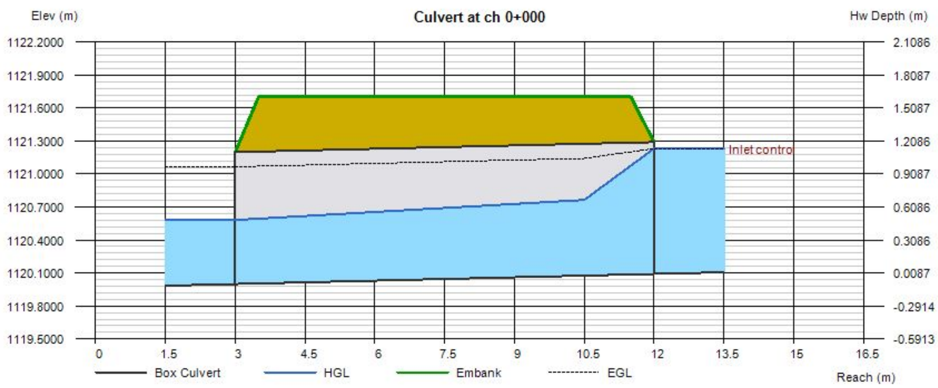


Figure C2: Hydraflow Express for culverts

Table C10: Culvert and Channel Calculations

Culvert	Culvert type	Culvert Size	US Inv	DS Inv	Culvert Length	Bottom width	Side Slope	Depth in channel	Embankment above culvert invert	10 (cfs)	25 (cfs)	50 (cfs)	100 (cfs)	500 (cfs)	50 depth (ft)	100 depth (ft)	500 depth (ft)	DS depth (ft)
1	Double box	8x5	704.9	704.3	65	8	4	7.26	11.75		422	506	598	837		8.17	10.73	5.1
2	Double box	8x5.5	699	698.3	125	8	4	7.68	12.15		483	580	684	959		8.48	11.14	5.52
3	Double box	10x10	688.05	687.6	65	8	4	11.12	14.50		1154	1393	1660	2357		10.21	13.5	6.83
4	Double box	10x10	676.1	674	65	8	4	11.54	15.45		1266	1530	1824	2582		10.77	14.44	5.72
5	Circle	60"	706	705	60	0	3	3.82	7.10	98	128	153	181		5.54	6.05		3.82
6	Circle	66"	694	692.8	90	0	3	3.65	7.20	112	148	177	210		5.71	6.14		3.98
7	Circle	30"	707.9	705.3	65	0	3	1.57	4.70	20	27	33	39		3.11	3.68		1.35
8	Double box	5x6	694.3	693.6	95	0	3	5.40	9.50	288	387	473	566		6.46	8.42		4.25
9	Double box	6x6	689.3	689	65	0	3	4.95	8.60	311	418	507	604		6.55	7.57		3.9
10	Double box	10x5.5	707.5	707.4	65	0	3	4.73	8.00	227	306	373	446		6.05	6.92		3.9
11	Double box	10x6	702	701.5	65	0	3	3.90	8.50	252	340	414	496		6.4	7.47		3.84
12	Circle	54"	692.9	692.3	65	0	3	2.60	6.60	71	96	118	141		5	5.59		3.49
13	Circle	60"	688.9	688.5	95	0	3	3.61	7.30	93	126	154	184		5.45	6.21		3.87
14	Box	5x5.5	686.7	686.5	70	0	3	3.81	7.30	108	145	177	212		5.46	6.28		3.54
15	Box	5x6	686	685.7	65	0	3	3.96	7.60	121	163	197	235		5.58	6.57		3.68
19	Circle	54"	691.1	689.9	140	0	3	3.72	7.40	72	106	134	167		5.32	6.37		3.72

Table C11: Culvert and Channel Summary

CULVERT	DESCRIPTION	CULVERT LENGTH (FT)	CHANNEL TYPE	BOTTOM WIDTH (FT)	SIDE SLOPE (X H:1 V)	CHANNEL DEPTH (FT)	EMBANKMENT HEIGHT ABOVE CULVERT INVERT (FT)
1	DOUBLE 8' W x 5' H BOX	65	TRAPEZOIDAL	8	4	8.5	11.80
2	DOUBLE 8' W x 5.5' H BOX	145	TRAPEZOIDAL	8	4	9.0	12.20
3	DOUBLE 10' W x 10' H BOX	65	TRAPEZOIDAL	8	4	12.5	14.50
4	DOUBLE 10' W x 10' H BOX	85	TRAPEZOIDAL	8	4	13.0	15.50
5	60" DIAMETER	60	TRIANGULAR	0	3	5.0	7.10
6	66" DIAMETER	90	TRIANGULAR	0	3	5.0	7.20
7	30' DIAMETER	65	TRIANGULAR	0	3	2.0	4.70
8	DOUBLE 5' W x 6' H BOX	95	TRIANGULAR	0	3	6.5	9.50
9	DOUBLE 6' W x 6' H BOX	65	TRIANGULAR	0	3	6.0	8.60
10	DOUBLE 5' W x 5.5' H BOX	65	TRIANGULAR	0	3	6.0	8.00
11	DOUBLE 5' W x 6' H BOX	65	TRIANGULAR	0	3	5.0	8.50
12	54" DIAMETER	65	TRIANGULAR	0	3	4.0	6.60
13	60" DIAMETER	95	TRIANGULAR	0	3	5.0	7.30
14	5.5' W x 5' H BOX	70	TRIANGULAR	0	3	5.0	7.30
15	6' W x 5' H BOX	65	TRIANGULAR	0	3	5.0	7.60
16	DOUBLE 5' W x 5.5' H BOX	20	TRIANGULAR	0	3	6.0	8.00
17	30" DIAMETER	20	TRIANGULAR	0	3	2.0	4.70
18	66" DIAMETER	20	TRIANGULAR	0	3	5.0	7.20
19	54" DIAMETER	140	TRIANGULAR	0	3	5.0	7.40

Detention

Table C12: 5-year flows for release rate

Proposed	899.16	cfs
NE Passthrough	207	cfs
Site undetained	119	cfs
Site existing + passthrough	558	cfs
Site existing	341.16	cfs
Site passthrough	216.84	cfs
Allowable release	646	cfs
Inflow	2256	cfs

Bridge

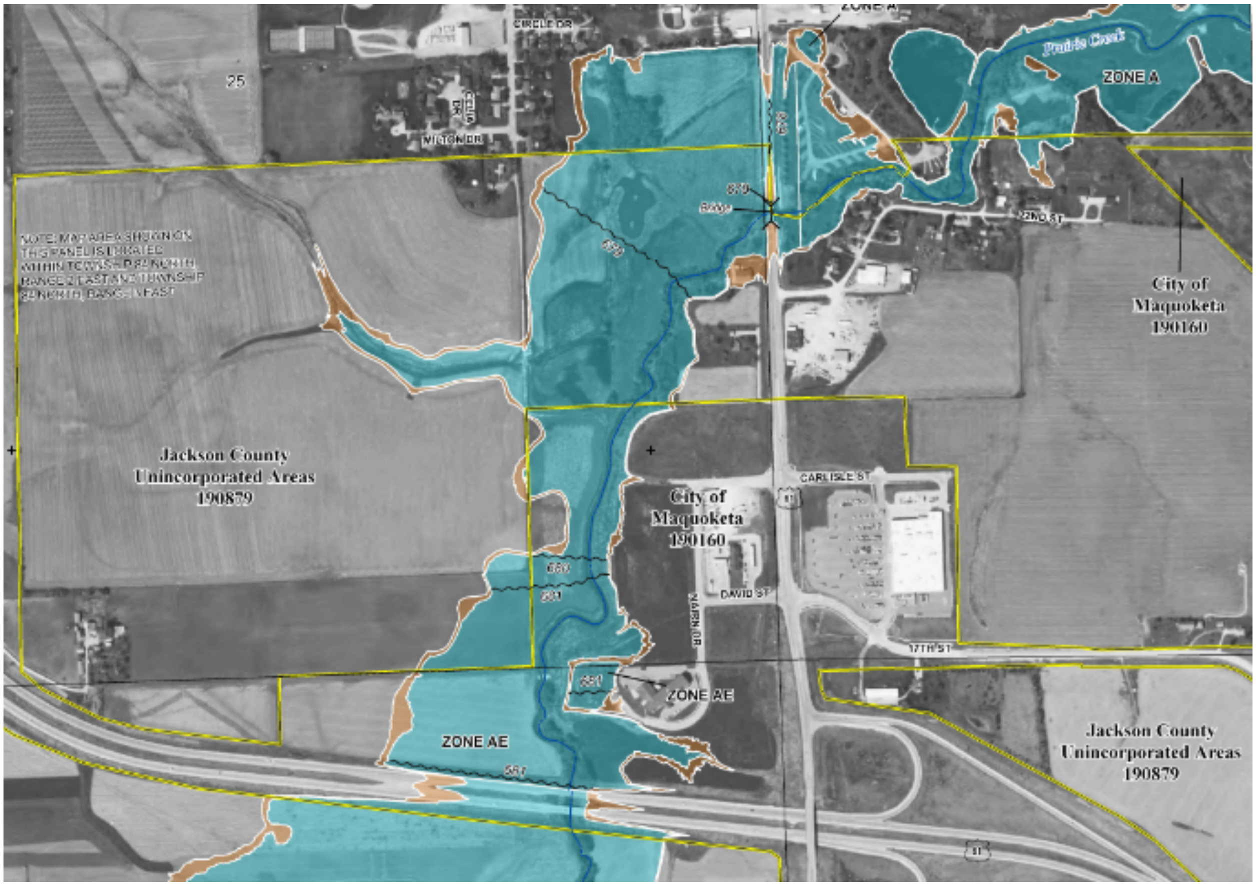


Figure C3: FEMA Flood Map

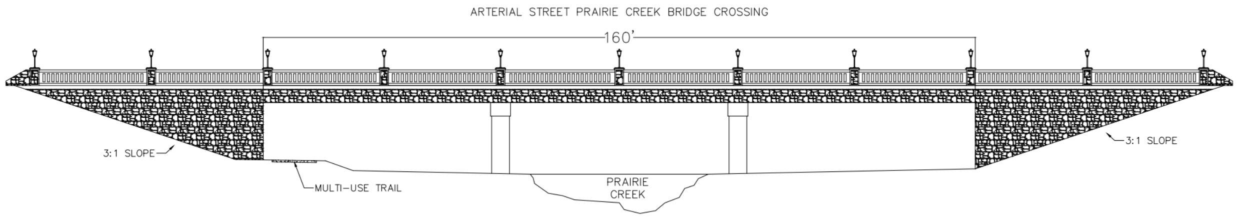


Figure C4: Bridge Side View

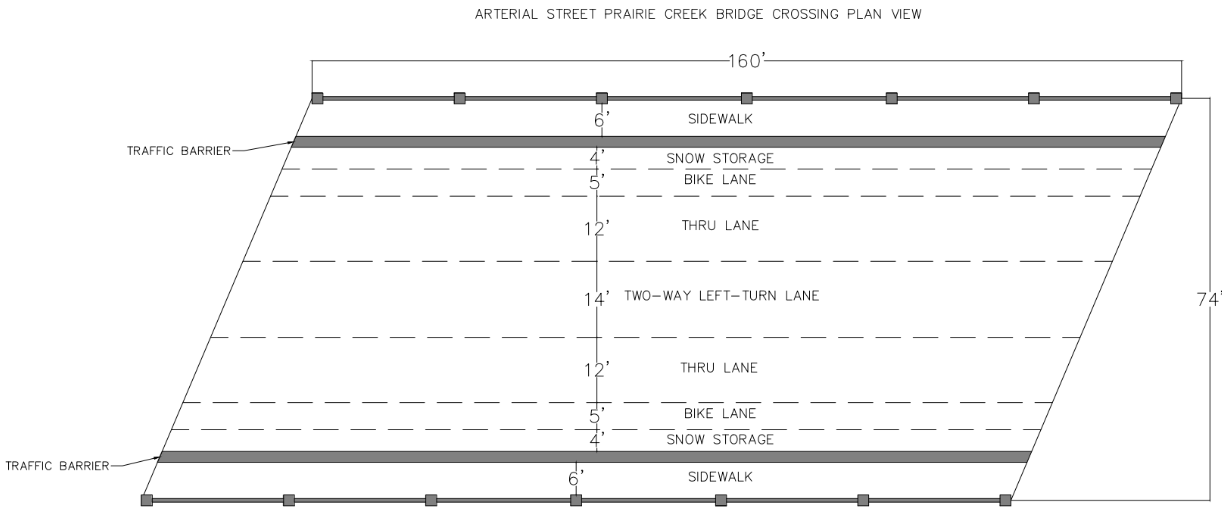


Figure C5: Bridge Plan View

Appendix D: Water Main

Area x Area Density x Rate = Average Daily Demand **Equation 4B-1.01**

Number of Units x Unit Density x Rate = Average Daily Demand **Equation 4B-1.02**

Figure D1: Average Daily Demand Equations

Table D1: Area and Unit Density Values based on Land Use

Table 4B-1.01: Density

Land Use	Area Density	Unit Density	Rate
Low Density (Single Family) Residential	10 people/AC	3.0 people/unit	100 gpcd
Medium Density (Multi-Family) Residential	15 people/AC	3.0 people/unit 6.0 people/duplex	100 gpcd
High Density (Multi-Family) Residential	30 people/AC	2.5 people/unit	100 gpcd
Office and Institutional	Special Design Density[1]		
Commercial	Special Design Density[1]		
Industrial	Special Design Density[1]		

[1] Special design densities should be subject to approval by the Jurisdictional Engineer based on methodology provided by the Project Engineer.

Table D2: Average Daily Demand Minimum

Single Family				
Number of Units	Unity Desnity (people/unit)	Rate (gpcd)	Average Day Demand (gpd)	Averge Day Demand (gpm)
462	3	100	138600	96.25
Multifamily				
Number of Units	Unity Desnity (people/unit)	Rate (gpcd)	Average Day Demand (gpd)	Averge Day Demand (gpm)
19	6	100	11400	7.916666667
		sum	150000	104.1666667

Table D3: Necessary Fire Flow Requirements

Distance Between Buildings	Needed Fire Flow
Over 100'	500 gpm
31' to 100'	750 gpm
11' to 30'	1,000 gpm
10' or less	1,500 gpm

Table D4: Water Main Offset from Centerline

ROAD CLASSIFICATION	OFFSET FROM CENTER LINE	
ARTERIAL	25	FT
COLLECTOR	16.5	FT
LOCAL	13.5	FT

Appendix E: Sanitary

1. Discharge (Q) Average Daily Flow (minimum):

Area x Area Density x Flow Rate = Average Daily Flow **Equation 3B-1.01**

Number of Units x Unit Density x Flow Rate = Average Daily Flow **Equation 3B-1.02**

Figure E1: Average Daily Flow Equations for Sanitary Sewer

Table E1: Area and Unit Densities and FlowRates for Sanitary Sewer Based on Land Use

Table 3B-1.01: Minimum Values

Land Use	Area Density	Unit Density	Rate
Low Density (Single Family) Residential	10 people / AC	3 people / unit	100 gpcd*
Medium Density (Multi-Family) Residential	15 people / AC 6.0 people / duplex	3 people / unit	100 gpcd*
High Density (Multi-Family) Residential	30 people / AC	2.5 people / unit	100 gpcd*
Office and Institutional	5,000 gpd / AC (IDNR)	Special Design Density	N/A
Commercial and Light Industrial	5,000 gpd/AC (IDNR)	Special Design Density	N/A
Industrial	10,000 gpd/AC (IDNR)	Special Design Density	N/A

* Iowa Department of Natural Resources (DNR) - Dry Weather Flow - One hundred gallons per capita per day (gpcd) should be used in design calculations as the minimum average dry weather flow. This 100 gpcd value may, with adequate justification, include maximum allowable infiltration for proposed sewer lines.

Figure 3B-1.01: Ratio of Peak to Average Daily Sewage Flow

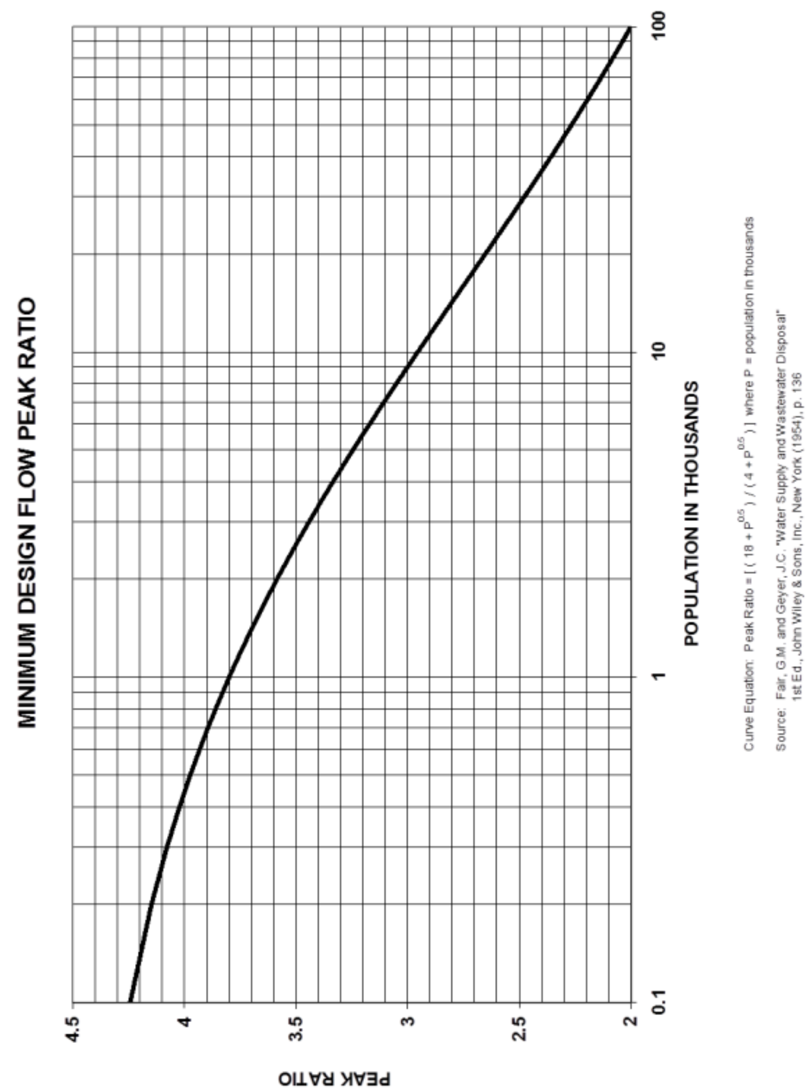


Figure E2: Minimum Design Flow Peak Ratio

Figure 3C-1.01: Flow for Circular Pipe Flowing Full (Based on Manning's Equation n=0.013)

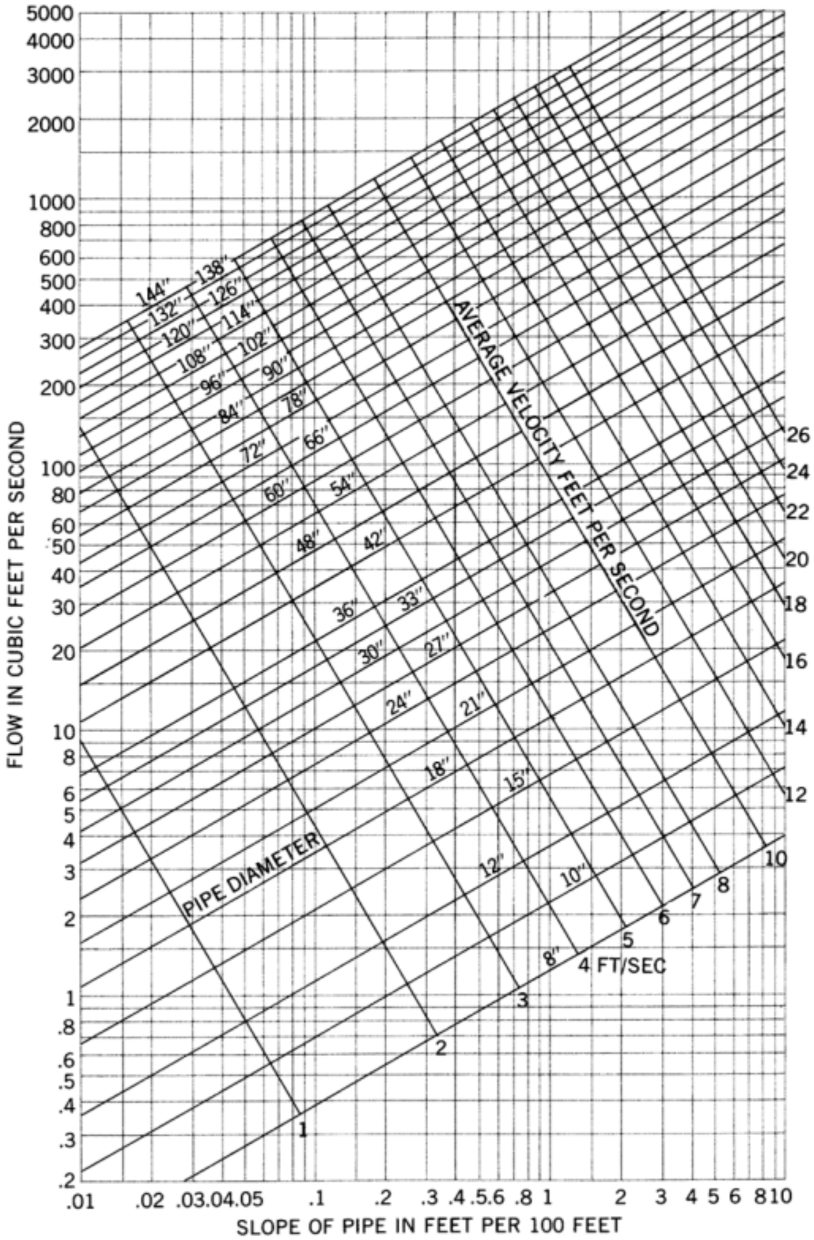


Figure E3: Flow for Circular Pipe Flowing Full

TableE2: Sanitary Sewer Flow Calculations for Proposed Development Area

Area 1 - Single Family Residential		
Area	179.13	AC
Area Density	10	people/AC
Number of Units	439	Units
Unit Density	3	People/Unit
Flow Rate	100	gpcd
Daily Demand (3B-1.01)	179133	gpd
Daily Demand (3B-1.02)	131700	gpd
Average Daily Demand	131700	gpd
Area 2 - Multi-Family Residential		
Area	7.33	AC
Area Density	15	people/AC
Number of Units	38	Units
Unit Density	3	People/Unit
Flow Rate	100	gpcd
Daily Demand (3B-1.01)	11000	gpd
Daily Demand (3B-1.02)	11400	gpd
Average Daily Demand	11000	gpd
3 - Commercial and Light Industrial		
Area	19.7	AC
Area Density	5000	gpd/AC
Daily Demand	98472	gpd
West of Prairie Creek		
Site Average Daily Demand	241172	gpd
4 - Commercial and Light Industrial (East)		
Area	7.8	AC
Area Density	5000	gpd/AC
Daily Demand	38767	gpd
East of Prairie Creek		
Site Average Daily Demand	38767	gpd

Table E3: Sanitary Sewer Flow Calculations for Existing Development in Drainage Basin to the North of Proposed Site

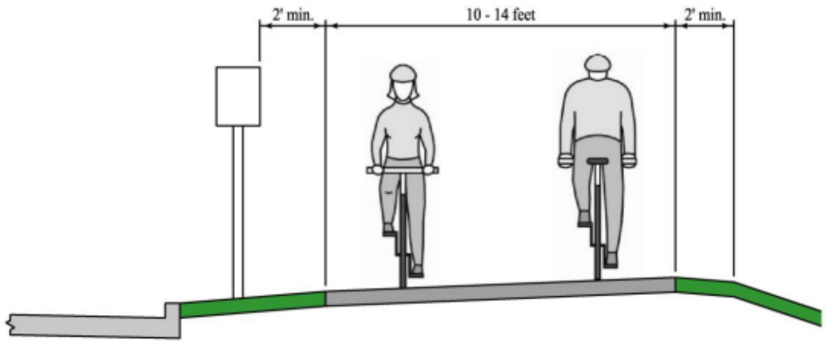
North of proposed site		
Area 1 - Single Family Residential		
Area	50.44	AC
Area Density	10	people/AC
Number of Units	80	Units
Unit Density	3	People/Unit
Flow Rate	100	gpcd
Daily Demand (3B-1.01)	50443	gpd
Daily Demand (3B-1.02)	24000	gpd
Average Daily Demand	24000	gpd

Table E4: Sanitary Sewer Calculations for Existing Development in Drainage Basin to the West of Proposed Site

West of Highway 61 and proposed site		
Area 1 - Single Family Residential		
Area	126.62	AC
Area Density	10	people/AC
Number of Units	237	Units
Unit Density	3	People/Unit
Flow Rate	100	gpcd
Daily Demand (3B-1.01)	126617	gpd
Daily Demand (3B-1.02)	71221	gpd
Average Daily Demand	71221	gpd
Area 2 - Multi-Family Residential		
Area	16.79	AC
Area Density	15	people/AC
Number of Units	87	Units
Unit Density	3	People/Unit
Flow Rate	100	gpcd
Daily Demand (3B-1.01)	25190	gpd
Daily Demand (3B-1.02)	26106	gpd
Average Daily Demand	25190	gpd
3 - Commercial and Light Industrial		
Area	21.0	AC
Area Density	5000	gpd/AC
Average Daily Demand	104971	gpd
Overall Existing Daily Demand	225382	gpd

Appendix F: Green Space and Trail

Figure 12B-2.01: Typical Cross-Section of Two-Way Shared Use Path on Independent Right-of-Way



Source: Adapted from *AASHTO Bike Guide* Exhibit 5.1

Figure F1: SUDAS Two-Way Shared Use Path Right-of-Way

Appendix G: Engineer's Cost Estimate

Table G1: Iowa DOT Densities Used for Estimating Quantities

IOWA DOT
Design Bureau

1B-4

Densities for Use in Estimating Quantities

Design Manual
Chapter 1
Chapter Title
Originally Issued: 06-02-00
Revised: 07-27-21

The following densities should be used for estimating quantities of Hot Mix Asphalt (HMA) material.

Table 1: HMA Densities

Material	Density	Density Values for Scott County Projects	Density Values for District 6
HMA	145 pcf	—	—
High Performance Thin Lift Overlay (non-slag mixture)	150 pcf	—	—
High Performance Thin Lift Overlay (slag mixture)	170 pcf	—	—
Crushed HMA for use as Subbase	127 pcf	—	—
Base Course	145 pcf	155 pcf	150 pcf
Intermediate Course	147 pcf	155 pcf	150 pcf
Surface Course	147 pcf	160 pcf	155 pcf

The following densities should be used for estimating quantities of granular material.

Table 2: Granular Material Densities

Material	Density
Granular Subbase	135 pcf
Granular Backfill	125 pcf
Granular Blanket	125 pcf
Granular Shoulders	140 pcf
Special Backfill (treatment)	140 pcf
Porous Backfill	120 pcf
Flooded Backfill	125 pcf
Class "A" Crushed Stone	140 pcf
Class "D" Revetment	110 pcf
Class "E" Revetment	105 pcf
Erosion Stone	120 pcf
Recycled Pavement	135 pcf
Macadam Stone	130 pcf
Crushed Concrete for use as Subbase	135 pcf
P.C.C. Pavement Broken for use as Class "E" Rip-Rap	120 pcf
Rolled Stone Base	140 pcf
Modified Subbase	140 pcf
Crushed Brick	115 pcf
Trench Foundation	127 pcf

STANDARD OR SLIP FORM PORTLAND CEMENT CONCRETE		
ARTERIAL PAVMENT WIDTH (EXCLUDING 3-FOOT CURB AND GUTTER)	48	FT
ARTERIAL ROAD LENGTH	6596.94	FT
AREA OF PCC	316653.12	SQ FT
	17591.8	SY

HOT MIX ASPHALT MIXTURE, COMMERCIAL MIX (INCLUDES ASPHALT BINDER), AS PER PLAN		
COLLECTOR PAVMENT WIDTH (EXCLUDING 3-FOOT CURB AND GUTTER)	31	FT
COLLECTOR PAVEMENT DEPTH	3	IN
COLLECTOR PAVMENT LENGTH	7667.05	FT
LOCAL PAVMENT WIDTH (EXCLUDING 3-FOOT CURB AND GUTTER)	25	FT
LOCAL PAVEMENT DEPTH	3	IN
LOCAL PAVMENT LENGTH	20754.82	FT
VOLUME OF HMA	189137.263	CU FT
DENSITY OF HMA	145	PCF
TONS OF HMA	13712.4515	TON

CURB AND GUTTER, P.C. CONCRETE 3.0 FT		
LENGTH OF ARTERIAL ROADS	6596.94	FT
LENGTH OF COLLECTOR ROADS	7667.05	FT
LENGTH OF LOCAL ROADS	20754.82	FT
NUMBER OF CURB & GUTTER PER ROAD	2	
TOTAL LENGTH OF CURB & GUTTER	70037.6	LF

Figure G1: Quantity Estimate Calculations for Measurable Quantities

MODIFIED SUBBASE		
ARTERIAL ROAD BASE DEPTH	6	IN
ARTERIAL ROAD BASE WIDTH	60	FT
ARTERIAL ROAD LENGTH	6596.94	FT
VOLUME OF ARTERIAL BASE MATERIAL	197908.2	CU FT
	7329.9	CY
COLLECTOR ROAD BASE DEPTH	10	IN
COLLECTOR ROAD BASE WIDTH	44	FT
COLLECTOR ROAD LENGTH	7667.05	FT
VOLUME OF COLLETOR BASE MATERIAL	281125.167	CU FT
	10412.0	CY
LOCAL ROAD BASE DEPTH	10	IN
LOCAL ROAD BASE WIDTH	37	FT
LOCAL ROAD LENGTH	20754.82	FT
VOLUME OF LOCAL BASE MATERIAL	639940.283	CU FT
	23701.5	CY
TOALT VOLUME OF BASE MATERIAL	41443.5	CY

RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 5 IN.		
WIDTH OF TRAIL	10	FT
LENGTH OF TRAIL	13689	FT
AREA OF PCC	136890	SQ FT
	7605.0	SY

RECREATIONAL TRAIL, PORTLAND CEMENT CONCRETE, 7 IN.		
WIDTH OF TRAIL	10	FT
LENGTH OF TRAIL	3187.73	FT
AREA OF PCC	31877.30	SQ FT
	1771.0	SY

Figure G1 (Continued): Quantity Estimate Calculations for Measurable Quantities

INTAKE, SW-505		
TOTAL LENGTH OF ROAD	35018.81	FT
ASSUMED LENGTH STORM RUNS ALONG	80%	
TOTAL LENGTH OF STORM SEWER	28015.048	FT
ASSUMED INTAKE PAIR EVERY	250	FT
TOTAL NUMBER OF INTAKES	224	

STORM SEWER GRAVITY MAIN, TRENCHED, 18 IN.		
TOTAL LENGTH OF ROADS	35018.81	FT
ASSUMED LENGTH STORM RUNS ALONG	80%	
TOTAL LENGTH OF LONGITUDINAL PIPE	28015.0	FT
AVERAGE ROAD WIDTH	35	FT
ESTIMATED NUMBER OF INTAKE PAIRS	112	
TOTAL LENGTH OF LATERAL PIPE	3922	FT
TOTAL LENGTH OF STORM SEWER PIPE	31937.2	LF

Figure G2: Quantity Estimate Calculations for Assumed Storm Sewer Along Roadway

PROPOSED BRIDGE		
SPAN OF BRIDGE	160	FT
WIDTH OF BRIDGE	65	FT
SURFACE AREA OF BRIDGE	10400	SQ FT
COST PER SQ FT	$90	
NUMBER OF PEIRS	2	
COST PER PEIR	$25,000	
BRIDGE ASTHETICS COST	3%	
TOTAL BRIDGE COST	$ 1,015,580.00	

Figure G3: Proposed Bridge Cost Estimate Calculations

ITEM	AREA (ACRE)	DEPTH (FT) (ASSUMED)	QUANTITY	UNIT	UNIT PRICE	TOTAL
TOP SOIL STRIP AND SALVAGE	333.9	0.5	269346.0	CY	$ 2.25	$ 606,028.50
EXCAVATION CLASS 10	333.9	2	1077384.0	CY	$ 3.50	$ 3,770,844.00
SEEDING & FERTILIZING	333.9	-	333.9	ACRE	$ 1,000.00	$ 333,900.00
					TOTAL	$ 4,710,772.50
					25% PROJECT COST	$ 5,238,120.30
					DIFFERENCE	$ 527,347.80

Figure G4: Earthwork Contingency Estimate

Table G2: RSMeans Cost Handbook Rounding Standards

RSMeans uses the following rounding standards:

Prices From	To	Rounded to nearest
$0.01	$5.00	$0.01
5.01	20.00	0.05
20.01	100.00	1.00
100.01	1,000.00	5.00
1,000.01	10,000.00	25.00
10,000.01	10,000.00	100.00
50,000.01	Up	500.00