The following document was produced by a senior design team from the Rose-Hulman Institute of Technology (RHIT). This document was an academic exercise for the students in which the Bloomington/Monroe County Metropolitan Planning Organization (MPO) and its Citizens Advisory Committee (CAC) provided the students with a real world scenario on which to work.

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Rogers Street Corridor Context Sensitive Design Study

Final Report

Prepared for:

Bloomington/Monroe County MPO
401 N. Morton Street
Bloomington, Indiana 47402

By:

Atlas Engineering, Inc.
5500 Wabash Ave, CM 2579
Terre Haute, Indiana 47803

April 29, 2007

Atlas Engineering, Inc.

5500 Wabash Ave, CM 2579
Terre Haute, IN 47803
Email: Wienanbm@rose-hulman.edu
Cell: 412-443-7242

April 29, 2007

Mr. Scott Robinson
Long Range/Transportation Manager
Bloomington/Monroe County MPO
401 N. Morton St.
Bloomington, IN 47402

Rogers Street Context Sensitive Design

Dear Mr. Robinson:

Atlas Engineering is pleased to submit this final report entitled Rogers Street Corridor Context Sensitive Design Study for your review. This report details the design for the phased implementation of Rogers Street extending from Tapp/Country Club Road to 11th Street, as well as the design for a multiuse trail located along the west side of the corridor.

We have completed the design and provided plan drawings for the corridor. The option we have chosen to design, a shared multiuse trail, was selected through the use of a decision matrix and your approval. Our report details the project approach, as well as the design solutions.

Our design work includes a stormwater management system which is to be implemented using best management practices in areas where right-of-way is available. We have also planned for the phased construction of the corridor, providing a detailed traffic control plan for the area surrounding the hospital.

Atlas Engineering is very appreciative of the help you have offered to this point, and we anticipate that this project will be a great success for the City of Bloomington and for the community. We are excited about presenting this project to the Citizens Advisory Committee at their monthly meeting on April 18. Please contact Bryan Wienand at 412-443-7242 if you have any questions.

Yours Sincerely,

Nicole Sanders
Project Manager

Responses to questions asked in public meeting

On Wednesday, April 18, 2007, Atlas Engineering presented to the Citizens Advisory Committee in Bloomington, Indiana. At the conclusion of the presentation a number of questions were asked about the design presented by Atlas. The following is a list of questions and responses to those questions and where more information regarding the question can be found in the report.

What is the sidewalk width and is it consistent for the entire study area?

- The sidewalk width will be five feet for the entire study area and will always run along the eastern side of the corridor.

Is the pavement width (3") sufficient for trucks and heavy vehicles? It seems 3" is not enough.

- Yes, three inches of hot mix asphalt surface coarse if enough for heavy traffic on Rogers Street. The pavement was designed for an estimate of 350 Equivalent Single Axle Loads. We used the 2020 LOS Maps provided by the City of Bloomington to project future truck traffic through the corridor. The pavement design is sufficient since we also included eight inches of compacted aggregate base atop nine inches of sandy gravel subbase coarse. For more information about pavement design, refer to Appendix G on the final report.

What happens if the bio-swales and rain gardens fail? How much run-off can they handle?

- The bioretention swales and rain gardens should be more capable of handling stormwater than traditional grasses and vegetation, because the design stipulates that sandy topsoils be used underneath the surface vegetation. However, even if the stormwater runoff overflows the swales, inlets are also spaced along the street at specified intervals based on many factors, such as drainage area, street slope, and upstream flows. Also, these inlets, which are always in combination with the bioretention swales and rain gardens, are designed to accommodate peak flows without the implementation of either swales or rain gardens.

How is the center turn lane going to fit within the entire study area? It seems too wide with all the other improvements for some areas. What extent is the road going to be widened?

- The center turn lane is only going to be implemented from Smith St. to 8th Street, because 65 feet of right-of-way is available between those areas.

Are sidewalks on both sides for the entire project?

- No, the sidewalk will only run along the east side of the corridor, with the exception of the segment from Patterson St. to Coolidge St. where only 38 feet of right-of-way exists. The multiuse trail will run along the west side of the corridor for its entire length.

Are stormwater improvements needed for the whole study area? They can be very expensive.

- Stormwater improvements are recommended for the entire study area because the entire corridor currently lacks stormwater management structures.

How much are the stormwater improvements or can you breakout their costs for the project?

- A detailed explanation can be found in Appendix K.

Description	Drainage	Rogers Street	Multiuse Trail	Sidewalk	Green Space
Phase I	$460,000	$600,000	$60,000	$115,000	$8,500
Phase II	$340,000	$395,000	$35,000	$90,000	$7,000
Phase III	$620,000	$355,000	$50,000	$130,000	$8,500
Phase IV	$710,000	$430,000	$50,000	$315,000	$8,500
Phase V	$560,000	$420,000	$65,000	$135,000	$11,000
10% Contingency	$250,000	$220,000	$26,000	$78,500	$4,350
Sub - Total	$2,940,000	$2,420,000	$290,000	$860,000	$50,000

How much did you reduce the stormwater runoff by using the rain gardens and swales? (or I think he was asking if you had to use a lower standard (5 year event?) to design these improvements or if you reduced the number of standard inlets by using these)

- Stormwater runoff was designed to control the 10-year flood. The rain gardens and bioretention swales increase the infiltration into the groundwater table, but it is difficult to accurately predict by how much they will reduce stormwater runoff. There are several factors which affect the rate of infiltration into the ground, such as intensity of rainfall and the types of topsoils chosen.

Bus bump outs are great but bus drives do not use them we need to find a way to educate all drivers on these.

- While we acknowledge that bus bump outs only work in areas where both people using the corridor and bus drivers need to be educated, with the proper signage and enforcement, bump outs provide the corridor with a more efficient flow of traffic.

Will increased turning radii increase the travel distance for pedestrians?

- Increasing turning radii has a two-fold effect on traffic. It allows more time for the driver of the vehicle to see the pedestrian. By increasing the turning radii, only a small increase is seen in the length of the intersection. Therefore, an increase in turning radii actually makes an intersection safer for traveling across because pedestrians are seen before the turn is made.

Will the increase turning radii have negative impacts on pedestrians with the increased distance?

- An increase in turning radii has positive impacts on pedestrians due to sight distance.

Was the sidewalk redirected anywhere along the study area?

- Yes, in one area between W 11th St. and W 10th St. where a bus bump out forces the sidewalk to curve around the bump out. Besides that, the sidewalk is not redirected anywhere along the corridor. If this project were to be built, we recommend that city engineers look at the placement of the sidewalk and use their best judgment as to the best place to cross the street and balance right of way concerns.

Street lighting was part of the study proposal; did you incorporate any street lighting improvements or recommendations?

- There are no street lighting recommendations included in the Rogers Street Corridor Context Sensitive Design Study. Atlas Engineering considered the aesthetic value and the spacing of the street lighting on Kirkwood Avenue to be a valuable example of what the street lighting on Rogers Street should resemble.

How about pedestrian bump-outs, are there any in your final design?

- Pedestrian bump-outs are not included in our design but the City of Bloomington can see the possibility of including them where there is enough right-of-way

Comment to support for the bioretention swales and rain gardens for other beneficial reasons (stormwater treatment – cooling, filtering)

- Bioretention swales (Figure F.2 in the body of the report) provide stormwater treatment, conveyance functions, and aesthetic enhancement for the corridor. In essence, the swale component provides pretreatment of stormwater to remove coarse to medium sediments, while the bioretention system removes finer particulates and associated contaminants. Bioretention swales provide flow retardation for frequent storm events, which is of particular importance for the Bloomington area due to the high percentage of low-permeability clays present in the ground. They are considered a Best Management Practice (BMP) and have received praise for their success in the city of Portland, Oregon.

Comment that transportation designs should not just focus on moving vehicles but should focus on creating places. This study does have some elements that try to do this but it would be nice to look at other design issues than just moving vehicles

- The multiuse trail was designed to promote alternative transportation throughout the corridor.

DISCLAIMER

The contents of this engineering design report were prepared by civil engineering students at Rose-Hulman Institute of Technology for their senior capstone design class. **Atlas Engineering, Inc.** is a fictitious company created by these students (**John Baer, Luis Pettengill, Nicole Sanders, Zach Schiff, and Bryan Wienand**) for the purpose of this class. These students are not registered professional engineers! All material presented herein should be reviewed and stamped by a professional engineer prior to construction. A liability waiver has been signed by the client, and copies are available from the client and from Rose-Hulman Institute of Technology.

Executive Summary

The Bloomington/Monroe County Metropolitan Planning Organization (MPO), in conjunction with the Citizens Advisory Committee (CAC), is interested in redeveloping a 2.5 mile stretch of the Rogers Street corridor in Bloomington, Indiana. This section of Rogers Street is a primary north/south route through the heart of the city, serving as an emergency route for the fire department and the Bloomington Hospital, as well as a connection to Indiana University.

Atlas Engineering was contacted by the Bloomington/Monroe County MPO to develop a design alternative which would improve the flow of traffic throughout the corridor and serve various modes of transportation, such as pedestrian, bicycle, etc. The alternative developed utilizes an 8-foot multi-use trail which will run on the west side of Rogers Street with a 5-foot-wide sidewalk to be placed on the east side of Rogers Street. Historical districts, such as Prospect Hill, as well as other establishments located along the corridor, create limited right-of-way in some locations. In areas where the right-of-way is not limited, the plan includes parallel on-street parking and a center turn lane to improve the flow of traffic.

A unique stormwater management system is proposed which will provide adequate stormwater drainage and incorporate best management practices (BMP's) for water quality enhancement. The system uses standard drop inlets along the length of the corridor on the east side. On the west side, in areas where right-of-way is available, standard drop inlets are used in conjunction with bioretention swales and rain gardens. All standard drop inlets route stormwater into existing infrastructure located on adjacent roadways.

To minimize the effects of construction on local neighborhoods and traffic, Atlas has separated the project into five phases. Planned detours for each phase have been established, including a detailed signage layout for phase III, which includes the Bloomington Hospital. A cost estimate for each phase was completed and the total estimated cost of the project is $2.9 million.

Table of Contents

1.0 Project Description

1.1 Background and Site Location

The Rogers Street corridor is located in Bloomington, Indiana which is approximately 50 miles southwest of Indianapolis (Figure 1). Monroe County was created by an act of the Indiana General Assembly in 1818; the same time that the city of Bloomington was officially established. The public square was laid out on a wheat field with 276 feet on each side and streets 82 ½ feet wide. Here, thirty families took up residence and established stores, taverns, and industries. By 1823, a population of 500 was scattered around this public square. (Adapted from Wikipedia, 2006) In 1848, the local college became a university with only 50 students. Today, Bloomington is Indiana's 7th largest city, serving as home to more than 70,000 Hoosiers. Bloomington is also the home of Indiana University's campus, attended by about 40,000 students. (Adapted from Bloomington Indiana Tourism Center, 2006)

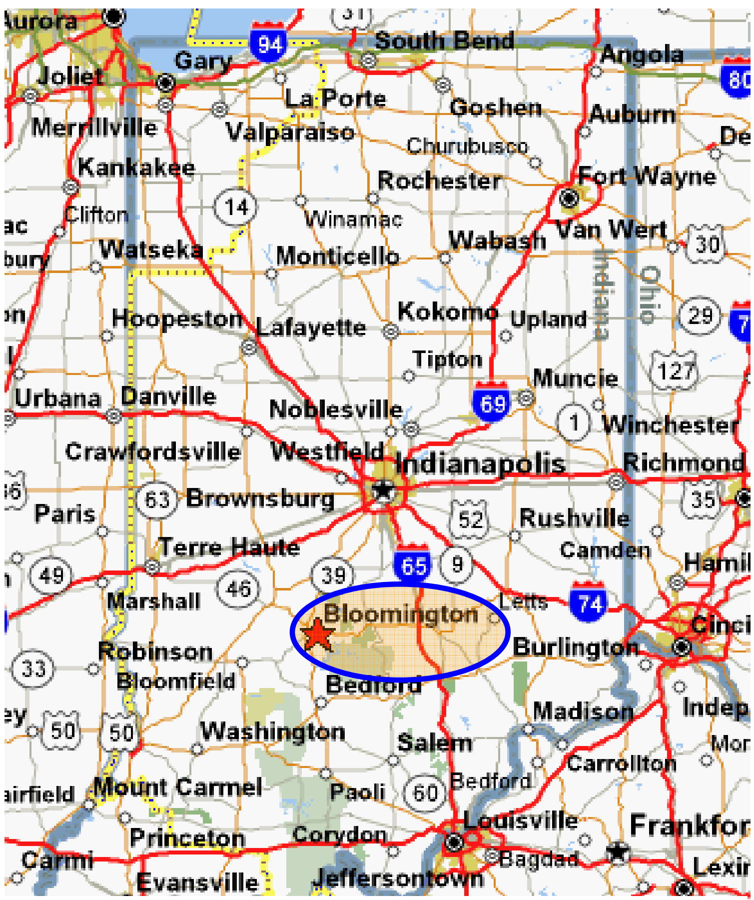

Figure 1: Location of Bloomington, Indiana
(Adapted from Mapquest, 2006)

The Rogers Street corridor's transportation needs have increased dramatically in recent years due to neighborhood revitalization and economic growth. This trend is expected to continue with the development and construction of the B-Line multiuse trail, located to the east of the corridor. Rogers Street is also experiencing increases in motorized, pedestrian, and bicycle traffic, with the city of Bloomington planning for future improvements in some locations. However, the corridor is experiencing a decline in overall appearance, character, and transportation utility, posing a threat to both continued revitalization and private investment.

The Rogers Street corridor, shown in Figure 2 (p.3), connects several established neighborhoods, including various parts of downtown Bloomington. This corridor is a major north/south arterial in the city. There are several modes of transportation that this corridor provides: vehicular, truck, emergency, public transit, bicycle, and pedestrian. Atlas Engineering's scope will focus on redesigning and improving a 2.5 mile segment of the Rogers Street corridor, from Tapp/Country Club Road to 11th Street. Right- of-way constraints exist at several intersections along the corridor and present unique challenges for future transportation improvements, which will serve various residential, commercial, industrial, and institutional land uses.

1.2 Client and Project

Atlas Engineering was contacted by the Bloomington/Monroe County Metropolitan Planning Organization (MPO). The MPO is responsible for administering the policies, programs and regulations that manage the development of the Bloomington community. Atlas' chief contacts for this project are Scott Robinson, the Long Range/Transportation Manager for the city of Bloomington, and Raymond Hess, the Transportation Planner for the city of Bloomington. Representatives from the Citizens Advisory Committee (CAC) have also provided community input to Atlas Engineering, but have not acted as a direct client.

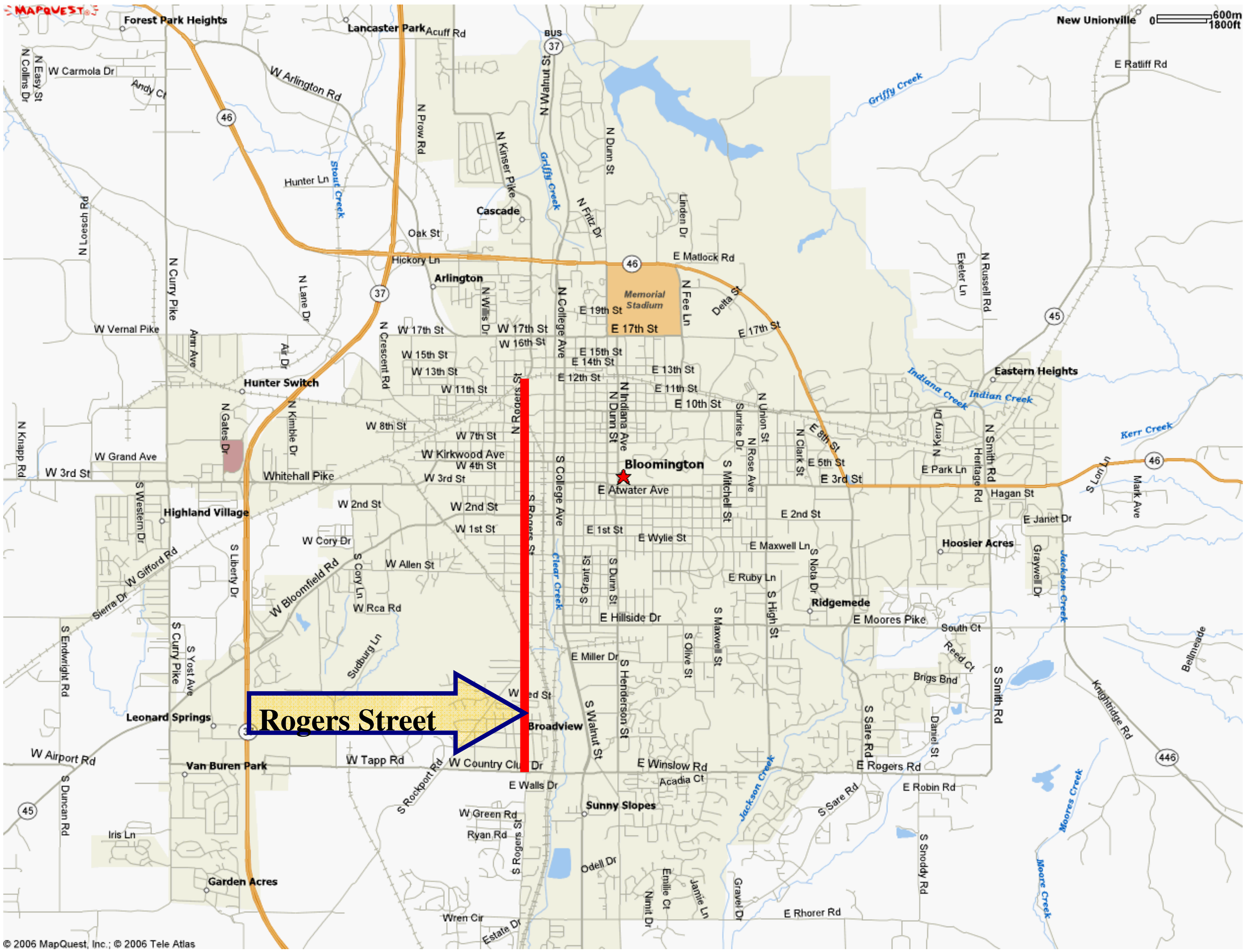

Figure 2: Map of Bloomington with Rogers Street Highlighted
(Adapted from Mapquest, 2006)

2.0 Design Requirements

The major design requirements which Atlas Engineering's design have fulfilled are as follows:

- Improvements to Rogers Street intersections throughout the corridor
- Improvements to current parking conditions
- Provides for sidewalks and handicap accessibility along the entire corridor
- Integrates B-line multiuse trail into the corridor for various modes of transportation
- Provides adequate and unique stormwater management practices for the entire corridor

Road intersections along Rogers Street have been improved by redesigning turn lanes and synchronizing street lights. According to Scott Robinson, the turning radius on street corners has been an issue in previous projects completed for the city of Bloomington. A larger radius allows truck drivers to make turns on tight corners and reduces damage to surrounding street curbs. Roundabouts are also a desirable method of increasing capacity and efficiency. However, due to right-of-way constraints, there are currently no locations along Rogers Street which Atlas Engineering recommends for the implementation of a roundabout.

Improvements to current parking conditions have been another crucial aspect of Atlas' design. Current parking conditions, especially in the business and historical zones, are not well utilized or clearly marked and are somewhat dangerous. Atlas Engineering has identified the most appropriate locations for on-street parking to alleviate traffic congestion during peak hours. In one section of the corridor, several businesses have utilized back-out parking as a way to alleviate their parking issues. Since pull-in parking spaces are known to cause accidents, Atlas Engineering's design assesses several different parking alternatives throughout various business and residential areas.

Sidewalks have been provided along the corridor where none are present, and they have been improved in others areas where necessary. Also, the current infrastructure of some sections of the corridor is underdeveloped and outdated, with several areas having sidewalks in a state of disrepair or completely lacking a sidewalk altogether. Many of the existing sidewalks and curbs along Rogers Street are not handicap accessible. Atlas' final design provides a sidewalk along the corridor with proper access for the handicapped, concurrently improving pedestrian safety.

The city intends to extend development of the B-Line multiuse trail (located to the east of the corridor) as an alternative mode of transportation in an effort to alleviate traffic throughout the city of Bloomington. The city has already obtained drawings for the re-alignment of the B-Line multiuse trial with Rogers Street, such that the trail crosses at ninety degree angles, which have been incorporated into Atlas' final design drawings.

There is a lack of stormwater structures and stormwater management practices along the Rogers Street corridor. Atlas Engineering has provided a complete stormwater management solution for the entire 2.5 mile section of Rogers Street. Incorporated into this design are standard drop inlets, bioretention swales, and rain gardens at various locations along the corridor, which will serve as aesthetic and functional improvements to the corridor.

2.1 Client Requirements/Requests

The following client requests have been included in Atlas' final design:

- Documentation of current property ownership, right-of-way constraints, and all applicable codes and regulations for the entire 2.5 mile corridor
- Traffic signal synchronization
- Considerations for green design and environmentally friendly alternatives
- Solutions sensitive to input from the Citizen's Advisory Committee (CAC)
- Proposal of three practical yet creative alternative corridor designs which accommodate pedestrian, bicycle, and vehicular transportation needs
- Schematic drawings of the three alternatives
- Atlas Engineering's recommendation of the best possible alternative for the Rogers Street corridor – a shared multiuse trail along the west side of the corridor
- Plan and profile drawings for the chosen alternative
- Pavement design for reconstruction of existing road

- Storm water management design and plans for the corridor
- Phased implementation plan and design with cost estimate

2.2 Constraints

This project has presented many challenging constraints, which Atlas Engineering has adhered to throughout the duration of the project. For example, Rogers Street passes directly through Prospect Hill - a historic district of the city of Bloomington, entailing aesthetic and right-of-way limitations. Also, many challenging right-of-way constraints exist at virtually every intersection along the length of the corridor. The Indiana Department of Transportation (INDOT) and American Association of State Highway and Transportation Officials (AASHTO) standards have been met or exceeded throughout the design of the corridor. The Bloomington MPO has also informed Atlas Engineering that project budget is an important aspect of the design, but should not serve as a creative hindrance. Because traffic rerouting is required for the proposed construction along Rogers Street, considerations of alternative routes have been made for the Bloomington Hospital. Lastly, aesthetic aspects of Atlas' design have attempted to assimilate to other local roadways, such that visual continuity between Rogers Street corridor and neighboring roadways has been maintained.

2.3 Deliverables

Atlas Engineering provided the city of Bloomington MPO with a progress report on January 12, 2007 and this final design summary report was provided on May 4, 2007, including the items listed in Section 2.1 and adhering to the constraints set forth in section 2.2. A final oral presentation summarizing Atlas' recommendations was given to the client and the CAC during a monthly meeting held by the CAC on April 18, 2007 at City Hall in Bloomington.

This final report contains a preliminary feasibility study that includes findings on transportation and stormwater management, topography, soil types, and codes and regulations. Information regarding utility lines, historical districts, pedestrians, bicycles, local ordinances, and right-of-way constraints is also included in this report.

3.0 Project Approach

Atlas Engineering has completed all of the design requirements presented by the City of Bloomington and the Metropolitan Planning Organization based on the following project approach.

- **Photographic Survey -** Photographs of the Rogers Street corridor have been taken and distributed to group members to aid in the design process.
- **Codes and Regulations -** Atlas Engineering has researched and followed all codes and regulations that will ensure that federal and state funding can be received for the construction of the Rogers Street corridor.
- **Preliminary Feasibility Study -** A collection of topographic maps, zoning maps, floodplain maps, and existing right-of-way maps as well as the location of current utility lines, historic districts, existing roads, and transportation access have been collected and will be presented to the client.
- **Description of Transportation Corridor Options -** Three design options have been formulated and analyzed. They differ in how pedestrian and bicycle traffic move along the corridor and the methods by which they will be improved.
- **Assessment of Transportation Corridor Options -** Key components of the design have been identified and given specific weighting values by our client. This input has been used to complete a decision matrix and to choose the most appropriate option for the Rogers Street corridor.
- **Stormwater Management Design -** Using the 10-year flood data, the drainage area of the corridor and specifications set forth by the City of Bloomington Utilities Department, a stormwater management design has been completed.
- **Pavement Design -** Using soil conditions found during the preliminary feasibility study, two pavement designs were proposed to the client. The first has been designed to meet single-axle load applications and would be used for driving lanes. The second design provides for adequate strength on the shared multiuse trail according to the standards set forth in Iowa's *Asphalt Paving Design Guide* (APAI, 2007).

- **Trail Design -** A multiuse trail has been designed according to AASHTO guidelines. The trail has been designed to accommodate two-way traffic for pedestrians and bicyclists as well as other modes of transportation.
- **Traffic Control Plan -** Detailed detour routes have been completed for each phase of the Rogers Street corridor's construction. Alternative business entrance and local housing access have also been identified in key locations.
- **Plans and Specifications -** Plan drawings have been provided for the chosen design alternative. The specifications have also been summarized and referenced using the Manual on Uniform Traffic Control Devices (FHWA, 2004).
- **Cost Estimate -** The Indiana Department of Transportation bid calculator was used to determine a cost estimate for each phase of the Rogers Street corridor's construction.

4.0 Design Solution

4.1 Photographic Survey

Atlas Engineering has compiled a collection of photographs covering the 2.5 mile segment of Rogers Street from Country Club Road to Eleventh Street. Four pictures were taken per intersection and have been indexed according to their location and orientation in Appendix A. Atlas used the photographic survey to better visualize of the Rogers Street corridor and the communities it serves. The photographic survey also helped identify current conditions along the corridor and served as a reference for the completed design.

4.2 Codes and Regulations

Atlas Engineering found pertinent codes and regulations that would be vital to adhere to for the Rogers Street corridor Context Sensitive Design. Sources for these codes and regulations are:

- Indiana's Department of Tranportation's (INDOT) 2006 *Standard Specifications Book*
- American Association of State Highway Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (1999)
- AASHTO *A Policy on Geometric Design of Highways and Streets* (2004)
- Low Impact Development (LID) – general references
- Indiana Department of Environmental Management (IDEM) *Stormwater Pollution* (2006)
- Context Sensitive Solutions (Transportation Research Board, 2003)
- Americans with Disabilities Act (ADA) *Accessibility Guidelines for Buildings and Facilities* (2006)
- Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices* (2004)

By adhering to these codes and regulations Atlas Engineering believes that the Rogers Street corridor will be able to receive state and federal funding for construction.

Also included in this final report is the complete design of the chosen alternative as selected by the client – an 8-foot multiuse trail along the west side of the corridor. Also included are detailed plan and profile drawings of Atlas' proposed corridor alternative and a construction cost analysis based on a phased implementation process.

This final report will need to be reviewed and submitted for approval by a licensed professional engineer. All drawings are 11"x17" sheets. Atlas Engineering has provided electronic files of all AutoCAD and ArcGIS drawings and an Adobe PDF version of the final report to the client.

Atlas Engineering found information concerning the proper design specifications for slopes, alignments, vertical clearances, lane widths, and curb and shoulder details through INDOT and AASHTO policies. Guidelines concerning runoff volume controls and water quality controls were also found using IDEM guidelines as well as the guidelines set forth to meet LID practices. The process for following Context Sensitive Solutions (CSS) was identified and proper ADA requirements for the project were found. A more detailed outline of this information is available in Appendix B.

4.3 Preliminary Feasibility Study

Atlas Engineering performed a preliminary feasibility study (PFS) to document the current conditions of the corridor. The PFS includes current zoning and the City of Bloomington's comprehensive plan, utility availability, transportation and access requirements, site characteristics and topography, soils present and the identification of any wetlands or floodplains along the site. The PFS was performed so that a proper recommendation could be given to the Bloomington/Monroe County MPO for the redevelopment of the site.

After examining the site, Atlas Engineering found that streams, wetlands, and floodplains were in the vicinity of the site; however, they do not significantly impact this project since the road is already in existence. Atlas Engineering has also reviewed the 1981 Soil Conservation Service (SCS) Survey of Monroe County, Indiana, for preliminary geotechnical information and present soil conditions on the site. Based on the soil conditions found in the SCS Survey, Atlas Engineering suggests that a thorough soil investigation analysis be performed before construction is started. The PFS can be viewed in its entirety in Appendix C.

4.4 Description of Transportation Corridor Options

Atlas Engineering developed three distinct transportation options for implementation on the Rogers Street corridor. In order to have the options meet the needs of the client as well as the community, input was received from various individuals; including the client, CAC representatives, Bloomington's fire chief, a Bloomington Hospital representative, and a Bloomington Utilities Department representative. The available right-of-way was found using GIS mapping and the limitations they imposed factored heavily into the development of the options. To simplify the creation of cross-sectional drawings Atlas Engineering separated the corridor into four regions based on the amount of right-of-way present. Atlas was instructed by the client that the proposed design should not allow for the purchasing of any right-of-way at this time.

The three options created and presented to the client were very similar in how they would carry the vehicular traffic along Rogers Street. The three transportation corridor options differed, however, in how bicycle traffic and pedestrians would move along the corridor. Option 1 was designed for the implementation of bicycle lanes on both sides of the corridor. Option 2 would provide sidewalks on both sides of Rogers Street. Option 3 implements a shared multiuse trail throughout the length of the corridor on the west side with a sidewalk along the length of the east side. A detailed description of each option can be found in Appendix D.

4.5 Assessment of Transportation Corridor Options

A decision matrix was created by Atlas Engineering to determine which transportation corridor option should be recommended to the City of Bloomington for future development. The three options were rated on a scale of “one to three”, with three being the most desired and one being the least, in four different design criteria. The four criteria were: impact on local businesses and neighborhoods, feasibility, transportation improvement, and public support (CAC approval). Input from the Bloomington/Monroe County MPO determined appropriate weighting factors for each criterion.

Table 1 displays the results of this decision matrix. Atlas’ recommended option for the future development of the corridor is Option 3: A multi-use trail on the west side of the street and a sidewalk on the east side. Figure 3 shows a rendering of Atlas’ recommended transportation corridor option. Justification for each of the scores assigned to each of the three options in the decision matrix is provided in Appendix E, as well as Atlas’ recommendation for the City of Bloomington.

Table 1: Decision Matrix

Transportation Corridor Option	Local Impact (30%)	Feasibility (25%)	Transportation Improvement (25%)	Local Support (20%)	Weighted Average	Rank
# 1 Bicycle Lanes	1	2	1	2	**1.45**	3
# 2 No Bicycle Lanes	1	2	2	2	**1.70**	2
# 3 Multiuse Trail	1	3	3	3	***2. 40***	1

Recommended Alternative

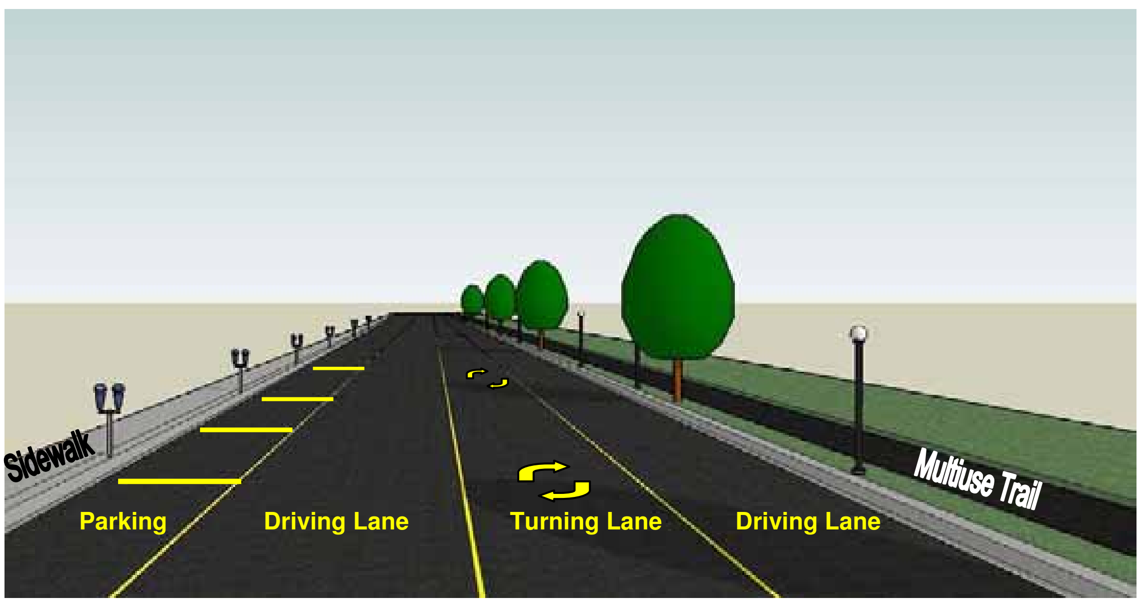

Figure 3: Rendering of Recommended Alternative

4.6 Stormwater Management Design

The Bloomington/Monroe County Metropolitan Planning Organization has requested that Atlas Engineering provide a comprehensive stormwater management design for the Rogers Street corridor, a corridor which currently has no existing stormwater structures of any kind. Atlas' stormwater management solution, which is provided in Appendix F, has been designed for implementation and takes into consideration green engineering concepts and environmentally-friendly design alternatives, such as bioretention swales (Figure 4) and rain gardens (Figure 5). Because the right-of-way throughout the Rogers Street corridor varies a great deal, unique solutions have been developed which provide both adequate stormwater drainage and the incorporation of best management practices (BMPs).

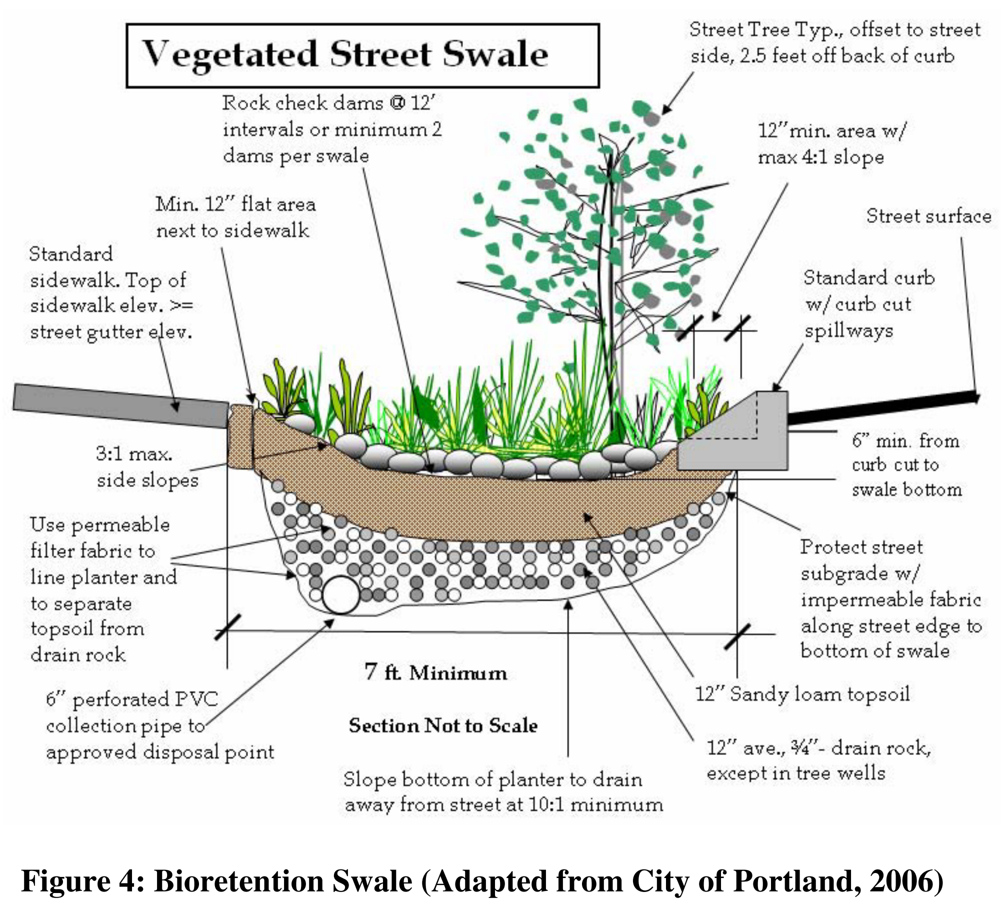

Figure 4: Bioretention Swale (Adapted from City of Portland, 2006)

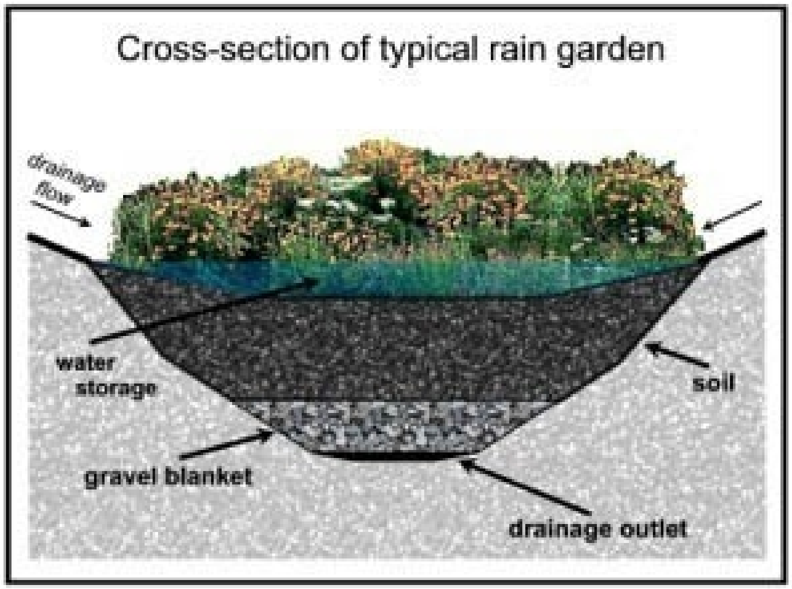

Figure 5: Rain Garden (Adapted from City of Portland, 2004)

To ensure adequate stormwater drainage, the hydrologic design incorporates drop inlets spaced at appropriate intervals between intersections throughout the length of the corridor in combination with green forms of stormwater management, such as the aforementioned bioretention swales and rain gardens. The decisions made to evaluate the appropriateness of where to place standard inlets versus bioretention swales and rain gardens were based on a variety of factors, including: availability of right-of-way, aesthetic value, availability of existing stormwater structures to connect to, volumetric flow of stormwater for a given section of the corridor, and ease of constructability. Table 2 shows Atlas' recommended locations for the placement of standard inlets, bioretention swales, and rain gardens throughout the entire length of the corridor. A visual representation of the placement of the bioretention swales and rain gardens can be found in Appendix J, Figures J2.2 to J2.5, J2.11, and J2.18. Also included in Appendix F are design calculations for pipe sizing and inlet spacing, as well as figures of elevations throughout the corridor and other illustrations of rain gardens and bioretention swales.

Table 2: Locations of Recommended Stormwater Systems

Intersecting Roadways	Proposed Stormwater Structure West Side of Corridor	Proposed Stormwater Structure East Side of Corridor	Stormwater Routing Location (Existing)
11th St. to 8th St.	Standard Drop Inlets	Standard Drop Inlets	8th St.
7th St. to 8th St.	7' Wide Bioretention Swales	Standard Drop Inlets	8th St.
7th St. to 4th St.	7' Wide Bioretention Swales	Standard Drop Inlets	4th St.
Smith St. to 4th St.	7' Wide Bioretention Swales	Standard Drop Inlets	4th St.
Smith St. to 2nd St.	Standard Drop Inlets	Standard Drop Inlets	2nd St.
Dodds St. to 2nd St.	Standard Drop Inlets	Standard Drop Inlets	2nd St.
Dodds St. to Patterson St.	Standard Drop Inlets	Standard Drop Inlets	Patterson St.
Patterson St. Intersection	Rain Garden	Standard Drop Inlets	Patterson St.
Patterson St. to Hillside St.	Standard Drop Inlets	Standard Drop Inlets	Hillside St.
Chambers St. to Hillside St	Standard Drop Inlets	Standard Drop Inlets	Hillside St.
Chambers St. to Jed St.	Standard Drop Inlets	Standard Drop Inlets	Jed St.
Jed St. Intersection	Rain Garden	Standard Drop Inlets	Jed St.
Graham St. to Ralston St.	Standard Drop Inlets	Standard Drop Inlets	Ralston St.
Tapp Road to Ralston St.	Standard Drop Inlets	Standard Drop Inlets	Ralston St.

4.7 Pavement Design

Atlas Engineering has designed the pavement for a 2-lane, 48-foot wide road and an 8-foot wide shared multiuse trail west of Rogers Street. The trail will be used by different modes of transportation including bicycles, wheelchairs, skates, and pedestrians. Hot mix asphalt (HMA) pavement was selected because HMA will provide a smooth ride, a friction coarse enough to ensure adequate skid resistance properties throughout the design life, and a water-resistant surface suitable for all potential users. Atlas followed the guidelines set forth in the Asphalt Paving Association of Iowa's *Asphalt Paving Design Guide* (APAI, 2007) to design the multiuse trail and the guidelines set forth in the book *Principles of Pavement Design* (Yoder and Witczak, 1975) for the road design.

Based on the results on the pavement design for the trail and Rogers Street, Atlas recommends a three-inch HMA surface coarse over four inches of crushed stone aggregate base course for the trail. For Rogers Street, we recommend three inches of

Figure 6: Cross section of pavement design (Washington State Department of Transportation, 2007)

HMA for the surface course and eight inches of compacted aggregate base course atop nine inches of sandy gravel subbase course (Figure 6). The City of Bloomington will decide whether current base and subbase material properties are acceptable after current surface is milled, patched, and a proper soil analysis conducted. If the coarse conditions are acceptable, two inches of milling and patching will be sufficient along the road. If the coarse conditions are not acceptable, the pavement should be removed and replaced with the recommended surface course, base, and subbase materials and thicknesses. A more detailed explanation for pavement design is found in Appendix G.

4.8 Trail Design

A shared multiuse trail will be constructed to improve current transportation conditions along Rogers Street. The eight-foot-wide, shared-use trail will support two-way traffic accommodating bicyclists, pedestrians, rollerblades, skateboards, etc. A visual representation of the trail layout in relation to Rogers Street can be found in Appendix J, Figures J2.0 to J2.22. The *Guide for the Development of Bicycle Facilities* (AASHTO, 1999) lays out the guidelines for the design of bicycle facilities and was heavily used for the trail design. The trail was also designed for people with various disabilities by following the guidelines set forth in the *Americans with Disabilities Act* (ADA, 1990). This was done to safely accommodate all probable users and promote further use of the trail.

The trail requires a maximum three percent grade to accommodate people with disabilities and a minimum cross-slope of two percent in harmony with existing topography to provide adequate drainage. A three-foot clearance is expected from any trail-side obstructions such as trees, fences, and guardrails. The AASHTO *Bicycle Guide* (AASHTO, 1999) recommends a minimum design speed of 20 mph for the trail to ensure users safety as well as 100-foot minimum desirable radius of curvature at intersections. A stopping sight distance of 120 feet is recommended for the safety of the users to provide them the opportunity to see and react accordingly to vehicular traffic. A more detailed explanation of trail design features can be found in Appendix H.

4.9 Traffic Control Plan

In preparation for the construction of Atlas' proposed changes along the corridor, a traffic control plan has been created to successfully accommodate the changes in traffic patterns during construction. To minimize the effects on local businesses, neighborhoods, and travel times, the construction of the corridor has been divided into five distinct phases:

- 11th Street to Kirkwood Avenue
- Kirkwood Avenue to 2nd Street
- 2nd Street to Patterson Street
- Patterson Street to Rockport Road
- Rockport Road to Country Club/Tapp Road

Special considerations were made with regard to emergency vehicle access to Bloomington Hospital as well as fire emergency vehicles throughout the corridor. For details about road closures, rerouting, and mapping of each phase of construction, see Appendix I.

4.10 Plans and Specifications

Atlas Engineering has prepared a set of plan drawings to represent the features that the Rogers Street corridor will have possess upon completion of construction. Included on the plan drawings are pavement markings, parking configurations and the placement of the trail in relation to the street. Detailed specifications for the placement of signs and the dimensions of pavement markings were found and referenced using the Manual on

Uniform Traffic Control Devices (MUTCD) (FHWA, 2004). The specifications were outlined and referenced so that detail specification drawings could be created from them.

The plan drawings were completed by implementing the cross sections detailed in Appendix E. The cross sections had to be slightly altered as the varying right-of-ways were connected. It was also found that existing structures intrude on the right-of-way. The detailed plan drawings and specifications are provided in Appendix J.

4.11 Cost Estimate

Atlas Engineering has prepared a cost estimate for the *Rogers Street Corridor Context Sensitive Design Study* in Bloomington, Indiana. The design includes adding a sandy gravel subbase, a coarse aggregate base, and hot mix asphalt overlay throughout the 24-foot wide road. The phased construction will also include an 8-foot multiuse trail along the west of Rogers Street and a 5-foot sidewalk along portions of Rogers Street, due to limiting right-of-way. A cost estimate was conducted using the Indiana Department of Transportation (INDOT, 2007) unit price averages primarily with the RSMean Building Construction Cost Data Manual(Construction Publishers and Consultants, 2005) when items were not included or well specified in the INDOT unit price averages.

The Rogers Street corridor was divided into five phases in order to increase constructability and to minimize the impact on local businesses and neighborhoods during construction. The cost estimate was conducted to provide an estimate for each phase and can be seen in Table 3 below. The total estimated cost of the Rogers Street corridor was estimated to be $6,550,000. This cost estimate excludes any utilities relocation. Please refer to Appendix K for a more detailed description of the cost estimate.

Table 3: Five Phase Cost Estimate

Phase	Cost
l	$ 1,360,000
ll	$ 950,000
lll	$ 1,270,000
lV	$ 1,660,000
V	$ 1,310,000
Total Cost	$ 6,550,000

5.0 References Cited

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APPENDIX A- PHOTOGRAPHIC SURVEY

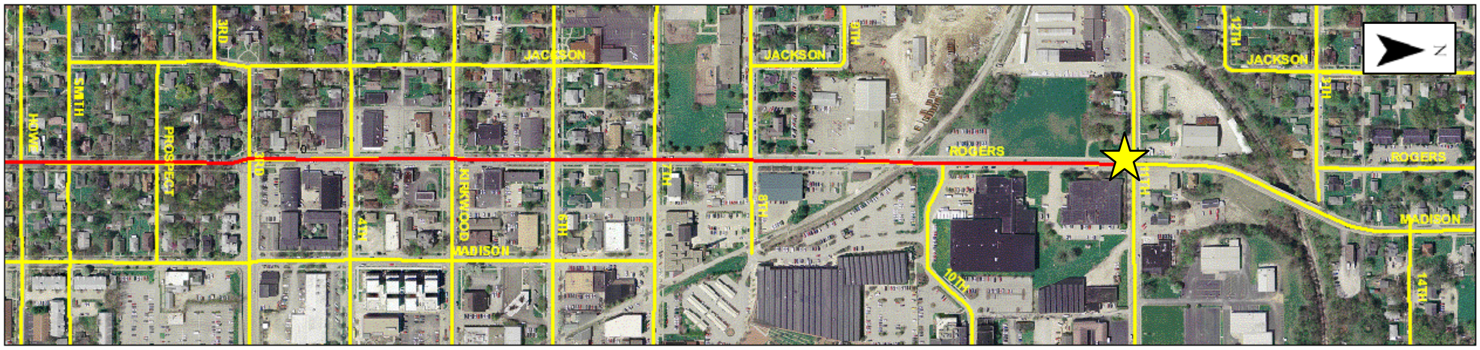
A.1 Introduction to the Photographic Survey

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street Corridor. Atlas Engineering has compiled a photographic survey of the Rogers Street corridor to serve as an aid for the City of Bloomington. The photographic survey's purpose is to document the existing conditions of each intersection within the Rogers Street corridor. The survey features high-resolution digital photographs of the entire 2.5 mile segment of Rogers Street as well as an aerial photograph showing the location of the intersections. All photographs are labeled according to location and orientation. The photographs have been included on the final report CD and are organized according to intersection, then orientation. The index has also been placed in the file of pictures.

A.2 Photographic Survey Index

A.3 Images of Photographic Survey

Rogers Street and 11th Street Intersection



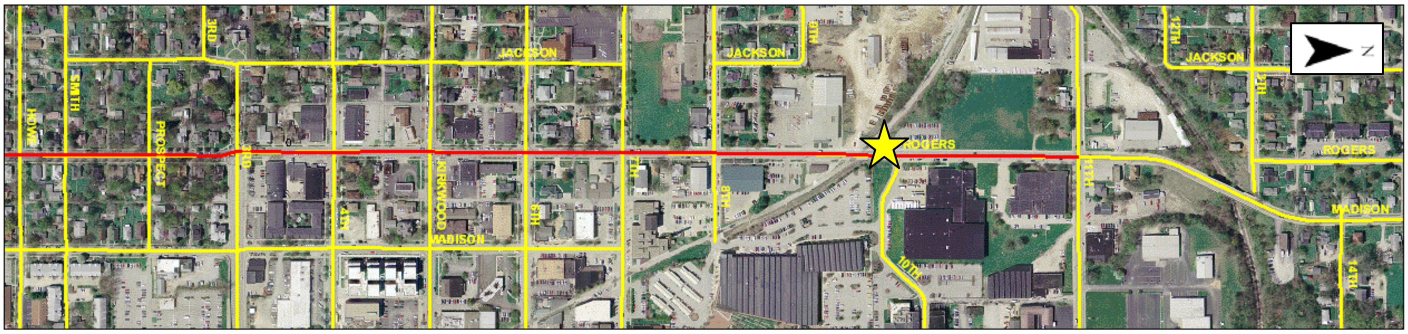
1-Rogers Street & 11th Street, Facing North

2-Rogers Street & 11th Street, Facing West

3-Rogers Street & 11th Street, Facing South

4-Rogers Street & 11th Street, Facing East

Rogers Street and 10th Street Intersection



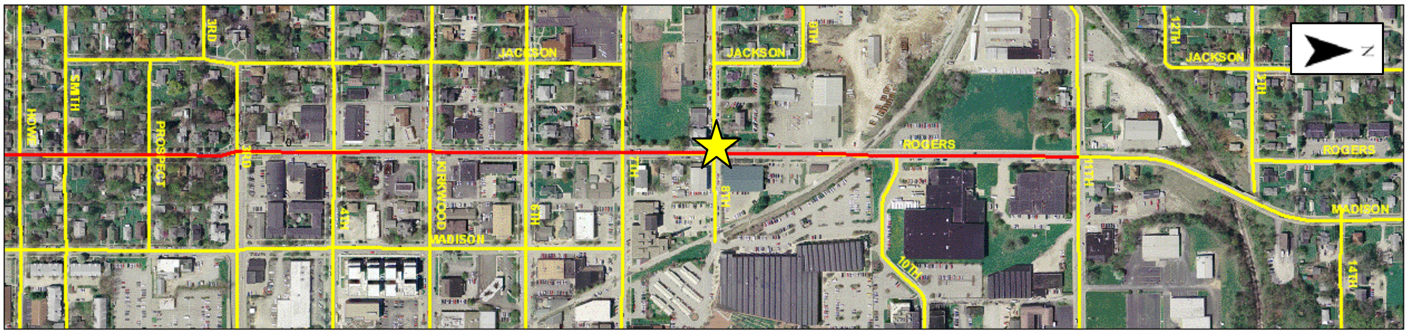
5-Rogers Street & 10th Street, Facing North

6-Rogers Street & 10th Street, Facing West

7-Rogers Street & 10th Street, Facing South

8-Rogers Street & 10th Street, Facing East

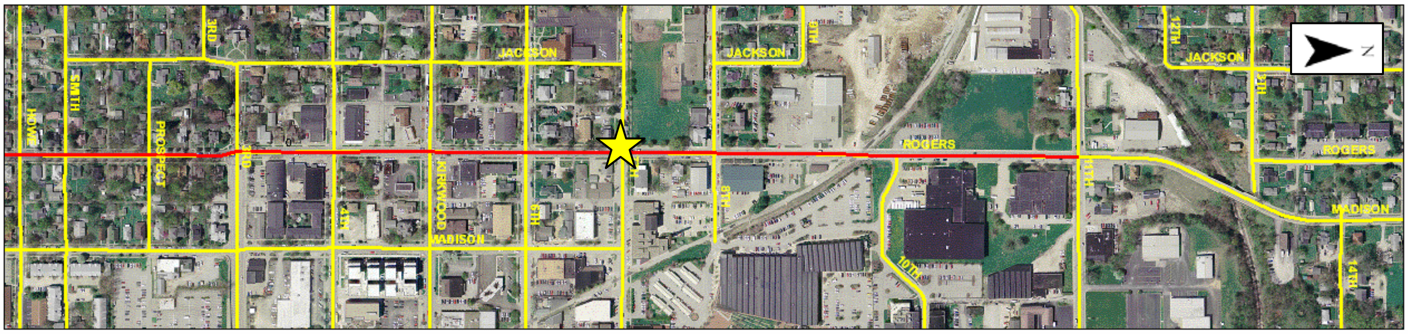
Rogers Street and 8th Street Intersection



9-Rogers Street & 8th Street, Facing North **10-Rogers Street & 8th Street, Facing West**

11-Rogers Street & 8th Street, Facing South **12-Rogers Street & 8th Street, Facing East**

Rogers Street and 7th Street Intersection



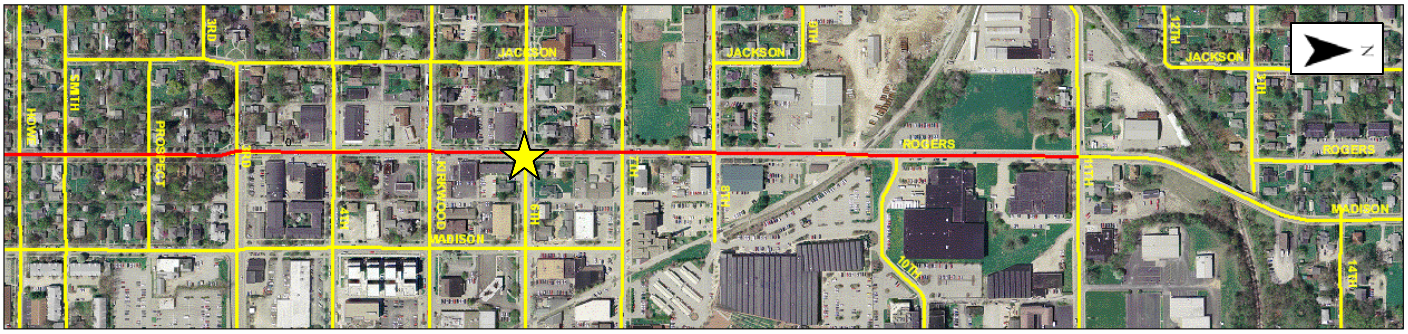
13-Rogers Street & 7th Street, Facing North

14-Rogers Street & 7th Street, Facing West

15-Rogers Street & 7th Street, Facing South

16-Rogers Street & 7th Street, Facing East

Rogers Street and 6th Street Intersection



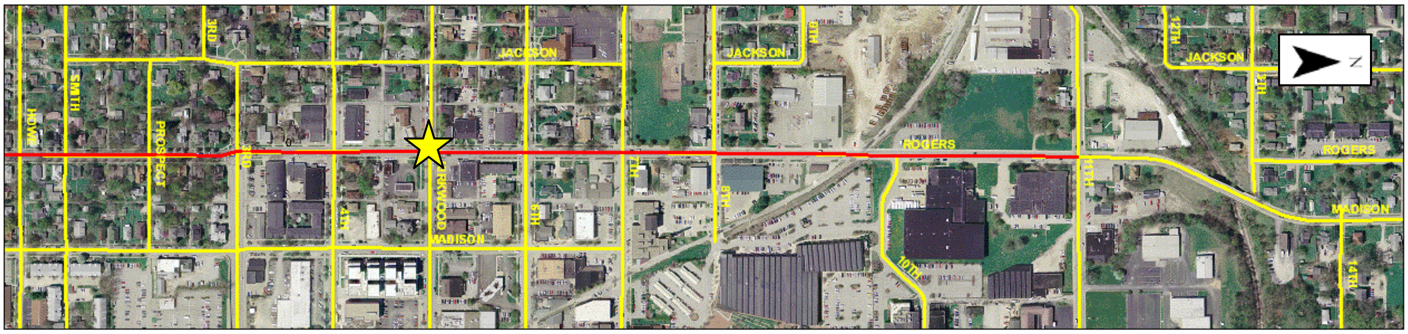
17-Rogers Street & 6th Street, Facing North

18-Rogers Street & 6th Street, Facing West

19-Rogers Street & 6th Street, Facing South

20-Rogers Street & 6th Street, Facing East

Rogers Street and Kirkwood Avenue Intersection



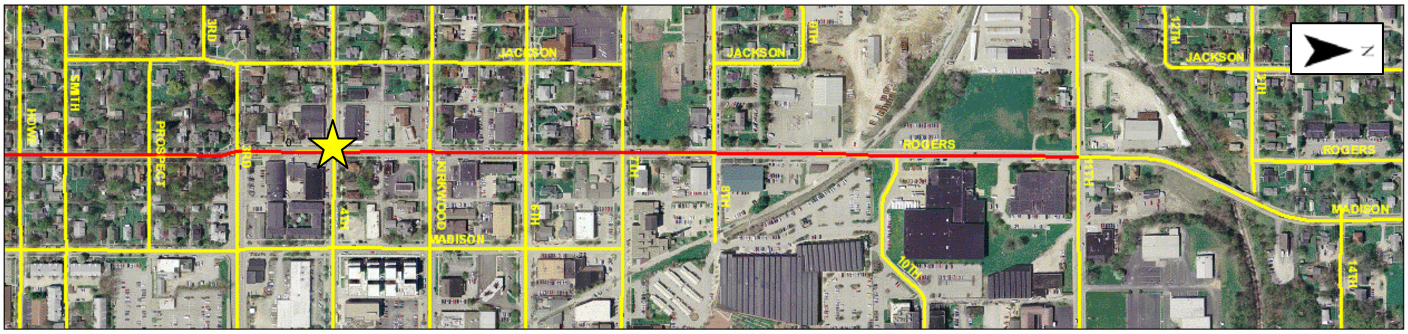
21-Rogers Street & Kirkwood Ave, Facing North

22-Rogers Street & Kirkwood Ave, Facing West

23-Rogers Street & Kirkwood Ave, Facing South

24-Rogers Street & 6th Street, Facing East

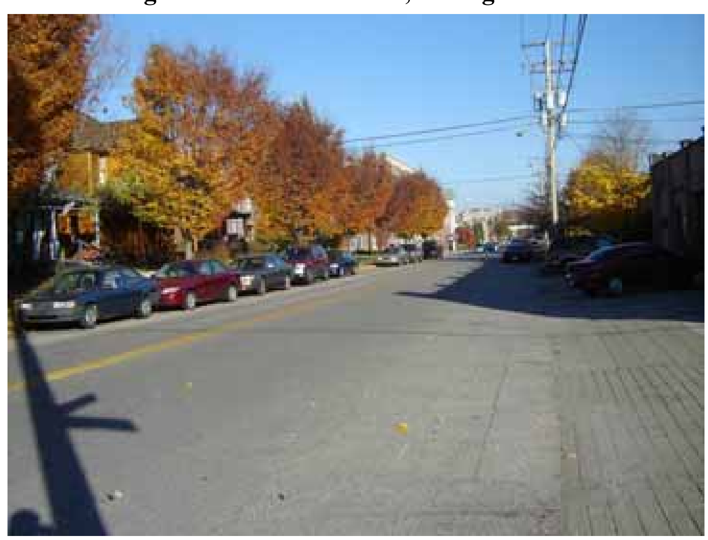
Rogers Street and 4th Street Intersection



25-Rogers Street & 4th Street, Facing North

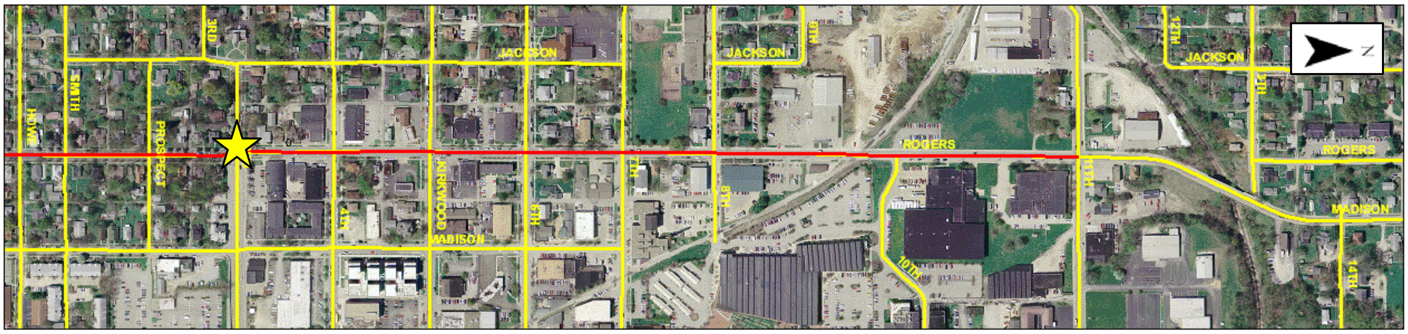
26-Rogers Street & 4th Street, Facing West

27-Rogers Street & 4th Street, Facing South



28-Rogers Street & 4th Street, Facing East

Rogers Street and 3rd Street Intersection



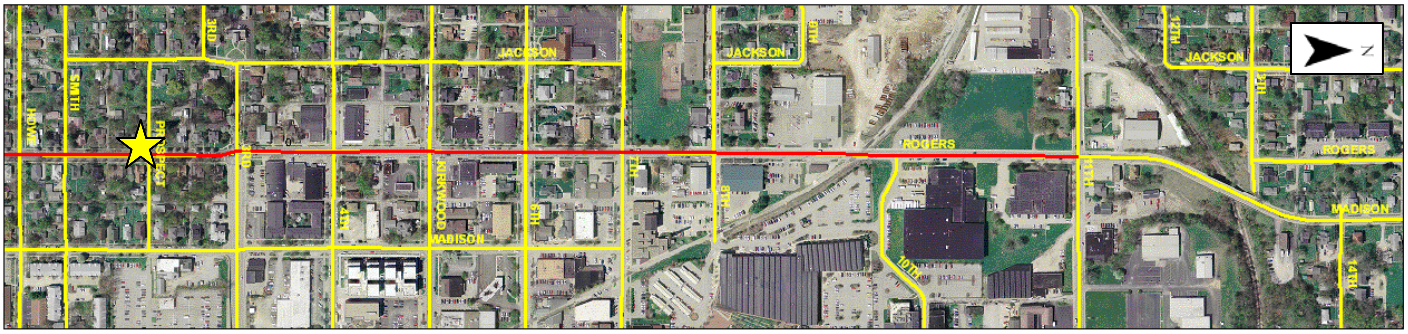
29-Rogers Street & 3rd Street, Facing North

30-Rogers Street & 3rd Street, Facing West

31-Rogers Street & 3rd Street, Facing South

32-Rogers Street & 3rd Street, Facing East

Rogers Street and Prospect Avenue Intersection



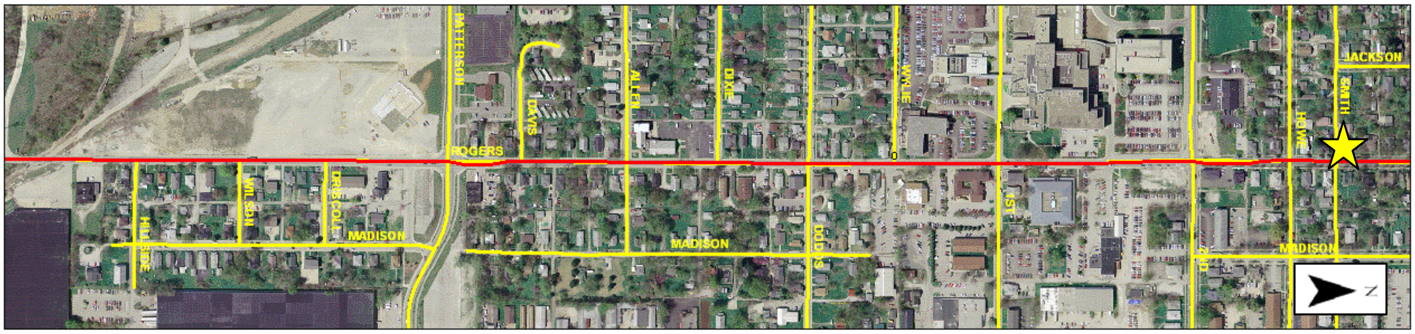
33-Rogers Street & Prospect Ave, Facing North

34-Rogers Street & Prospect Ave, Facing West

35-Rogers Street & Prospect Ave, Facing South

36-Rogers Street & Prospect Ave, Facing East

Rogers Street and Smith Avenue Intersection



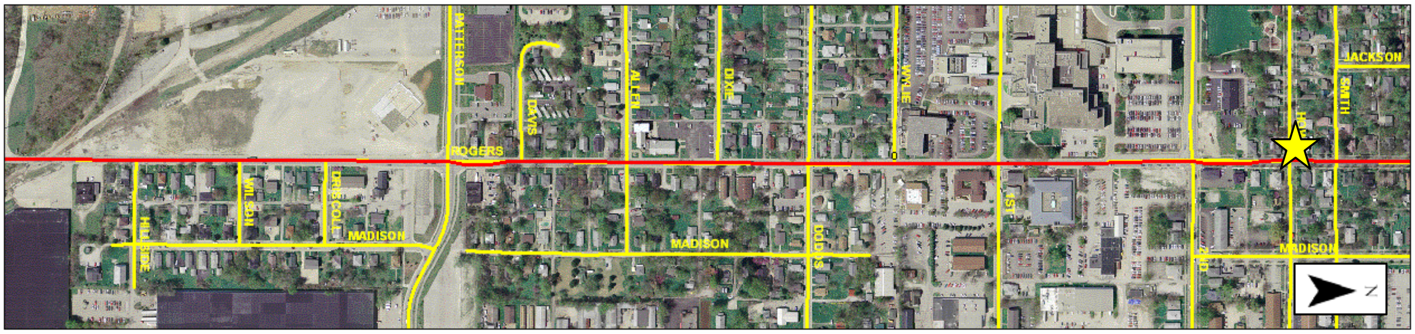
37-Rogers Street & Smith Ave, Facing North

38-Rogers Street & Smith Ave, Facing West

39-Rogers Street & Smith Ave, Facing South

40-Rogers Street & Smith Ave, Facing East

Rogers Street and Howe Street Intersection



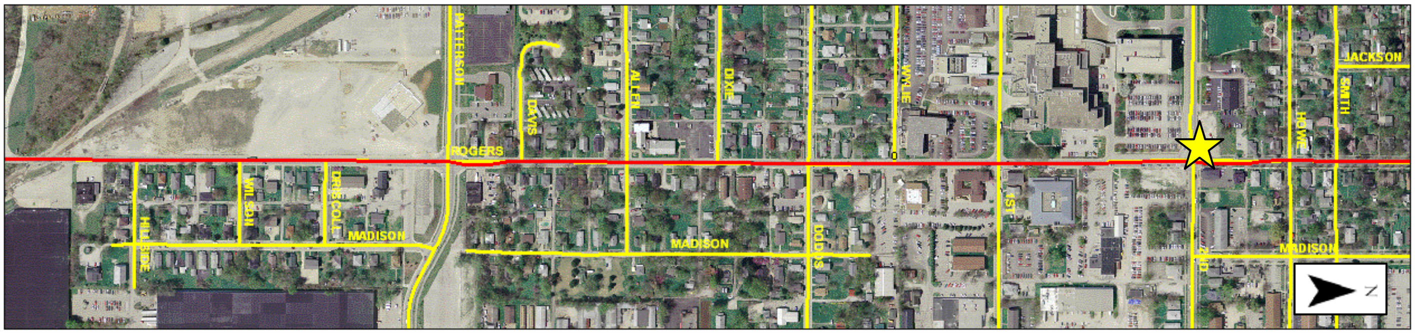
41-Rogers Street & Howe Street, Facing North

42-Rogers Street & Howe Street, Facing West

43-Rogers Street & Howe Street, Facing South

44-Rogers Street & Howe Street, Facing East

Rogers Street and 2nd Street Intersection



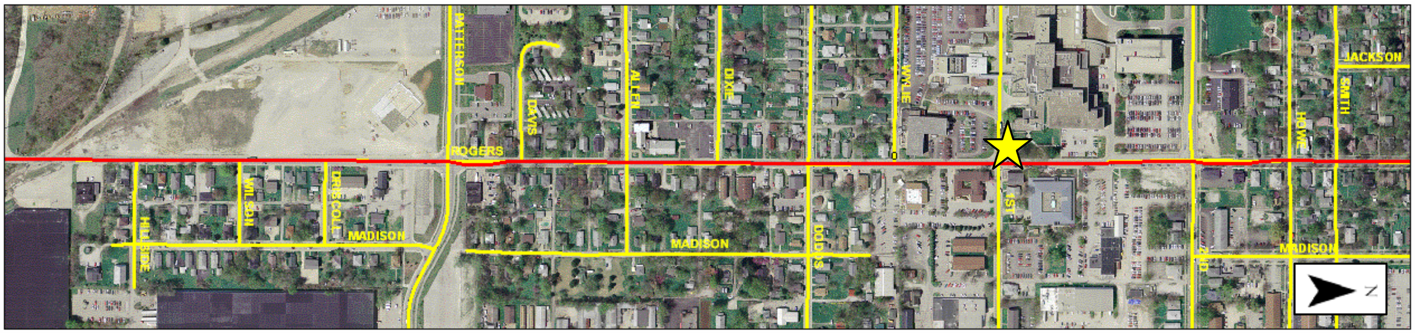
45-Rogers Street & 2nd Street, Facing North

46-Rogers Street & 2nd Street, Facing West

47-Rogers Street & 2nd Street, Facing South

48-Rogers Street & 2nd Street, Facing East

Rogers Street and 1st Street Intersection



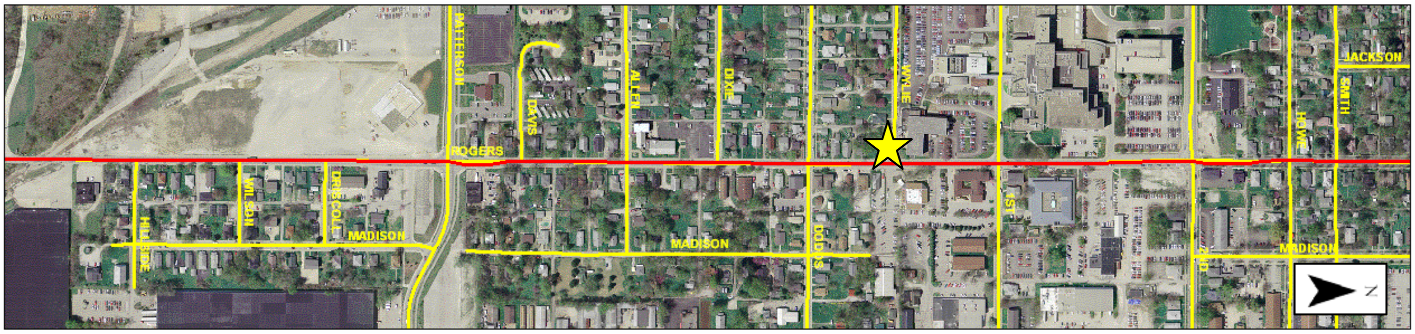
49-Rogers Street & 1st Street, Facing North

50-Rogers Street & 1st Street, Facing West

51-Rogers Street & 1st Street, Facing South

52-Rogers Street & 1st Street, Facing East

Rogers Street and Wylie Street Intersection



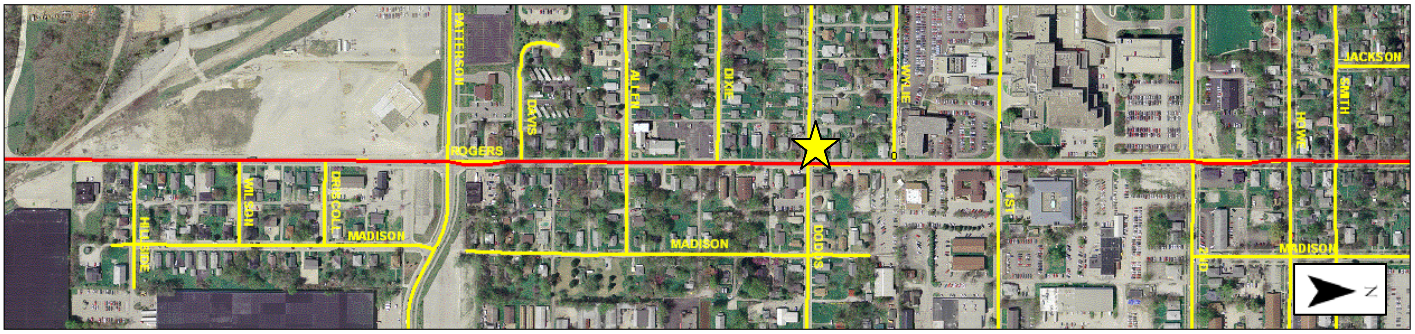
53-Rogers Street & Wylie Street, Facing North

54-Rogers Street & Wylie Street, Facing West

55-Rogers Street & Wylie Street, Facing South

56-Rogers Street & Wylie Street, Facing East

Rogers Street and Dodds Street Intersection



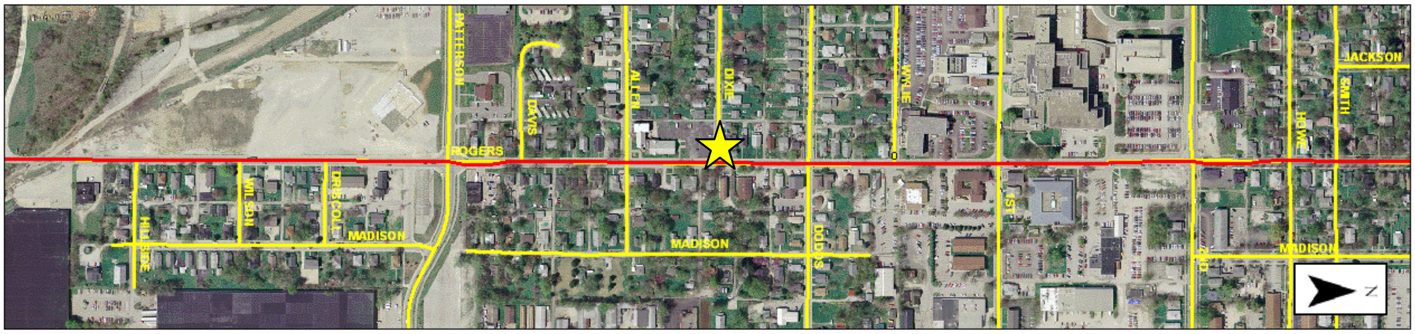
57-Rogers Street & Dodds Street, Facing North


58-Rogers Street & Dodds Street, Facing West


59-Rogers Street & Dodds Street, Facing South


60-Rogers Street & Dodds Street, Facing East

Rogers Street and Dixie Street Intersection



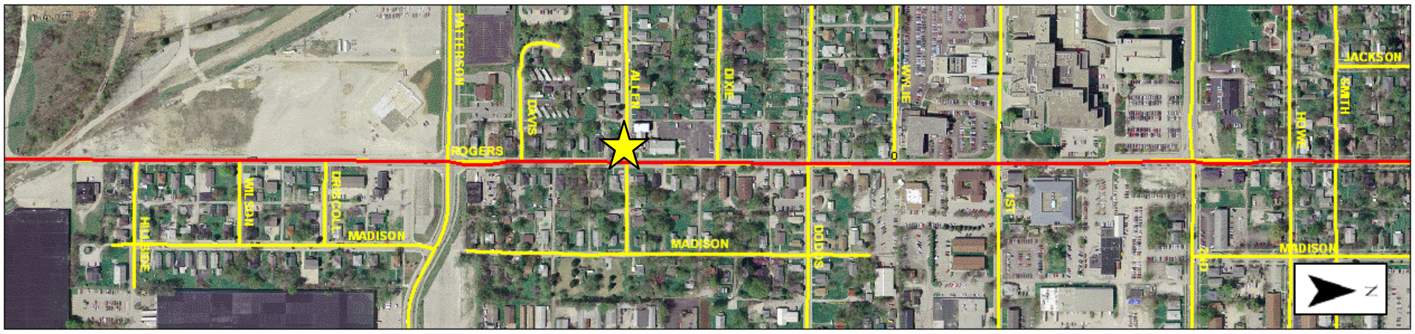
61-Rogers Street & Dixie Street, Facing North

62-Rogers Street & Dixie Street, Facing West

63-Rogers Street & Dixie Street, Facing South

64-Rogers Street & Dixie Street, Facing East

Rogers Street and Allen Street Intersection

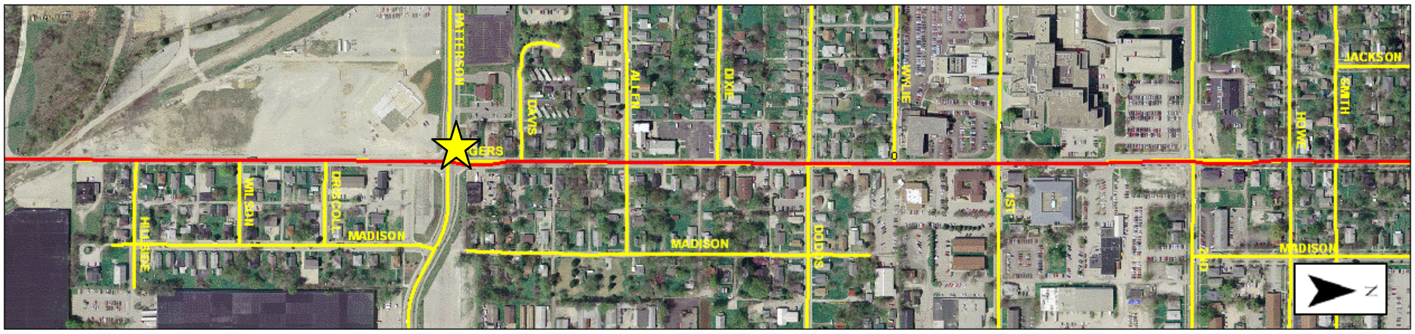


65-Rogers Street & Allen Street, Facing North

66-Rogers Street & Allen Street, Facing West

67-Rogers Street & Allen Street, Facing South

68-Rogers Street & Allen Street, Facing East



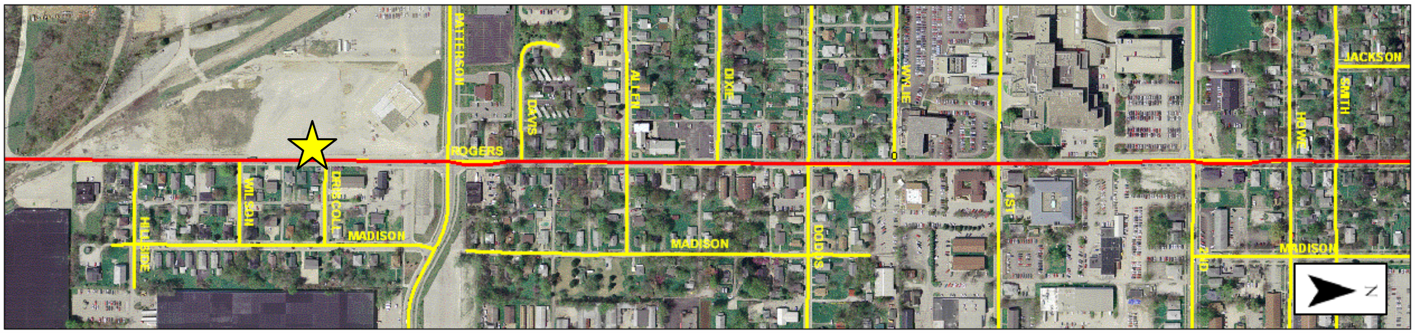
69-Rogers Street & Patterson Dr, Facing North

70-Rogers Street & Patterson Dr, Facing West

71-Rogers Street & Patterson Dr, Facing South

72-Rogers Street & Patterson Dr, Facing East

Rogers Street and Driscoll Street Intersection



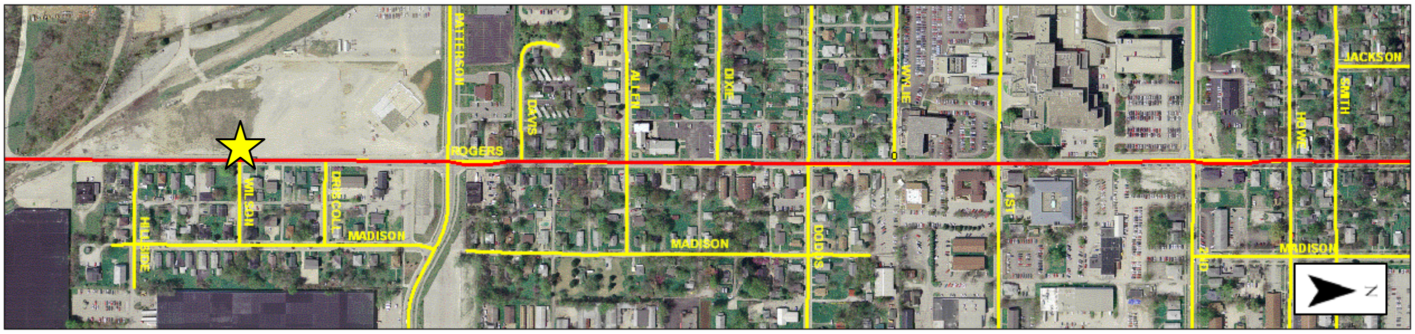
73-Rogers Street & Driscoll Street, Facing North

74-Rogers Street & Driscoll Street, Facing West

75-Rogers Street & Driscoll Street, Facing South

76-Rogers Street & Driscoll Street, Facing East

Rogers Street and Wilson Street Intersection



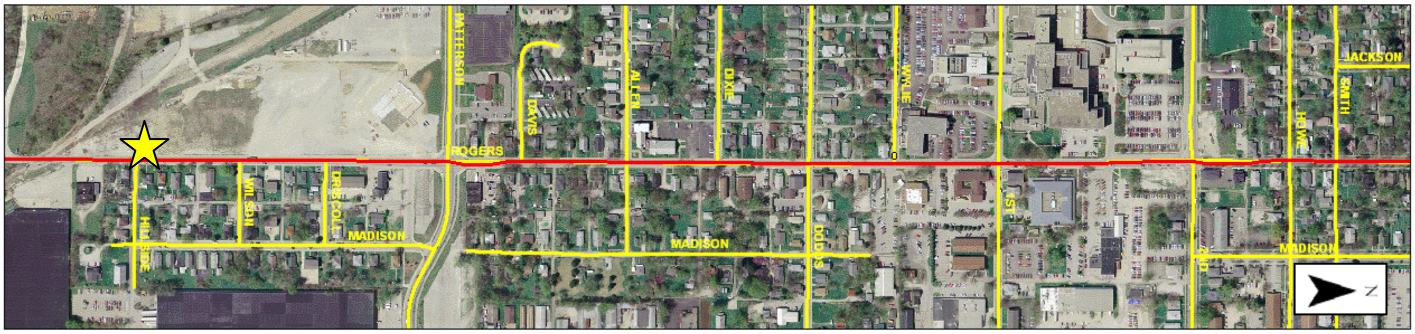
77-Rogers Street & Wilson Street, Facing North

78-Rogers Street & Wilson Street, Facing West

79-Rogers Street & Wilson Street, Facing South

80-Rogers Street & Wilson Street, Facing East

Rogers Street and Hillside Street Intersection



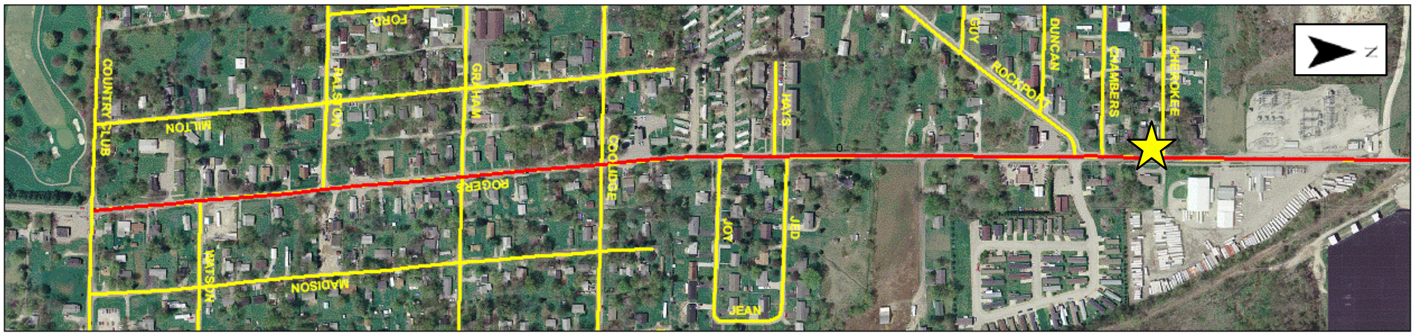
81-Rogers Street & Hillside Street, Facing North

82-Rogers Street & Hillside Street, Facing West

83-Rogers Street & Hillside Street, Facing South

84-Rogers Street & Hillside Street, Facing East

Rogers Street and Cherokee Dr Intersection



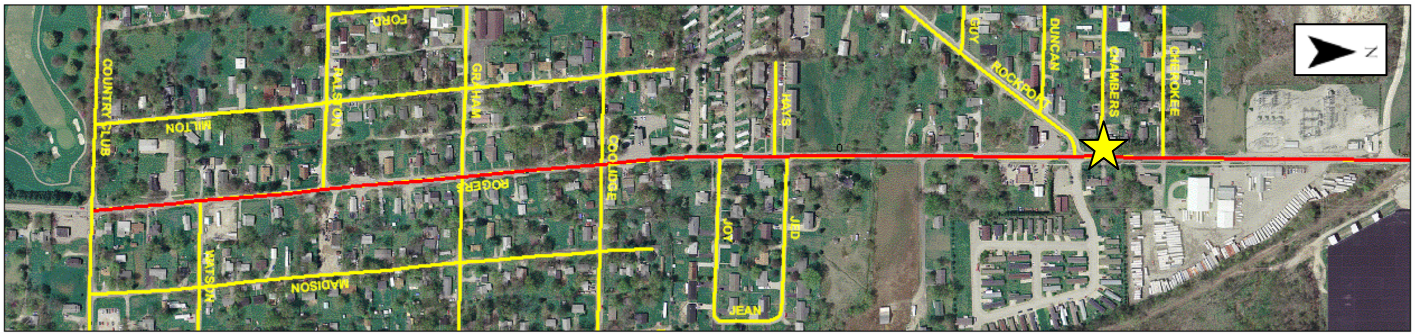
85-Rogers Street & Cherokee Dr, Facing North

86-Rogers Street & Cherokee Dr, Facing West

87-Rogers Street & Cherokee Dr Street, Facing South

88-Rogers Street & Cherokee Dr, Facing East

Rogers Street and Chambers Drive Intersection



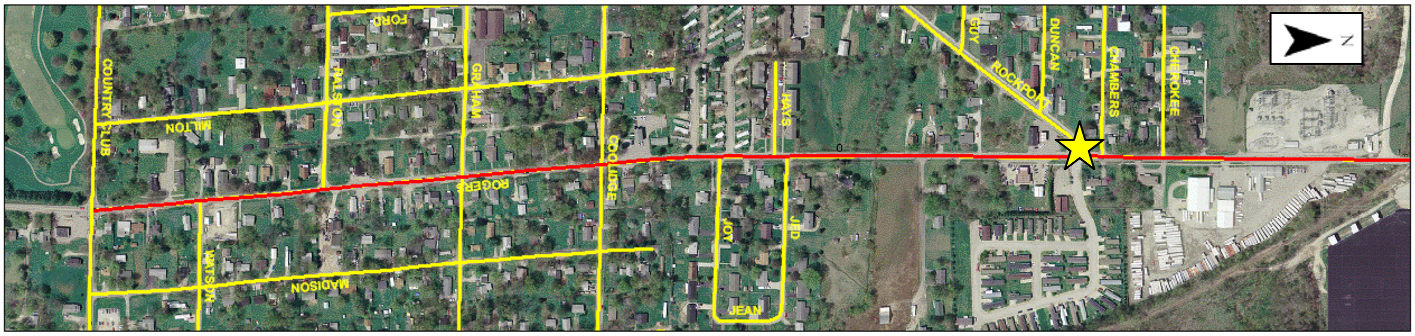
89-Rogers Street & Chambers Drive, Facing North

90-Rogers Street & Chambers Drive, Facing West

91-Rogers Street & Chambers Drive, Facing South

92-Rogers Street & Chambers Drive, Facing East

Rogers Street and Rockport Road Intersection



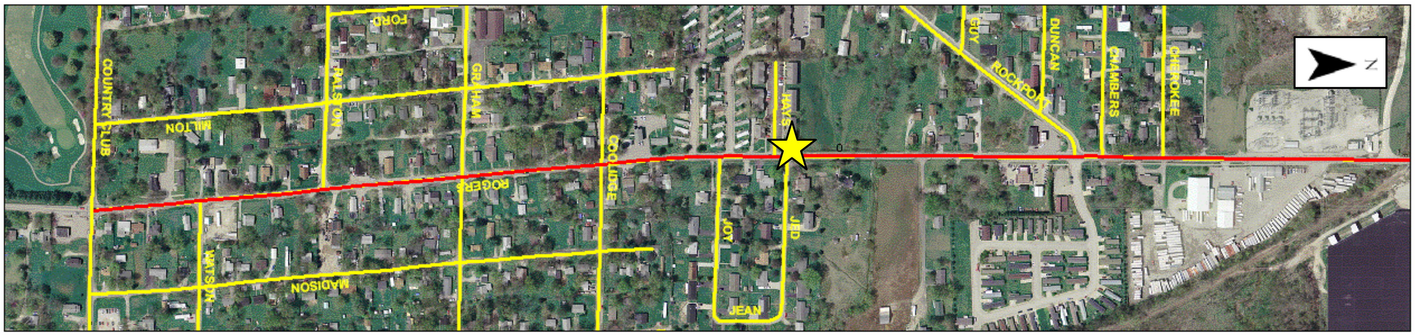
93-Rogers Street & Rockport Road, Facing North

94-Rogers Street & Rockport Road, Facing West

95-Rogers Street & Rockport Road, Facing South

96-Rogers Street & Rockport Road, Facing East

Rogers Street and Jed Street Intersection



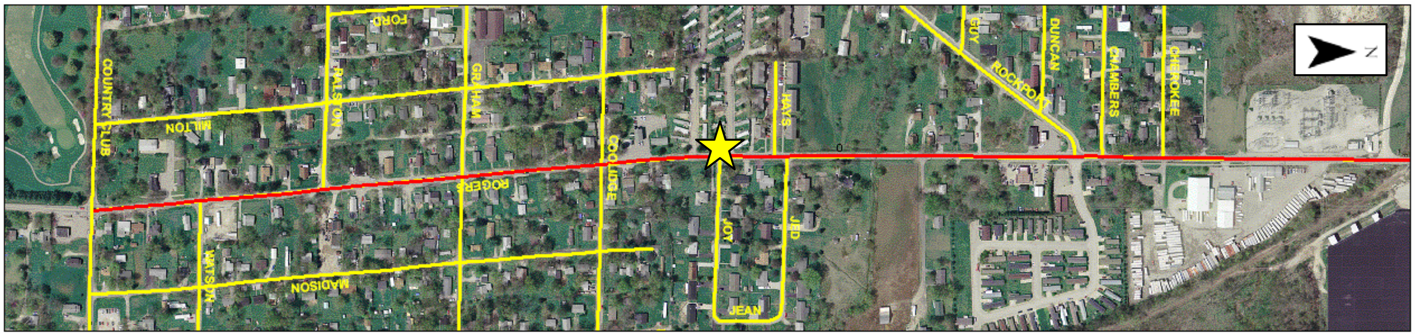
97-Rogers Street & Jed Street, Facing North

98-Rogers Street & Jed Street, Facing West

99-Rogers Street & Jed Street, Facing South

100-Rogers Street & Jed Street, Facing East

Rogers Street and Joy Street Intersection



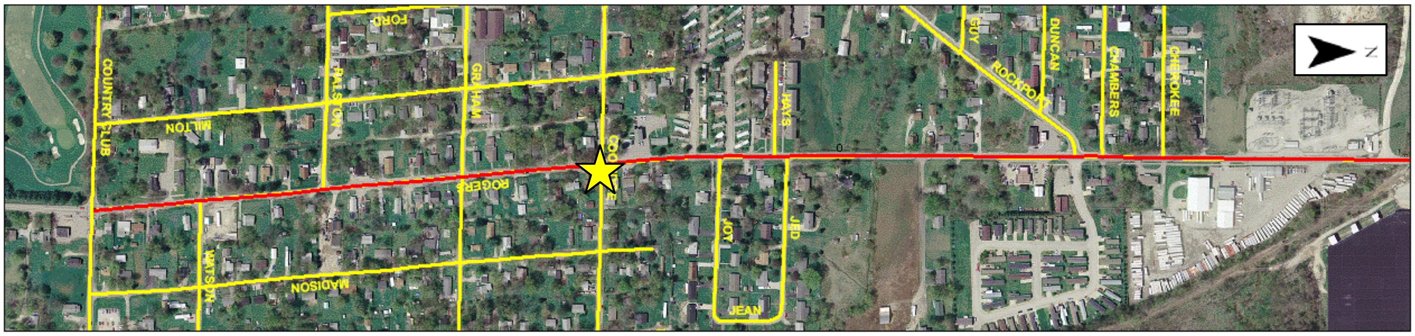
101-Rogers Street & Joy Street, Facing North

102-Rogers Street & Joy Street, Facing West

103-Rogers Street & Joy Street, Facing South

104-Rogers Street & Joy Street, Facing East

Rogers Street and Coolidge Drive Intersection



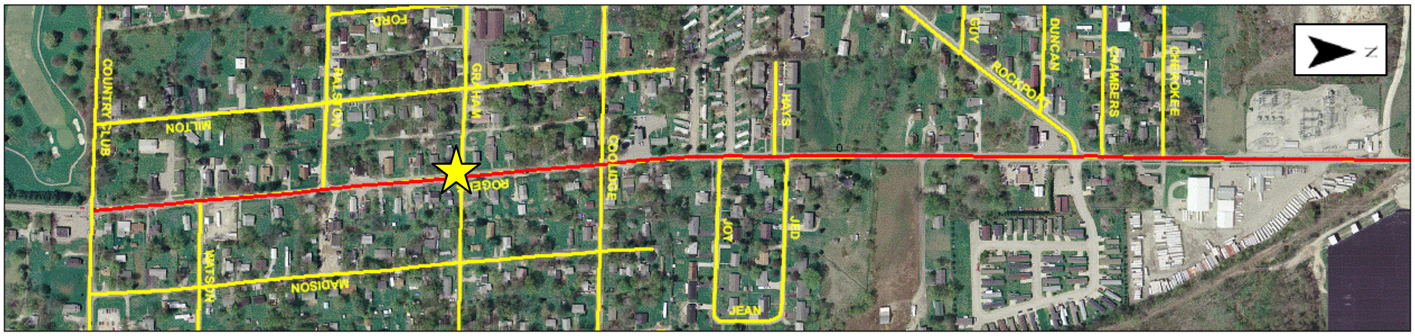
105-Rogers Street & Coolidge Dr, Facing North

106-Rogers Street & Coolidge Dr, Facing West

107-Rogers Street & Coolidge Dr, Facing South

108-Rogers Street & Coolidge Dr, Facing East

Rogers Street and Graham Drive Intersection



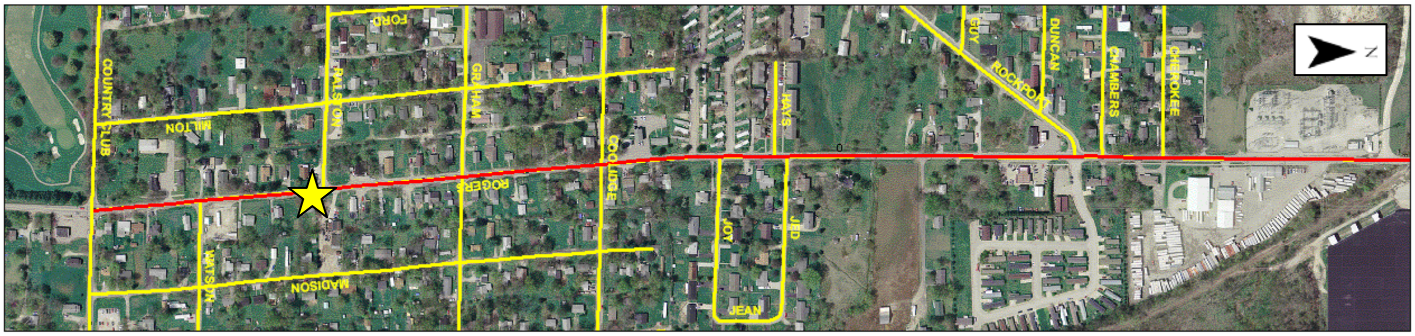
109-Rogers Street & Graham Dr, Facing North

110-Rogers Street & Graham Dr, Facing West

111-Rogers Street & Graham Dr, Facing South

112-Rogers Street & Graham Dr, Facing East

Rogers Street and Ralston Drive Intersection



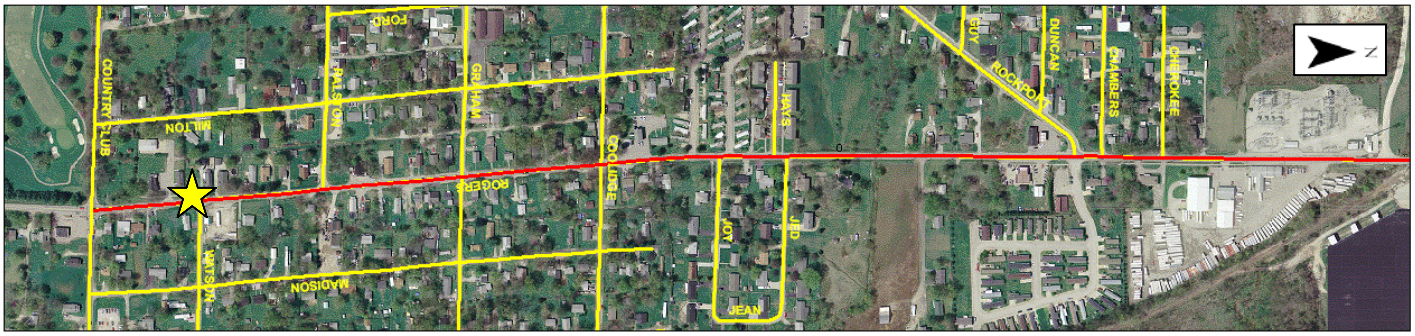
113-Rogers Street & Ralston Dr, Facing North

114-Rogers Street & Ralston Dr, Facing West

115-Rogers Street & Ralston Dr, Facing South

116-Rogers Street & Ralston Dr, Facing East

Rogers Street and Watson St Intersection



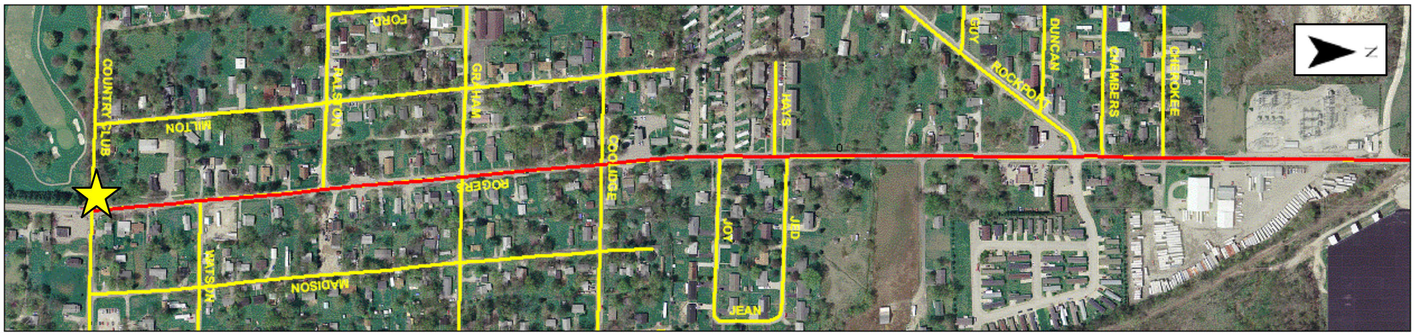
117-Rogers Street & Watson St, Facing North

118-Rogers Street & Watson St, Facing West

119-Rogers Street & Watson St, Facing South

120-Rogers Street & Watson St, Facing East

Rogers Street and Country Club Intersection



121-Rogers Street & Country Club, Facing North

122-Rogers Street & Country Club, Facing West

123-Rogers Street & Country Club, Facing South

124-Rogers Street & Country Club, Facing East

APPENDIX B – CODES AND REGULATIONS

B.1 Introduction to Codes and Regulations

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street Corridor. The purpose of this appendix is to summarize the codes and guidelines that have aided Atlas Engineering in ensuring that the final report meets state and federal regulations as well as the expectations of the local community. Indiana Department of Transportation (INDOT) and American Associations of State Highway Transportation Officials (AASHTO) guidelines have been summarized as they pertain to the Rogers Street Corridor. Context Sensitive Solutions and Low Impact Development guidelines have also been assessed in this appendix.

B.2 INDOT 2006 Standard Specifications Book

Atlas Engineering's complies with the guidelines set forth in the Indiana Department of Transportation's(INDOT) *2006 Standard Specifications Book*(INDOT, 2006). The *2006 Standard Specifications Book* provides useful information for the development of details such as road width, pavement structure, and right-of-way. According to Indiana law, the specifications must be followed in the design of any transportation system within the state of Indiana. Atlas Engineering has used these specifications to design pavement thickness and grade. The *Standard Specification Book* has also been used for the design of many other various aspects of our corridor, including:

- Proper removal and relaying of concrete, stone-slab, and brick sidewalk
- Finishing of the shoulders, curbing, gutters, and shoulder drains
- Design of traffic control devices

B.3 AASHTO Guide for the Development of Bicycle Facilities

Atlas Engineering has used the guidance of the AASHTO *Guide for the Development of Bicycle Facilities* (AASHTO, 1999) for many of the various design aspects for the intersection of Rogers Street and the B2 Multiuse Trail that currently exist in the City of Bloomington. The *Guide for the Development of Bicycle Facilities* provides guidelines for the most practical alternatives for the design of trail/road intersections. Other design characteristics that have been aided by the guidelines are drainage, shared roadways, bike lanes and widths, and traffic issues.

B.4 AASHTO Policies on Geometric Design of Highways and Streets

Atlas Engineering has used AASHTO's *A Policy on Geometric Design of Highways and Streets* (2004), also referred to as the AASHTO Green Book, in the road-design process. This reference aided in the creation of a cost-effective solution that provides operational efficiency, comfort, safety, and convenience for the consumer. According to AASHTO, Rogers Street is classified as an urban arterial. Therefore, chapter seven of the book provides applicable specifications. The AASHTO Green Book provides the minimum requirements for grade, alignment, cross slope, vertical clearances, lane widths, and curbs and shoulders.

B.5 Indiana Department of Environmental Management

The Indiana Department of Environmental Management (IDEM) is responsible for administering the state's stormwater management program. Rule 13 is Indiana's version of Phase II of the Clean Water Act; it outlines the processes used to improve or maintain the quality of stormwater. Rule 13 requires specific entities to apply for a permit before draining stormwater into the state's water bodies (almost any stream). Atlas Engineering used this code (see Appendix F) to ensure satisfactory treatment of stormwater and to examine stormwater run-off pollution into Bloomington's water bodies.

B.6 Low Impact Development

Atlas Engineering has used the *Natural Approaches to Stormwater Management* (2006) that is enacted by the Lacey City Council in Washington State, since the City of Bloomington and the state of Indiana do not currently have an ordinance. There are four guidelines that must be acknowledged in order for the development of Rogers Street to meet Low Impact Development (LID) practices: runoff volume control, peak runoff rate control, flow frequency duration control, and water quality control. The LID guidelines which have been essential to the redesign of the Rogers Street Corridor are the design of bio-retention swales and rain gardens along the road which aid in avoiding stormwater discharging directly into streams.

B.7 Context Sensitive Solutions

The use of Context Sensitive Solutions (CSS) is intended to maintain the current environmental conditions of local roads. Atlas Engineering has used CSS guidelines from the National Cooperative Highway Research Program (Neuman, 2003) to develop a plan that meets the specialized needs of the client and site, rather than using generalized codes referenced in the AASHTO Green Book on highway design. Part of using CSS designs is seeking public involvement from the beginning of the project. For the Rogers Street corridor, such involvement will be made by the city of Bloomington's Citizen's Advisory Committee (CAC). The CAC consists of individuals representing the opinions of their local neighborhood.

B.8 Americans with Disabilities Act

The Americans with Disabilities Act (ADA) established the *Accessibility Guidelines for Buildings and Facilities* (ADAAG) in 1990. The document outlines standard requirements for the accessibility of buildings and facilities by individuals with disabilities. Atlas Engineering has used the ADAAG document when designing the sidewalks, slopes, curb ramps, and parking and passenger loading zones along the Rogers Street corridor.

B.9 Manual on Uniform Traffic Control Devices

The Manual on Uniform Traffic Control Devices, or MUTCD, defines the standards by which road managers nationwide install and maintain traffic control devices on all streets and highways. Atlas Engineering has used the MUTCD for several areas of the corridor, most notably appendix I – Traffic Control Plan, as well as Appendix J – Plans and Specifications. The code was used for the multiuse trail's street crossing, proper roadway signage, proper detour and construction signage, and other various roadway specifications set forth in Atlas' design.

B.10 References

Indiana Department of Transportation 2006 Standard Specifications Book, 2006. Indiana Department of Transportation. Retrieved 20 Oct. 2006, from source <http://www.ai.org/dot/div/contracts/standards/book/index.html>.

Guide for the Development of Bicycle Facilities, American Association of State and Highway Transportation Officials Task Force on Geometric Design, 1999.

A Policy on Geometric Design of Highways and Streets (Green Book), American Association of State and Highway Transportation Officials, 1994.

Indiana Department of Environmental Management. *Stormwater Pollution*. October 7, 2006, from source http://www.in.gov/idem/

Government of Monroe County, Indiana. *Storm Water Quality Home Page* and *Rule 13*. October 7, 2006, from source <http://www.co.monroe.in.us/stormwaterquality/>

Low Impact Development (LID) Practices for Storm Water Management. September 24, 2006, from source <http://www.toolbase.org/TechInventory/techDetails.aspx?ContentDetailID=909>

Natural Approaches to Stormwater Management. September 24, 2006, from source <http://www.psat.wa.gov/Publications/LID_studies/ordinances_regulations.htm>

Neuman, Timothy R., et al. "National Cooperative Highway Research Program Report 480: A Guide to Best Practices for Achieving Context Sensitive Solutions." Transportation Reasearch Board 24 April 2003.

Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities. November 16, 2006, from source <http://www.access-board.gov/adaag/html/adaag.htm#purpose >

Federal Highway Administration (FHWA). (2004). *Manual on Uniform Traffic Control Devices*. 2003 ed., Rev.1. Washington, D.C.: FHWA.

APPENDIX C – PRELIMINARY FEASIBILITY STUDY

C.1 Introduction

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street Corridor. The purpose of this appendix is to assess if the redevelopment of the Corridor is feasible for the proposed site. Property locations, zoning, available utilities, and access requirements, topography of the land, soils, streams, wetlands, and floodplains were examined in the assessment.

C.2 Tract Location

The Rogers Street Corridor is located in Bloomington, Indiana which is approximately 55 miles southwest of Indianapolis (Figure C1.0). Atlas Engineering's design will focus on a 2.5 mile segment that intersects Tapp/Country Club Road to the south and 11th Street to the north (Figure C1.1). Rogers Street is a major north/south connector in the city; connecting several established neighborhoods, including parts of downtown Bloomington.

C.3 Zoning/Comprehensive Plan

The Rogers Street Corridor contains several different categories of zoning types, and they are labeled and displayed in Figure C2.0. The four zone categories present in the corridor are commercial, industrial, and residential. Because Atlas Engineering will not be doing any site development, rezoning will not be considered at any point during design. The construction phase of the historical district poses a significant challenge in maintaining context sensitive design, because the preservation of certain elements of Bloomington's history, such as historic buildings, sites, and other significant resources, is vital to the project. Any exterior alterations that will occur within Prospect Hill's Historical District must be carefully reviewed and approved by the Historic Preservation Planner (HPP) prior to the beginning of any work.

C.4 Utility Availability

Water: According to the City of Bloomington GIS information, a main water line runs below the street along portions of Rogers Street. Atlas Engineering will not disturb the water line in its current location (Figure C3.0).

Sanitary Sewer: According to the City of Bloomington GIS information, sanitary sewer pipelines also run below the street along portions of the corridor. The utilities department from the City of Bloomington stated that no further installation of sanitary sewer pipelines were required (Figure C3.0).

Storm Sewer: According to the City of Bloomington GIS information, there are no storm sewer lines located anywhere in the corridor itself. However, storm sewer lines do cross Rogers Street in multiple locations throughout the 2.5 mile segment and run adjacent to several connecting roads. Atlas Engineering will incorporate a complete stormwater design and will establish a stormwater outlet for the new pipelines along the corridor in the final design plans (Figure C3.0).

Electric: There are no underground power lines. However, overhead power lines run along the site. As requested by the client, Atlas Engineering will not be expected to move any power lines from their current overhead position to underground locations.

Gas: Underground gas lines are 6-inch lines that run below the entire length of Rogers Street. As directed by the client, Atlas Engineering will not be expected to design or modify underground gas lines.

C.5 Transportation/Access Requirements

Being a major north/south corridor for the city of Bloomington, the 2.5 mile segment of Rogers Street is accessible at many locations. Major access points along the 2.5 mile project site include Third Street, Patterson Street, Rockport Street, Coolidge Road, and Country Club Drive. The main east/west entrance into the city is State Road 46, which intersects Rogers Street at the northern end of the corridor. For more detailed street intersections, refer to Figure C4.0.

C.6 Site Characteristics and Topography

The Rogers Street Corridor consists of single family houses, commercial buildings, and Bloomington Hospital. Abandoned railroad tracks are located east of Patterson Street and cross Rogers Street near the center of Atlas' 2.5 mile segment. The intersection of Rogers Street with an existing multi-use trail, south of Hillside Street, will need to be realigned (the multi-use trail) to cross at a ninety degree angle. The city has already completed a preliminary design of this realignment and it will be incorporated into Atlas' final plan drawings of the corridor. Site characteristics and topographical information are available on Figure C5.0.

C.7 Soils

Atlas Engineering has reviewed the 1981 Soil Conservation Service (SCS) Survey of Monroe County, Indiana, for preliminary geotechnical information and present soil conditions on the site (Figure C6.0). Table C-1 lists the current soil types located on the site according to the soil survey and the percentages of each soil type.

Table C.1: Present soil types and characteristics (Soil Conservation Service, 1981)

Soil Name	Symbol	% of Site	Drainage	Permeability	Available Water Capacity	Erosion Hazard
Caneyville Silt Loam, 12-18% slope	CaD	25	Well	Mod Slow	Low	Moderate
Crider-Urban Land Complex, 2-6% slope	CtB	20	Low	Moderate	High	Slight
Crider-Urban Land Complex, 6-12% slope	CtC	12	Low	Moderate	High	Slight
Haymond Silt Loam	Hd	15	Well	Moderate	Very High	Slight
Wakeland Silt Loam	Wa	15	Low	Mod Slow	Very High	Slight
Udorthents, Loamy	Ua	13	Low	Mod - Mod Slow	Moderate	High

Caneyville Silt Loam is not good for building and road construction. This soil has low strength, is moderately sloped, and has a rapid surface runoff. A strong sub-grade is needed in order to prevent soil failure in the case of future development.

Crider-Urban Land Complex soils are not good for building and road construction because of their low strength, especially for slopes less than 12%. A strong sub-grade is needed in order to prevent soil failure in the case of future development; and, the SCS recommends a more detailed on-site soil investigation for this soil type.

Haymond Silt Loam and Wakeland Silt Loam are not good for building and road construction because of the soils' frequent flooding and frost action. Fill is required in order to prevent soil failure in the event of future development.

Udorthents, Loamy has variable soil materials and conditions. This soil is highly susceptible to hazardous erosion and SCS recommends a more detailed on-site soil investigation.

C.8 Streams

A stream was found in the vicinity of the project leading to a creek. The stream should not impact this project since the road is already in existence. (Figure C7.0).

C.9 Wetlands

Wetlands were found in the vicinity of the corridor. The wetland should not impact this project since the road is already in existence (Figure C8.0).

C.10 Floodplain

The 100-year flood maps for the City of Bloomington were reviewed for the possible existence of floodplains in the vicinity of the project site. A creek is located in the vicinity of the project within the 100-yr floodplain (Figure C9.0). Again, the creek and corresponding floodplain should not impact this project significantly since the road is already in existence.

C.11 Qualifier

The purpose of this Preliminary Feasibility Study is to determine the possibility of improving the design of the Rogers Street Corridor to meet current and future transportation needs. The information presented herein was obtained from public officials and government agencies whose opinions are generally reliable and sufficient for preliminary planning purposes.

It should be noted that this study is an initial step for the project's development. This investigation should be taken as a source of information for future development.

C.12 Recommendation

After examining the site, Atlas Engineering recommends that the Bloomington MPO continue with redevelopment of the site. A thorough soil investigation analysis should be conducted so that Atlas can provide proper design alternatives for the corridor. The City of Bloomington currently owns a core drill, and test results from the core drill would provide Atlas a more detailed soil analysis. There are several key reasons that a geotechnical investigation would aid in the overall design and improvement of the corridor. Proper soil information is useful for drainage information and for indicating probable settlement problems in design. It can also be useful for incorporating Low Impact Development Guidelines and proper pavement design.

C.13 References

Soil Conservation Service. *Soil Survey of Monroe County, Indiana,* series 1994, U.S. Department of Agriculture and Soil Conservation Service, Washington, D.C., 1994

City of Bloomington GIS FTP Site. *City of Bloomington Metropolitan Planning Organization.* December 2006.

Indiana Spatial Data Service. *Indiana University Information Technology Services*. http://www.indiana.edu/~gisdata/ (December 2006)

A GIS Atlas for Indiana. *Indiana Geological Service*. http://129.79.145.7/arcims/statewide_mxd/index.html (December 2006)

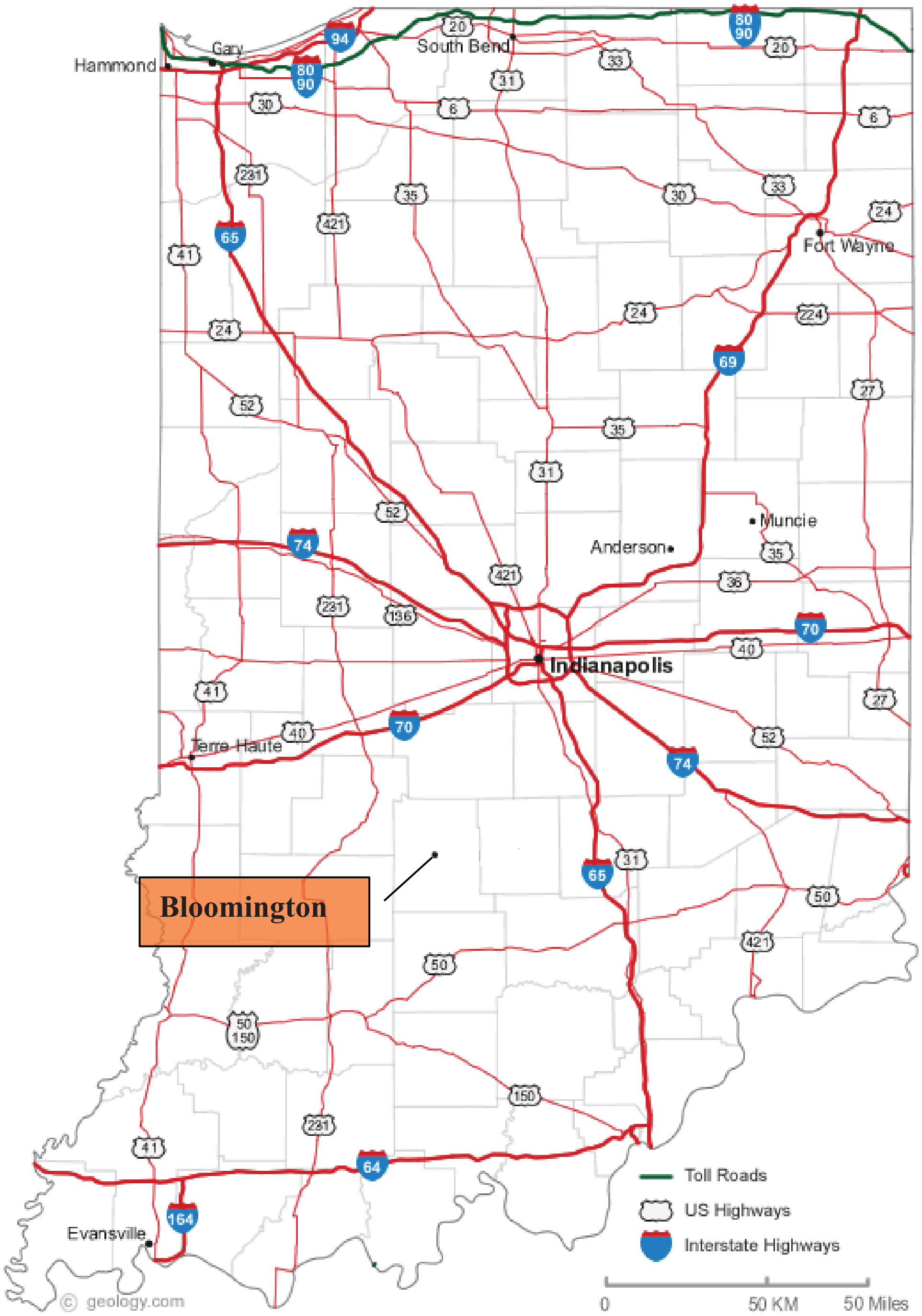


Figure C1.0: Location of Bloomington, Indiana
(Adapted from Indiana State Map Collection, Geology.com)

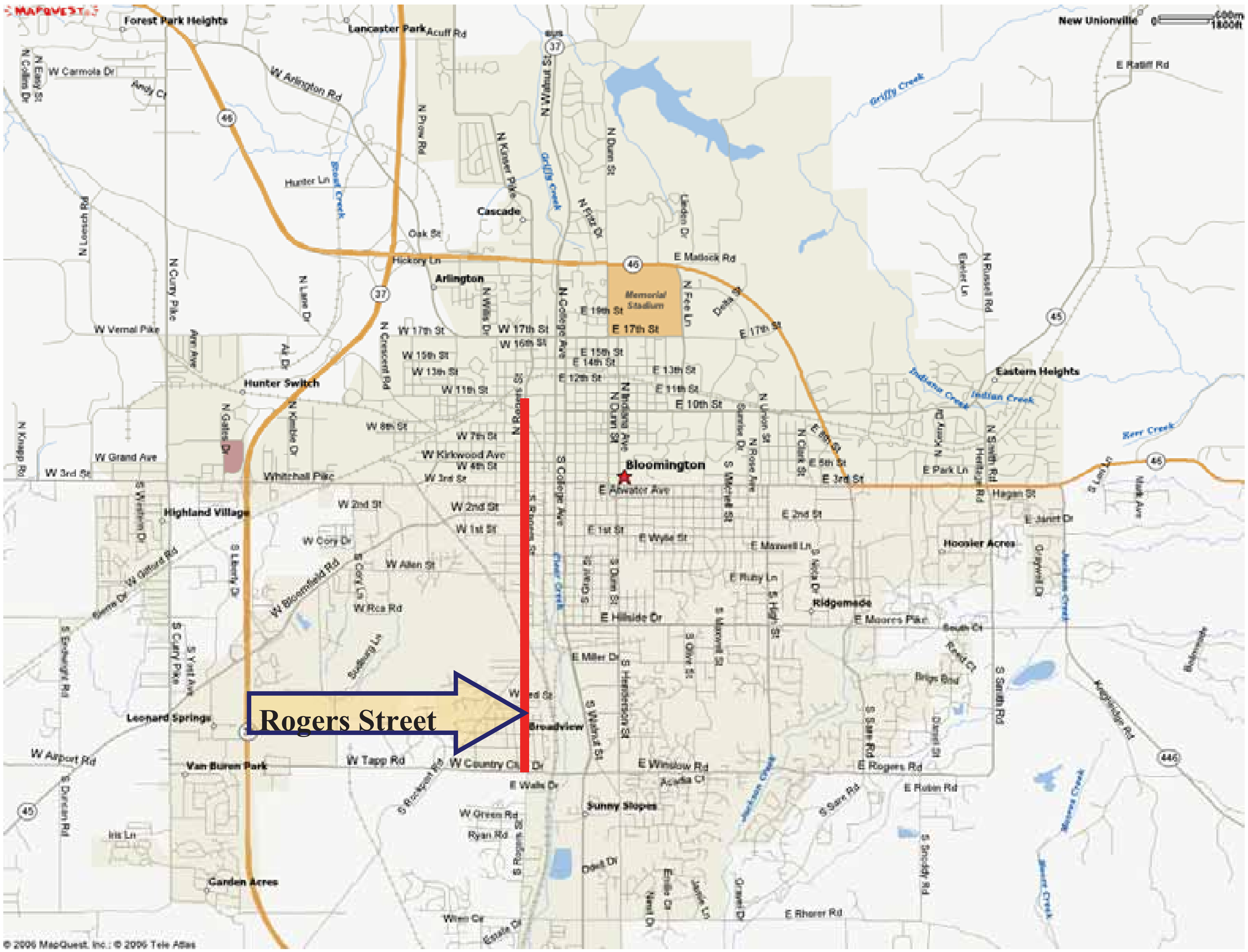
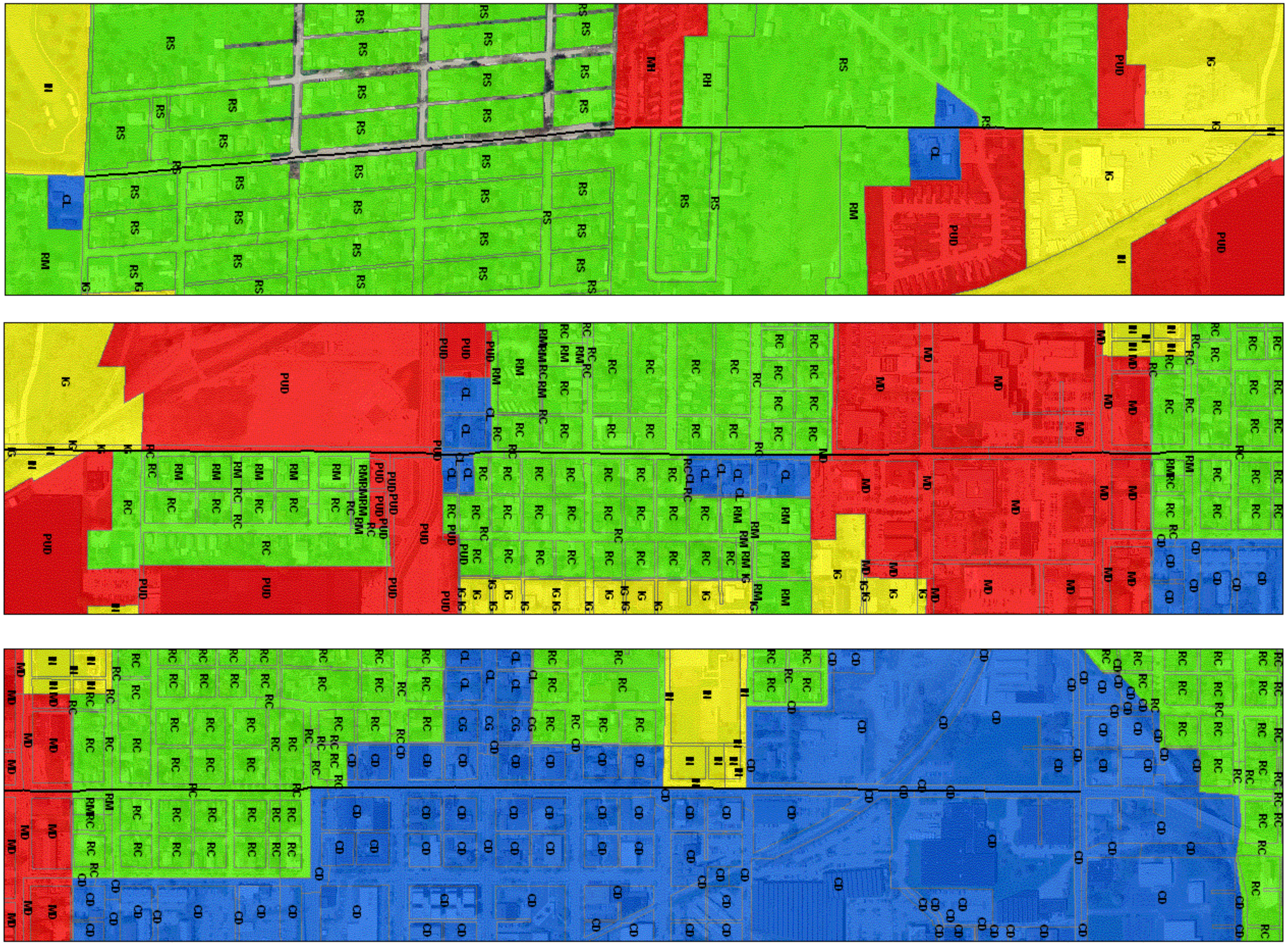


Figure C1.1: Map of Bloomington with Rogers Street Highlighted
(Adapted from Mapquest, 2006)

Figure C2.0: Zoning Districts



Legend

Rogers Street Centerline

rogers_zoning

Zoning

- CA, CD, CG, CL — Commercial
- IG, IN — Industrial
- MD, MH, PUD — Municipalities/Public
- RC, RH, RM, RS — Residential

N

1 inch equals 300 feet

Atlas Engineering, Inc.

Figure C3.0: Utilities

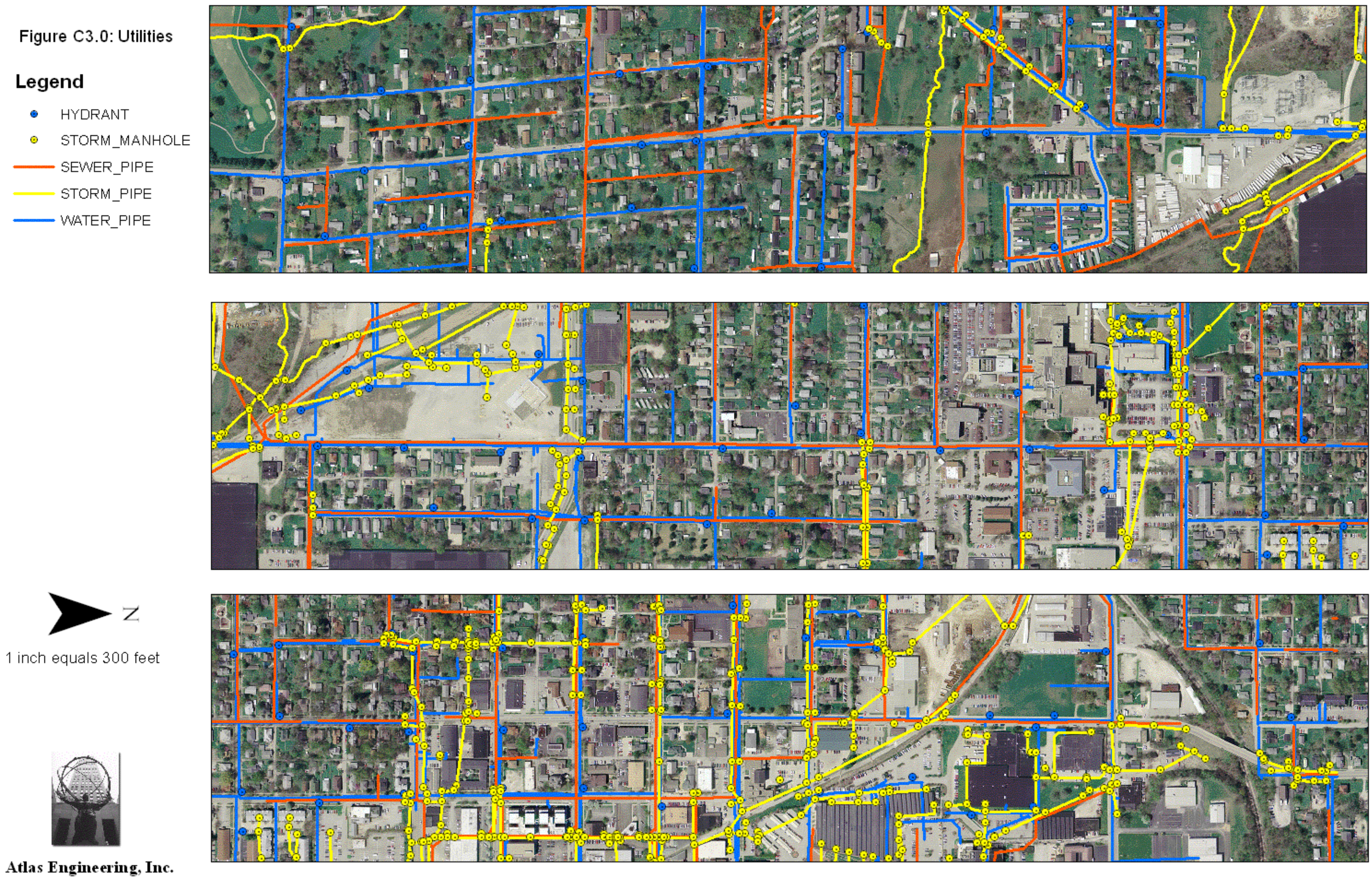
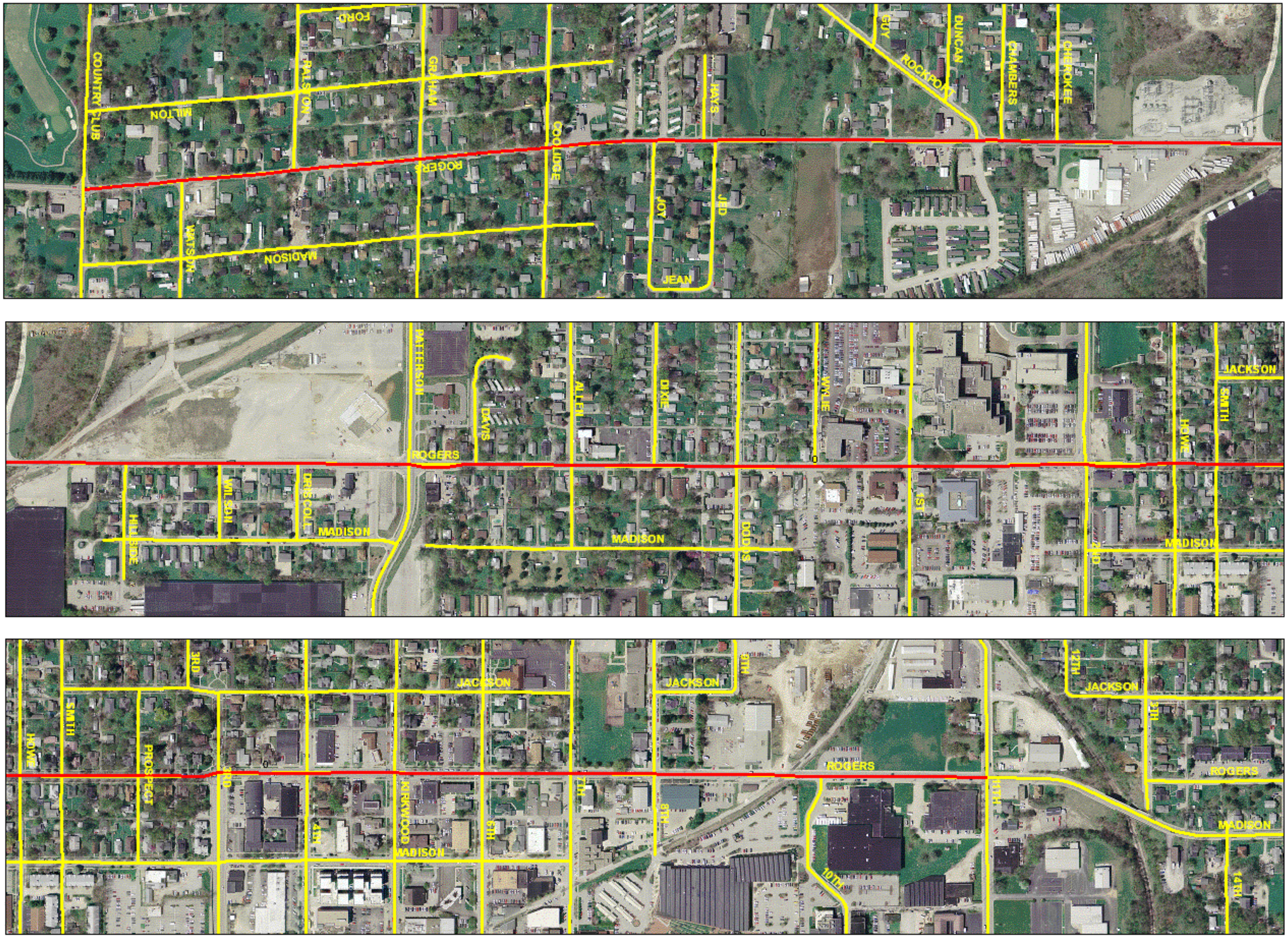


Figure C4.0: Major Roads

Legend

Rogers Street Centerline

Rogers_Corridor_Roads



N

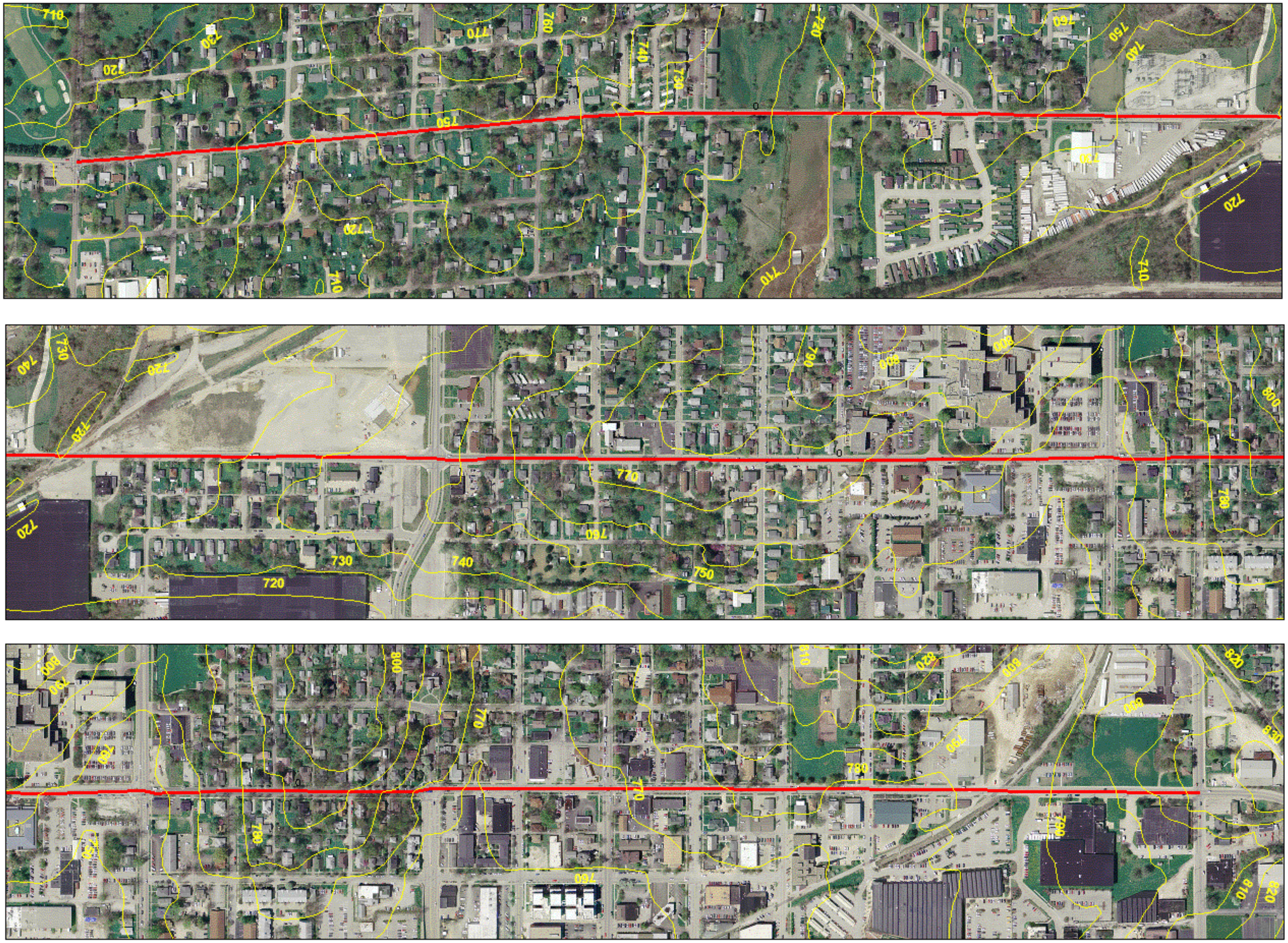
1 inch equals 300 feet

Atlas Engineering, Inc.

Figure C5.0: Topography

Legend

- Contours_24K_USGS_Bloomington
- Rogers Street Centerline

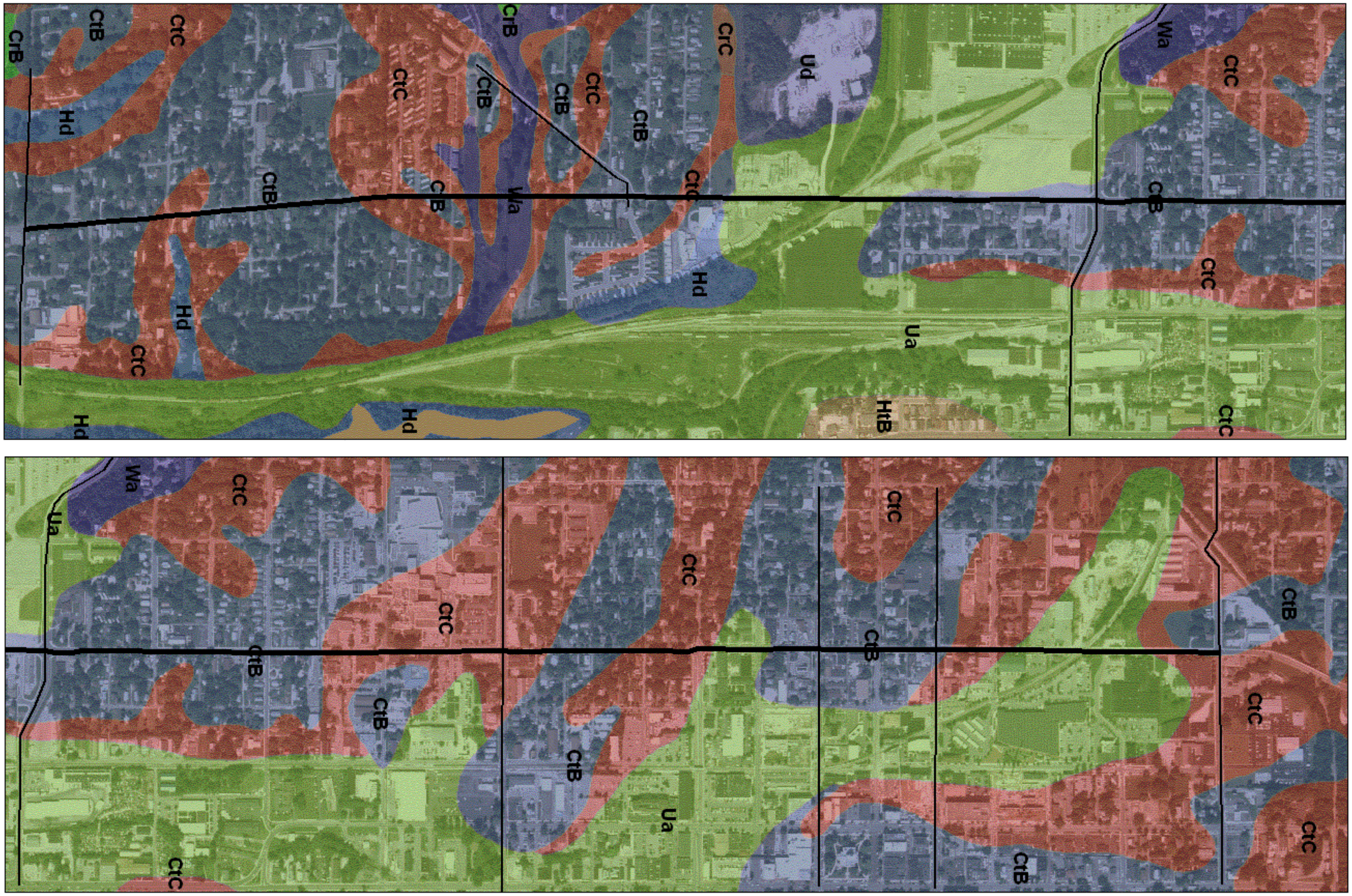


N

1 inch equals 400 feet

Atlas Engineering, Inc.

Figure C6.0: Soils

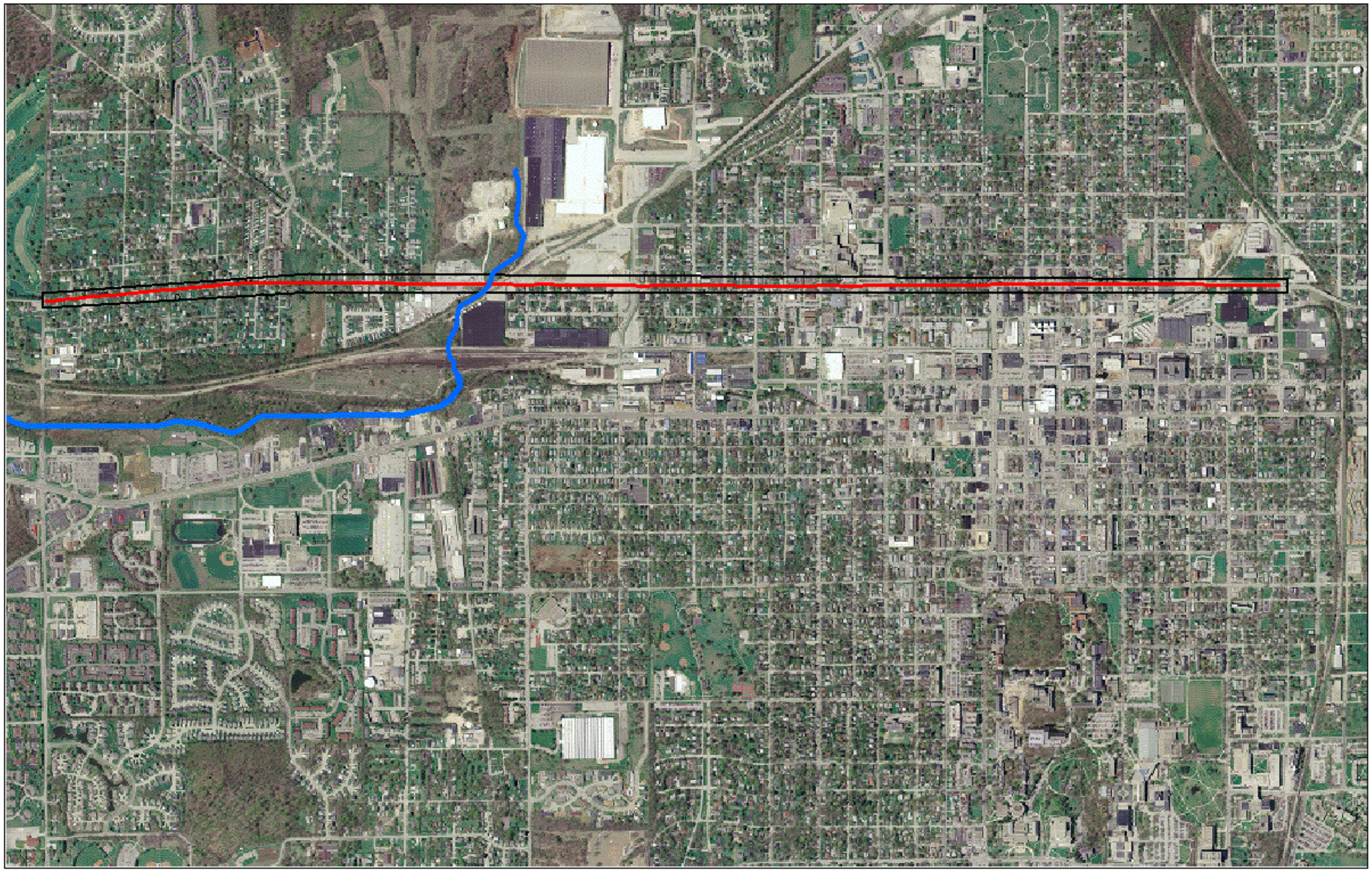


Atlas Engineering, Inc.

Figure C7.0: Streams

Legend

- Streams
- Rogers Street Centerline
- Roger Street Corridor

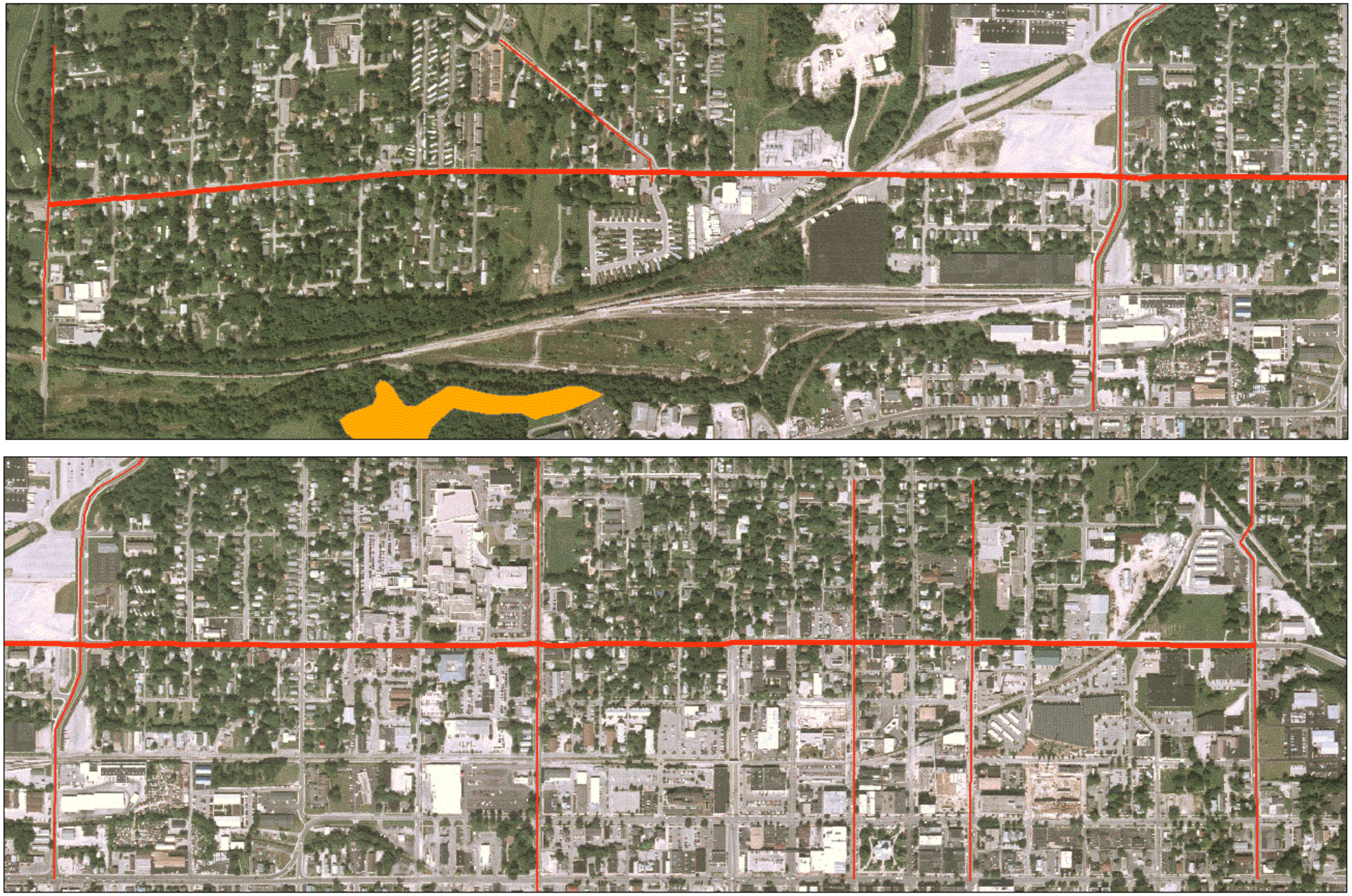


N

1 inch equals 1,200 feet

Atlas Engineering, Inc.

Figure C8.0: Wetlands



Legend

- Rogers Street Centerline
- Major Intersections - Rogers
- Wetlands

N

1 inch equals 600 feet

Atlas Engineering, Inc.

Figure C9.0: 100-Year Floodplains

Legend

Floodplains

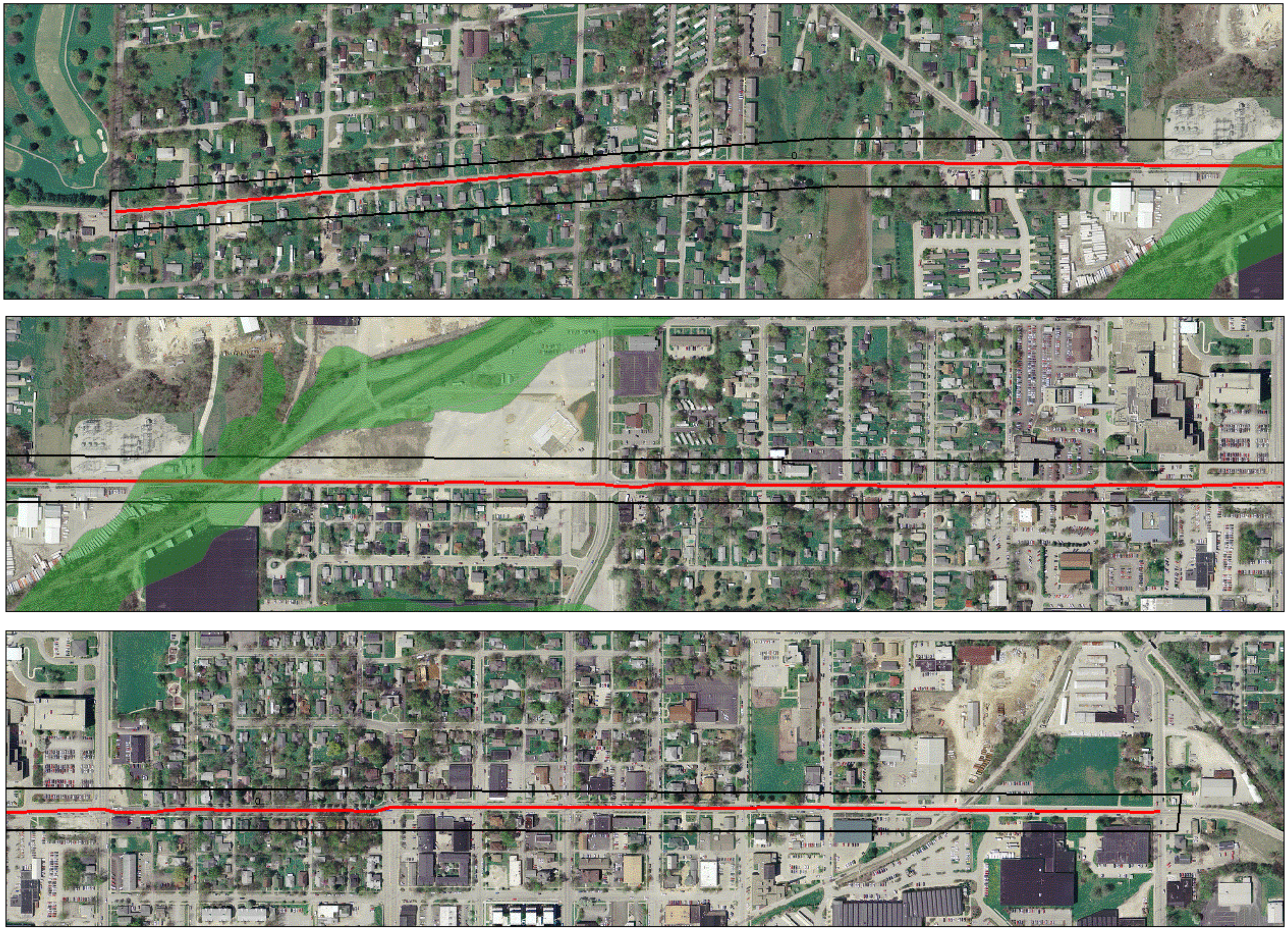
FLOOD ZONE

- A
- AE
- AH
- AO
- X
- Rogers Street Centerline
- Roger Street Corridor

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.
ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.
ZONE X	Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.
ZONE X	Areas determined to be outside 500-year flood plain.
ZONE D	Areas in which flood hazards are undetermined.

N

1 inch equals 400 feet



Atlas Engineering, Inc.

APPENDIX D – DESCRIPTION OF TRANSPORTATION CORRIDOR OPTION

D.1 Introduction

Atlas Engineering has developed three distinct options for the redesign of the Rogers Street Corridor in Bloomington, Indiana. While each of these options will improve transportation and provide aesthetic enhancement to the corridor, each has several important differences, which are summarized below. In conjunction with the client and the Bloomington C.A.C., Atlas Engineering has recommended Option 3 – the Rogers Street corridor including the implementation of a multiuse trail, for the future of Rogers Street. Despite the fact that Option 3 has been designed in full, descriptions of Options 1 and 2 are summarized here for comparative purposes.

D.2 Description of Option 1:

Bicycle lanes on both sides of the corridor throughout the Rogers Street corridor

Each of the figures shown in this option, Figures 1A, 1B, 1C, and 1D, provide for a five or six foot bike lane to be placed on both sides of Rogers Street throughout the length of the corridor, excluding the areas in which right-of-way is not available (designated as "0 right-of-way" in Table D.1).

Impact on Local Businesses and Neighborhoods: This option would provide safer and more efficient conditions for bicyclists throughout the corridor; however, construction would have a considerable impact on local businesses. Bloomington Hospital, by contrast, should not be significantly affected by this option or options 2 & 3 because phased construction implementation and careful detour routing has been analyzed. For more information regarding phased construction and detour routing, see Appendix I – Traffic Control Plan. Atlas Engineering's design attempts to minimize the increase in the amount of travel time to Bloomington Hospital as much as possible.

Feasibility: Constructing either one or two bicycle lanes would be economically feasible, given the budget presented to Atlas via the client. The preliminary cost estimate of this option is $3,050,000 (Refer to Table D.2: Mean's Manual Preliminary Cost Estimate – Option 1).

Transportation Improvement: This option will improve conditions for bicyclers with the addition of bicycle lanes; however, due to limited and varying amounts of right-of-way, emergency vehicles will be forced to navigate slightly more restrictive driving lanes of 11 feet and 11.5 feet throughout areas of the corridor, as opposed to standard 12 feet driving lanes. The level of service will not be increased significantly in this option, as it does not provide for the addition of any turning lanes throughout the corridor

Public Support: The Citizen's Advisory Committee (CAC) has expressed that Option 1 is the least desired of the three options presented, which will be reflected in the rating given to this option in the decision matrix shown in Appendix E.

D.3 Description of Option 2:

The Rogers Street corridor without the implementation of bicycle lanes or a multiuse trail

Each of the figures shown in this option, Figures 2A, 2B, 2C, 2D, and 2E provide for standard twelve feet driving lanes without the addition of a bicycle lane or multiuse trail. While this option would not provide significant amounts of change along the corridor, it would still increase the amount of green space and on-street parking available throughout Rogers Street. The level of service will also be increased with the addition of a turning lane in several areas where sufficient right-of-way is available.

Impact on Local Businesses and Neighborhoods: This option would not improve service to bicyclists and construction would still have a considerable impact on local businesses.

Feasibility: This option is also economically feasible. Atlas Engineering's Preliminary cost estimate for this option is $3,200,000 (Refer to Table D.3: Mean's Manual Preliminary Cost Estimate – Option 2). Similar to Option 1, Bloomington Hospital should not be significantly affected by this option or either options because phased construction implementation and careful detour routing will be analyzed.

Transportation Improvement: Similar to option 1, driving lanes of 11.5 feet must be used in certain areas due to limited right-of-way and the implementation of green space as an aesthetic improvement to the corridor. However, an advantage of this option is the addition of parallel parking lanes as well as turning lanes which would improve the level of service throughout certain areas of the corridor.

Public Support: The CAC has expressed that Option 2 is the second-rated option of the three options presented, which will be reflected in the rating given to Option 2 in the decision matrix shown in Appendix E.

D.4 Description of Option 3:

The Rogers street corridor including the implementation of a multiuse trail (*Recommended Option*)

Each of the figures shown in this option, Figures 3A, 3B, 3C, and 3D incorporate the addition of an eight foot multiuse trail into the Rogers Street corridor. Opposed to bicycle lanes, which can obviously accommodate bicyclists only, a multiuse trail is intended for use by pedestrians, bicycles, rollerblades, skateboards, etc. This multiuse trail would connect directly into the multiuse trail of an ongoing project on the southern end of the Rogers Street corridor led by Brock Ridgway of Eagle Ridge Engineering Services, LLC. It would also provide greater access to Rogers St. from the existing B-Line multiuse trail located to the east of the corridor.

Impact on Local Businesses and Neighborhoods: This option will greatly improve pedestrian, bicycle, and other forms of non-vehicular transportation throughout the corridor. Construction will have a considerable impact on local businesses, just as options 1 and 2 will.

Feasibility: This option, like options 1 and 2, will also be economically feasible. Atlas Engineering's preliminary cost estimate for Option 3 is $2,675,000 (Refer to Table D.4: Mean's Manual Preliminary Cost Estimate – Option 3); thus, Option 3 is the most cost effective option. Similar to Option's 1 and 2, Bloomington Hospital should not be significantly affected by this option or because phased construction implementation and careful detour routing have been analyzed.

Transportation Improvement: The implementation of a multiuse trail with Option 3 provides a significant increase in the flow of non-vehicular modes of transportation and the presence of turning lanes in certain areas of the corridor will also increase the level of service. It also has a distinct advantage in comparison to Options 1 and 2 in that continuity of the multiuse trail will be maintained on the southern end of the corridor beyond the 2.5 mile segment currently being designed by Atlas Engineering.

Public Support: The CAC has expressed that Option 3 is the most desired option of the three presented to them, which will be reflected in the rating given to Option 3 in the decision matrix shown in Appendix E.

D.5 Sources of Input

These options were developed after receiving input from various individuals in the Bloomington community. Atlas Engineering's transportation corridor alternatives attempted to meet the needs and desires of each of these parties. Input was received from:

- Our client – Scott Robinson, Long Range/Transportation Planner for the City of Bloomington's Metropolitan Planning Organization
- Paul and Elizabeth Cox - representatives from the Citizen's Advisory Committee (CAC)
- Jeff Barlow - fire chief for the City of Bloomington Fire Department
- Jane Fleet – a representative from the City of Bloomington's Utilities Department
- Brock Ridgway – Professional Engineer, Eagle Ridge Civil Engineering Services, LLC
- Pat Martin – Chief Planner for the City of Terre Haute Engineering Department

D.6 Governing Right-of-Way

To develop the cross-sections for the Rogers Street Corridor, Atlas Engineering first used GIS mapping to determine the amount of right-of-way available at each of the thirty-two intersections throughout the length of the corridor. Table D.1 shows how the amount of right-of-way varies significantly throughout the length of the corridor. Because of this variation, the range of values of right-of-way were used to separate the corridor into four distinct regions, over which the minimum value of right-of-way determined the width of the cross-section used for design. For example, Table D.4 shows that the available amount of right-of-way between Watson Drive, Ralston Drive, and Graham Dive. is 42 feet, 43 feet, and 45 feet, respectively. Therefore, the minimum value of 42 feet became the governing cross-sectional width for this region, meaning that the entire area of the Rogers Street corridor between Watson Drive and Graham Drive has been designed to accommodate a 42 foot-wide cross section. This technique was used to determine three other cross-sectional widths of 38 feet, 46 feet, and 65 feet respectively, which could be applied to corresponding regions of the corridor, as shown on Table D.4. Each of our design options, therefore, contains four cross-sectional drawings – one for each of the four governing values of right-of-way.

Table D.1:Right-of-Way Availability and Governing Right-of-Way for the Rogers Street Corridor

Street Intersection	Right - of - way (ft.)	Governing Right-of-Way (ft.)
Eleventh St.	46	46
Tenth St.	47	46
Eighth St.	75	65
Seventh St.	77	65
Sixth St.	74	65
Kirkwood Ave.	74	65
Fourth St.	72	65
Third St.	65	65
Prospect St.	65	65
Smith Ave.	66	65
Howe St.	59	46
Second St.	47	46
First St.	43	42
Wylie St.	38	38
Dodds St.	39.5	38
Dixie St.	39.5	38
Allen St.	40	38
Davis St.	39	38
Patterson St.	67	65
Driscoll St. *(up to 230 ft)	39	38
Wilson/Driscoll Intersection	39	38
Wilson St.*	43	42
Hillside Dr.*	0	0
Cherokee Dr*.	0	0
Chambers Dr.*	0	0
Rockport Rd.*	0	0
Jed St.*	0	0
Joy St.*	0	0
Coolidge St. **(up to 250 ft)	57	46
Coolidge St.	51	46
Graham Dr.	45	42
Ralston Dr.	43	42
Watson Dr.	42	42
Country Club/Tapp Road	0	0

North

South

*Indicates an area where no right-of-way is currently available for redevelopment
**Indicates a right-of–way transition that occurs on a street, not an intersection

D.7 Description of Cross-Sectional Drawings

Within each of the three options created by Atlas Engineering, right-of-way varies significantly. Therefore, for each of the three options that have been created, four separate cross-sectional drawings were created to correspond to the aforementioned governing right-of-way values of 38 feet, 42 feet, 46 feet, and 65 feet, respectively. For option 2 an additional cross-section has been provided for the 65-foot cross section reflecting different amounts of on-street parking, turn lanes, and green space. These cross-sectional drawings are labeled and ordered A through D (Options 1 and 3) or A through E (Option 2). Therefore, Option 1A implies two distinct features: “Option 1” means that bicycle lanes are being implemented on both sides of the corridor and “A” refers to the governing value of 38 feet of available right-of-way. Options 2 and 3 follow this same format.

Option 1 – Bicycle lanes on both sides of the corridor throughout Rogers Street

Each of the drawings shown in this section, Figures 1A, 1B, 1C, and 1D, provide for a five to six foot bike lane to be placed on both sides of the street throughout the length of the corridor, excluding the areas in which right-of-way is not available (designated as 0’s in Table D.4).

Figure 1A, shown on page D-12, is for the 38 foot governing cross section. A five foot bike lane will be included on both sides of the corridor. They will be located between the driving lane and a six inch curb and gutter. Due to the limited right-of-way, driving lanes are restricted to 11.5 feet each, rather than the 12 foot standard

Figure 1B, shown on page D-12, is for the 42 foot governing cross section. Similar to the 38 foot section, a five foot bike lane will be located on both sides of the corridor. This figure differs in the five foot side walk that is placed on the west side of the corridor. Due to the limited right-of-way, driving lanes are restricted to 11 feet each, rather than the 12 foot standard.

Figure 1C, shown on page D-13, is for the 46 foot governing cross section. A five foot sidewalk is included on each side of the street, along with an eight foot bicycle lane and full-size twelve foot driving lanes. One foot of green space is also included along the outside edges of the sidewalks.

Figure 1D, shown on page D-13, is for the 65 foot governing cross section. The larger amount of right-of-way available in this cross section allows for the addition of on-street parallel-parking for one side of the street. An eight foot bicycle lane is included, along with twelve foot driving lanes, five foot sidewalks, and six feet of green space along each side of the street.

Option 2 – Rogers St. corridor without bicycle lanes or multiuse trail

Figure 2A, shown on page D-14, is for the 38 foot governing cross section. Five foot sidewalks are included on each side of the street, along with twelve foot driving lanes and four feet of green space along one side of the street.

Figure 2B, shown on page D-14, is for the 42 foot governing cross section. This option is identical to Option 2A, with the only exception being that six feet of green space is available on one side of the street.

Figure 2C, shown on page D-15, is for the 46 foot governing cross section. This option includes twelve foot driving lanes as well as an eight foot lane designated for on-street parallel parking. Five foot sidewalks are placed on each side of the street, as well as a foot of green space along the outside edge of each sidewalk.

Figure 2D, shown on page D-15, is the first of two options for the 65 ft. governing cross section. This option includes 8 feet of parallel parking on both sides of the street, along with 6.5 feet of green space on each side of the street.

Figure 2E, shown on page D-16, is the second of two options for the 65 foot governing cross section. It includes a center turning lane as well as on-street parallel parking available on both sides of the street. While it does have sidewalks on both sides like option 2D, it does not have green space on either side of the street.

Option 3 – Rogers St. Corridor With a Multiuse Trail (*Recommended Option*)

Each of the options shown in this section, Options 3A, 3B, 3C, and 3D incorporate the addition of an eight foot multiuse trail into the Rogers Street Corridor.

Figure 3A, shown on page D-17, is for the 38 foot governing cross section. An eight foot multiuse trail is utilized on one side of the street, while a four foot sidewalk is included on the opposite side. Standard driving lane widths of 12 feet are utilized and curb inlets are 6 inches on both sides of the street. Curb inlet spacing is shown in detail in Appendix F – Hydrologic Design.

Figure 3B, shown on page D-17, is for the 42 foot governing cross section. It is identical to the 38 foot cross sections, with the only exception being that Option 3B incorporates four feet of green space along the west side of the roadway for aesthetic enhancement.

Figure 3C, shown on page D-18, is for the 46 foot governing cross-section. This option includes an eight foot on-street parallel parking lane, a five foot sidewalk along one side of the street, an eight foot multiuse trail opposite the sidewalk. Standard 12 foot lane widths are maintained.

Figure 3D, shown on page D-18, is for the 65 ft governing cross section. The large amount of right-of-way available in this cross section allows for an eight foot multiuse trail, an eight foot on-street parallel-parking lane, a standard twelve foot center turning lane, a five foot sidewalk opposite the multiuse trail, and seven feet of green space along the multiuse trail. The larger amount of green space available in these areas with 65 feet of right of way represents a great opportunity to improve the aesthetic quality of the corridor

D.11 Conclusions

Atlas Engineering has prepared each of the cross-sections in Options 1, 2, and 3 in accordance with the wishes of the City of Bloomington's Metropolitan Planning Organization. Based on Atlas' recommendation, the MPO has chosen Option 3 to be designed, entailing a hydrologic and pavement design. Hydrologic design for Option 3 is shown in Appendix F, pavement design is detailed in Appendix G, and complete cross-sectional drawings are shown on pages D-18 through D-24.

Table D.2: Means Manual Preliminary Cost Estimate - Option 1

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Mobilization/Demobilization/Project Administration	1	LSUM	$ 40,000.00	$ 40,000.00
Construction Engineering	1	LSUM	$ 20,000.00	$ 20,000.00
Field Office	8	MOS	$ 2,000.00	$ 16,000.00
Clearing	1	LSUM	$ 15,000.00	$ 15,000.00
Drainage				
B-Borrow for Structure Backfill	2400	CYD	$ 22.70	$ 54,480.00
Reinforced Concrete Pipe, 12"	1200	LFT	$ 22.91	$ 27,492.00
Reinforced Concrete Pipe, 15"	1200	LFT	$ 26.31	$ 31,572.00
Reinforced Concrete Pipe, 18"	1400	LFT	$ 28.56	$ 39,984.00
Reinforced Concrete Pipe, 24"	800	LFT	$ 40.21	$ 32,168.00
Reinforced Concrete Pipe, 30"	750	LFT	$ 59.45	$ 44,587.50
Concrete Pipe End Sections	8	EACH	$ 375.00	$ 3,000.00
Manhole C-4	8	EACH	$ 1,320.80	$ 10,566.40
Manhole D-4	8	EACH	$ 1,824.40	$ 14,595.20
Catch Basin K-10	65	EACH	$ 1,000.00	$ 65,000.00
Inlet J-10	80	EACH	$ 1,000.00	$ 80,000.00
Culvert, Precast Box, 4'x8'	100	LFT	$ 450.00	$ 45,000.00
Class A Concrete for Structures	10	CYD	$ 96.00	$ 960.00
Pipe for Underdrains, 6"	10000	LFT	$ 2.00	$ 20,000.00
Aggregate for Underdrains	3500	SYD	$ 8.92	$ 31,220.00
Geotextile for Underdrains	5000	SYD	$ 2.00	$ 10,000.00
Geotextiles	350	SYD	$ 2.00	$ 700.00
Riprap, Revetment	150	TON	$ 20.04	$ 3,006.00
Adjust Casting to Grade	25	EACH	$ 500.00	$ 12,500.00
Sidewalk				
4" Concrete Sidewalk	56,045	SFT	$ 2.75	$ 154,123.75
Concrete Sidewalk Removal	5,605	SFT	$ 2.63	$ 14,739.84
PVC Sign Inserts	35	EACH	$ 40.00	$ 1,400.00
Concrete Curb & Gutter	20,272	LFT	$ 6.19	$ 125,483.68
Concrete Curb Removal	600	LFT	$ 3.44	$ 2,064.00
Concrete Pavement Removal	750	SYD	$ 10.43	$ 7,822.50
Concrete Pavement for Drives	1,600	SYD	$ 8.18	$ 13,088.00
Rogers Street and Trail Pavement				
Common Excavation	1	LSUM	$ 25,000.00	$ 25,000.00
Rock Excavation	1250	CYD	$ 175.00	$ 218,750.00
Borrow	3000	CYD	$ 22.70	$ 68,100.00
Proofrolling/Fine Grading	5	LSUM	$ 3,500.00	$ 17,500.00
Undercut/Replace	650	CYD	$ 30.00	$ 19,500.00
Base Course Aggregate 3" deep	75396	SYD	$ 3.46	$ 260,870.16
Driving Lane 4" thick HMA	75396	SYD	$ 8.80	$ 663,484.80
Parallel Parking 4" thick HMA	8144	SYD	$ 8.80	$ 71,667.20
Trail HMA Overlay	50264	SYD	$ 8.80	$ 442,323.20
Signs, reflective aluminum street	150	EACH	$ 129.95	$ 19,492.50
White Painted Lines, 4" for bike lane	22000	LFT	$ 0.26	$ 5,720.00
White Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
White Painted Lines, 4" for parallel parking	3200	LFT	$ 0.26	$ 832.00
White Painted Lines, 8" for crossing	2500	LFT	$ 0.39	$ 975.00
Yellow Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
Green Space				
Topsoil	750	CY	$ 40.00	$ 30,000.00
Mulched Seeding	450	SYD	$ 4.26	$ 1,917.00

Table D.2: Means Manual Preliminary Cost Estimate - Option 1

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Sod	18324	SFT	$ 0.57	$ 10,365.89
Green Space (Ginkgo, 6'-7')	150	EACH	$ 226.50	$ 33,975.00
Miscellaneous				
QC Testing / Videotaping	1	LSUM	$ 12,500.00	$ 12,500.00
Protection of Utilities	1	LSUM	$ 5,000.00	$ 5,000.00
Misc Pipe/Utility/Structure Removals	1	LSUM	$ 5,000.00	$ 5,000.00
Private Utility Relocations (Gas, Telephone)	1	LSUM	$ 17,500.00	$ 17,500.00
City Utility Relocations	1	LSUM	$ 17,500.00	$ 17,500.00
Construction Contingency @ 10%	1	LSUM	$ 288,972.56	$ 288,972.56

Subtotal: $ 3,178,698

Bloomington Cost Index: 91.40%

Subtotal: $2,905,330.13

Constuction Inspection at 10%: $ 317,870

TOTAL CONSTUCTION PHASE COSTS: $ 3,496,568

COST: $ 3,500,000

Table D.3: Means Manual Preliminary Cost Estimate - Option 2

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Mobilization/Demobilization/Project Administration	1	LSUM	$ 40,000.00	$ 40,000.00
Construction Engineering	1	LSUM	$ 20,000.00	$ 20,000.00
Field Office	8	MOS	$ 2,000.00	$ 16,000.00
Clearing	1	LSUM	$ 15,000.00	$ 15,000.00
Drainage				
B-Borrow for Structure Backfill	2400	CYD	$ 22.70	$ 54,480.00
Reinforced Concrete Pipe, 12"	1200	LFT	$ 22.91	$ 27,492.00
Reinforced Concrete Pipe, 15"	1200	LFT	$ 26.31	$ 31,572.00
Reinforced Concrete Pipe, 18"	1400	LFT	$ 28.56	$ 39,984.00
Reinforced Concrete Pipe, 24"	800	LFT	$ 40.21	$ 32,168.00
Reinforced Concrete Pipe, 30"	750	LFT	$ 59.45	$ 44,587.50
Concrete Pipe End Sections	6	EACH	$ 375.00	$ 2,250.00
Manhole C-4	6	EACH	$ 1,320.80	$ 7,924.80
Manhole D-4	6	EACH	$ 1,824.40	$ 10,946.40
Catch Basin K-10	60	EACH	$ 1,000.00	$ 60,000.00
Inlet J-10	75	EACH	$ 1,000.00	$ 75,000.00
Culvert, Precast Box, 4'x8'	100	LFT	$ 450.00	$ 45,000.00
Class A Concrete for Structures	10	CYD	$ 96.00	$ 960.00
Pipe for Underdrains, 6"	10000	LFT	$ 2.00	$ 20,000.00
Aggregate for Underdrains	3500	SYD	$ 8.92	$ 31,220.00
Geotextile for Underdrains	5000	SYD	$ 2.00	$ 10,000.00
Geotextiles	250	SYD	$ 2.00	$ 500.00
Riprap, Revetment	150	TON	$ 20.04	$ 3,006.00
Adjust Casting to Grade	25	EACH	$ 500.00	$ 12,500.00
Sidewalk				
4" Concrete Sidewalk	101,360	SFT	$ 2.75	$ 278,740.00
Concrete Sidewalk Removal	8,250	SFT	$ 2.63	$ 21,697.50
PVC Sign Inserts	75	EACH	$ 40.00	$ 3,000.00
Concrete Curb & Gutter	40,544	LFT	$ 6.19	$ 250,967.36
Concrete Curb Removal	500	LFT	$ 3.44	$ 1,720.00
Concrete Pavement Removal	300	SYD	$ 10.43	$ 3,129.00
Concrete Pavement for Drives	1,600	SYD	$ 8.18	$ 13,088.00
Rogers Street Pavement				
Common Excavation	1	LSUM	$ 25,000.00	$ 25,000.00
Rock Excavation	1000	CYD	$ 175.00	$ 175,000.00
Borrow	2000	CYD	$ 22.70	$ 45,400.00
Proofrolling/Fine Grading	3	LSUM	$ 3,500.00	$ 10,500.00
Undercut/Replace	500	CYD	$ 30.00	$ 15,000.00
Base Course Aggregate 3" deep	75396	SYD	$ 3.46	$ 260,870.16
Driving Lane 4" thick HMA	75396	SYD	$ 8.80	$ 663,484.80
Parallel Parking 4" thick HMA	8144	SYD	$ 8.80	$ 71,667.20
Signs, reflective aluminum street	125	EACH	$ 129.95	$ 16,243.75
White Painted Lines, 4" for bike lane	0	LFT	$ 0.26	$ -
White Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
White Painted Lines, 4" for parallel parking	9050	LFT	$ 0.26	$ 2,353.00
White Painted Lines, 8" for crossing	2500	LFT	$ 0.39	$ 975.00
Yellow Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
Green Space				
Topsoil	600	CY	$ 40.00	$ 24,000.00
Mulched Seeding	100	SYD	$ 4.26	$ 426.00
Sod	18324	SFT	$ 0.57	$ 10,365.89

Table D.3: Means Manual Preliminary Cost Estimate - Option 2

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Green Space (Ginkgo, 6'-7')	331	EACH	$ 226.50	$ 74,880.90
Miscellaneous				
QC Testing / Videotaping	1	LSUM	$ 12,500.00	$ 12,500.00
Protection of Utilities	1	LSUM	$ 5,000.00	$ 5,000.00
Misc Pipe/Utility/Structure Removals	1	LSUM	$ 5,000.00	$ 5,000.00
Private Utility Relocations (Gas, Telephone)	1	LSUM	$ 17,500.00	$ 17,500.00
City Utility Relocations	1	LSUM	$ 17,500.00	$ 17,500.00
Construction Contingency @ 10%	1	LSUM	$ 263,179.93	$ 263,179.93

Subtotal:	**$ 2,894,979**
Bloomington Cost Index:	**91.40%**
Subtotal:	**$2,646,010.97**
Constuction Inspection at 10%:	**$ 289,498**
TOTAL CONSTUCTION PHASE COSTS:	**$ 3,184,477**

COST:	**$ 3,200,000**

Table D.4: Means Manual Preliminary Cost Estimate - Option 3

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Mobilization/Demobilization/Project Administration	1	LSUM	$ 40,000.00	$ 40,000.00
Construction Engineering	1	LSUM	$ 20,000.00	$ 20,000.00
Field Office	8	MOS	$ 2,000.00	$ 16,000.00
Clearing	1	LSUM	$ 15,000.00	$ 15,000.00
Drainage				
B-Borrow for Structure Backfill	2400	CYD	$ 22.70	$ 54,480.00
Reinforced Concrete Pipe, 12"	1200	LFT	$ 22.91	$ 27,492.00
Reinforced Concrete Pipe, 15"	1200	LFT	$ 26.31	$ 31,572.00
Reinforced Concrete Pipe, 18"	1400	LFT	$ 28.56	$ 39,984.00
Reinforced Concrete Pipe, 24"	800	LFT	$ 40.21	$ 32,168.00
Reinforced Concrete Pipe, 30"	750	LFT	$ 59.45	$ 44,587.50
Concrete Pipe End Sections	6	EACH	$ 375.00	$ 2,250.00
Manhole C-4	6	EACH	$ 1,320.80	$ 7,924.80
Manhole D-4	6	EACH	$ 1,824.40	$ 10,946.40
Catch Basin K-10	60	EACH	$ 1,000.00	$ 60,000.00
Inlet J-10	75	EACH	$ 1,000.00	$ 75,000.00
Culvert, Precast Box, 4'x8'	100	LFT	$ 450.00	$ 45,000.00
Class A Concrete for Structures	10	CYD	$ 96.00	$ 960.00
Pipe for Underdrains, 6"	10000	LFT	$ 2.00	$ 20,000.00
Aggregate for Underdrains	3500	SYD	$ 8.92	$ 31,220.00
Geotextile for Underdrains	5000	SYD	$ 2.00	$ 10,000.00
Geotextiles	250	SYD	$ 2.00	$ 500.00
Riprap, Revetment	125	TON	$ 20.04	$ 2,505.00
Adjust Casting to Grade	25	EACH	$ 500.00	$ 12,500.00
Sidewalk				
4" Concrete Sidewalk	26,060	SFT	$ 2.75	$ 71,665.00
Concrete Sidewalk Removal	2,085	SFT	$ 2.63	$ 5,483.02
PVC Sign Inserts	45	EACH	$ 40.00	$ 1,800.00
Concrete Curb & Gutter	20,272	LFT	$ 6.19	$ 125,483.68
Concrete Curb Removal	500	LFT	$ 3.44	$ 1,720.00
Concrete Pavement Removal	200	SYD	$ 10.43	$ 2,086.00
Concrete Pavement for Drives	1,600	SYD	$ 8.18	$ 13,088.00
Rogers Street Pavement and Multi-use Trail				
Common Excavation	1	LSUM	$ 25,000.00	$ 25,000.00
Rock Excavation	750	CYD	$ 175.00	$ 131,250.00
Borrow	2000	CYD	$ 22.70	$ 45,400.00
Proofrolling/Fine Grading	3	LSUM	$ 3,500.00	$ 10,500.00
Undercut/Replace	500	CYD	$ 30.00	$ 15,000.00
Base Course Aggregate 3" deep	75396	SYD	$ 3.46	$ 260,870.16
Driving Lane 4" thick HMA	75396	SYD	$ 8.80	$ 663,484.80
Parallel Parking 4" thick HMA	8144	SYD	$ 8.80	$ 71,667.20
Trail HMA overlay	25132	SYD	$ 8.80	$ 221,161.60
Signs, reflective aluminum street	125	EACH	$ 129.95	$ 16,243.75
White Painted Lines, 4" for multiuse trail	10000	LFT	$ 0.26	$ 2,600.00
White Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
White Painted Lines, 4" for parallel parking	6000	LFT	$ 0.26	$ 1,560.00
White Painted Lines, 8" for crossing	2500	LFT	$ 0.39	$ 975.00
Yellow Painted Lines, 4" for driving lanes	10000	LFT	$ 0.26	$ 2,600.00
Green Space				
Topsoil	600	CY	$ 40.00	$ 24,000.00
Mulched Seeding	350	SYD	$ 4.26	$ 1,491.00

Table D.4: Means Manual Preliminary Cost Estimate - Option 3

Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Unit Cost	Total Amount
Sod	18324	SFT	$ 0.57	$ 10,365.89
Green Space (Ginkgo, 6'-7')	100	EACH	$ 226.50	$ 22,650.00
Miscellaneous				$ -
QC Testing / Videotaping	1	LSUM	$ 12,500.00	$ 12,500.00
Protection of Utilities	1	LSUM	$ 5,000.00	$ 5,000.00
Misc Pipe/Utility/Structure Removals	1	LSUM	$ 5,000.00	$ 5,000.00
Private Utility Relocations (Gas, Telephone)	1	LSUM	$ 17,500.00	$ 17,500.00
City Utility Relocations	1	LSUM	$ 17,500.00	$ 17,500.00
Construction Contingency @ 10%	1	LSUM	$ 240,833.48	$ 240,833.48

Subtotal: $ 2,649,168

Bloomington Cost Index: 91.40%

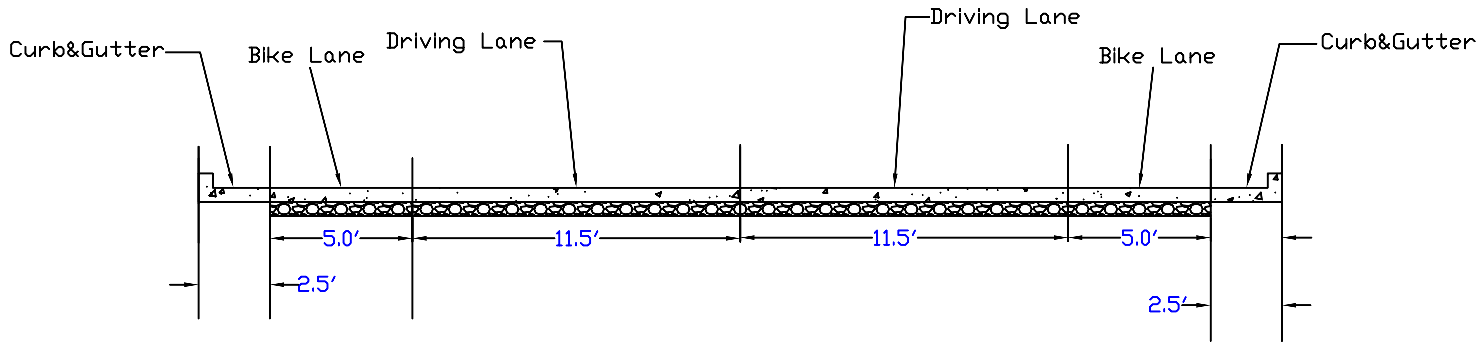
Subtotal: $2,421,339.81

Constuction Inspection at 10%: $ 264,917

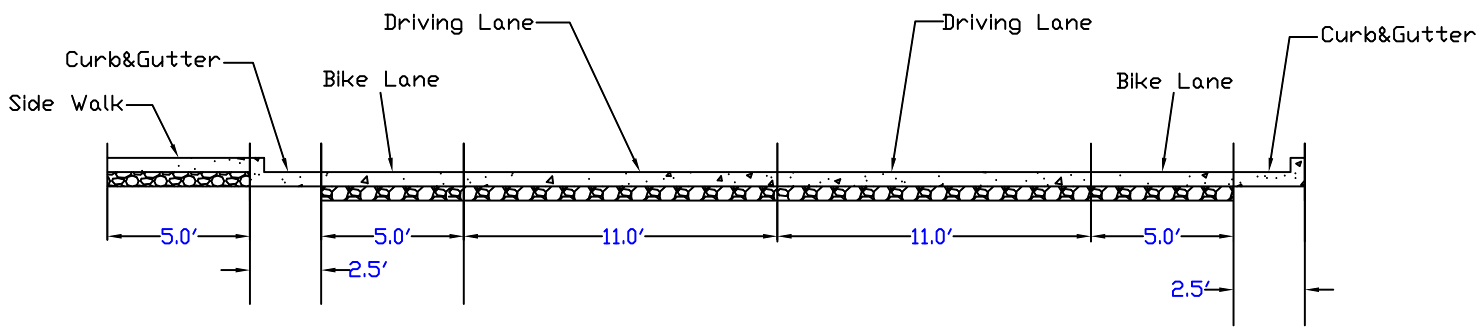
TOTAL CONSTUCTION PHASE COSTS: $ 2,914,085

COST: $ 2,675,000

Option 1A - 38 ft. of Right of Way with Two Bike Lanes



Option 1B - 42 ft. of Right of Way with Two Bike Lanes



No.	DATE	REVISION

Atlas Engineering
5500 Wabash Ave., CM 2171
Terre Haute, IN
47803
Telephone: 412.443.7242

CERTIFIED BY: DESIGN ENGINEER DATE

DESIGNED BY: BMW | DRAWN BY: BMW

CHECKED BY: JAB | APPROVED BY: JAB

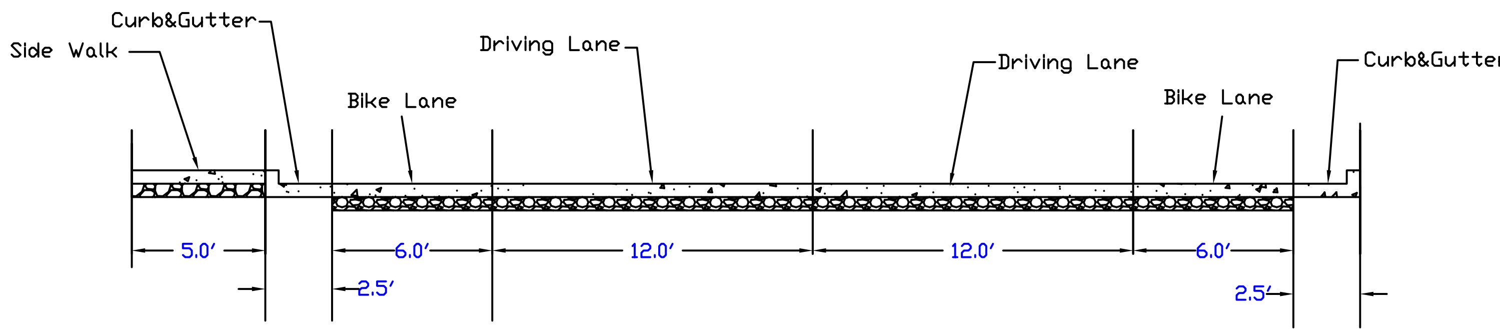
PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

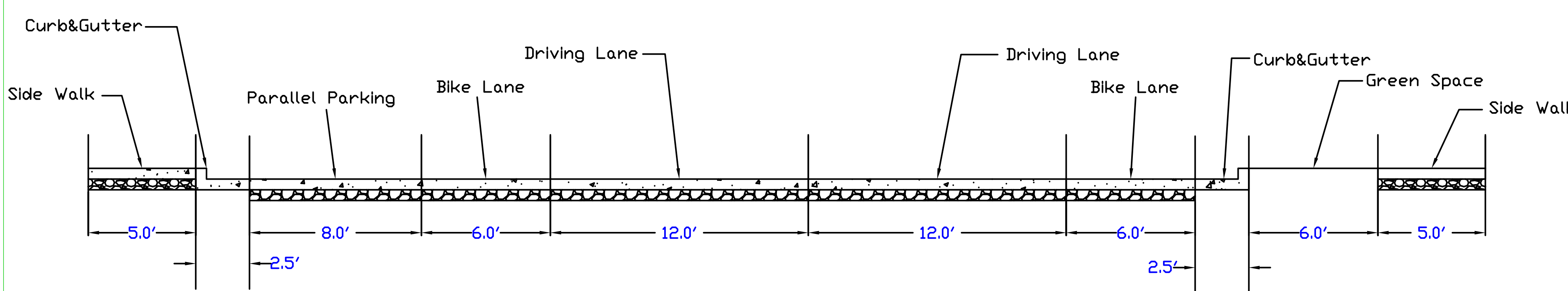
FIGURES 1-A AND 1-B

PROJECT No: XXXXXX
DATE: 11-29-06
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 18

Option 1C - 46 ft. of Right of Way with Two Bike Lane



Option 1D - 65 ft. of Right of Way with Two Bike Lane & Parallel Parking



No.	DATE	REVISION

Atlas Engineering
5500 Wabash Ave., CM 2171
Terre Haute, IN
47803
Telephone: 412.443.7242

CERTIFIED BY: ______ DESIGN ENGINEER DATE

DESIGNED BY: BMW | DRAWN BY: BMW
CHECKED BY: JAB | APPROVED BY: JAB

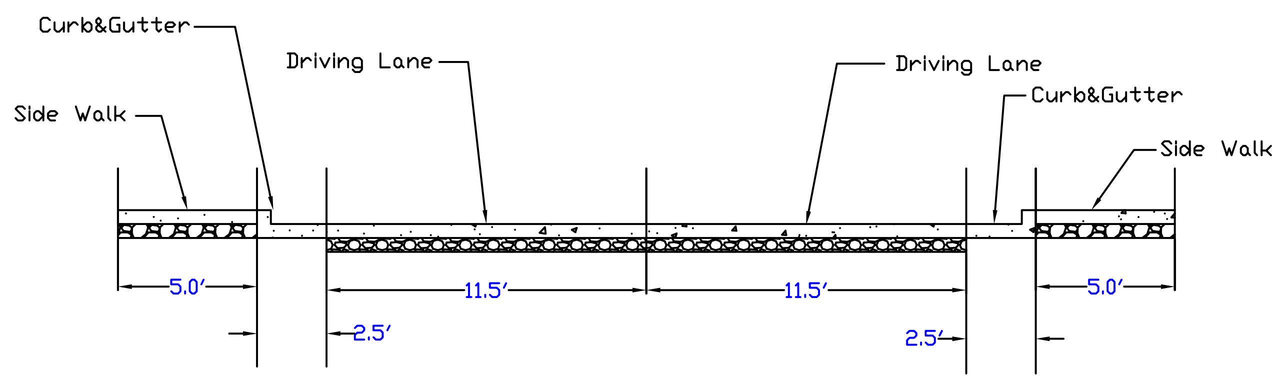
PROJECT:
ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

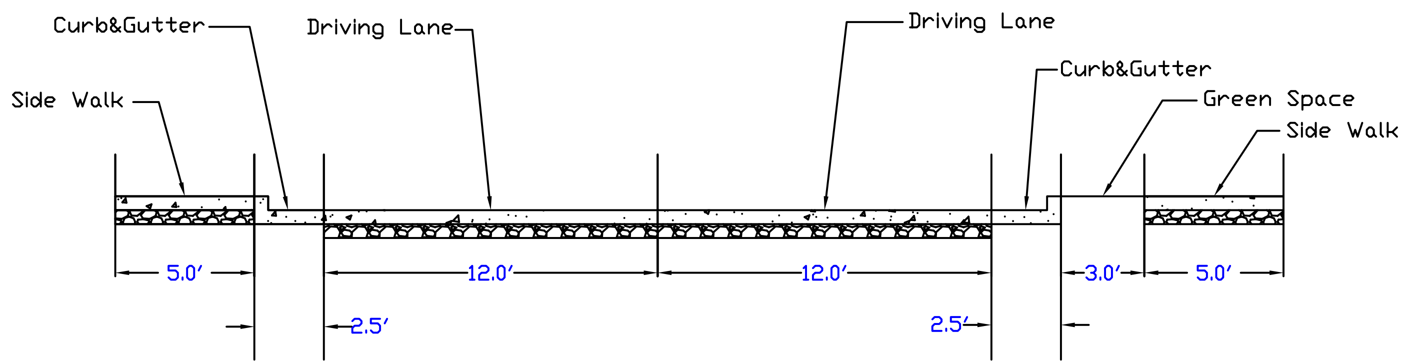
FIGURES 1-C AND 1-D

PROJECT No: XXXXXX
DATE: 11-29-06
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 19

Option 2A - 38 ft. of Right of Way with No Bike Lanes



Option 2B - 42 ft. of Right of Way with No Bike Lanes



No.	DATE	REVISION

Atlas Engineering
5500 Wabash Ave., CM 2171
Terre Haute, IN
47803
Telephone: 412.443.7242

CERTIFIED BY: DESIGN ENGINEER DATE

DESIGNED BY: BMW DRAWN BY: BMW

CHECKED BY: JAB APPROVED BY: JAB

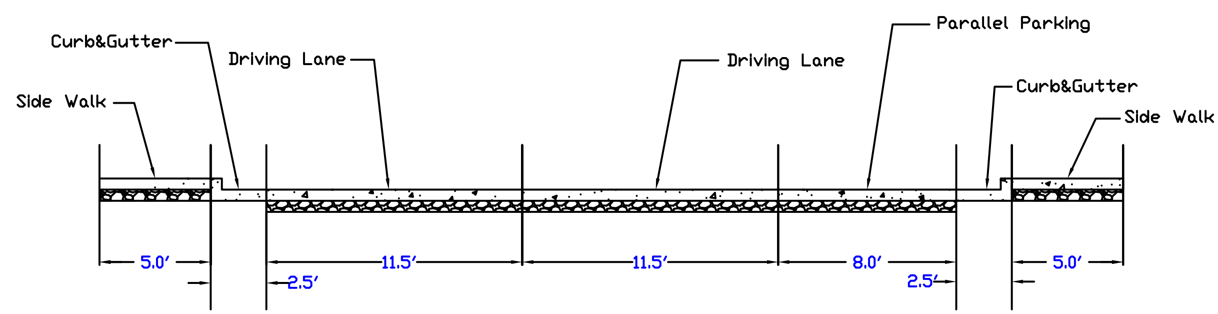
PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

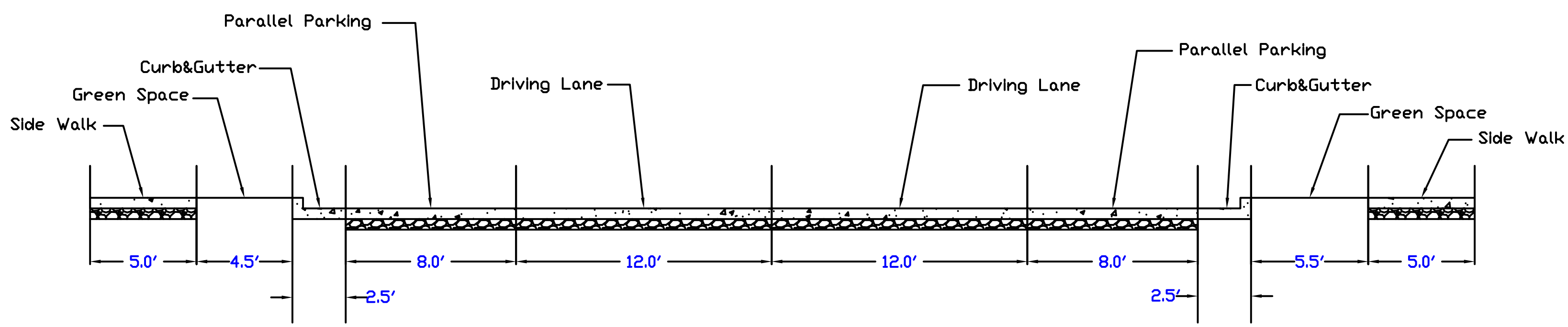
FIGURES 2-A AND 2-B

PROJECT No: XXXXXX
DATE: 11-29-06
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 20

Option 2C - 46 ft. of Right of Way with Parallel Parking



Option 2D - 65 ft. of Right of Way with Parallel Parking on Both Sides



No.	DATE	REVISION

Atlas Engineering
5500 Wabash Ave., CM 2171
Terre Haute, IN
47803
Telephone: 412.443.7242

CERTIFIED BY: ____ DESIGN ENGINEER ____ DATE

DESIGNED BY: BMW | DRAWN BY: BMW
CHECKED BY: JAB | APPROVED BY: JAB

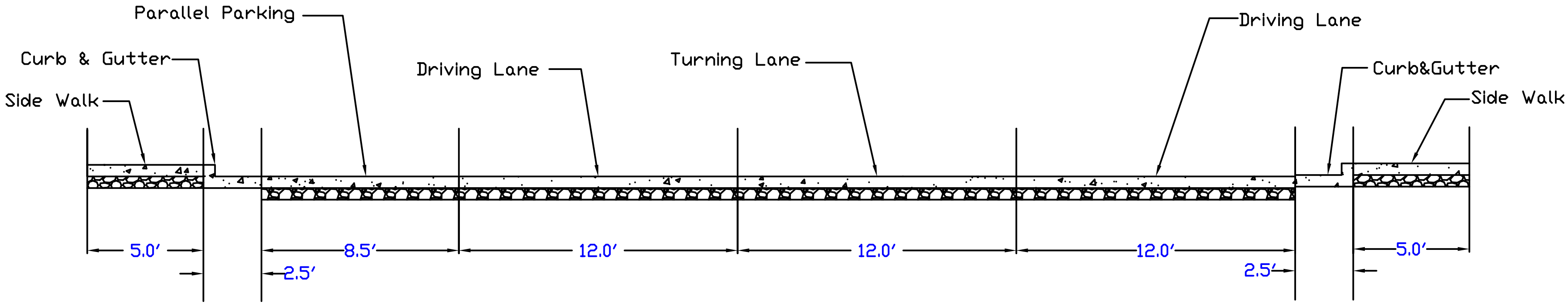
PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

FIGURES 2-C AND 2-D

PROJECT No: XXXXXX
DATE: 11-29-06
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 21

Option 2E - 65 ft. of Right of Way with a Center Turning Lane and Parallel Parking on One Side



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CHECKED BY: JAB APPROVED BY: JAB

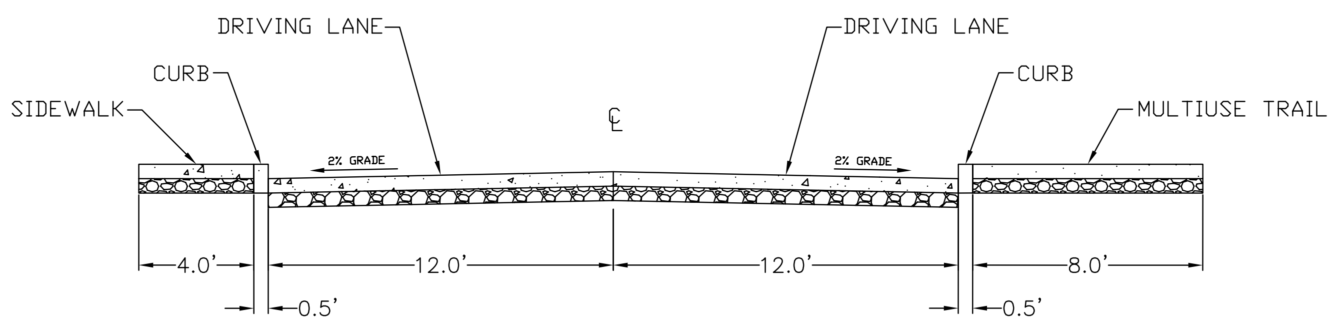
PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

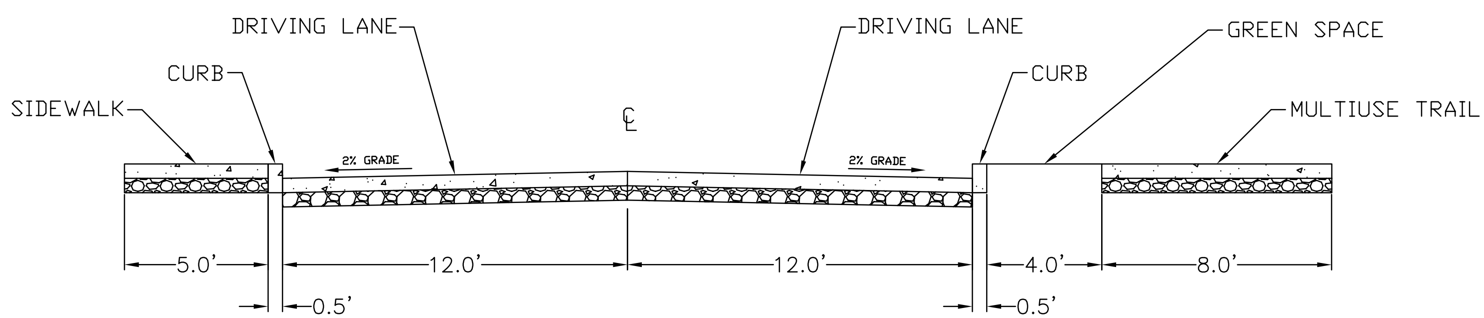
FIGURE 2-E

PROJECT No: XXXXXX
DATE: 11-29-06
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 22

OPTION 3A: 38' CROSS SECTION WITH MULTIUSE TRAIL



OPTION 3B: 42' CROSS SECTION WITH MULTIUSE TRAIL & SIDEWALK



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DRAWN BY: JAB
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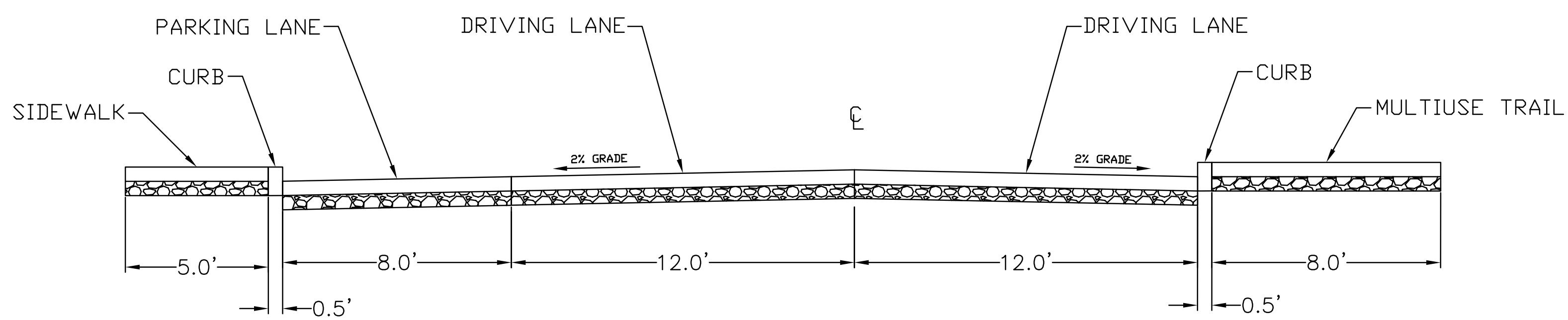
PROJECT:
ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, IN

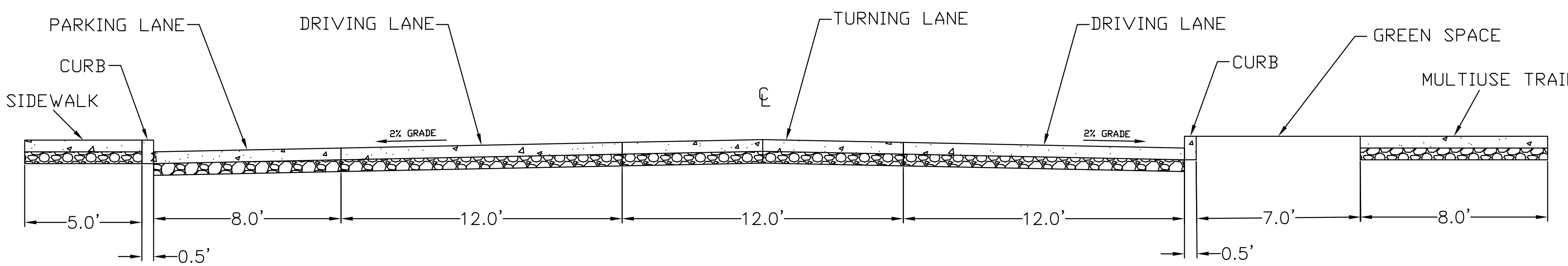
FIGURES 3-A AND 3-B

PROJECT No: XXXXXX
DATE: 3-29-07
HORIZ. SCALE: NO SCALE
VERT. SCALE: NO SCALE
SHEET NO. D - 23

OPTION 3C: 46' CROSS SECTION WITH MULTIUSE TRAIL



OPTION 3D: 65' CROSS SECTION WITH MULTIUSE TRAIL & SIDEWALK



No.	DATE	REVISION

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CERTIFIED BY: ______ DESIGN ENGINEER DATE

DESIGNED BY: JAB | DRAWN BY: JAB
CHECKED BY: BMW | APPROVED BY: BMW

PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

ROGERS STREET
BLOOMINGTON, INDIANA

FIGURES 3-C AND 3-D

PROJECT No: XXXXXX | HORIZ. SCALE: NO SCALE
DATE: 4-29-07 | VERT. SCALE: NO SCALE
SHEET NO. D - 24

APPENDIX E – ASSESSMENT OF TRANSPORTATION CORRIDOR OPTIONS

E.1 Introduction

The Rogers Street Corridor is a major north/south connector for the city of Bloomington that serves a number of transportation needs. These needs have increased dramatically in recent years, due to neighborhood revitalization and economic growth. However, a multitude of problems have been developing along the corridor and are in desperate need of remediation. These problems include, but are not limited to; traffic congestion, a lack of right-of-way and on-street parking, conflicts between motorized vehicles, pedestrians and bicyclists, and a lack of stormwater drainage structures. To provide relief for the growing pressures that the corridor is putting on the city, Atlas Engineering has developed three distinct alternatives for the Rogers Street Corridor in Bloomington. These alternatives are described in detail in Appendix D – Assessment of Transportation Corridor Options. Through client input and the use of a decision matrix (Table E.1)with weighting criteria, the following four criteria were utilized by Atlas Engineering to evaluate each of these alternatives:

1) Impact on Local Businesses and Neighborhoods – 30%
2) Feasibility – 25%
3) Transportation Improvement – 25%
4) Public Support – 20%

Table E.1: **Rogers Street Corridor Decision Matrix and Recommendation**

Design Option	Local Impact (30%)	Feasibility (25%)	Transportation Improvement (25%)	Local Support (20%)	Weighted Average	Rank
# **1** **Bicycle Lanes**	1	2	1	2	1.45	3
# 2 No Bicycle Lanes	1	2	2	2	1.70	2
# 3 Multiuse Trail	1	3	3	3	*2.40*	1

E.2 Recommended Alternative

Using the decision matrix, Atlas Engineering evaluated the different cross-section alternatives to provide a final design recommendation for the Bloomington/Monroe County Metropolitan Planning Organization (MPO). The values used in the decision matrix are based on a point value system of one to three, with three being the most favorable and one being the least. The values assigned to each option were established according to the characteristics of the alternatives as described in Appendix D. After each alternative was rated, the weighted average of each option was calculated and used to determine the overall rank of each design alternative. Table E.1 lists the ranking as well as the weighted average value for each of the three proposed design alternatives. These criteria are described in detail in sections E.3, E.4, E.5, and E.6.

E.3 Impact on Local Businesses and Neighborhoods

The Rogers Street Corridor Context Sensitive Design Study is a project that is currently being driven by community action. The project being presented to Atlas Engineering was driven by local Bloomington communities as a request for an improved north/south connector through the city. Therefore, the impact of Atlas Engineering's design recommendation on local businesses and neighborhoods is an important factor to assess in alternative selection process. Regardless of which alternative the city selects, Atlas Engineering will strive to minimize the amount of impact to local businesses and neighborhoods and provide access to Bloomington Hospital to the fullest extent possible throughout construction of the project through phased implementation and carefully planned detour routes.

The expected impact that each of the three proposed alternatives would have on the local community has been evaluated through input from both our client and local business owners along Rogers Street. Table E.2 shows the different point values assigned to the expected impact on local businesses and neighborhoods. A rating of 1 has been assigned to each of the three alternatives proposed by Atlas, because the construction phase of each alternative will have a significant impact on businesses and neighborhoods, as well as increase travel times through the corridor. Based on our client's judgment, the expected impact on local businesses and neighborhoods is worth 30 percent of the final score in the decision matrix.

Table E.2: Impact on Local Businesses and Neighborhoods Rating Criteria.

Rating	Description
3	No/Minimal impact during construction to local businesses and neighborhoods, such that travel times are not increased and local businesses maintain standard operating conditions
2	Either impact to local neighborhoods increases travel times significantly or local businesses are forced to alter standard operation conditions - but not both
1	Impact to both businesses and neighborhoods is significant enough to increase travel times and alter standard operating conditions of businesses

E.4 Feasibility

There are two major factors that affect the feasibility of the Rogers Street Corridor design alternatives: the impact of construction on Bloomington Hospital and the estimated cost of the completed project. The impact on the hospital is important to consider when rating the feasibility because the Rogers Street Corridor is a main north/south emergency vehicle route through the city. The cost of the selected alternative and the cost of the project will also factor into the feasibility because 20 percent of the project's funding will need to be generated locally. However, it is noteworthy to mention that the Bloomington/Monroe County MPO vehemently expressed that the cost of the completed project should *not* interfere with the overall creativity of Atlas' design alternatives. The feasibility ratings of the different alternatives are outlined in Table E.3. Through our client's input, a weighting factor of 25 percent was assigned to the feasibility of the selected design alternative.

Alternative 1, the implementation of bicycle lanes along the corridor, received a rating of 2, because the estimated cost of the completed project was between \$3 and \$5 million and the construction anticipated with this alternative would have only a minor impact on Bloomington Hospital, if any.

Alternative 2, which does not provide for the implementation of bicycle lanes or a multiuse trail, was also given a rating of 2 because the construction associated with this alternative would have a minor impact on Bloomington Hospital. The estimated cost of construction for this alternative was also in the $3 to $5 million range.

Alternative 3, which implements a multiuse trail into the corridor, was given a rating of 3 because the estimated cost of construction for this project was under $3 million. Also, because a multiuse trail would provide continuity with an existing multiuse trail currently being constructed along the southern end of the corridor, we feel that travel times to Bloomington Hospital would not be affected.

Table E.3: Feasibility rating criteria

Rating	Description
3	Cost of completed project is < $3 million and implementation does not effect travel times to Bloomington Hospital during construction
2	Either cost of completed project is between $3 and $5 million or implementation has minor impact on travel times to Bloomington Hospital during construction
1	Either cost of completed project is > $5 million or implementation significantly impacts travel times to hospital

*Any option that significantly impacts travel times to Bloomington Hospital will be assigned a rating of 1.

E.5 Transportation Improvement

The movement of traffic along the Rogers Street Corridor should be improved by implementing Alternative 1, 2, or 3. The amount of improvement each alternative would provide to the corridor was also necessary to quantify and include in the decision matrix. The rating values are shown in Table E.4. Alternative 1 was given a rating of 1 because turning lanes were not included in this design and, therefore, the level of service is not anticipated to increase substantially. Alternative 2 was given a rating of 2 because the addition of turning lanes will improve the level of service for vehicles, but the lack of bicycle lanes or a multiuse trail will not improve the flow of non-vehicular modes of transportation. Alternative 3 received a rating of 3 because the level of service will be improved through the addition of turning lanes and intersection improvements and other modes of non-vehicular transportation will also be improved with the implementation of a multiuse trail along the entire length of the corridor. Similar to the other criteria, the weighting factor for transportation improvement was assigned by our client: the improvement of traffic flow along the Rogers Street Corridor was given a weighting factor of 25 percent.

Table E.4: Transportation improvement rating criteria

Rating	Description
3	LOS is increased significantly and all modes of transportation, such as pedestrian, bicycle, rollerblading, etc., have been improved
2	LOS is increased and some, but not all other modes of transportation have been improved
1	Either LOS remains the same or other modes of transportation have not been improved

*LOS (Level of Service) will increase with the addition of turning lanes to alleviate traffic congestion

E.6 Public Support (CAC)

Atlas Engineering conducted a meeting with our client as well as the Bloomington/Monroe County Citizens Advisory Committee (CAC) in order to receive community input on the three proposed design alternatives. Based on the comments from the client as well as the CAC, the rating values for public support (Table E.5) were established. Alternative's 1 and 2 each received a rating of 2 because the Citizen's Advisory Committee did not fully support either of these options. Alternative 3, on the other hand, received the highest possible rating of 3 because the CAC fully supported the implementation of a multiuse trail and the City of Bloomington has also approved of the design. The support of the Bloomington community as well as our client is given a weighting factor of 20 percent.

Table E.5: Public support rating criteria

Rating	Description
3	CAC input has been included in design and the City of Bloomington approves design
2	CAC input has been taken into account but not observed and City of Bloomington approves design
1	CAC input has not been considered and City of Bloomington has declined the design

E.7 Final Recommendation

After careful evaluation, and through the use of the decision matrix (Table E.1), Atlas Engineering's recommended alternative for the city of Bloomington is the implementation of a multiuse trail along the entire length of the corridor. Figure E1.0, shown below, shows a rendering of the expected final design for the 65-foot cross section. This recommendation is based strictly on the final scores produced by the four criteria established in the decision matrix, which attempted to incorporate as many of the main components of the project as possible. With the support of the City of Bloomington and Citizen's Advisory Committee, Atlas Engineering has created the complete design of this alternative.

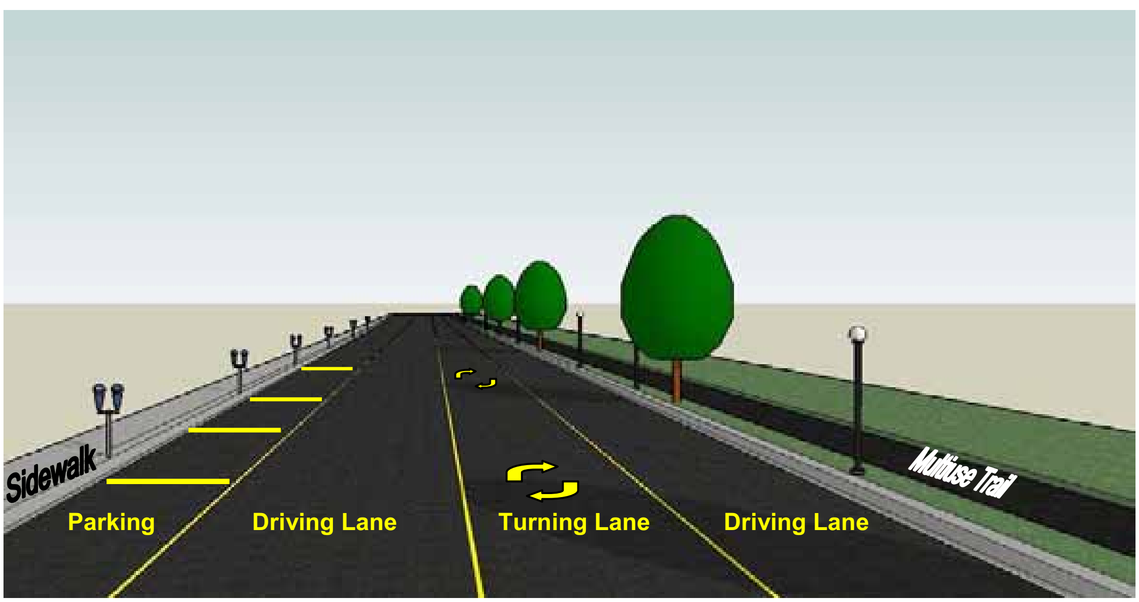

Figure E1.0: Rendering of Recommended Transportation Corridor Option

APPENDIX F – STORMWATER MANAGEMENT DESIGN

F.1 Introduction

The Bloomington/Monroe County Metropolitan Planning Organization has requested that Atlas Engineering provide a comprehensive stormwater management design for the Rogers Street corridor, a corridor which currently has no existing stormwater structures of any kind. The stormwater management solution provided herein has been designed for implementation and takes into consideration green engineering concepts and environmentally-friendly design alternatives, such as bioretention swales and rain gardens. Because the right-of-way throughout the Rogers Street corridor varies a great deal, unique solutions have been developed which provide both adequate stormwater drainage and the incorporation of Best Management Practices (BMPs). The specifications set forth by the City of Bloomington, which have been met in this design, are identified in section F.8.

F.2 Description of Stormwater Management Solution

To ensure adequate stormwater drainage, Atlas Engineering has provided a comprehensive design of drop inlets spaced at appropriate intervals between intersections throughout the length of the corridor in combination with green forms of stormwater management, such as bioretention swales and rain gardens. Sections F.5 and F.6 describe the distribution of standard stormwater drainage inlets, bioretention swales, and rain gardens throughout the corridor, as well as justifying the locations of each. The decisions made to evaluate the appropriateness of where to place standard inlets versus bioretention swales and rain gardens were based on a variety of factors, including: availability of right-of-way, aesthetic value, availability of existing stormwater structures to connect to, volumetric flow of stormwater for a given section of Rogers Street, and ease of constructability. Atlas Engineering recognizes that green engineering practices are not always implemented into stormwater designs for a variety of reasons. While Atlas strongly recommends the implementation of bioretention swales and rain gardens, a comprehensive design of standard drop-inlets has been provided in the event that the Bloomington MPO decides to implement a standard inlet drainage system (exclusively) without bioretention swales or rain gardens.

F.3 Drainage Inlet Number and Spacing

To determine the appropriate number of inlets as well as spacing between inlets for each section of roadway (from intersection to intersection) on Rogers Street, the following standard design procedure was followed (Akan and Houghtalen, 2003):

1) The drainage area for each side of the corridor, east and west, was determined in G.I.S. and then sub-divided into the areas between street intersections of Rogers and all intersecting east-to-west streets.
2) The land use was determined based on field inspection along the corridor to determine the rational coefficient, C, for each sub-area. In most cases, C values were relatively low (approximately 0.2)
3) Using the design-storm frequency and the maximum allowable gutter-spread specified by the City of Bloomington, Manning's equation was used to compute the volumetric flow rate of the design storm and equated to the Rational Equation to solve for a corresponding drainage area.
4) This computed drainage area was compared to the existing drainage sub-area between the intersections in question. The ratio of computed to existing drainage areas was used to determine the number of drainage inlets needed between intersections. Spacing was then determined by dividing the length of roadway between intersections by the number of inlets needed, calculated through the aforementioned Manning's and Rational equations.

In several areas of the corridor, the natural slope of the roadway was less than 0.5%. For these areas, Atlas assumed values of 0.5%, which need to be implemented during construction to ensure adequate stormwater drainage (AASHTO, 2004). Figure F1.0 shows the spot elevations at each intersection along the corridor as well as the relative distances between intersections. Table F.1 shows the relative slope between each intersection along the corridor. A summary of the number and spacing of drainage inlets between intersections is shown in Table F.2 (Supporting calculations for inlet spacing are provided in Table F.8 beginning on page F-22.)

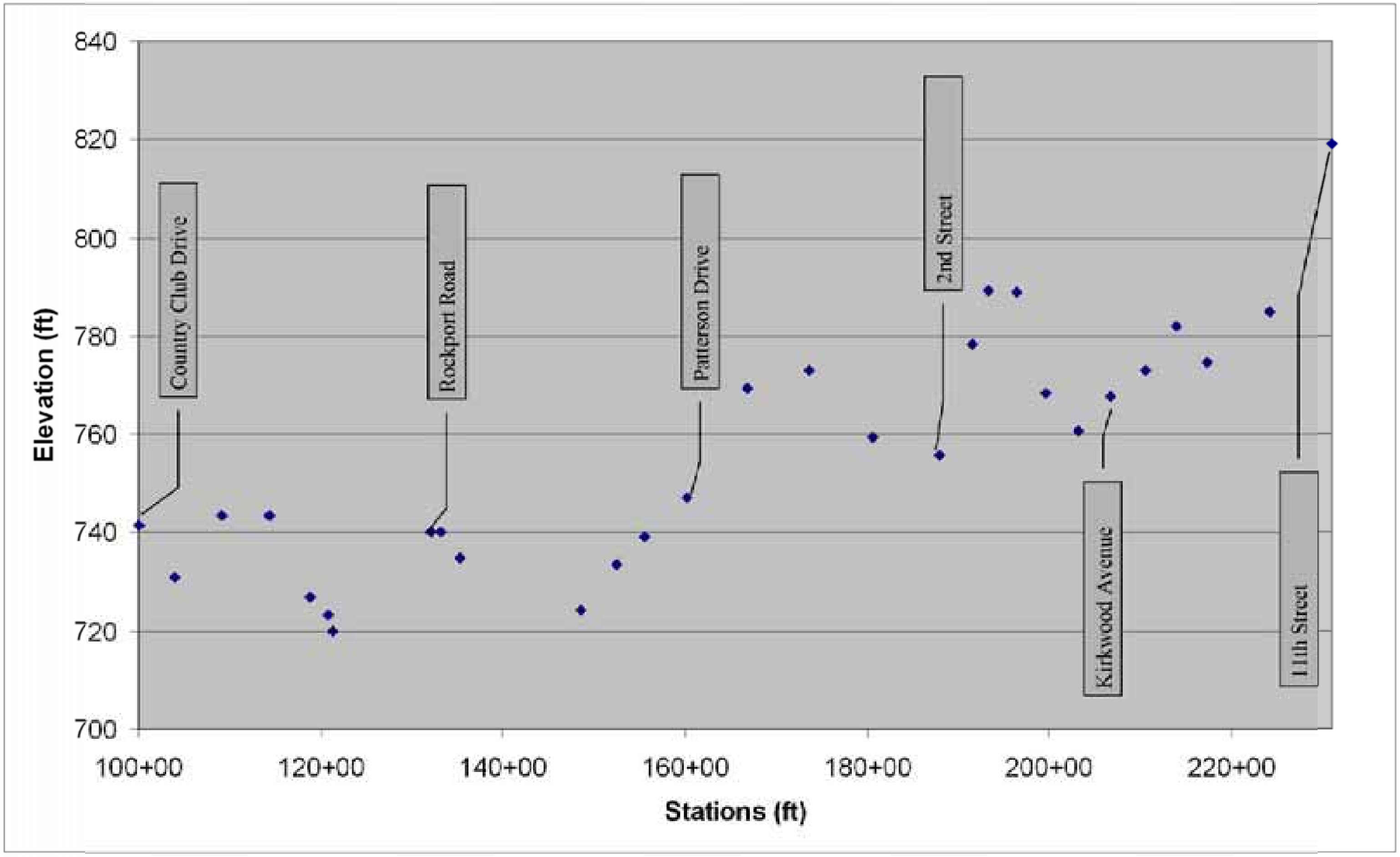

Figure F1.0: Spot Elevations at Intersections

Table F.1: Distances and Slopes Between Intersections

Intersections	Distance Between Intersections (ft)	Slope between Intersections (ft)
Eleventh Street to Tenth Street	680.4	0.05
Tenth St. to Eighth Street	684.2	0.02
Seventh St. to Eighth Street	340.8	0.02
Seventh St. to Sixth Street	341.7	0.03
Sixth St. to Kirkwood Ave	361.2	0.02
Kirkwood Ave. to Fourth Street	358.8	0.02
Third St. to Fourth St.	358.8	0.02
Prospect St. to Third St.	329.6	0.06
Prospect St. to Smith Ave.	312.6	0.01
Smith Ave. to Howe Street	171.4	0.06
Howe St. to Second St.	365.2	0.06
First St. to Second St.	718.8	0.01
Dodds St. to First St.	708.4	0.02
Dodds St. to Allen St.	678	0.01
Allen St. to Patterson St.	665.1	0.03
Patterson St. to Driscoll St.	456.3	0.02
Driscoll St. to Wilson St.	318.3	0.02
Wilson St. to Hillside St.	386.4	0.02
Cherokee St. to Hillside St.	1322.4	0.01
Chambers Dr. to Cherokee St.	226.4	0.02
Chambers Dr. to Rockport Rd.	102.2	0.01
Rockport Rd. to Jed St.	1069.2	0.02
Hays St. to Jed St.	49.4	0.07
Joy St. to Hays St.	200.4	0.02
Coolidge St. to Joy St.	441.6	0.04
Graham Dr. to Coolidge St.	519.6	0.01
Graham St. to Ralston St.	519.3	0.02
Ralston Dr. to Tapp Rd.	401.6	0.03

Table F.2: Summary of Inlet Number and Spacing

Intersections	Inlet Spacing West (ft)	Number of Inlets West	Inlet Spacing East (ft)	Number of Inlets East
Eleventh Street to Tenth Street	113	6	85	8
Tenth St. to Eighth Street	62	11	49	14
*Seventh St. to Eighth Street	43	8	57	6
*Seventh St. to Sixth Street	114	3	114	3
*Sixth St. to Kirkwood Ave	90	4	90	4
*Kirkwood Ave. to Fourth Street	120	3	90	4
*Third St. to Fourth St.	60	6	120	3
*Prospect St. to Third St.	165	2	165	2
*Prospect St. to Smith Ave.	52	6	63	5
Smith Ave. to Howe Street	86	2	171	1
Howe St. to Second St.	183	2	73	5
First St. to Second St.	60	12	55	13
Dodds St. to First St.	51	14	51	14
Dodds St. to Allen St.	57	12	97	7
Allen St. to **Patterson St.	74	9	67	10
**Patterson St. to Driscoll St.	51	9	42	11
Driscoll St. to Wilson St.	107	3	53	6
Wilson St. to Hillside St.	129	3	64	6
Cherokee St. to Hillside St.	70	19	47	28
Chambers Dr. to Cherokee St.	57	4	75	3
Chambers Dr. to Rockport Rd.	51	2	51	2
Rockport Rd. to **Jed St.	119	9	178	6
Hays St. to **Jed St.	49	1	49	1
Joy St. to Hays St.	50	4	100	2
Coolidge St. to Joy St.	74	6	147	3
Graham Dr. to Coolidge St.	130	4	130	4
Graham St. to Ralston St.	173	3	173	3
Ralston Dr. to Tapp Rd.	100	4	134	3

***Denotes areas for recommended bioretention swales**

****Denotes areas for recommended rain gardens**

Note: Supporting calculations for inlet spacing are provided in Table F.8 beginning on page F-22.

F.4 Pipe Sizing

To determine the appropriate pipe sizes for the stormwater management system for each section of roadway (from intersection to intersection) on Rogers Street, the following standard design procedure was followed (Akan and Houghtalen, 2003):

1.) The drainage area for each side of the corridor, east and west, was determined in G.I.S. and then subdivided into areas between street intersections of Rogers and all intersecting east-to-west streets.
2.) The land use was determined based on field inspection along the corridor to determine the rational coefficient, C, for each sub-area.
3.) The time of concentration for each stormwater pipe was determined using an inlet time of five minutes and the calculated flow time of the upstream pipes.
4.) The design discharge for each roadway section was found using the rational formula. The design rainfall intensity was determined from *The City of Bloomington Utility Department Construction Specifications* (2006).
5.) The required minimum pipe size was found using Manning's formula. The Manning's roughness factor used was 0.016 and the slope used was that of the natural road surface.
6.) The design pipe size was then determined based on standard sizes of 12, 15, 18, and 24 inches in diameter.
7.) Once the pipe diameter was determined the pipe flow time was calculated by assuming full flow in a circular storm sewer and calculating the flow velocity using Manning's formula.

As stated before in several areas of the corridor Atlas assumed a slope of 0.5% to ensure adequate stormwater drainage. The pipe size distribution for the west side of the corridor can be found in Table F.4 (page F-14), while Table F.6 (page F-18) contains the pipe size distributions for the east side of the corridor. Also, it is important to note that the bioretention swales recommended for certain areas of the corridor (Table F.3, page F-10) are to be constructed with openings spaced identical to those of the standard drop-inlets described in section F.3. These openings are necessary to allow street runoff to enter the bioretention swales where it is infiltrated.

F.5 Implementation of Best Management Practices

Best Management Practices (BMP's) such as bioretention swales and rain gardens are recommended in certain areas of the Rogers Street corridor to minimize the impact of urban development and restore the hydrologic cycle closer to its pre-developed condition. As it has been alluded to before, limited right-of-way in certain areas of the corridor poses challenges to green design. In areas in which sufficient right-of-way is available, particularly in the historic district of Prospect Hill, 7-foot wide bioretention swales have been designed to accommodate stormwater along the west side of the roadway.

Bioretention swales (Figure F.2) provide stormwater treatment, conveyance functions, and aesthetic enhancement for the corridor. In essence, the swale component provides pretreatment of stormwater to remove coarse to medium sediments, while the bioretention system removes finer particulates and associated contaminants (City of Brisbane, 2005). Bioretention swales provide flow retardation for frequent storm events, which is of particular importance for the Bloomington area due to the high percentage of low-permeability clays present in the ground. The bioretention swale treatment process

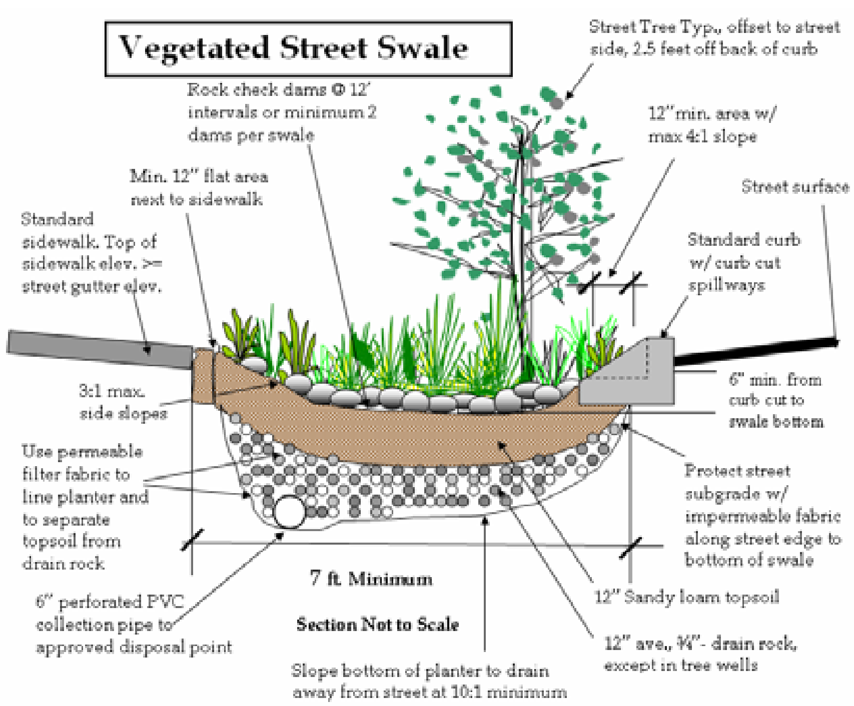

Figure F.2: Cross-section of a Vegetated Street Swale (Adapted from City of Portland, 2004)

operates by slowing stormwater runoff through surface vegetation associated with the swale (typically native grasses and plants) and then percolating the runoff through a prescribed filter media. Bioretention swales can use a variety of vegetation types including turf, sedges and tufted grasses. An important consideration in choosing vegetation for the Rogers Street corridor, beyond aesthetics, is that it must be capable of withstanding the design flows specified as well as dense enough to prevent scouring of deposited sediments.

Rain gardens (Figure F.3), another BMP recommended by Atlas Engineering to be implemented into the Rogers Street corridor at the intersections of Patterson Street and Jed Street, are somewhat similar to bioretention swales, with several key differences. Rain gardens are low-maintenance landscaped area that are specially designed to contain, filter and soak up stormwater runoff from rooftops, patios, driveways, or basement sump pumps (Broughton, 2001). Unlike bioretention swales, rain gardens are essentially an infiltration technique, in which water is captured in a garden (featuring native plants) and slowly infiltrates into the ground, rather than a stormwater sewer.

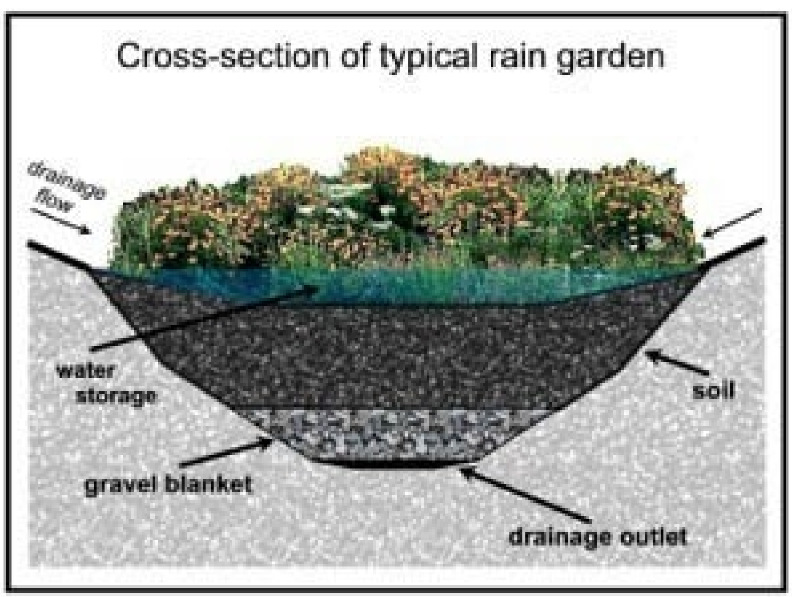

Figure F.3: Cross-section of a Typical Rain Garden (Adapted from City of Portland, 2004)

F.6 Stormwater Routing

A major design consideration for stormwater management along the Rogers Street corridor has been the locations of existing stormwater drainage structures along adjacent streets: it is important that existing systems are not overtaxed. Table F.3 summarizes the locations of Atlas' recommended stormwater management systems as well as the locations of existing stormwater structures on adjacent streets. A plan layout of the location for bioretention swales and rain gardens can be found in Appendix J, Figures J2.2 to J2.5, J2.11, and J2.18. Details of these stormwater management systems are provided in the next section.

Table F.3: Locations of Recommended Stormwater Systems

Intersecting Roadways	Proposed Stormwater Structure West Side of Corridor	Proposed Stormwater Structure East Side of Corridor	Stormwater Routing Location (Existing)
11th St. to 8th St.	Standard Drop Inlets	Standard Drop Inlets	8th St.
7th St. to 8th St.	7' Wide Bioretention Swales	Standard Drop Inlets	8th St.
7th St. to 4th St.	7' Wide Bioretention Swales	Standard Drop Inlets	4th St.
Smith St. to 4th St.	Standard Drop Inlets	Standard Drop Inlets	4th St.
Smith St. to 2nd St.	Standard Drop Inlets	Standard Drop Inlets	2nd St.
Dodds St. to 2nd St.	Standard Drop Inlets	Standard Drop Inlets	2nd St.
Dodds St. to Patterson St.	Standard Drop Inlets	Standard Drop Inlets	Patterson St.
Patterson St. Intersection	Rain Garden	Standard Drop Inlets	Patterson St.
Patterson St. to Hillside St.	Standard Drop Inlets	Standard Drop Inlets	Hillside St.
Chambers St. to Hillside St	Standard Drop Inlets	Standard Drop Inlets	Hillside St.
Chambers St. to Jed St.	Standard Drop Inlets	Standard Drop Inlets	Jed St.
Jed St. Intersection	Rain Garden	Standard Drop Inlets	Jed St.
Graham St. to Ralston St.	Standard Drop Inlets	Standard Drop Inlets	Ralston St.
Tapp Road to Ralston St.	Standard Drop Inlets	Standard Drop Inlets	Ralston St.

F.7 Justification of Stormwater Routing Locations

Using GIS, Atlas Engineering identified adjacent roadways with existing stormwater structures to determine the locations to which stormwater would be routed.

8th Street, 4th Street, 2nd Street & Patterson Street:

8th Street, 4th Street, 2nd Street, and Patterson Street all have existing stormwater drainage structures currently in place with adequate capacity to handle the additional flow generated by the addition of stormwater structures on Rogers Street.

7th Street to Smith Street:

Seven foot wide bioretention swales shall be implemented along the west side of the corridor from 7th Street to Smith Street and serve several key functions, including: providing a buffer between the proposed multiuse trail and the roadway, serving as an aesthetic enhancement to the historic Prospect Hill District, and lastly as a BMP.

Patterson Street:

At the intersection of Patterson Street and Rogers Street, a rain garden shall be implemented, from which outfall from the standard drainage inlets along Rogers will be channeled into the rain garden. This rain garden will serve as a BMP, which is detailed in section F.5.

Hillside Street:

At Hillside Street, stormwater structures exist approximately 77 feet from its intersection with Rogers, implying that additional construction will be necessary to connect Rogers' stormwater to the existing Hillside Street structures.

Jed Street:

The intersection of Jed Street and Rogers Street is in close proximity to an existing stream, which will serve as an outfall for stormwater directed to the Jed Street intersection. Another rain garden shall be implemented in close proximity to this stream at the Jed Street intersection, which will serve as a best management practice.

Ralston Street

Lastly, Ralston Street has stormwater drainage structures approximately 300 feet east of its intersection with Rogers. Stormwater will be directed to this location, as it is not feasible to direct stormwater to Jed Street due to the natural slope of the land between Country Club/Tapp Rd. and Jed Street.

F.8 Specifications

The following specifications were set forth by the City of Bloomington Utilities Department (2006) to be applied to the hydrologic design of the Rogers Street Corridor:

1) Inlets, catch basins, concrete curbs and gutters along all streets and storm sewers shall be designed to accommodate the peak discharge produced by the 10-year design interval storm.
2) All structures shall be protected from flooding damage during the 100-year design interval storm and shall be consistent with the capacity of downstream storm sewer facilities.
3) Storm sewer systems shall be designed using the Rainfall Intensity-Duration-Frequency Curves (IDF curves) for Bloomington, Indiana. The IDF curves are developed by the City of Bloomington Utilities Department (CBU) using the latest information from the National Weather Service. Rainfall duration shall be equal to time of concentration. The Rational Method with an assumed time of concentration of 5 minutes is acceptable for inlet design.
4) Plans and profiles of the storm system shall be submitted to CBU for review. Hydraulic calculations for each inlet and run of pipe shall accompany all storm sewer plans submitted to CBU for review. Hydraulic calculations must be prepared by or under the direct supervision of a licensed professional engineer registered in the State of Indiana and engaged in storm drainage design.
5) Bicycle lanes and on street parking spaces may be fully encroached during the 10-year storm.
6) Inlets shall be located at the following locations:
    a) An intersection if runoff would cross any leg of the intersection
    b) An intersection of local or collector street with a collector or arterial to prevent runoff from the local or collector street from entering the collector or arterial
7) Arterials and Collectors shall be designed so that runoff does not reduce the clear travel lane to less than 8.0 feet for any lane.

F.9 References

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Table F.4: West Side Pipe Sizing Distribution

Pipe Reference	Pipe	t_0 (min)	Upstream pipes along longest path	t_f (min)	T_c (min)	*I* (in./hr)	Σ CA (acres)	Q_p (cfs)	D_r (ft)	D (ft)	Pipe flow time (min)
A	11th St. to 10th St. (West Side)	5	-	0.00	5.00	7.081	0.394	2.810	0.732	1.00	1.43
B	10th St. to 8th St. (West Side)	5	A	1.43	6.43	7.081	0.771	5.502	1.180	1.25	1.94
C	7th St. to 8th St. (West Side)	5	-	0.00	5.00	7.081	0.305	2.176	0.783	1.00	1.05
D	7th St. to 6th St. (West Side)	5	-	0.00	5.00	7.081	0.114	0.815	0.520	1.00	1.45
E	6th St. to Kirkwood (West Side)	5	D	1.45	6.45	7.081	0.234	1.672	0.755	1.00	1.37
F	Kirkwood to 4th St. (West Side)	5	D, E	2.82	7.82	7.081	0.353	2.519	0.842	1.00	1.12
G	3rd St. to 4th St. (West Side)	5	H	1.06	6.06	7.081	0.238	1.702	0.714	1.00	1.19
H	Prospect to 3rd St. (West Side)	5	-	0.00	5.00	7.081	0.124	0.885	0.455	1.00	1.06
I	Prospect to Smith (West Side)	5	-	0.00	5.00	7.081	0.110	0.788	0.700	1.00	2.15
J	Smith to Howe (West Side)	5	I	2.15	7.15	7.081	0.210	1.502	0.556	1.00	0.39
K	Howe to 2nd St. (West Side)	5	I, J	2.54	7.54	7.081	0.333	2.379	0.661	1.00	0.74
L	1st St. to 2nd St. (West Side)	5	M	2.04	7.04	7.081	1.037	7.403	1.609	2.00	2.75
M	Dodds to 1st St. (West Side)	5	-	0.00	5.00	7.081	0.560	3.998	1.002	1.00	2.04
N	Dodds to Allen (West Side)	5	-	0.00	5.00	7.081	0.477	3.407	1.199	1.25	3.21
O	Allen to Patterson (West Side)	5	N	3.21	8.21	7.081	0.947	6.763	1.094	1.25	1.30
P	Patterson to Driscoll (West Side)	5	N, O	4.50	9.50	7.081	1.274	9.095	1.377	1.50	1.05
Q	Driscoll to Wilson (West Side)	5	N, O, P	5.56	10.56	7.081	1.366	9.755	1.429	1.50	0.74
R	Wilson to Hillside (West Side)	5	N, O, P, Q	6.30	11.30	7.081	1.478	10.556	1.380	1.50	0.77
S	Cherokee to Hillside (West Side)	5	T	0.78	5.78	7.081	0.961	6.863	1.443	1.50	4.50
T	Chambers to Cherokee (West Side)	5	-	0.00	5.00	7.081	0.183	1.305	0.640	1.00	0.78
U	Chambers to Rockport (West Side)	5	-	0.00	5.00	7.081	0.041	0.295	0.484	1.00	0.93
V	Rockport to Jed (West Side)	5	U	0.93	5.93	7.081	0.365	2.608	0.853	1.00	3.33
W	Hays to Jed (West Side)	5	Z, Y, X	5.41	10.41	7.081	0.601	4.290	0.817	1.00	0.08
X	Joy to Hays (West Side)	5	Z, Y	4.84	9.84	7.081	0.562	4.014	1.003	1.00	0.58
Y	Coolidge to Joy (West Side)	5	Z	3.81	8.81	7.081	0.406	2.897	0.784	1.00	1.03
Z	Graham to Coolidge (West Side)	5	-	0.00	5.00	7.081	0.081	0.580	0.624	1.00	3.81
AA	Graham to Ralston (West Side)	5	-	0.00	5.00	7.081	0.117	0.832	0.532	1.00	1.96
BB	Country Club to Ralston (West Side)	5	-	0.00	5.00	7.081	0.184	1.317	0.618	1.00	1.28

Table F.5: West Side Pipe Flow Times

	11th to 10th	10th to 8th	7th to 8th	7th to 6th	6th to Kirkwood	Kirkwood to 4th	3rd to 4th	Prospect to 3rd	Prospect to Smith	Smith to Howe	Howe to 2nd	1st to 2nd
D (ft)	1	1.25	1	1	1	1	1	1	1	1	1	2.00
Q (cfs)	2.810	5.502	2.176	0.815	1.672	2.519	1.702	0.885	0.788	1.502	2.379	7.403
A_f (ft^2)	0.785	1.227	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	3.142
R_f (ft)	0.250	0.313	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.500
n	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
S_0	0.05	0.015	0.021	0.026	0.015	0.019	0.021	0.063	0.005	0.062	0.062	0.0052
Q_f (cfs)	6.490	6.445	4.206	4.680	3.555	4.001	4.206	7.285	2.052	7.227	7.227	13.290
V_f (fps)	8.264	5.252	5.356	5.959	4.526	5.094	5.356	9.276	2.613	9.202	9.202	4.230
Q/Q_f	0.433	0.854	0.517	0.174	0.470	0.630	0.405	0.122	0.384	0.208	0.329	0.557
y/D	0.45	0.71	0.51	0.23	0.47	0.57	0.44	0.17	0.43	0.31	0.39	0.54
V/V_f	0.96	1.12	1.01	0.66	0.97	1.05	0.94	0.56	0.93	0.79	0.89	1.03
y (ft)	0.450	0.888	0.510	0.230	0.470	0.570	0.440	0.170	0.430	0.310	0.390	1.080
V (fps)	7.933	5.883	5.409	3.933	4.390	5.349	5.034	5.195	2.430	7.270	8.190	4.357
L (ft)	680.4	684.3	340.8	341.7	361	358.9	358.7	329.6	312.8	171.4	365.1	719.3
L/V (min)	1.429	1.939	1.050	1.448	1.370	1.118	1.188	1.058	2.145	0.393	0.743	2.751

n = 0.016
k_n = 1.49

Table F.5 (cont): West Side Pipe Flow Times

	Dodds to 1st	Dodds to Allen	Allen to Patterson	Patterson to Driscoll	Driscoll to Wilson	Wilson to Hillside	Cherokee to Hillside	Chambers to Cherokee	Chambers to Rockport	Rockport to Jed	Hays to Jed	Joy to Hays
D (ft)	1	1.25	1.25	1.50	1.50	1.5	1.50	1	1	1	1	1
Q (cfs)	3.998	3.407	6.763	9.095	9.755	10.556	6.863	1.305	0.295	2.608	4.290	4.014
A_f (ft^2)	0.785	1.227	1.227	1.767	1.767	1.767	1.767	0.785	0.785	0.785	0.785	0.785
R_f (ft)	0.250	0.313	0.313	0.375	0.375	0.375	0.375	0.250	0.250	0.250	0.250	0.250
n	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
S_0	0.019	0.0053	0.034	0.018	0.017	0.024	0.008	0.022	0.005	0.019	0.065	0.019
Q_f (cfs)	4.001	3.831	9.704	11.481	11.158	13.258	7.654	4.305	2.052	4.001	7.400	4.001
V_f (fps)	5.094	3.122	7.907	6.497	6.314	7.502	4.331	5.482	2.613	5.094	9.422	5.094
Q/Q_f	0.999	0.889	0.697	0.792	0.874	0.796	0.897	0.303	0.144	0.652	0.580	1.003
y/D	0.82	0.73	0.62	0.67	0.73	0.68	0.74	0.38	0.25	0.58	0.55	0.82
V/V_f	1.14	1.13	1.08	1.11	1.13	1.11	1.13	0.88	0.7	1.05	1.04	1.14
y (ft)	0.820	0.913	0.775	1.005	1.095	1.020	1.110	0.380	0.250	0.580	0.550	0.820
V (fps)	5.807	3.528	8.540	7.212	7.135	8.328	4.895	4.824	1.829	5.349	9.799	5.807
L (ft)	709.1	678.5	664.7	456.1	318.3	386.4	1321.6	226.2	102.2	1069.5	49.4	200.5
L/V (min)	2.035	3.205	1.297	1.054	0.744	0.773	4.500	0.782	0.931	3.333	0.084	0.575

n = 0.016
k_n = 1.49

Table F.5 (cont): West Side Pipe Flow Times

	Coolidge to Joy	Graham to Coolidge	Graham to Ralston	Country Club to Ralston
D (ft)	1	1	1	1
Q (cfs)	2.897	0.580	0.832	1.317
A_f (ft^2)	0.785	0.785	0.785	0.785
R_f (ft)	0.250	0.250	0.250	0.250
n	0.016	0.016	0.016	0.016
S_0	0.037	0.005	0.024	0.027
Q_f (cfs)	5.583	2.052	4.497	4.769
V_f (fps)	7.109	2.613	5.725	6.073
Q/Q_f	0.519	0.282	0.185	0.276
y/D	0.51	0.37	0.29	0.36
V/V_f	1.01	0.87	0.77	0.86
y (ft)	0.510	0.370	0.290	0.360
V (fps)	7.180	2.274	4.408	5.222
L (ft)	441.8	519.9	519.1	401.5
L/V (min)	1.026	3.811	1.963	1.281

n = 0.016
k_n = 1.49

Table F.6: East Side Pipe Sizing Distribution

Pipe Reference	Pipe	t_0 (min)	Upstream pipes along longest path	t_f (min)	T_c (min)	I (in./hr)	ΣCA (acres)	Q_p (cfs)	D_r (ft)	D (ft)	Pipe flow time (min)
A	11th St. to 10th St. (East Side)	5	-	0.00	5.00	7.081	0.502	3.587	0.802	1.00	1.33
B	10th St. to 8th St. (East Side)	5	A	1.33	6.33	7.081	1.008	7.194	1.305	1.25	1.90
C	7th St. to 8th St. (East Side)	5	-	0.00	5.00	7.081	0.225	1.609	0.699	1.00	1.13
D	7th St. to 6th St. (East Side)	5	-	0.00	5.00	7.081	0.122	0.874	0.534	1.00	1.24
E	6th St. to Kirkwood (East Side)	5	D	1.24	6.24	7.081	0.242	1.726	0.764	1.00	1.34
F	Kirkwood to 4th St. (East Side)	5	D, E	2.58	7.58	7.081	0.368	2.630	0.856	1.00	1.10
G	3rd St. to 4th St. (East Side)	5	H	0.86	5.86	7.081	0.250	1.785	0.727	1.00	1.16
H	Prospect to 3rd St. (East Side)	5	-	0.00	5.00	7.081	0.122	0.873	0.452	1.00	0.86
I	Prospect to Smith (East Side)	5	-	0.00	5.00	7.081	0.099	0.710	0.673	1.00	2.17
J	Smith to Howe (East Side)	5	I	2.17	7.17	7.081	0.171	1.220	0.514	1.00	0.42
K	Howe to 2nd St. (East Side)	5	I, J	2.59	7.59	7.081	0.489	3.493	0.763	1.00	0.67
L	1st St. to 2nd St. (East Side)	5	M	2.04	7.04	7.081	1.085	7.748	1.637	2.00	2.72
M	Dodds to 1st St. (East Side)	5	-	0.00	5.00	7.081	0.531	3.794	0.982	1.00	2.04
N	Dodds to Allen (East Side)	5	-	0.00	5.00	7.081	0.277	1.979	0.978	1.00	3.69
O	Allen to Patterson (East Side)	5	N	3.69	8.69	7.081	0.769	5.492	1.012	1.25	1.36
P	Patterson to Driscoll (East Side)	5	N, O	5.05	10.05	7.081	1.188	8.482	1.342	1.50	1.06
Q	Driscoll to Wilson (East Side)	5	N, O, P	6.11	11.11	7.081	1.408	10.052	1.445	1.50	0.74
R	Wilson to Hillside (East Side)	5	N, O, P, Q	6.85	11.85	7.081	1.675	11.957	1.446	1.50	0.76
S	Cherokee to Hillside (East Side)	5	T	0.81	5.81	7.081	1.311	9.361	1.621	2.00	4.08
T	Chambers to Cherokee (East Side)	5	-	0.00	5.00	7.081	0.168	1.198	0.620	1.00	0.81
U	Chambers to Rockport (East Side)	5	-	0.00	5.00	7.081	0.038	0.271	0.469	1.00	0.93
V	Rockport to Jed (East Side)	5	U	0.93	5.93	7.081	0.246	1.753	0.735	1.00	3.64
W	Hays to Jed (East Side)	5	Z, Y, X	5.66	10.66	7.081	0.344	2.459	0.663	1.00	0.10
X	Joy to Hays (East Side)	5	Z, Y	5.03	10.03	7.081	0.324	2.316	0.816	1.00	0.63
Y	Coolidge to Joy (East Side)	5	Z	3.86	8.86	7.081	0.243	1.738	0.647	1.00	1.18
Z	Graham to Coolidge (East Side)	5	-	0.00	5.00	7.081	0.081	0.580	0.624	1.00	3.86
AA	Graham to Ralston (East Side)	5	-	0.00	5.00	7.081	0.1215	0.868	0.541	1.00	1.96
BB	Country Club to Ralston (East Side)	5	-	0.00	5.00	7.081	0.1158	0.827	0.519	1.00	1.90

Table F.7: East Side Pipe Flow Times

	11th to 10th	10th to 8th	7th to 8th	7th to 6th	6th to Kirkwood	Kirkwood to 4th	3rd to 4th	Prospect to 3rd	Prospect to Smith	Smith to Howe	Howe to 2nd	1st to 2nd
D (ft)	1	1.25	1	1	1	1	1	1	1	1	1	2.00
Q (cfs)	3.587	7.194	1.609	0.874	1.726	2.630	1.785	0.873	0.710	1.220	3.493	7.748
A_f (ft^2)	0.785	1.227	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	3.142
R_f (ft)	0.250	0.313	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.500
n	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
S_0	0.05	0.015	0.021	0.026	0.015	0.019	0.021	0.063	0.005	0.062	0.062	0.0052
Q_f (cfs)	6.490	6.445	4.206	4.680	3.555	4.001	4.206	7.285	2.052	7.227	7.227	13.290
V_f (fps)	8.264	5.252	5.356	5.959	4.526	5.094	5.356	9.276	2.613	9.202	9.202	4.230
Q/Q_f	0.553	1.116	0.383	0.187	0.486	0.657	0.424	0.120	0.346	0.169	0.483	0.583
y/D	0.53	0.84	0.43	0.29	0.49	0.59	0.45	0.24	0.41	0.28	0.48	0.55
V/V_f	1.03	1.14	0.94	0.77	0.99	1.07	0.96	0.69	0.92	0.74	0.98	1.04
y (ft)	0.530	1.050	0.430	0.290	0.490	0.590	0.450	0.240	0.410	0.280	0.480	1.100
V (fps)	8.512	5.988	5.034	4.588	4.481	5.451	5.141	6.400	2.404	6.810	9.018	4.400
L (ft)	680.4	684.3	340.8	341.7	361	358.9	358.7	329.6	312.8	171.4	365.1	719.3
L/V (min)	1.332	1.905	1.128	1.241	1.343	1.097	1.163	0.858	2.168	0.420	0.675	2.725

n = 0.016
k_n = 1.49

Table F.7 (cont): East Side Pipe Flow Times

	Dodds to 1st	Dodds to Allen	Allen to Patterson	Patterson to Driscoll	Driscoll to Wilson	Wilson to Hillside	Cherokee to Hillside	Chambers to Cherokee	Chambers to Rockport	Rockport to Jed	Hays to Jed	Joy to Hays
D (ft)	1	1.00	1.25	1.50	1.50	1.5	2.00	1	1	1	1	1
Q (cfs)	3.794	1.979	5.492	8.482	10.052	11.957	9.361	1.198	0.271	1.753	2.459	2.316
A_f (ft^2)	0.785	0.785	1.227	1.767	1.767	1.767	3.142	0.785	0.785	0.785	0.785	0.785
R_f (ft)	0.250	0.250	0.313	0.375	0.375	0.375	0.500	0.250	0.250	0.250	0.250	0.250
n	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
S_0	0.019	0.0053	0.034	0.018	0.017	0.024	0.008	0.022	0.005	0.019	0.065	0.019
Q_f (cfs)	4.001	2.113	9.704	11.481	11.158	13.258	16.484	4.305	2.052	4.001	7.400	4.001
V_f (fps)	5.094	2.690	7.907	6.497	6.314	7.502	5.247	5.482	2.613	5.094	9.422	5.094
Q/Q_f	0.948	0.937	0.566	0.739	0.901	0.902	0.568	0.278	0.132	0.438	0.332	0.579
y/D	0.76	0.77	0.54	0.64	0.74	0.74	0.54	0.36	0.25	0.46	0.39	0.56
V/V_f	1.14	1.14	1.03	1.1	1.13	1.13	1.03	0.85	0.7	0.96	0.89	1.04
y (ft)	0.760	0.770	0.675	0.960	1.110	1.110	1.080	0.360	0.250	0.460	0.390	0.560
V (fps)	5.807	3.067	8.145	7.147	7.135	8.478	5.405	4.659	1.829	4.890	8.386	5.298
L (ft)	709.1	678.5	664.7	456.1	318.3	386.4	1321.6	226.2	102.2	1069.5	49.4	200.5
L/V (min)	2.035	3.687	1.360	1.064	0.744	0.760	4.076	0.809	0.931	3.645	0.098	0.631

n = 0.016
k_n = 1.49

Table F.7 (cont): East Side Pipe Flow Times

	Coolidge to Joy	Graham to Coolidge	Graham to Ralston	Country Club to Ralston
D (ft)	1	1	1	1
Q (cfs)	1.738	0.580	0.868	0.827
A_f (ft^2)	0.785	0.785	0.785	0.785
R_f (ft)	0.250	0.250	0.250	0.250
n	0.016	0.016	0.016	0.016
S_0	0.037	0.005	0.024	0.027
Q_f (cfs)	5.583	2.052	4.497	4.769
V_f (fps)	7.109	2.613	5.725	6.073
Q/Q_f	0.311	0.282	0.193	0.173
y/D	0.38	0.36	0.29	0.18
V/V_f	0.88	0.86	0.77	0.58
y (ft)	0.380	0.360	0.290	0.180
V (fps)	6.256	2.247	4.408	3.522
L (ft)	441.8	519.9	519.1	401.5
L/V (min)	1.177	3.856	1.963	1.900

n = 0.016

k_n = 1.49

Table F.8: - Sample Calculations of Inlet Spacing

1) Find Q using Manning's Equation:

$$Q = \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL^{\frac{1}{2}}}{2.64n}$$

where

Q = Street (Gutter) Flow
kn = conversion constant = 1.49 ft^1/3/sec,
T = Top Width,
n = Manning's Roughness,
Sx = Cross Slope, and
SL = Longitudinal Bottom Slope

$$kn := 1.49 \frac{ft^{\frac{1}{3}}}{s} \qquad n := 0.016$$

*Sx = 2% for the entire corridor as specified by the Bloomington Utilities Department

$$T := 4ft \qquad Sx := .02$$

Top Width = 4 feet because travel lanes are 12 feet wide and an 8.0 foot clear travel lane must be maintained throughout the 10-year design storm as specified by the Bloomington Utilities Department.

For example: $SL := .05$

$$Qmanning := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL^{\frac{1}{2}}}{2.64 \cdot n}$$

This value will change for each city block

$$Qmanning = 0.469 \frac{ft^3}{s}$$

Rational Method Runoff Coefficient, typically computed as a weighted average for Asphalt and Residential Lawns:

$$Crc := 0.2$$

$$Qrational = Crc \cdot i \cdot A$$

Bloomington Design Storm Rainfall Intensity:

Setting Manning's Q equal to Rational Q:

$$i := 7.081 \frac{in}{hr}$$

$$Area := \frac{Qmanning}{Crc \cdot i}$$

solving for Area:

$$Area = 0.328\,acre$$

Now compare computed area to available area between intersecting streets to obtain number of inlets needed and spacing required for inlets (see next page)

11th Street to 10th Street:

$Area1West := 85730ft^2 \quad Area1East := 109408ft^2$

$Area1West = 1.968\,acre \quad Area1East = 2.512\,acre$

$$Q1 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL1^{\frac{1}{2}}}{2.64 \cdot n} \quad C1 := .2 \quad SL1 := \frac{819.1 - 785}{680.4} \quad SL1 = 0.05$$

$$Q1 = 0.469\frac{ft^3}{s} \quad Area1\_1 := \frac{Q1}{C1 \cdot i} \quad Area1\_1 = 0.329\,acre$$

$$InletsWest := \frac{Area1West}{Area1\_1} \quad InletsWest = 5.99 \quad SpacingWest := \frac{680.4ft}{6} \quad \boxed{SpacingWest = 113.4\,ft}$$

$$InletsEast := \frac{Area1East}{Area1\_1} \quad InletsEast = 7.645 \quad SpacingEast := \frac{680.4ft}{8} \quad \boxed{SpacingEast = 85.05\,ft}$$

Tenth Street to 8th Street:

$Area2West := 82116ft^2 \quad Area2East := 110035ft^2$

$Area2West = 1.885\,acre \quad Area2East = 2.526\,acre$

$$Q2 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL2^{\frac{1}{2}}}{2.64 \cdot n} \quad C2 := .2 \quad SL2 := \frac{785 - 774.7}{684.3} \quad SL2 = 0.015$$

$$Q2 = 0.257\frac{ft^3}{s} \quad Area2\_2 := \frac{Q2}{C2 \cdot i} \quad Area2\_2 = 0.18\,acre$$

$$InletsWest2 := \frac{Area2West}{Area2\_2} \quad InletsWest2 = 10.47 \quad SpacingWest2 := \frac{684.3ft}{11} \quad \boxed{SpacingWest2 = 62.209\,ft}$$

$$InletsEast2 := \frac{Area2East}{Area2\_2} \quad InletsEast2 = 14.029 \quad SpacingEast2 := 684.3\frac{ft}{14} \quad \boxed{SpacingEast2 = 48.879\,ft}$$

Seventh Street to Eighth Street:

$Area3West := 66387ft^2 \quad Area3East := 49075ft^2$

$Area3West = 1.524\,acre \quad Area3East = 1.127\,acre$

$$Q3 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL3^{\frac{1}{2}}}{2.64 \cdot n} \quad C3 := .2 \quad SL3 := \frac{781.9 - 774.7}{340.8} \quad SL3 = 0.021$$

$$Area3\_3 := \frac{Q3}{C3 \cdot i} \quad Area3\_3 = 0.213\,acre$$

$$Q3 = 0.305\frac{ft^3}{s}$$

$InletsWest3 := \frac{Area3West}{Area3\_3}$ $\quad InletsWest3 = 7.144$ $\quad SpacingWest3 := \frac{340.8ft}{8}$ $\quad \boxed{SpacingWest3 = 42.6\,ft}$

$InletsEast3 := \frac{Area3East}{Area3\_3}$ $\quad InletsEast3 = 5.281$ $\quad SpacingEast3 := \frac{340.8ft}{6}$ $\quad \boxed{SpacingEast3 = 56.8\,ft}$

Seventh Street to Sixth Street:

$Area4West := 24876ft^2$ $\quad Area4East := 26653ft^2$

$Area4West = 0.571\,acre$ $\quad Area4East = 0.612\,acre$

$$Q4 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL4^{\frac{1}{2}}}{2.64 \cdot n}$$

$C4 := .2$ $\quad SL4 := \frac{781.9 - 772.9}{341.7}$ $\quad SL4 = 0.026$

$Area4\_4 := \frac{Q4}{C4 \cdot i}$ $\quad Area4\_4 = 0.238\,acre$

$Q4 = 0.34\frac{ft^3}{s}$

$InletsWest4 := \frac{Area4West}{Area4\_4}$ $\quad InletsWest4 = 2.398$ $\quad SpacingWest4 := \frac{341.7ft}{3}$ $\quad \boxed{SpacingWest4 = 113.9\,ft}$

$InletsEast4 := \frac{Area4East}{Area4\_4}$ $\quad InletsEast4 = 2.569$ $\quad SpacingEast4 := \frac{341.7ft}{3}$ $\quad \boxed{SpacingEast4 = 113.9\,ft}$

Sixth Street to Kirkwood Ave:

$Area5West := 26136ft^2$ $\quad Area5East := 25992ft^2$

$Area5West = 0.6\,acre$ $\quad Area5East = 0.597\,acre$

$$Q5 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL5^{\frac{1}{2}}}{2.64 \cdot n}$$

$C5 := .2$ $\quad SL5 := \frac{772.9 - 767.6}{361}$ $\quad SL5 = 0.015$

$Area5\_5 := \frac{Q5}{C5 \cdot i}$ $\quad Area5\_5 = 0.178\,acre$

$Q5 = 0.254\,\frac{1}{s}\,ft^3$

$InletsWest5 := \frac{Area5West}{Area5\_5}$ $\quad InletsWest5 = 3.374$ $\quad SpacingWest5 := \frac{361ft}{4}$ $\quad \boxed{SpacingWest5 = 90.25\,ft}$

$InletsEast5 := \frac{Area5East}{Area5\_5}$ $\quad InletsEast5 = 3.355$ $\quad SpacingEast5 := \frac{361ft}{4}$ $\quad \boxed{SpacingEast5 = 90.25\,ft}$

Kirkwood Avenue to Fourth Street:

$Area6West := 25840ft^2$ $\quad Area6East := 27564ft^2$

$Area6West = 0.593\,acre$ $\quad Area6East = 0.633\,acre$

$$Q6 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL6^{\frac{1}{2}}}{2.64 \cdot n}$$

$C6 := .2$ $\quad SL6 := \frac{767.6 - 760.8}{358.9}$ $\quad SL6 = 0.019$

$Area6\_6 := \frac{Q6}{C6 \cdot i}$ $\quad Area6\_6 = 0.202\,acre$

$Q6 = 0.288 \frac{ft^3}{s}$

$InletsWest6 := \frac{Area6West}{Area6\_6}$ $\quad InletsWest6 = 2.936$ $\quad SpacingWest6 := \frac{358.9ft}{3}$ $\quad \boxed{SpacingWest6 = 119.633\,ft}$

$InletsEast6 := \frac{Area6East}{Area6\_6}$ $\quad InletsEast6 = 3.132$ $\quad SpacingEast6 := \frac{358.9ft}{4}$ $\quad \boxed{SpacingEast6 = 89.725\,ft}$

Third Street to Fourth Street:

$Area7West := 24931ft^2$ $\quad Area7East := 27835ft^2$

$Area7West = 0.572\,acre$ $\quad Area7East = 0.639\,acre$

$$Q7 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL7^{\frac{1}{2}}}{2.64 \cdot n}$$

$C7 := .2$ $\quad SL7 := \frac{768.4 - 760.8}{358.7}$ $\quad SL7 = 0.021$

$Q7 = 0.305 \frac{ft^3}{s}$ $\quad Area7\_7 := \frac{Q7}{C7 \cdot i}$ $\quad Area7\_7 = 0.214\,acre$

$InletsWest7 := \frac{Area7West}{Area7\_7}$ $\quad InletsWest = 5.99$ $\quad SpacingWest7 := \frac{358.7ft}{6}$ $\quad \boxed{SpacingWest7 = 59.783\,ft}$

$InletsEast7 := \frac{Area7East}{Area7\_7}$ $\quad InletsEast7 = 2.991$ $\quad SpacingEast7 := \frac{358.7ft}{3}$ $\quad \boxed{SpacingEast7 = 119.567\,f}$

Prospect Street to Third Street:

$Area8West := 27027ft^2$ $\quad Area8East := 26631ft^2$

$Area8West = 0.62\,acre$ $\quad Area8East = 0.611\,acre$

$$Q8 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL8^{\frac{1}{2}}}{2.64 \cdot n}$$

$C8 := .2$ $\quad SL8 := \frac{789 - 768.4}{329.6}$ $\quad SL8 = 0.063$

$Area8\_8 := \frac{Q8}{C8 \cdot i}$ $\quad Area8\_8 = 0.367\,acre$

$Q8 = 0.524 \frac{ft^3}{s}$

$\text{InletsWest8} := \frac{\text{Area8West}}{\text{Area8\_8}}$ $\text{InletsWest8} = 1.691$ $\text{SpacingWest8} := \frac{329.6\text{ft}}{2}$ $\boxed{\text{SpacingWest8} = 164.8\text{ft}}$

$\text{InletsEast8} := \frac{\text{Area8East}}{\text{Area8\_8}}$ $\text{InletsEast8} = 1.666$ $\text{SpacingEast8} := \frac{329.6\text{ft}}{2}$ $\boxed{\text{SpacingEast8} = 164.8\text{ft}}$

Prospect Street to Smith Avenue:

$\text{Area9West} := 24024\text{ft}^2$ $\text{Area9East} := 21645\text{ft}^2$

$\text{Area9West} = 0.552\,\text{acre}$ $\text{Area9East} = 0.497\,\text{acre}$

$$Q9 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot .005^{\frac{1}{2}}}{2.64 \cdot n}$$ $C9 := .2$ $SL9 := \frac{789.1 - 789}{312.8}$ $SL9 = 3.197 \times 10^{-4}$

$Q9 = 0.148 \frac{\text{ft}^3}{s}$

Slope does not meet minimum requirement, therefore a value of 0.005 is used in Manning's Equation to find flow.

$\text{Area9\_9} := \frac{Q9}{C9 \cdot i}$ $\text{Area9\_9} = 0.104\,\text{acre}$

$\text{InletsWest9} := \frac{\text{Area9West}}{\text{Area9\_9}}$ $\text{InletsWest9} = 5.314$ $\text{SpacingWest9} := \frac{312.8\text{ft}}{6}$ $\boxed{\text{SpacingWest9} = 52.133\text{ft}}$

$\text{InletsEast9} := \frac{\text{Area9East}}{\text{Area9\_9}}$ $\text{InletsEast9} = 4.788$ $\text{SpacingEast9} := \frac{312.8\text{ft}}{5}$ $\boxed{\text{SpacingEast9} = 62.56\text{ft}}$

Smith Avenue to Howe Street:

$\text{Area10West} := 21777\text{ft}^2$ $\text{Area10East} := 15563\text{ft}^2$

$\text{Area10West} = 0.5\,\text{acre}$ $\text{Area10East} = 0.357\,\text{acre}$

$$Q10 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL10^{\frac{1}{2}}}{2.64 \cdot n}$$ $C10 := .2$ $SL10 := \frac{789.1 - 778.4}{171.4}$ $SL10 = 0.062$

$\text{Area10\_10} := \frac{Q10}{C10 \cdot i}$ $\text{Area10\_10} = 0.367\,\text{acre}$

$Q10 = 0.524 \frac{\text{ft}^3}{s}$

$\text{InletsWest10} := \frac{\text{Area10West}}{\text{Area10\_10}}$ $\text{InletsWest10} = 1.363$ $\text{SpacingWest10} := \frac{171.4\text{ft}}{2}$ $\boxed{\text{SpacingWest10} = 85.7\text{ft}}$

$\text{InletsEast10} := \frac{\text{Area10East}}{\text{Area10\_10}}$ $\text{InletsEast10} = 0.974$ $\text{SpacingEast10} := \frac{171.4\text{ft}}{1}$ $\boxed{\text{SpacingEast10} = 171.4\text{ft}}$

Howe Street to Second Street:

$Area11West := 26725ft^2 \quad Area11East := 69369 \cdot ft^2$

$Area11West = 0.614\,acre \quad Area11East = 1.592\,acre$

$$Q11 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL11^{\frac{1}{2}}}{2.64 \cdot n} \qquad C11 := .2 \qquad SL11 := \frac{778.4 - 755.6}{365.1} \qquad SL11 = 0.062$$

$$Q11 = 0.524\frac{ft^3}{s} \qquad Area11\_11 := \frac{Q11}{C11 \cdot i} \qquad Area11\_11 = 0.367\,acre$$

$$InletsWest11 := \frac{Area11West}{Area11\_11} \qquad InletsWest11 = 1.673 \qquad SpacingWest11 := \frac{365.1ft}{2}$$

$$\boxed{SpacingWest11 = 182.55\,ft}$$

$$InletsEast11 := \frac{Area11East}{Area11\_11} \qquad InletsEast11 = 4.342 \qquad SpacingEast11 := \frac{365.1ft}{5}$$

$$\boxed{SpacingEast11 = 73.02\,ft}$$

First Street to Second Street:

$Area12West := 103866ft^2 \quad Area12East := 120612ft^2$

$Area12West = 2.384\,acre \quad Area12East = 2.769\,acre$

$$Q12 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL12^{\frac{1}{2}}}{2.64 \cdot n} \qquad C12 := .1 \qquad SL12 := \frac{759.4 - 755.6}{719.3} \qquad SL12 = 5.283 \times 10^{-3}$$

$$Q12 = 0.152\frac{ft^3}{s} \qquad Area12\_12 := \frac{Q12}{C12 \cdot i} \qquad Area12\_12 = 0.213\,acre$$

$$InletsWest12 := \frac{Area12West}{Area12\_12} \qquad InletsWest12 = 11.177 \qquad SpacingWest12 := \frac{719.3ft}{12}$$

$$\boxed{SpacingWest12 = 59.942\,ft}$$

$$InletsEast12 := \frac{Area12East}{Area12\_12} \qquad InletsEast12 = 12.979 \qquad SpacingEast12 := \frac{719.3ft}{13}$$

$$\boxed{SpacingEast12 = 55.331\,ft}$$

Dodds Street to First Street:

$Area13West := 121965ft^2$ $Area13East := 115725ft^2$

$Area13West = 2.8\,acre$ $Area13East = 2.657\,acre$

$$Q13 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL13^{\frac{1}{2}}}{2.64 \cdot n}$$

$C13 := .2$ $SL13 := \frac{772.9 - 759.4}{709.1}$ $SL13 = 0.019$

$Q13 = 0.289 \frac{ft^3}{s}$ $Area13\_13 := \frac{Q13}{C13 \cdot i}$ $Area13\_13 = 0.202\,acre$

Slope does not meet minimum requirement, therefore a value of 0.005 is used in Manning's Equation to find flow.

$InletsWest13 := \frac{Area13West}{Area13\_13}$ $InletsWest13 = 13.827$ $SpacingWest13 := \frac{709.1ft}{14}$

$\boxed{SpacingWest13 = 50.65\,ft}$

$InletsEast13 := \frac{Area13East}{Area13\_13}$ $InletsEast13 = 13.119$ $SpacingEast13 := \frac{709.1ft}{14}$

$\boxed{SpacingEast13 = 50.65\,ft}$

Dodds Street to Allen Street:

$Area14West := 103946ft^2$ $Area14East := 60386ft^2$

$Area14West = 2.386\,acre$ $Area14East = 1.386\,acre$

$$Q14 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL14^{\frac{1}{2}}}{2.64 \cdot n}$$

$C14 := .1$ $SL14 := \frac{772.9 - 769.3}{678.5}$ $SL14 = 5.306 \times 10^{-3}$

$Q14 = 0.153 \frac{ft^3}{s}$ $Area14\_14 := \frac{Q14}{C14 \cdot i}$ $Area14\_14 = 0.214\,acre$

$InletsWest14 := \frac{Area14West}{Area14\_14}$ $InletsWest14 = 11.161$ $SpacingWest14 := \frac{678.5ft}{12}$

$\boxed{SpacingWest14 = 56.542\,ft}$

$InletsEast14 := \frac{Area14East}{Area14\_14}$ $InletsEast14 = 6.484$ $SpacingEast14 := \frac{678.5ft}{7}$

$\boxed{SpacingEast14 = 96.929\,ft}$

Allen Street to Patterson Street:

$Area15West := 102364ft^2 \qquad Area15East := 107149ft^2$

$Area15West = 2.35\,acre \qquad Area15East = 2.46\,acre$

$$Q15 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL15^{\frac{1}{2}}}{.64 \cdot n} \qquad C15 := .2 \qquad SL15 := \frac{769.3 - 747}{664.7} \qquad SL15 = 0.034$$

$$Q15 = 0.384\frac{ft^3}{s} \qquad Area15\_15 := \frac{Q15}{C15 \cdot i} \qquad Area15\_15 = 0.269\,acre$$

$$InletsWest15 := \frac{Area15West}{Area15\_15} \qquad InletsWest15 = 8.742 \qquad SpacingWest15 := \frac{664.7ft}{9}$$

$$\boxed{SpacingWest15 = 73.856\,ft}$$

$$InletsEast15 := \frac{Area15East}{Area15\_15} \qquad InletsEast15 = 9.151 \qquad SpacingEast15 := \frac{664.7ft}{}$$

$$\boxed{SpacingEast15 = 66.47\,ft}$$

Patterson Street to Driscoll St:

$Area16West := 71151ft^2 \qquad Area16East := 91220ft^2$

$Area16West = 1.633\,acre \qquad Area16East = 2.094\,acre$

$$Q16 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL16^{\frac{1}{2}}}{2.64 \cdot n} \qquad C16 := .2 \qquad SL16 := \frac{747 - 739}{456.1} \qquad SL16 = 0.018$$

$$Q16 = 0.278\frac{ft^3}{s} \qquad Area16\_16 := \frac{Q16}{C16 \cdot i} \qquad Area16\_16 = 0.194\,acre$$

$$InletsWest16 := \frac{Area16West}{Area16\_16} \qquad InletsWest16 = 8.404 \qquad SpacingWest16 := \frac{456.1ft}{9}$$

$$\boxed{SpacingWest16 = 50.678\,ft}$$

$$InletsEast16 := \frac{Area16East}{Area16\_16} \qquad InletsEast16 = 10.774 \qquad SpacingEast16 := \frac{456.1ft}{11}$$

$$\boxed{SpacingEast16 = 41.464\,ft}$$

Driscoll Street to Wilson Street:

$Area17West := 20116ft^2$ $Area17East := 47872ft^2$

$Area17West = 0.462\,acre$ $Area17East = 1.099\,acre$

$$Q17 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL17^{\frac{1}{2}}}{2.64 \cdot n}$$ $C17 := .2$ $SL17 := \frac{739 - 733.6}{318.3}$ $SL17 = 0.017$

$Q17 = 0.273\frac{ft^3}{s}$ $Area17\_17 := \frac{Q17}{C17 \cdot i}$ $Area17\_17 = 0.191\,acre$

$InletsWest17 := \frac{Area17West}{Area17\_17}$ $InletsWest17 = 2.416$ $SpacingWest17 := \frac{318.3ft}{3}$

$\boxed{SpacingWest17 = 106.1\,ft}$

$InletsEast17 := \frac{Area17East}{Area17\_17}$ $InletsEast17 = 5.749$ $SpacingEast17 := \frac{318.3ft}{6}$

$\boxed{SpacingEast17 = 53.05\,ft}$

Wilson Street to Hillside Street: $Area18West := 24420ft^2$ $Area18East := 58114ft^2$

$Area18West = 0.561\,acre$ $Area18East = 1.334\,acre$

$$Q18 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL18^{\frac{1}{2}}}{2.64 \cdot n}$$ $C18 := .2$ $SL18 := \frac{733.6 - 724.2}{386.4}$ $SL18 = 0.024$

$Area18\_18 := \frac{Q18}{C18 \cdot i}$ $Area18\_18 = 9.971 \times 10^3\,ft^2$

$Q18 = 0.327\frac{ft^3}{s}$

$InletsWest18 := \frac{Area18West}{Area18\_18}$ $InletsWest18 = 2.449$ $SpacingWest18 := \frac{386.4ft}{3}$

$\boxed{SpacingWest18 = 128.8\,ft}$

$InletsEast18 := \frac{Area18East}{Area18\_18}$ $InletsEast18 = 5.828$ $SpacingEast18 := \frac{386.4ft}{6}$

$\boxed{SpacingEast18 = 64.4\,ft}$

Cherokee Street to Hillside Street:

$\text{Area19West} := 169557\,\text{ft}^2 \qquad \text{Area19East} := 248989\,\text{ft}^2$

$\text{Area19West} = 3.892\,\text{acre} \qquad \text{Area19East} = 5.716\,\text{acre}$

$\text{C19} := .1 \qquad \text{SL19} := \dfrac{735 - 724.2}{1321.6} \qquad \text{SL19} = 8.172 \times 10^{-3}$

$$\text{Q19} := \frac{\text{kn}\cdot T^{\frac{8}{3}}\cdot \text{Sx}^{\frac{5}{3}}\cdot .005^{\frac{1}{2}}}{2.64\cdot n} \qquad \text{Area19\_19} := \frac{\text{Q19}}{\text{C19}\cdot i} \qquad \text{Area19\_19} = 0.208\,\text{acre}$$

$$\text{InletsWest19} := \frac{\text{Area19West}}{\text{Area19\_19}} \qquad \text{InletsWest19} = 18.754 \qquad \text{SpacingWest19} := \frac{1321.6\,\text{ft}}{19}$$

$$\boxed{\text{SpacingWest19} = 69.558\,\text{ft}}$$

$$\text{InletsEast19} := \frac{\text{Area19East}}{\text{Area19\_19}} \qquad \text{InletsEast19} = 27.54 \qquad \text{SpacingEast19} := \frac{1321.6\,\text{ft}}{28}$$

$$\boxed{\text{SpacingEast19} = 47.2\,\text{ft}}$$

Chambers Drive to Cherokee Street:

$\text{Area20West} := 39811\,\text{ft}^2 \qquad \text{Area20East} := 36553\,\text{ft}^2$

$\text{Area20West} = 0.914\,\text{acre} \qquad \text{Area20East} = 0.839\,\text{acre}$

$$\text{Q20} := \frac{\text{kn}\cdot T^{\frac{8}{3}}\cdot \text{Sx}^{\frac{5}{3}}\cdot \text{SL20}^{\frac{1}{2}}}{2.64\cdot n} \qquad \text{C20} := .15 \qquad \text{SL20} := \frac{740 - 735}{226.2} \qquad \text{SL20} = 0.022$$

$$\text{Area20\_20} := \frac{\text{Q20}}{\text{C20}\cdot i} \qquad \text{Area20\_20} = 0.291\,\text{acre}$$

$$\text{Q20} = 0.312\,\frac{\text{ft}^3}{s}$$

$$\text{InletsWest20} := \frac{\text{Area20West}}{\text{Area20\_20}} \qquad \text{InletsWest20} = 3.141 \qquad \text{SpacingWest20} := \frac{226.2\,\text{ft}}{4}$$

$$\boxed{\text{SpacingWest20} = 56.55\,\text{ft}}$$

$$\text{InletsEast20} := \frac{\text{Area20East}}{\text{Area20\_20}} \qquad \text{InletsEast20} = 2.884 \qquad \text{SpacingEast20} := \frac{226.2\,\text{ft}}{3}$$

$$\boxed{\text{SpacingEast20} = 75.4\,\text{ft}}$$

Chambers Drive to Rockport Road:

$Area21West := 17987ft^2$ $Area21East := 16515ft^2$

$Area21West = 0.413\,acre$ $Area21East = 0.379\,acre$

$C21 := .1$ $SL21 := \frac{740.2 - 740}{102.2}$ $SL21 = 1.957 \times 10^{-3}$

$$Q21 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot .005^{\frac{1}{2}}}{2.64 \cdot n}$$

$Area21\_21 := \frac{Q21}{C21 \cdot i}$ $Area21\_21 = 0.208\,acre$

$Q21 = 0.148 \frac{ft^3}{s}$

$InletsWest21 := \frac{Area21West}{Area21\_21}$ $InletsWest21 = 1.99$ $SpacingWest21 := \frac{102.2ft}{2}$

$\boxed{SpacingWest21 = 51.1\,ft}$

$InletsEast21 := \frac{Area21East}{Area21\_21}$ $InletsEast21 = 1.827$ $SpacingEast21 := \frac{102.2ft}{2}$

$\boxed{SpacingEast21 = 51.1\,ft}$

Rockport Road to Jed Street:

$Area22West := 159141ft^2$ $Area22East := 106950ft^2$

$Area22West = 3.653\,acre$ $Area22East = 2.455\,acre$

$$Q22 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL22^{\frac{1}{2}}}{2.64 \cdot n}$$

$C22 := .1$ $SL22 := \frac{740.2 - 720}{1069.5}$ $SL22 = 0.019$

$Area22\_22 := \frac{Q22}{C22 \cdot i}$ $Area22\_22 = 0.403\,acre$

$Q22 = 0.288 \frac{ft^3}{s}$

$InletsWest22 := \frac{Area22West}{Area22\_22}$ $InletsWest22 = 9.057$ $SpacingWest22 := \frac{1069.5ft}{9}$

$\boxed{SpacingWest22 = 118.833\,ft}$

$InletsEast22 := \frac{Area22East}{Area22\_22}$ $InletsEast22 = 6.086$ $SpacingEast22 := \frac{1069.5ft}{6}$

$\boxed{SpacingEast22 = 178.25\,ft}$

Hays Street to Jed Street:

$Area23West := 8398ft^2$ $Area23East := 4347ft^2$

$Area23West = 0.193\,acre$ $Area23East = 0.1\,acre$

$$Q23 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL23^{\frac{1}{2}}}{2.64 \cdot n}$$

$C23 := .2$ $SL23 := \frac{723.2 - 720}{49.4}$ $SL23 = 0.065$

$Area23\_23 := \frac{Q23}{C23 \cdot i}$ $Area23\_23 = 0.374\,acre$

$Q23 = 0.533\frac{ft^3}{s}$

$InletsWest23 := \frac{Area23West}{Area23\_23}$ $InletsWest23 = 0.516$ $SpacingWest23 := \frac{49.4ft}{1}$

$\boxed{SpacingWest23 = 49.4\,ft}$

$InletsEast23 := \frac{Area23East}{Area23\_23}$ $InletsEast23 = 0.267$ $SpacingEast23 := \frac{49.4ft}{1}$

$\boxed{SpacingEast23 = 49.4\,ft}$

Joy Street to Hays Street:

$Area24West := 34085ft^2$ $Area24East := 17644ft^2$

$Area24West = 0.782\,acre$ $Area24East = 0.405\,acre$

$$Q24 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL24^{\frac{1}{2}}}{2.64 \cdot n}$$

$C24 := .2$ $SL24 := \frac{727 - 723.2}{200.5}$ $SL24 = 0.019$

$Area24\_24 := \frac{Q24}{C24 \cdot i}$ $Area24\_24 = 0.202\,acre$

$Q24 = 0.289\frac{ft^3}{s}$

$InletsWest24 := \frac{Area24West}{Area24\_24}$ $InletsWest24 = 3.873$ $SpacingWest24 := \frac{200.5ft}{4}$

$\boxed{SpacingWest24 = 50.125\,ft}$

$InletsEast24 := \frac{Area24East}{Area24\_24}$ $InletsEast24 = 2.005$ $SpacingEast24 := \frac{200.5ft}{2}$

$\boxed{SpacingEast24 = 100.25\,ft}$

Coolidge Street to Joy Street: $Area25West := 70688ft^2$ $Area25East := 35344ft^2$

$Area25West = 1.623\,acre$ $Area25East = 0.811\,acre$

$$Q25 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL25^{\frac{1}{2}}}{2.64 \cdot n}$$

$C25 := .2$

$SL25 := \frac{743.3 - 727}{441.8}$ $SL25 = 0.037$

$Q25 = 0.403\frac{ft^3}{s}$ $Area25\_25 := \frac{Q25}{C25 \cdot i}$ $Area25\_25 = 0.282\,acre$

$InletsWest25 := \frac{Area25West}{Area25\_25}$ $InletsWest25 = 5.757$ $SpacingWest25 := \frac{441.8ft}{6}$

$\boxed{SpacingWest25 = 73.633\,ft}$

$InletsEast25 := \frac{Area25East}{Area25\_25}$ $InletsEast25 = 2.878$ $SpacingEast25 := \frac{441.8ft}{3}$

$\boxed{SpacingEast25 = 147.267\,ft}$

Graham Street to Coolidge Street:

$Area26West := 35353ft^2$ $Area26East := 35353ft^2$

$Area26West = 0.812\,acre$ $Area26East = 0.812\,acre$

$$Q26 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot .005^{\frac{1}{2}}}{2.64 \cdot n}$$

$C26 := .1$

$SL26 := \frac{743.5 - 743.3}{519.9}$ $SL26 = 3.847 \times 10^{-4}$

$Area26\_26 := \frac{Q26}{C26 \cdot i}$ $Area26\_26 = 0.208\,acre$

$Q26 = 0.148\frac{ft^3}{s}$

$InletsWest26 := \frac{Area26West}{Area26\_26}$ $InletsWest26 = 3.91$ $SpacingWest26 := \frac{519.9ft}{4}$

$\boxed{SpacingWest26 = 129.975\,ft}$

$InletsEast26 := \frac{Area26East}{Area26\_26}$ $InletsEast26 = 3.91$

$SpacingEast26 := \frac{519.9ft}{4}$

$\boxed{SpacingEast26 = 129.975\,ft}$

Graham Street to Ralston Street:

$Area27West := 33845ft^2$ $Area27East := 35298ft^2$

$Area27West = 0.777\,acre$ $Area27East = 0.81\,acre$

$$Q27 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL27^{\frac{1}{2}}}{2.64 \cdot n}$$ $C27 := .15$ $SL27 := \frac{743.5 - 730.9}{519.1}$ $SL27 = 0.024$

$Q27 = 0.327 \frac{ft^3}{s}$ $Area27\_27 := \frac{Q27}{C27 \cdot i}$ $Area27\_27 = 0.305\,acre$

$InletsWest27 := \frac{Area27West}{Area27\_27}$ $InletsWest27 = 2.549$ $SpacingWest27 := \frac{519.1ft}{3}$

$\boxed{SpacingWest27 = 173.033\,ft}$

$InletsEast27 := \frac{Area27East}{Area27\_27}$ $InletsEast27 = 2.658$ $SpacingEast27 := \frac{519.1ft}{3}$

$\boxed{SpacingEast27 = 173.033\,ft}$

Ralston Drive to Country Club/Tapp Road:

$Area28West := 40150ft^2$ $Area28East := 25214ft^2$

$Area28West = 0.922\,acre$ $Area28East = 0.579\,acre$

$$Q28 := \frac{kn \cdot T^{\frac{8}{3}} \cdot Sx^{\frac{5}{3}} \cdot SL28^{\frac{1}{2}}}{2.64 \cdot n}$$ $C28 := .2$ $SL28 := \frac{741.6 - 730.9}{401.5}$ $SL28 = 0.027$

$Q28 = 0.342 \frac{ft^3}{s}$ $Area28\_28 := \frac{Q28}{C28 \cdot i}$ $Area28\_28 = 0.24\,acre$

$InletsWest28 := \frac{Area28West}{Area28\_28}$ $InletsWest28 = 3.847$ $SpacingWest28 := \frac{401.5ft}{4}$

$\boxed{SpacingWest28 = 100.375\,ft}$

$InletsEast28 := \frac{Area28East}{Area28\_28}$ $InletsEast28 = 2.416$ $SpacingEast28 := \frac{401.5ft}{3}$

$\boxed{SpacingEast28 = 133.833\,ft}$

APPENDIX G – PAVEMENT DESIGN

G.1 Introduction to Pavement Design

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street Corridor. Rogers Street, being a secondary arterial, needs to be designed for level-of-service class C to deal with acceptable degrees of congestion (AASHTO, 2004). The City of Bloomington wants to keep the current designed speed within the 30 to 60 mph range recommended by American Association of State Highway and Transportation Officials (AASHTO). Atlas Engineering has designed the pavement for a 12- foot lane width in each direction, an 8-foot multiuse trail west of Rogers Street as well as a 5-foot sidewalk on sections of the corridor as discussed in Appendix E.

The paved surface of the multiuse trail and of Rogers Street will be used by different modes of transportation including bicycles, wheelchairs, and skates for the trail, and emergency vehicles, trucks, and cars for the road. Atlas Engineering is committed to re-designing Rogers Street by treating the corridor as a rehabilitation project. Rehabilitation utilizes the existing pavement structure to significantly extend the service life of the road and lower cost of construction. Rehabilitation projects include milling the existing pavement, strengthening the subgrade structure, and placing a new asphalt overlay.

Atlas Engineering has selected hot mix asphalt (HMA) pavement to overlay Rogers Street because HMA will provide a smooth ride, a surface texture that ensures adequate skid resistance properties throughout the design life. HMA, the primary pavement in Indiana, has a lower initial cost and can be more rapidly installed than Portland Cement Concrete and eliminates the need for construction joints. Lastly, Atlas recommends that HMA be used to maintain continuity with neighboring roadways. The need for additional base coarse has been determined and a final decision must be made in consultation with the City of Bloomington.

Atlas Engineering recommended that the City of Bloomington conduct further soil testing to determine the conditions and thicknesses of the soil layers beneath the asphalt. With the current soil data, Atlas decided on using the thickness of compacted aggregate subgrade needed to meet the desired road design life, to provide adequate strength for single-axle load applications (ESAL), and to keep road maintenance to a minimum.

G.2 Multiuse Trail Pavement

Atlas Engineering has designed for a multiuse trail pavement, eight feet in width, along the west side of Rogers Street. The multiuse trail will not lie along the pavement; so Rogers Street's pavement design cannot be used for the trail design. In the event that emergency vehicles use the multiuse trail, sufficient strength has been provided for all possible modes of transportation.

Atlas has followed the guidelines set forth in the Asphalt Paving Association of Iowa's *Asphalt Paving Design Guide* (APAI, 2007) to design the multiuse trail. The APAI defines pedestrian and multiuse trails as traffic class 1 structures. Class 1 structures are not designed to withstand repeated loads from maintenance or emergency vehicles, but an occasional heavy-load application can be made without damage. In the APAI's design method, subgrade class and the California Bearing Ratio (CBR) were used. A CBR number was determined based on the strength of the subgrade soil. Following Table G.1, thickness chart for bikeways, paths, trails, and walkways, Atlas recommends a three inch HMA surface course with four inches of crushed stone aggregate base.

Table G.1: Thickness Chart: Bikeways, Paths, Trails, and Walkways (APAI 2007)

A. For Asphalt Concrete Base Pavements				
Design Criteria*			**Thickness in Inches Asphalt Concrete**	
Traffic Class (ADT)	**Subgrade Class**	**CBR**	**Surface**	**Total**
I	Good	9	3.0	3.0
	Moderate	6	3.5	3.5
	Poor	3	4.0	4.0

B. For Untreated Aggregate Base Pavements					
Design Criteria*			**Thickness in Inches**		
Traffic Class (ADT)	**Subgrade Class**	**CBR**	**Untreated Aggregate Base**	**Hot Mix Asphalt Surface**	**Total**
I	Good	9	4.0	2.5	6.5
	Moderate	6	4.0	3.0	7.0
	Poor	3	6.0	3.0	9.0

G.3 Sidewalk Design

Atlas Engineering has also designed a 5-foot wide sidewalk to be placed along Rogers Street in areas with sufficient available right-of-way. Sidewalks and sidewalk elements, such as curb ramps and driveway crossings, have been designed to provide efficient drainage as well as adequate access. Following proper codes and regulations set forth in the United States Department of Transportation Federal Highway Administration (FHWA, 1999), Atlas recommends a concrete sidewalk four inches thick. In harmony with existing sidewalks on adjacent roads, it is also recommended to continue using such designs for future sidewalk construction throughout the city, especially the sidewalk constructed on Kirkwood Avenue.

G.4 Pavement over Existing Road

Rogers Street is a high-volume arterial road connecting main activity centers with downtown Bloomington. Rogers Street currently has a moderate to poor subgrade condition with a CBR number of three. The APAI uses thickness charts to determine minimum thicknesses for arterial streets (APAI, 2007). According to the Asphalt Paving

Association of Iowa's *Asphalt Paving Design Guide* table for the thickness design of an arterial street, Rogers Street is a Traffic Class V (6,001 – 9,500 Average Daily Traffic). According to Table G.2, APAI stipulates that the pavement structure include three inches of asphalt pavement with nine inches of compacted aggregate base. Atlas Engineering recommends removal of the present subgrade and an asphalt overlay to further enhance Rogers Street's design life.

In addition to APAI's minimum thickness requirements, Atlas Engineering has checked the structural adequacy of the pavement and the guidelines set forth in the book *Principles of Pavement Design* (Yoder and Witczak, 1975) and compared the results. The most conservative pavement design thickness have been used in the road design.

Table G.2: Thickness Design: Arterial Street (APAI, 2007)

Design Criteria*			Thickness in Inches Asphalt Concrete		
Traffic Class (ADT)	Subgrade Class	Subgrade CBR	Base	Surface	Total
IV (1,501-4,500 ADT)	Good	9	5.5	2.0	7.5
	Moderate	6	6.5	2.0	8.5
	Poor	3	7.5	2.0	9.5
V (6,001-9,500 ADT)	Good	9	7.5	2.5	10.0
	Moderate	6	8.0	3.0	11.0
	Poor	3	9.0	3.0	12.0
VI (9,501 & Above ADT)	Good	9	Special design consideration needed. Refer to a more complete design procedure.		
	Moderate	6			
	Poor	3			

G.5 Determination of Structural Number

Atlas Engineering used a structural number analysis to check the strength and serviceability of the minimum thickness design used for the road pavement. The structural number is defined as an index number derived from an analysis of traffic, road-bed soil conditions, and a regional factor that may be converted to thickness of various flexible-pavement layers through the use of suitable layer coefficients related to the type of material being used in each layer of the pavement structure.

The support value of the soil is assumed to be 5.5, an intermediate and conservative value based on the current conditions at Rogers Street. Since there are a variety of road and trail users, terminal serviceability is assumed to be 2.5 out of a maximum of 5.0 because users are sensitive to small changes in the pavement smoothness. Atlas also assumed a maximum of 350 daily equivalent single axle loads based on information gathered by the City of Bloomington over a twenty year service life. The regional factor at our location is 1.0 (Figure G.1). These factors can be used in conjunction with a design nomograph (Figure G.2) to determine the regionally adjusted structural number of 3.40.

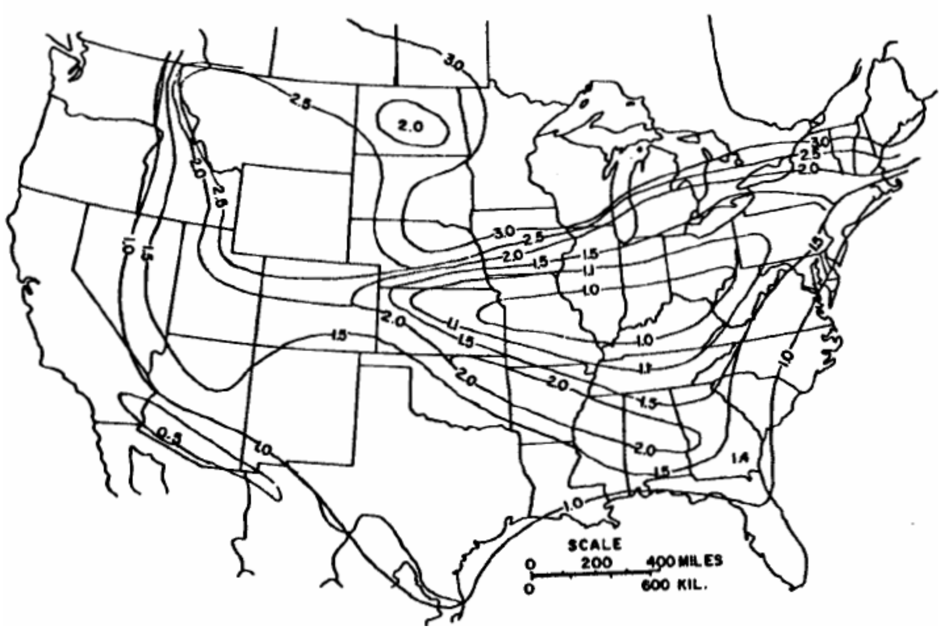


Figure G.1: *Diagram showing regional factors for pavement design* (Yoder and Witczak, 1975).

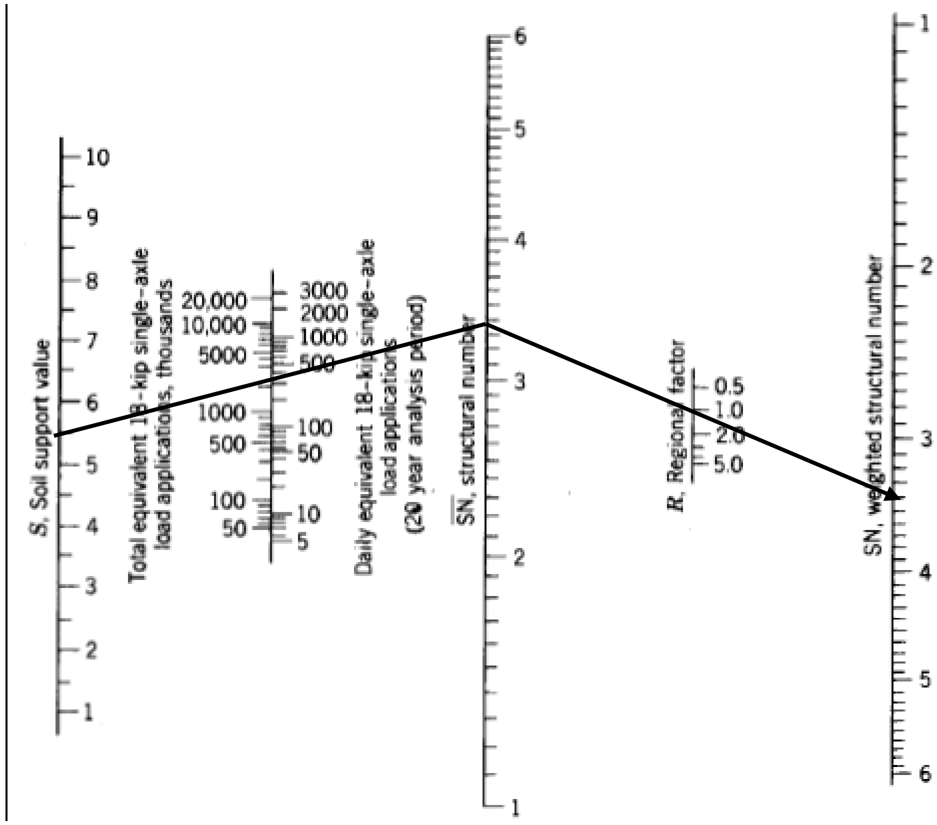


Figure G.2: *Nomograph used to estimate the required structural number* (Yoder and Witczak, 1975).

G.6 Pavement Design Calculation

The layer coefficient is the empirical relationship between the structural number for a pavement structure and the layer thickness expressing the relative ability of a material to function as a structural component of the pavement. Layer coefficients are designated by a_1, a_2, and a_3, for surface, base and subbase, respectively, and were proposed by AASHTO Committee on Design (AASHTO, 2004).

Comparison of Structural Number

$SN = a_1 * D_1 + a_2 * D_2 + a_3 * D_3$

Where

a_1 = material factor for hot-mix asphalt	D_1=thickness for hot-mix asphalt (in)
a_2 = material factor for stone base	D_2 = thickness of crushed stone base (in)
a_3 = material factor for sandy gravel sub base	D_3 = thickness of subbase (in)
a_1=0.440	D_1 = 3.00
a_2 = 0.140	D_2 = 8.00
a_3 = 0.110	D_3 = 0.00

SN = 2.44; not adequate since it is less than the required value of 3.40

$D3 = (SN – a_1D_1 – a_2D_2)/a_3$

D_3 = 8.73 inches → 9.00 inches

$\boxed{\mathbf{SN' = 3.43}}$

Since the structural number achieved by this design is less than the structural number required by our estimate, we can conclude that the pavement design is not sufficient and Atlas recommends that the existing pavement be removed and the sub-grade be placed throughout Rogers Street. Atlas Engineering recommends a three inch HMA overlay with four inches of crushed stone aggregate base for the multiuse trail. Because Rogers Street is a rehabilitation project, Atlas recommends a strengthened pavement structure that includes three inches of HMA for the overlay and eight inches of compacted aggregate base overlaid on nine inches of sandy gravel sub base. The City of Bloomington has to decide whether current base and sub-base material properties possess acceptable conditions for milling and patching wherever necessary along the road. The other option is to completely restore the entire corridor with the recommended overlay, base, and sub-base materials and thicknesses.

G.7 References

American Association of State Highway and Transportation Officials (AASHTO). (2004). "A Policy On Geometric Design of Highways and Streets." Washington, D.C.: AASHTO.

Asphalt Paving Association of Iowa (APAI). (2003). *Asphalt Paving Design Guide*. West Des Moines, Iowa: APIA.

Federal Highway Administration (FHWA), *Designing Sidewalks and Trails for Access*. 1999. Retrieved March 27, 2007, from source
< http://www.fhwa.dot.gov/environment/sidewalks/>

Yoder, E.J. and M. W. Witczak. *Principles of Pavement Design*, New York, New York: John Wiley and Sons, Inc.

APPENDIX H – TRAIL DESIGN

H.1 Introduction to Trail Design

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street corridor. Improvements to the current transportation conditions will be made by implementing a shared multiuse trail throughout the corridor. The shared multiuse trail will be eight feet wide, supporting two way traffic and accommodating bicyclists, pedestrians, rollerblades, skateboards, etc. Atlas Engineering will design a safe and convenient bicycle facility to encourage bicycle use in the shared multiuse trail. The American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (AASHTO, 1999) lays out the guidelines for the design of bicycle facilities (Figure H1.0).

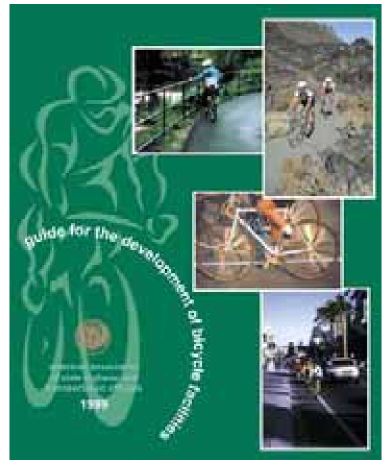


Figure H1.0: AASHTO Guide for the Development of Bicycle Facilities (AASHTO, 1999)

This appendix contains an overview of the trail user's profile, design issues associated with the trail, preliminary construction guidelines, and pavement markings for both the trail and Rogers Street. Typical bicycle and road signs will be included to provide guidance to the City of Bloomington and users for both the trail and the road. This appendix is not intended to be used as the final design for the actual trail, but rather to be used to help the reader comprehend technical aspects of designing a shared-use path. More detailed information can be found in the guidelines sponsored by AASHTO and the Manual of Uniform Traffic Control Devices (MUTCD, 2003).

H.2 Trail Use

Atlas Engineering has determined that the majority of the shared multiuse path is defined as "Shared Use Path" according to Chapter 2 in the AASHTO *Guide for the Development of Bicycle Facilities* (AASHTO, 1999). The trail has been designated as a shared use path because the trail provides continuity to other bicycle facilities and because the corridor is a common route for bicyclists. Rogers Streets also intersects with 32 other streets throughout the corridor. The trail can be characterized as a "Signed Shared Roadway" because the trail is a common route for bicyclists through a high demand roadway. Therefore, since the multiuse trail is intended for non-motorized vehicles and because of the high volume of vehicular traffic on Rogers Street, a signed shared roadway is not desirable.

H.3 Bicycle User Operating Space

According to the *Bicycle Guide* (AASHTO,1999), bicyclists require at least 40 inches of horizontal clearance and 100 inches of vertical clearance of essential operating space to ride comfortably on a shared multiuse trail. A minimum 1-lane, 4-foot width is assumed to be the preferential minimum width used by bicyclists. Figure H2.0 shows the minimum dimensions for safe and comfortable bicycle rides.

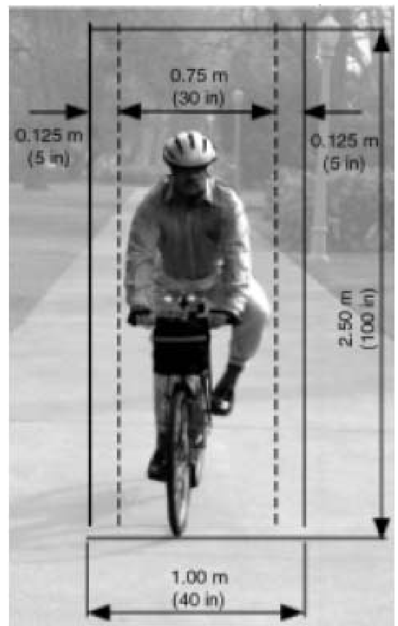


Figure H2.0: User Operating Space (AASHTO, Figure 1, 1999)

H.4 User Type Profiles

Bicyclists have different skills, abilities, confidence, and preferences. A 1994 report by the Federal Highway Administration (FHWA) defined user type profiles into three categories; A, B, and C. The shared multiuse path has been designed with accommodations to each profile group.

User type A: **A**dvanced or experienced riders that use their bicycles as they would their motor vehicles; riding for convenience and speed.

User type B: **B**asic or less confident adult riders that prefer riding on neighborhood streets and shared use paths, bike lanes, and wide shoulder lanes.

User type C: **C**hildren, who require an adequate buffer zone or delineated path to ride along safely without encouraging them to ride in the traveling lane of major arterials.

H.5 Design Standards for Shared Use Paths

The *Bicycle Guide* (AASHTO, 1999) defines a shared use path as a "bikeway physically separated from motorized vehicular traffic by an open space or barrier, and are also referred to as trails." Users are non-motorized and may include bicyclists, skaters, roller skaters, wheelchair users (both motorized and non-motorized), strollers, pedestrians, etc. A typical example of a shared use path is shown in Figure H3.0

Figure H3.0: Example of a Shared Use Path (AASHTO, 1999)

Since the trail is a two-way shared use path and the distance between the edge of the road and the shared use path is less than 5 feet, Atlas Engineering is recommending a suitable physical barrier. Such barriers serve both to prevent path users from making unwanted movement between the path and the road and to also reinforce the concept that the path is an independent facility. To prevent bicyclists from toppling over barriers, they should be a minimum of 42 inches high and should not impair sight distances at intersections. Barriers should be designed such that they are not a hazard to errant motorists.

Atlas also recommends that the City of Bloomington post bike route signs including destination information to indicate to cyclists that there are particular advantages to using these routes in comparison to alternate routes. For these signs to be more functional, supplemental destination plates should be placed beneath them when located along routes leading to high demand destinations. Signs would be placed at approximately every quarter mile, at all turns, and at major signalized intersections, such as 11th Street, Kirkwood Avenue, 3rd Street, and 2nd Street.

H.6 Trail Width and Clearance

The paved width and the operating width required for the shared use path are primary design considerations. Atlas Engineering has designed an 8-foot wide shared use path based on both allowable right-of-way as well as Bloomington's wish to keep a standardized and consistent path width with other trails throughout Bloomington. Pedestrian use of the facility is not expected to be high because there is a 5-foot sidewalk along the east side of Rogers Street, extending throughout the majority of the 2.5 mile corridor. There will also be good horizontal and vertical alignment providing safety for users. A minimum cross-slope of 2 percent should be used toward the downhill side to provide adequate drainage. Three feet of clearance should be made from any trail-side obstruction such as trees, fences, guardrails, etc.

H.7 Design Speed

The shared use path should be designed for a speed that is at least as high as the preferred speed of faster bicyclists. In general, the *Bicycle Guide* (AASHTO, 1999) recommends a minimum design speed of 20 mph. When downgrade exceeds 4 percent, a design speed of 30 mph or more is advisable. For the Rogers Street corridor, the slope of the shared use path will exceed 4 percent in three distinct areas: from Prospect Street to 3rd Street, from Smith Street to 2nd Street, and from Hays Street to Jed Street. Lower design speeds should not be selected to artificially lower user speeds. Due to the fact that the trail is along a highly motorized road, the design speed for all geometric calculations is 20 mph to ensure users safety.

H.8 Horizontal Alignment

Unlike automobiles, bicycles must be leaned while cornering to prevent the rider from falling outward due to momentum and the resulting centrifugal force. Lean angle is the amount of lean required to safely take a turn. Atlas Engineering will assume that persons with disabilities will use the trail and will meet the requirements of the Americans with

Disabilities Act (ADA). ADA guidelines require a maximum cross slope of 3 percent to avoid severe difficulties for people using wheelchairs. A design lean angle of 15° will be used in all design calculations to safely accommodate all probable users and taking into account the gently sloping hills of Rogers Street. According to Table H.1, the minimum desirable radius of horizontal curvature is 100 feet. Refer to Other Intersection Design Issues; section H.13, for warning strips on all intersections.

Table H.1: Desirable minimum radii for paved shared use paths based on 15° Lean Angle (AASHTO, Table 1, 1999)

Design Speed (V)		Minimum Radius (R)	
km/h	(mph)	m	(ft)
20	(12)	12	(36)
30	(20)	27	(100)
40	(25)	47	(156)
50	(30)	74	(225)

H.9 Grade

Grades greater than 5 percent are undesirable, unsafe, and inconvenient because the ascents are difficult for many bicyclists to climb and descents causes some bicyclists to exceed the trail's design speed. Following ADA guidelines on slopes and grades, the shared multiuse trail has a maximum 3 percent grade. When using a steeper grade, an additional 4 to 6 feet of width should be designed to permit slower bicyclists (users) to dismount and walk, provide signing that alerts users of the maximum percent grade, and exceed minimum stopping sight distances. The *Bicycle Guide* (AASHTO, 1999) provides suggested grade restrictions and grade lengths on Table H.2.

Table H.2: Suggested grade restrictions and grade lengths (AASHTO, 1999)

Grade	Grade Lengths
5 - 6%	For up to 800 ft
7%	For up to 400 ft
8%	For up to 300 ft
9%	For up to 200 ft
10%	For up to 100 ft
11+%	for up to 50 ft

H.10 Drainage

The recommended minimum slope of 2 percent provides for adequate drainage. Sloping in one direction is preferred to simplify construction and save on costs. Ditches, catch basins, and bio-retention swales (discussed in Appendix F) should be incorporated where the terrain permits. Drainage grates and manhole covers should be located outside the bicyclists travel path and the surface should be smooth to prevent water ponding and ice formation. Seeding, mulching, and sodding of adjacent slopes and other areas subject to erosion should be included. For a more detailed description of drainage please refer to Appendix F.

H.11 Stopping Sight Distance

Providing adequate stopping sight distance (SSD) is very important for the safety of users by giving them the opportunity to see and react to unexpected events. The distance required to bring a bicycle to a full controlled stop is a function of the perception-reaction time (2.5 seconds), the velocity, road conditions (coefficient of friction), and of the trails' grade. Figure H4.0 indicates the minimum stopping sight distances for various design speeds and grades based on a coefficient of friction of 0.25 to account for poor wet weather braking conditions. According to this graph, using our design speed of 20 mph and a maximum grade of 3 percent, the SSD of 120 feet is obtained for the Rogers Street corridor.

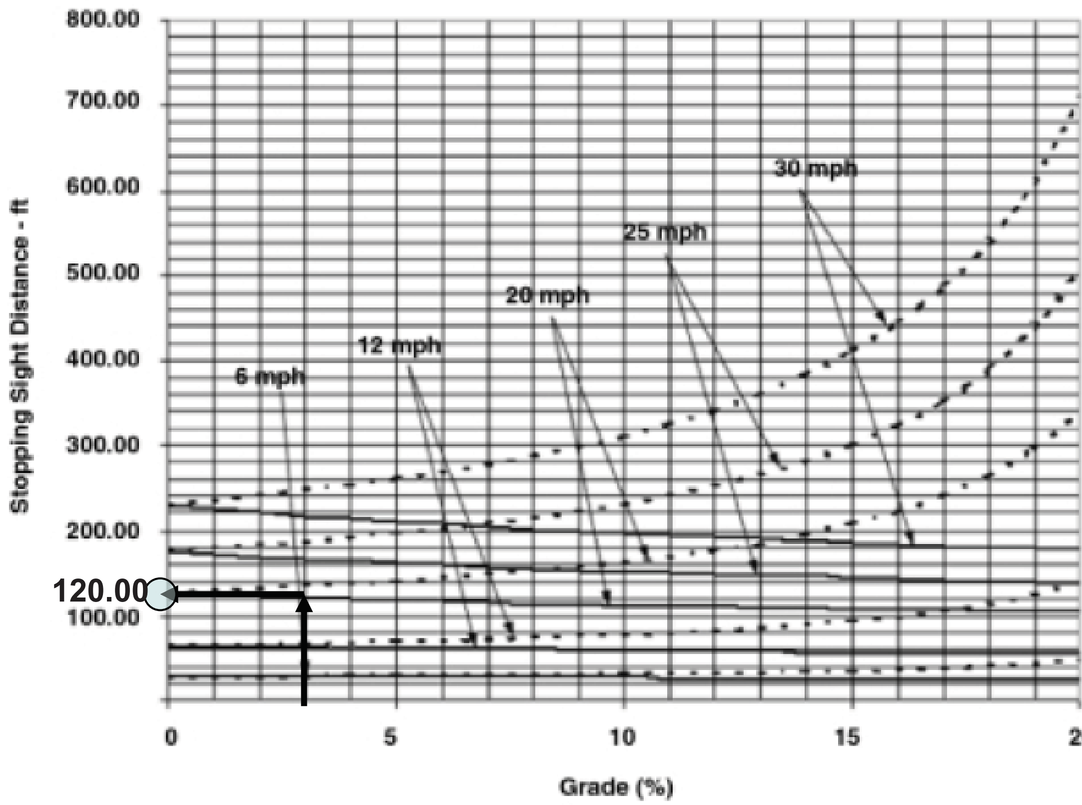


Figure H4.0: Minimum Stopping Sight Distance vs. Grades for various Design Speeds (AASHTO, Figure 19, 1999)

H.12 Sight Triangles

Sight triangles are areas along an intersection approach and their respective corner which should be clear of any type of obstructions that might block a driver's view of traffic, thus reducing the likelihood of an accident. The dimensions of the legs of the sight triangles depend on the road's design speed and of the traffic control device used for that particular intersection. Sight triangles depend on the driver's behavior, the driver's eye height, the location of a visual barrier, and incoming traffic. Although Rogers Street is a secondary arterial and its drivers have right-of-way with respect to the majority of its intersecting roads, adequate stopping sight distances are necessary to reduce accidents. Of the two types of clear sight triangles that are considered in intersection design, only approach sight triangles are applicable (AASHTO, 2004).

Approach sight triangles allow approaching vehicles sufficient time to respond to any potentially-conflicting vehicles by either reducing speed or stopping completely. The triangular area (Figure H5.0) should be free of any type of obstruction that might prevent a driver from recognizing an approaching vehicle. Approach sight triangles dimensions are based on assumptions derived from field data and are dependent of drivers' behavior and are necessary at uncontrolled or yield-controlled intersections (such as Rockport Road) and are not needed for intersections controlled by stop signs or traffic signals, as is the case for the majority of the intersections along Rogers Street Figure H5.0 illustrates the distance from the major road along the minor road (AASHTO, 2004).

Table H.3 shows the distance traveled by an approaching vehicle as a function of the design speeds of the roads where an intersection is located. Referring to Figure H5.0, road A is Rogers Street with a design speed of 50 mph and road B represents all other roads that intersect Rogers Street and are stop-controlled or yield controlled intersections (with a design speed of 30 mph). The dimensions for the approach sight triangle will be 245 feet along Rogers Street (road A) and 140 feet along road B. The dimensions for the approach sight triangle of the shared multiuse trail will be 90 feet (road A) and 140 feet along road B (AASHTO, 2004).

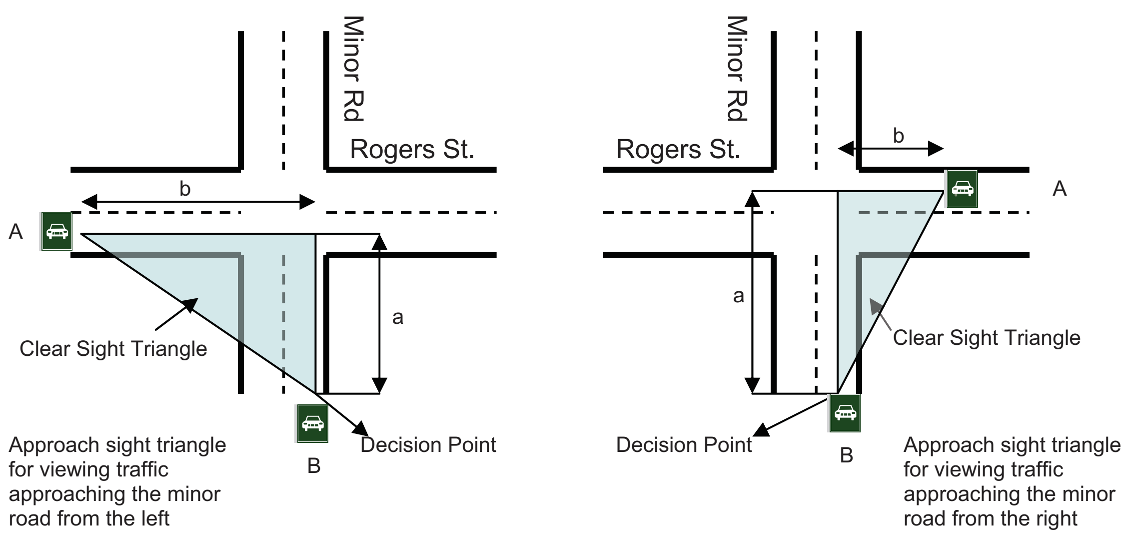


Figure H5.0: Intersection Sight Triangle (AASTHO, 2004)

Table H.3: Length of Sight Triangle with No Traffic Control (AASHTO, 2004)

US Customary	
Design speed (mph)	Length of leg (ft)
15	70
20	90
25	115
30	140
35	165
40	195
45	220
50	245
55	285
60	325
65	365
70	405
75	445
80	485

H.13 Other Intersection Design Issues

Regardless of the type of path-roadway intersection, there are several other design issues to consider according to the *Bicycle Guide*, (AASHTO 1999):

Traffic Signals/Stop Signs: Traffic signals for path-roadway intersections are appropriate under certain circumstances. Refer to the MUTCD (2003) for warrants for traffic signals; which classifies bicycle traffic paths as vehicular traffic. Atlas Engineering will include traffic signals on intersections that already have traffic lights, and stop signs on all other intersections along Rogers Street. For the traffic signals, the bicyclist signal button should be located 4 feet above the ground, an easily accessible position where bicyclists should not dismount to activate the signal. Path stop signs type, size, and location should be placed as close to the intended stopping point as possible in accordance with the MUTCD. Care should be taken to ensure that shared path signs do not confuse motorists.

Approach Treatment: Shared use path intersections and approaches should be on relatively flat grades and adequate warning signs are necessary to allow bicyclists to stop before reaching the intersection, especially on downgrades.

Ramp Widths: Ramps for curbs at intersections should be the same size as the shared use path, providing a smooth transition between the path and the road and should follow ADA requirements. Refer to Accessibility Requirements (page H-13) for more information on ADA requirements.

Restriction to Motor Vehicle Traffic: Some form of physical barrier may be necessary to prevent unauthorized motor vehicles for using the shared use path. Atlas Engineering recommends lockable, removable or reclining barrier posts to permit entrance by authorized vehicles if they see such restrictions applicable, especially on intersections. The posts (bollards) should be permanently reflectorized for nighttime visibility and painted a bright color for improved daytime visibility. Stripping an envelope around the post (bollard) is recommended as shown in Figure H6.0, where a single post (bollard) in the center of the shared multi-use trail will be sufficient. We recommend a solid yellow line strip to separate the two directions of travel on the trail.

On-street parking: On-street parking increases the potential for conflicts between motor vehicles and bicyclists. The most common bicycle riding location on urban roadways is the area between parked cars and moving motor vehicles. Where there is on-street parking, most notably on the northern end of the corridor near Prospect Hill, proper warning signs should be posted making both bicyclists and motorists aware of each other, serving to prevent injuries occurring from the opening of car doors.

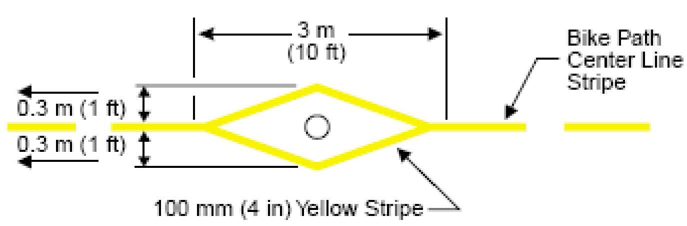


Figure H6.0: Pavement Markings for Bollards (AASHTO, Figure 26, 1999)

Pavement quality: Special attention should be paid to the quality of the trail's pavement The smoothness of the riding surface affects the comfort, safety, and speed of bicyclists because wide cracks, joints or drop-offs at the edge can trap a bicycle wheel and cause loss of control. For more information on pavement design, refer to Appendix K.

Drainage inlet grates and utility covers: These utilities represent potential obstructions to bicyclists. Bicycle-safe grates and covers should be used and located in a manner which will minimize severe or infrequent maneuvering by bicyclists. In order to reduce the impact the drainage inlet grates will have on bicyclists it is suggested to rotate them so they run perpendicular to the multiuse trail. Curb opening inlets should be considered to minimize the number of potential obstructions. The AASHTO *Bicycle Guide* recommends that drainage inlet grates and utility covers should be placed such that they are flush with the adjacent pavement surface.

Bicycle Parking Facilities: Bicycle parking facilities promote bicycling and should accommodate a wide range of bicycle shapes and sizes. Atlas recommends short-term facilities designed for decentralized parking, providing convenience for commuter and leisure riders. The City of Bloomington should consider provisions to interface bicycle travel with public transit, such as racks on buses or buses with the ability to carry bicycles aboard.

Amenities: The City of Bloomington can further promote the use of the shared path for riders, runners, and all possible users by providing benefits such as water fountains, emergency call boxes, and resting places. The amenities should have proper signs and be visible to passers to promote usage and enhance security; they should not interfere with pedestrian traffic, and should be easily accessed from the street and protected from motor vehicles.

Sidewalk for bicyclists: The designated use of sidewalks as a signed shared facility for bicycle travel is unsatisfactory. It is important to recognize that the development of extremely wide sidewalks does not necessarily add to the safety of sidewalk and bicycle travel, since wide sidewalks will encourage higher speed bicycle use and increase potential for conflicts with motor vehicles at intersections, pedestrians, and fixed objects. Signs prohibiting bicyclists to use the sidewalk should be placed to provide safety to pedestrians, cyclists, and motorists.

Accessibility Requirements: ADA prohibits discrimination against people with disabilities guaranteeing the right to participate fully and equally in all aspects of life. Well designed accessible facilities are usually more functional for all users, with and without disabilities. As explained earlier, it is preferable if grades are below 5 percent for wheelchair users and cross-slopes should not be greater than 2 to 3 percent for better control and better maneuvers. Curb ramps are typically an accommodation for bicyclists and wheelchair users, but they can also be used by the visually impaired as a warning of the transition from the path to the street since they get their cues from sound and touch. The visually impaired are having a harder time with cars getting quieter, curb radii wider, and street crossing longer. Detectable warnings and contrasting colors at the bottom of ramps may help detect the presence of a curb ramp. "Detectable warnings shall consist of raised truncated domes with a diameter of 0.9 inches, a height of 0.2 inches, and a center-to-center spacing of 2.35 inches. The warnings shall contrast visually with adjoining surfaces" (ADA Accessibility Guidelines for Buildings and Facilities, 2002).

H.14 Signage and Pavement Marking

All signage and pavement marking should follow the specifications that are present in the Federal Highway Association's Manual on Uniform Traffic Control Devices and are referred on the *Bicycle Guide* (AASHTO, 1999). All signs, signals, and markings for both the road and the shared use path should be properly maintained to provide safety to motorists and bicyclists. When installing signs and markings on bicycle facilities, an agency should be designated by the City of Bloomington to maintain these devices. Bicycle signs should be standard in shape, legend, color, and shall be reflectorized. Stop signs shall be installed at points where bicyclists are required to stop and should be placed as close as possible to the actual stopping point. Yield signs shall be placed at points where bicyclists have an adequate view of conflicting traffic as they approach the sign, and where bicyclists are required to yield their right-of-way to conflicting traffic. Figure H7.0 illustrates two examples of signing and markings for shared-use paths. Atlas recommends that the City of Bloomington designate two minimum width lanes across the multiuse trail – a solid yellow line should be used to separate the two directions of travel where passing is not permitted and a dashed yellow line should be used where passing is permitted. Figure H8.0 illustrates common center-line markings for the multi-use trail.

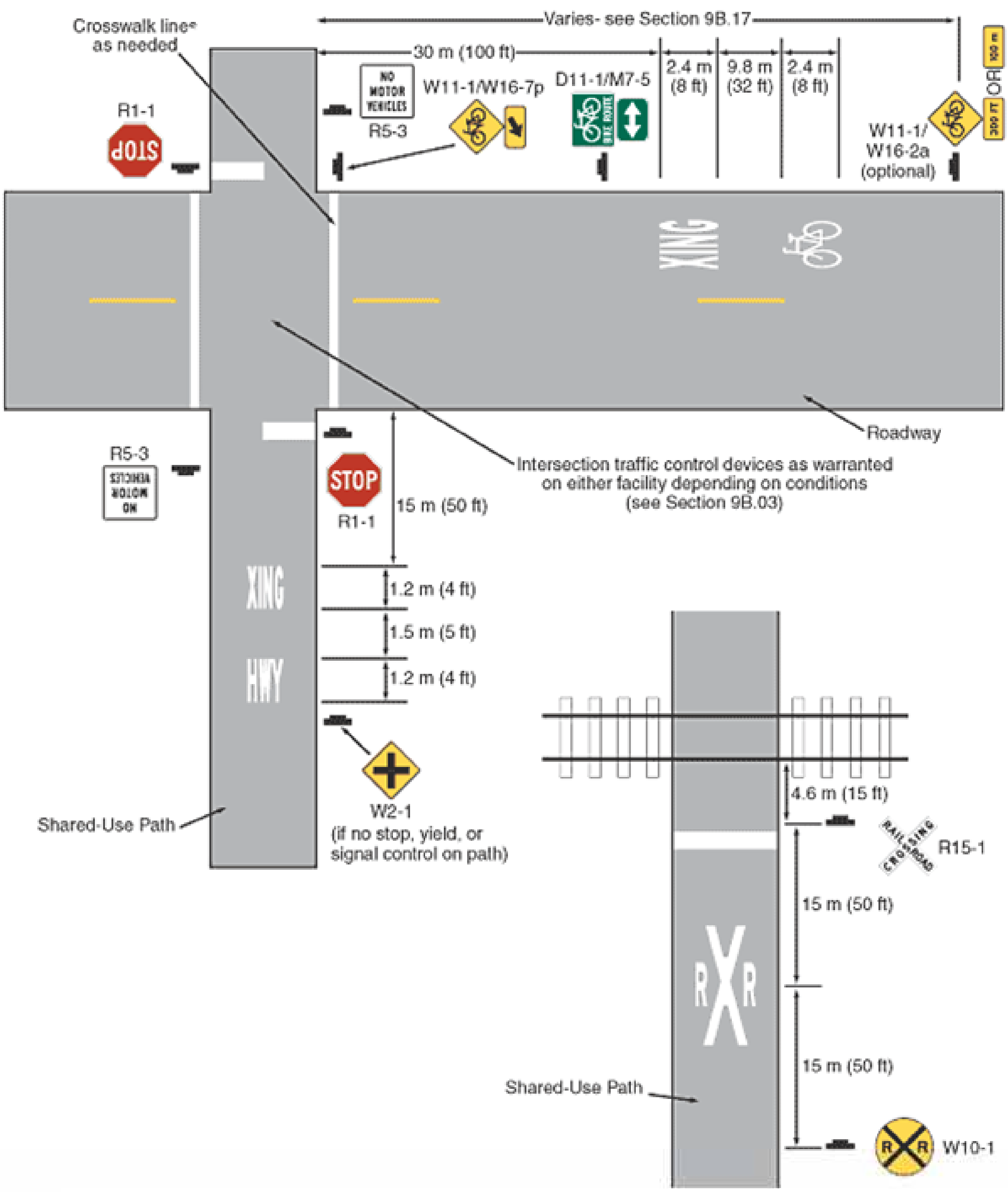


Figure H7.0: Examples of Signing and Markings for Shared-Use Paths (MUTCD, 2003)

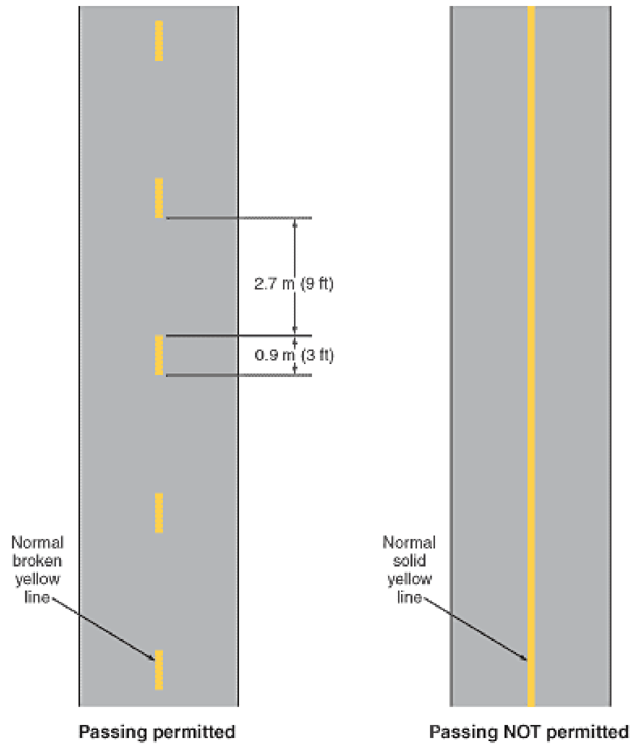


Figure H8.0: Center-Line Markings for shared-use paths (MUTCD, 2003)

H.15 References

American Association of State Highway and Transportation Officials (AASHTO). (1999). *Guide for the Development of Bicycle Facilities*. Washington, D.C.: AASHTO. Published Guidelines.

American Association of State Highway and Transportation Officials (AASHTO). (2004). *A Policy on Geometric Design of Highways and Streets*. 5th edition. Washington, D.C.: AASHTO.

Americans with Disabilities Act (ADA). (2002). ADA Standards for Accessible Design. Washington, D.C.: ADA.

Federal Highway Administration (FHWA). (2004). *Manual on Uniform Traffic Control Devices*. 2003 ed., Rev.1. Washington, D.C.: FHWA.

APPENDIX I – TRAFFIC CONTROL PLAN

I.1 Introduction

The Rogers Street Corridor in Bloomington, Indiana is a 2.5 mile secondary arterial that runs on the west side of downtown Bloomington. The Bloomington/Monroe County Metropolitan Planning Organization (MPO) has requested that Atlas Engineering present a design solution that will be capable of handling the increased traffic demands that are being placed on the corridor. An important step in the redevelopment of Rogers Street is the creation of a traffic control plan. The ultimate purpose of this plan is to effectively divert traffic around the areas of the corridor that are under construction such that the impact on local businesses, neighborhoods, and travel times is minimized. According to the Manual of Uniform Traffic Control Devices (MUTCD) "the needs and control of all road users (motorists, bicyclists, and pedestrians within the highway, including persons with disabilities in accordance with the Americans with Disabilities Act of 1990 (ADA), Title II, Paragraph 35.130) through a temporary traffic control zone shall be an essential part of highway construction, utility work, maintenance operations, and the management of traffic incidents (Federal Highway Administration, 2006)." It is critical that the safety of motorists traveling through the corridor and safety of the laborers is held paramount. The development of the traffic control plan will abide by the most current edition of the MUTCD.

I.2 Phasing

In order to maintain a minimal effect on local businesses and neighborhoods Atlas Engineering recommends separating the corridor into five separate phases. These have been planned to provide the most efficient detour routes and to provide the least impact on the aforementioned businesses and neighborhoods. The location of Bloomington Hospital at the intersection of Rogers Street and 2nd Street was also taken into consideration when phasing was being planned such that effective routes for emergency traffic will not be compromised. Atlas also believes that implementing these phases will reduce the length of construction time. The five phases that have been developed can be seen in Figure I2.1 and are divided as follows (North to South):

- 11th Street to Kirkwood Avenue
- Kirkwood Avenue to 2nd Street

- 2nd Street to Patterson Street
- Patterson Street to Rockport Road
- Rockport Road to Country Club Road /Tapp Road

I.3 Phase I: 11th Street to Kirkwood Avenue

The detours for this section of Rogers Street have been planned with particular attention to 11th Street serving as a major bus-route for the city, as well as Kirkwood Avenue serving as a major connector to Indiana University's campus. The planned detour route consists of Rogers Street being closed from the south side of the 11th Street intersection to the north side of Rogers' intersection of Kirkwood Avenue. All east/west roads that intersect Rogers Street during this phase will remain open at all times. Proper signage will be used to redirect traffic to College Street/Walnut Street and divert all traffic, with the exception of local traffic, from Morton Street, 6th Street and 7th Street. Proper signage will also be needed to indicate to westbound traffic on 3rd Street and 4th Street that Rogers Street will be closed. Furthermore, North Jackson Street, which runs parallel to Rogers Street to the west, intersects eight east/west roadways that connect to Rogers Street; therefore, signage will be required for each of the eight intersections at North Jackson Street indicating that Rogers Street is closed. (See Figure I1.1 for Phase I's detour route)

I.4 Phase II: Kirkwood Avenue to 2nd Street

This phase will require the same general plan as phase I. The south side of the intersection of Kirkwood Avenue and Rogers Street will be closed and will extend south to the intersection of 2nd Street and Rogers Street. Traffic traveling east on 3rd Street will also need to be rerouted to S. Patterson Drive and then from W. 2nd Street to its intersection with Rogers Street. Proper signage is required for all detours and rerouting. (See Figure I1-2 for Phase II's detour route)

I.5 Phase III: 2nd Street to Patterson Street

The general plan for this phase will consist of closing the south side of Rogers Street's intersection at 2nd Street and extending the closure to the north side of Patterson Street. Again, all east/west roads that intersect Rogers Street during this phase will remain open at all times. All traffic traveling westbound on Grimes Street must be rerouted to South Patterson Street. This traffic shall not be routed to Fairview Street. It is absolutely critical that Fairview Street remains open and accessible to traffic arriving and departing from the hospital. Only local residents on Fairview Street will be permitted with the emergency vehicle traffic. This plan will also hold true for traffic traveling east bound on Patterson Street to South Patterson Street. Also, traffic from the north will be diverted west to 2nd Street, then south to Rogers Street via Patterson St. (See Figure I1.3 for Phase III's detour route)

I.6 Phase IV: Paterson Street to Rockport Road

The south side of the intersection at Patterson Street will be closed extending south to the intersection of Rockport Road and Rogers Street. As before, all east/west roads that are intersecting Rogers Street will remain open at all times. More specifically, westbound traffic will be rerouted from Patterson Street to Grimes Street and then redirected south to Walnut Street. Signage will be provided along the detour route to direct the traffic to the intersection of Walnut Street and Country Club Road/Tapp Road. Signage will also be provided notifying detour traffic that Rogers Street and Rockport Road will both be open to only east bound traffic (right turn). This is important because Rockport Road, a major connector, will be bypassed with the implementation of the planned detour. Once traffic is diverted back to the intersection of Country Club Road/Tapp Road and Rogers Street, proper signage should be used notifying users that Rogers Street is closed to the north beginning at Rockport Road and extending north to Patterson Street. (See Figure I1.4 for Phase IV's detour route)

I.7 Phase V: Rockport Road to Country Club Road /Tapp Road

This will be the final phase of the project located on the south end. This phase will call for the closure of Rogers Street beginning at the south side of the intersection of Rockport Road and extending south to the intersection of Country Club/Tapp Road. Traffic will be rerouted on South Rockport Road to its intersection with Tapp Road. Proper signage will be provided along South Rockport Road informing motorists to continue to Tapp Road. Signage will also be provide to keep all traffic, except local traffic, from turning onto West Graham Drive, which is an east/west connector between South Rockport Road and Rogers Street. (See Figure I1.5 for Phase V's detour route)

I.8 Signage

The accurate placement of signs throughout the Rogers Street corridor is important for ensuring the safety of laborers, motorists and pedestrians. The MUTCD should be meticulously followed because it clearly specifies the locations of signs for each of the construction phases for the entire project. The following signs are directly related to the Rogers Street Corridor Context Sensitive Design Study:

- ROAD (STREET) CLOSED Sign (R11-2)
- Local Traffic Only Signs (R11-3a, R11-4)
- ROAD (STREET) WORK Sign (W20-1)
- DETOUR Sign (W20-2)
- ROAD (STREET) CLOSED Sign (W20-3)
- Special Warning Signs
- Detour Signs (M4-8, M4-8a, M4-8b, M4-9, M4-9a, M4-9b, M4-9c, and M4-10)
- Type I, II, or III Barricades
- Direction Indicator Barricades

Atlas Engineering has developed a schematic example of the traffic control plan for Phase III: 2nd Street to Patterson Street. This plan has been developed to be utilized as a guide for all other phases of the Rogers Street project. Detailed traffic control plans for all other phases shall follow the same format that has been provided in Figure I2.0.

The traffic control plan should be put into effect prior to the beginning of construction and should continue throughout the duration of the project. Once construction has concluded all traffic control devices which are no longer necessary or practical are to be to be removed.

I.9 References

American Association of State Highway and Transportation Officials (AASHTO). (2004). *A Policy on Geometric Design of Highways and Streets*. 5th edition. Washington, D.C.: AASHTO.

Federal Highway Administration (FHWA). (2004). *Manual on Uniform Traffic Control Devices*. 2003 ed., Rev.1. Washington, D.C.: FHWA.

Figure I1.1: Rogers Street Detour - Phase I

Atlas Engineering, Inc.

Legend

- Southbound Rogers Street Detour
- Northbound Rogers Street Detour
- Westbound 3rd Street Detour

N

Map Data adapted from Google Map

Figure I1.2: Rogers Street Detour - Phase II

Atlas Engineering, Inc.

Legend

Southbound Rogers Street Detour

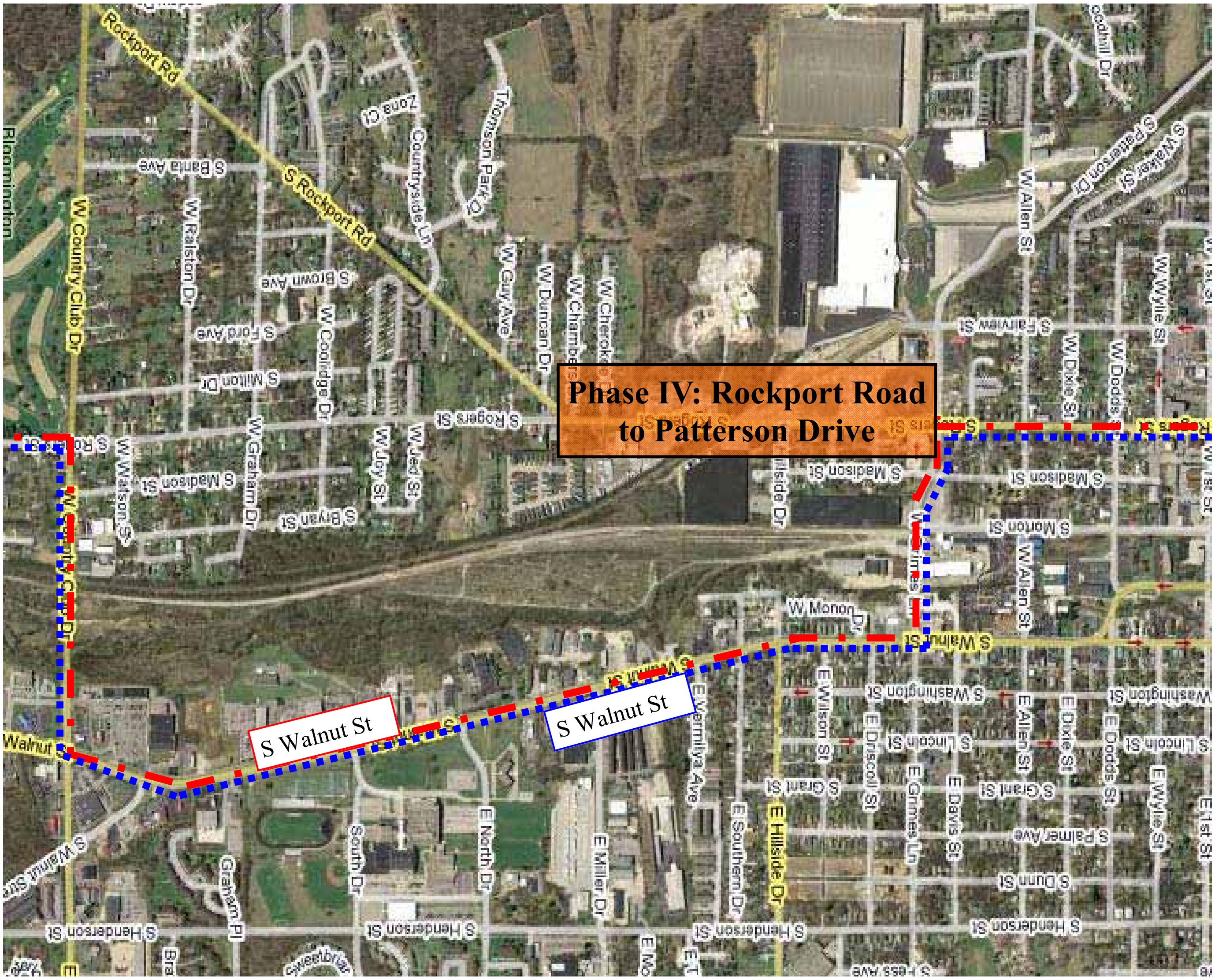
Northbound Rogers Street Detour

N

Map Data adapted from Google Map

Figure I1.3: Rogers Street Detour - Phase III

Atlas Engineering, Inc.



Legend

Southbound Rogers Street Detour

Northbound Rogers Street Detour

N

Map Data adapted from Google Map

Figure I1.4: Rogers Street Detour - Phase IV

Atlas Engineering, Inc.

Figure I1.5: Rogers Street Detour - Phase V

Atlas Engineering, Inc.

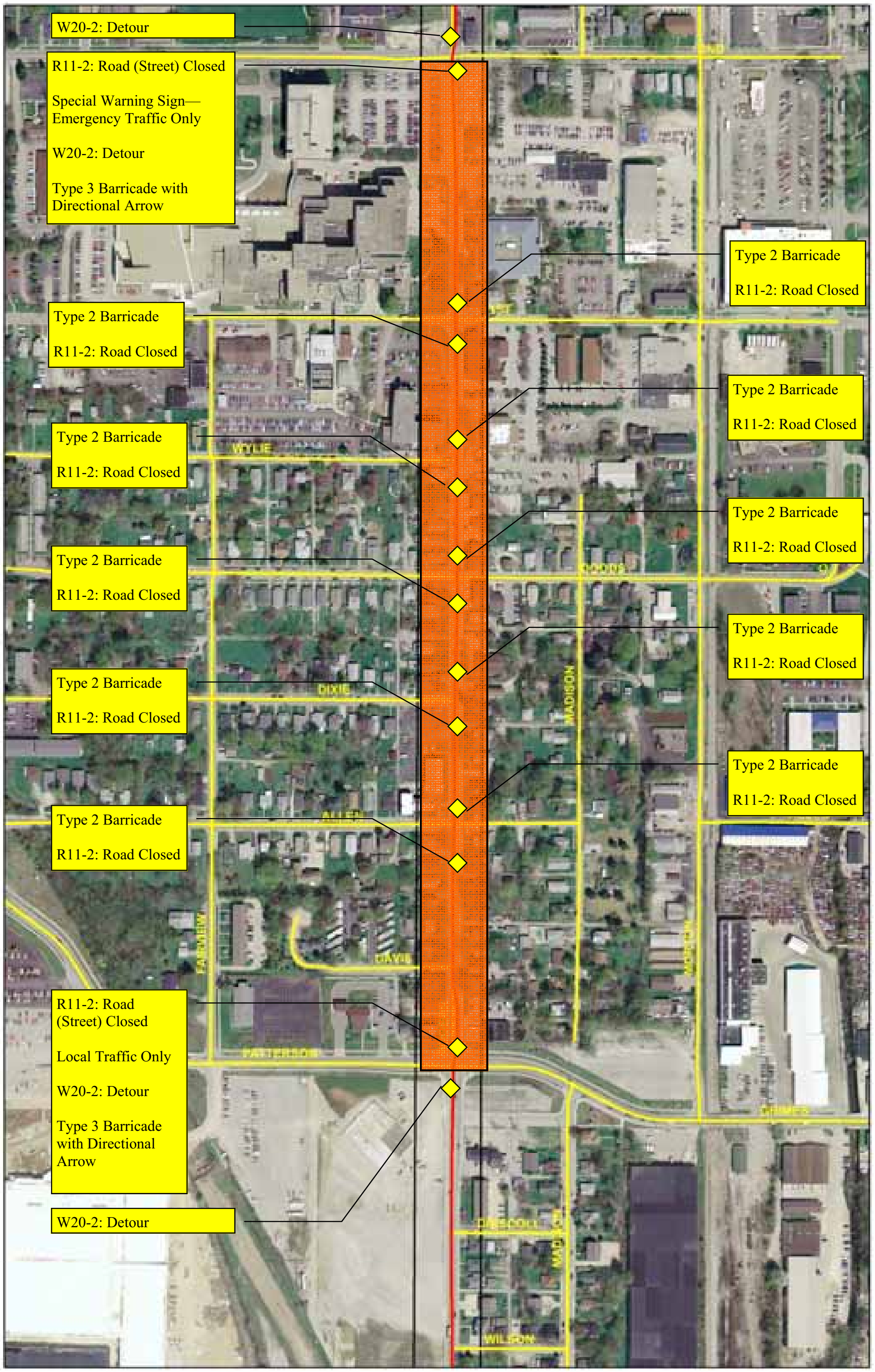


Figure 12.0 - Detour Signage

Legend

- Rogers Street Centerline
- Rogers_Corridor_Roads
- Roger Street Corridor

N

1 inch equals 300 feet

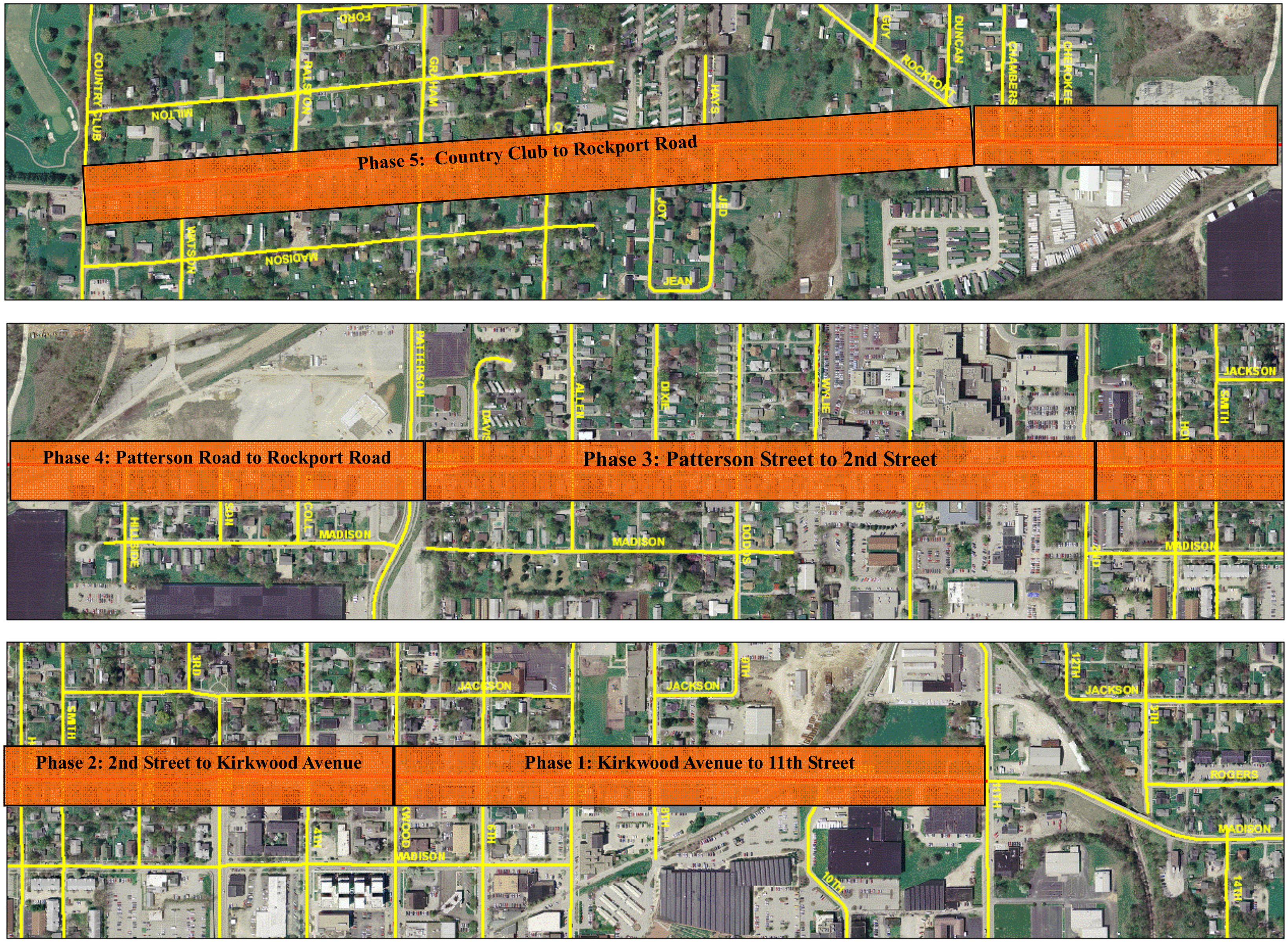
Atlas Engineering, Inc.

Figure I2.1: Phases Figure

Legend

Rogers Street Centerline

Rogers_Corridor_Roads



N

1 inch equals 300 feet

Atlas Engineering, Inc.

APPENDIX J – PLANS AND SPECIFICATIONS

J.1 Introduction

The Rogers Street corridor in Bloomington, Indiana is a 2.5 mile secondary arterial that runs on the west side of downtown Bloomington. The Bloomington/Monroe County Metropolitan Planning Organization (MPO) has requested that Atlas Engineering present a design solution that will be capable of handling the increased traffic demands currently being placed on the corridor. The proposed design of the Rogers Street corridor requires the documentation of specifications and the creation of plans for the entire corridor. The specifications included in this appendix provide guidelines for aspects of the project such as turning radii, pavement markings, placement of signs, and pedestrian and multiuse trail markings. The multiuse trail option (Appendix E) the preferred option for improving Rogers Street. The plans provided in this appendix include the multiuse trail as an integral part of the Rogers Street corridor. According to the Manual of Uniform Traffic Control Devices (MUTCD), design, placement, operation, maintenance, and uniformity are aspects of traffic control that should be carefully considered in order to promote the safety of all road users on streets and highways. The development of the specifications and plans use the most current editions of the MUTCD and the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets* (2004), shown below.

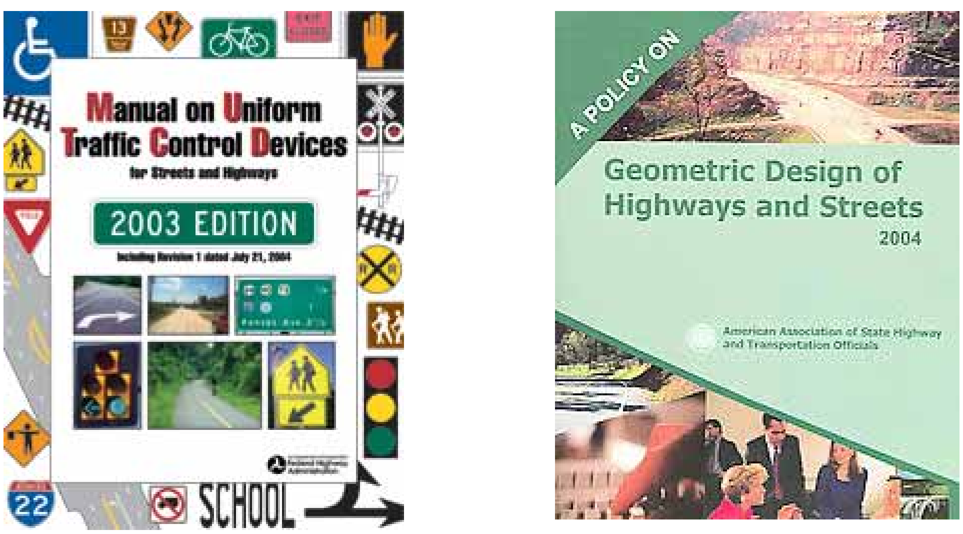


Figure J1.0: MUTCD 2003 Edition Cover and Geometric Design of Highways and Streets Cover

J.2 Specifications

Using the MUTCD manual and *A Policy on Geometric Design of Highways and Streets*, Atlas Engineering determined that the following guidelines are applicable to the Rogers Street corridor.

Sign Location

According to MUTCD Section 2A.16, signs should be located on the right side of the roadway where they can be easily recognized and understood by road users. In general, signs should be individually installed on separate posts or mountings except when one sign supplements another, route or directional signs are grouped to clarify information to motorists, or regulatory signs that do not conflict with each other are grouped. In Figure J1.1, an example of the height and lateral location of a sign is provided for a business district.

Signs should be located so that they are outside the clear zone, optimize nighttime visibility, minimize the effects of mud splatter and debris, do not obscure each other and are not hidden from view. Figure J1.2 shows examples of locations for some typical signs at intersections.

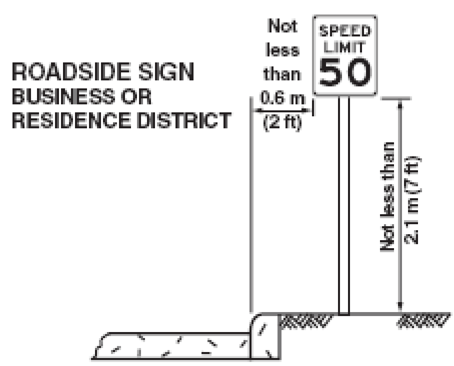


Figure J1.1: Example of Height and Lateral Location of Signs for Typical Installations (Adapted from MUTCD Figure 2A-1)

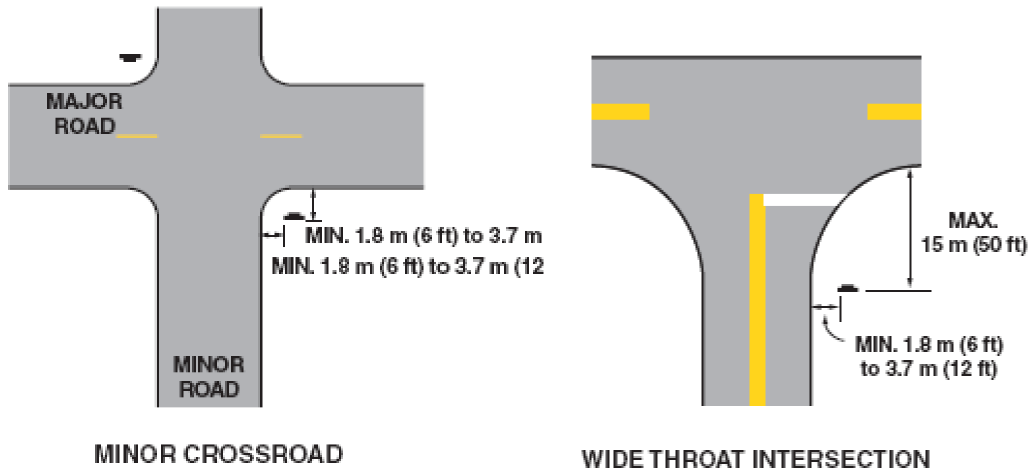


Figure J1.2: Examples of Locations of Typical Signs for Typical Intersections of Rogers Street (Adapted from MUTCD Figure 2A-2)

Regulatory Signs

Regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of legal requirements. A summary of regulatory signs, according to the MUTCD (FHWA, 2006) and applicable to the Rogers Street corridor are described below.

STOP signs (R1-1) shall be used to indicate that traffic is always required to stop. At intersections where all approaches are controlled by a STOP sign, a supplemental plaque (R1-3 or R1-4) shall be mounted below each STOP sign.

Speed Limit sign (R2-1) should be placed along the corridor to display the limit established by law. Speed limit signs shall be located at points of change from one speed to another.

The following parking signs are applicable within the Rogers Street corridor: Bus Stop sign (R7-107a) shall be placed in the Bus Stop bump-out provided in the northern section of the corridor. No parking signs (R7-1, R7-2, R7-3, or R7-6) shall be placed along the corridor in appropriate locations as deemed necessary by the city of Bloomington.

Markings

Markings shall be used to indicate maximum or special restrictions, to discourage or prohibit crossing, to show permission, and to provide guidance. A normal longitudinal line is 4 to 6 inches wide.

Yellow Centerline pavement markings in the Rogers Street corridor should consist of two normal solid yellow lines to delineate that passing is prohibited for traffic traveling in either direction. The purpose of the centerline is to control the position of the traffic at specific locations.

Edge line pavement markings shall delineate the right edge of the roadway where parking is provided in the Rogers Street corridor. Also, a normal solid line will be used perpendicular to the edge line to delineate parking spaces.

Raised pavement markings shall be 0.4 inches in height, mounted in the centerline, retro reflective, bidirectional, and yellow. For the multiuse trail crosswalks, white retro reflective pavement markings shall be used to increase awareness of drivers at dawn and dusk.

Stop and yield lines shall be placed at each intersection to indicate the point behind which vehicles are required to stop. They should be 12 to 24 inches wide and white. The placement of these lines is shown in the plan drawings.

Crosswalk markings provide guidance for pedestrians who are crossing roadways. They shall consist of solid white lines that shall not be less than 6 inches and greater than 24 inches. Examples of crosswalk markings are provided in Figure J1.3.

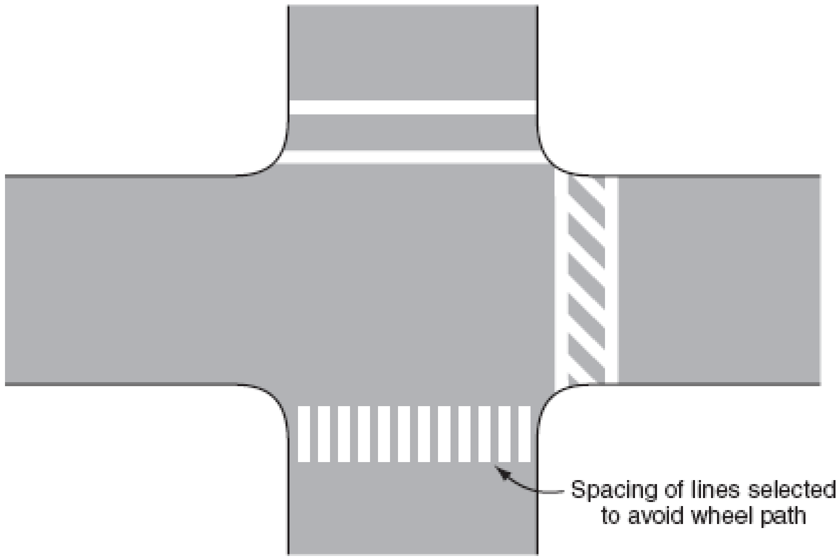


Figure J1.3: Examples of Crosswalk Markings
(Adapted from MUTCD Figure 3B-16)

Traffic Signals

In this project, Atlas Engineering recommends to continue the use of the traffic control signals that are currently in place. In the future, a study is advisable to provide recommendations as to how to increase the efficiency of traffic movements on Rogers Street.

Turning Radii

According to the AASHTO *A Policy on Geometric Design of Highways and Streets* (2004), the effective turning radius of the curb return should be no greater than that needed to accommodate the design radius. The curb return radius should be at least 5 ft to enable effective use of street-sweeping equipment. In industrial areas, it is desirable to ensure that the radius of curb return is no less than 30 ft.

J.3 Plans

Atlas Engineering has provided a plan view layout of the 2.5 mile corridor of Rogers Street. A horizontal alignment has been developed for the corridor that is numbered from station 0+00 to station 137+00. Providing an alignment will aid in the development of the corridor and in the phasing processes. This alignment begins at the northern most portion of the project, at the center of the intersection of 11th Street and Rogers Street, and extends south to the intersection of Country Club Road/Tapp Road and Rogers Street.

Along with a horizontal alignment, Atlas has also provided a number of proposed items that are listed as follows:

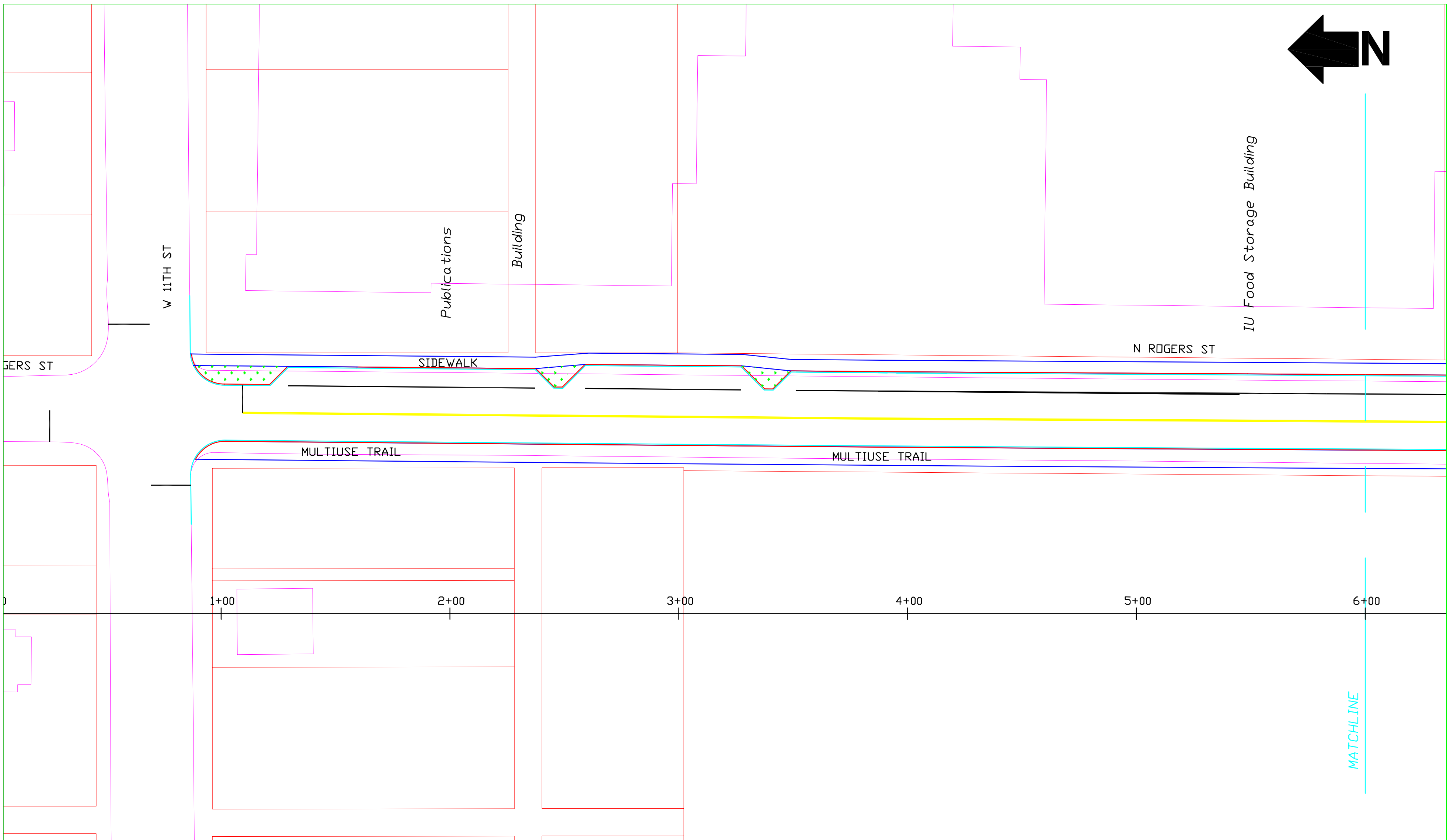
- bioretention swales,
- centerline of road,
- edges of curb,
- edges of pavement,
- edges of walk,
- green space,
- edges of trail, and
- pavement markings.

These aforementioned items have been drawn in the AutoCAD program as their own line types. All layouts have been set to a horizontal scale of one inch equals 40 feet. All of the proposals and specifications that have been described in full detail in the written report have been demonstrated in these drawings, which may be used as a reference tool.

J.4 References

Federal Highway Administration (FHWA). (2004). *Manual on Uniform Traffic Control Devices*. 2003 ed., Rev.1. Washington, D.C.: FHWA.

American Association of State Highway and Transportation Officials (AASHTO). (2004). *A Policy on Geometric Design of Highways and Streets*. 5th edition. Washington, D.C.: AASHTO.



No.	DATE	REVISION

CERTIFIED BY:

DESIGN ENGINEER DATE

DESIGNED BY: JAB DRAWN BY: JAB

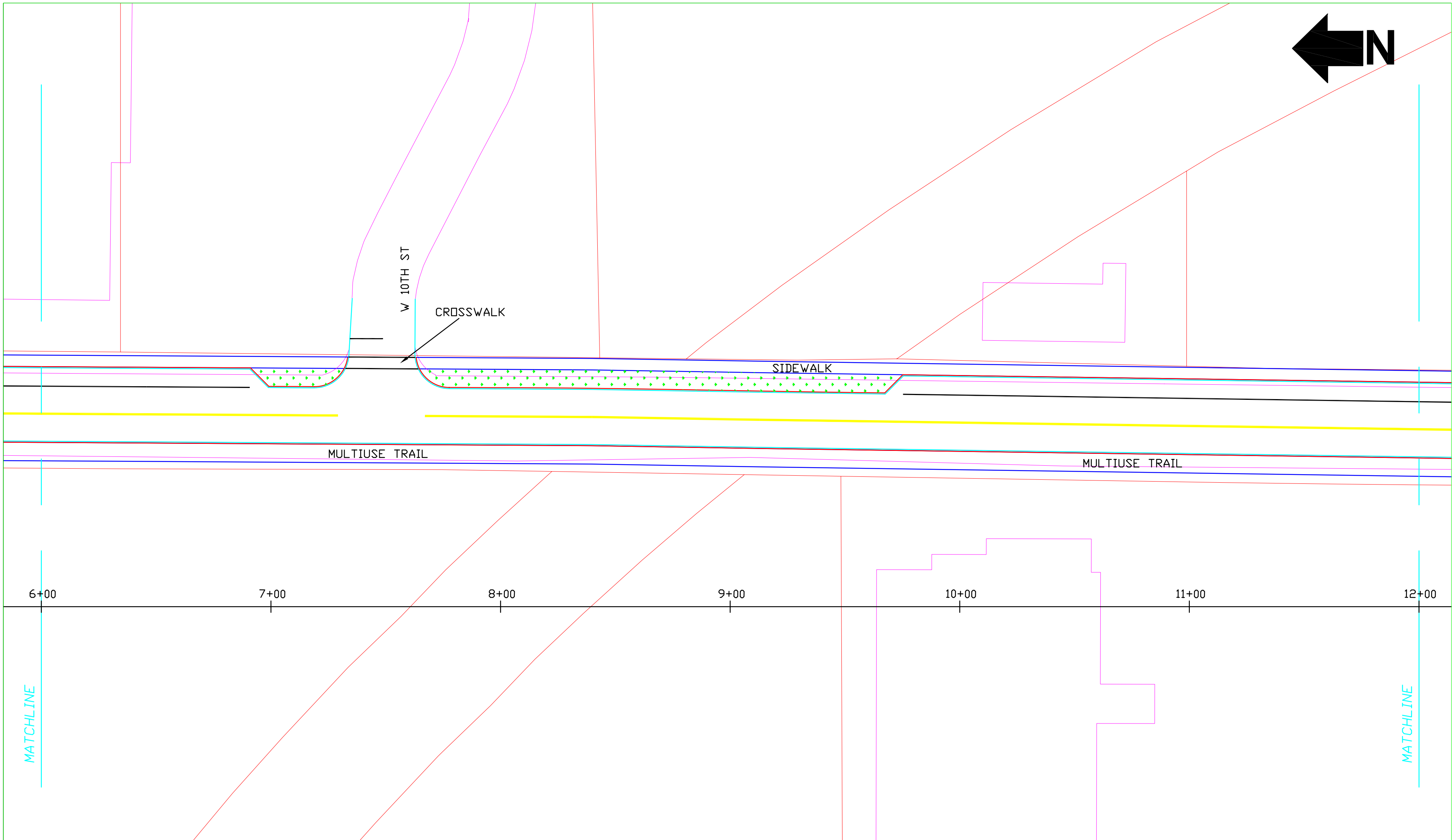
CHECKED BY: ZLS APPROVED BY: XXX

PROJECT:
ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

Plan View

ROGERS STREET
BLOOMINGTON, INDIANA

PROJECT No: XXXXXX
DATE: 4-29-07
AIP No:
HORIZ. SCALE: 1" = 40'
VERT. SCALE: NONE
SHEET NO. J2.0



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Telephone: 412.443.7242

CERTIFIED BY: ____ DESIGN ENGINEER ____ DATE

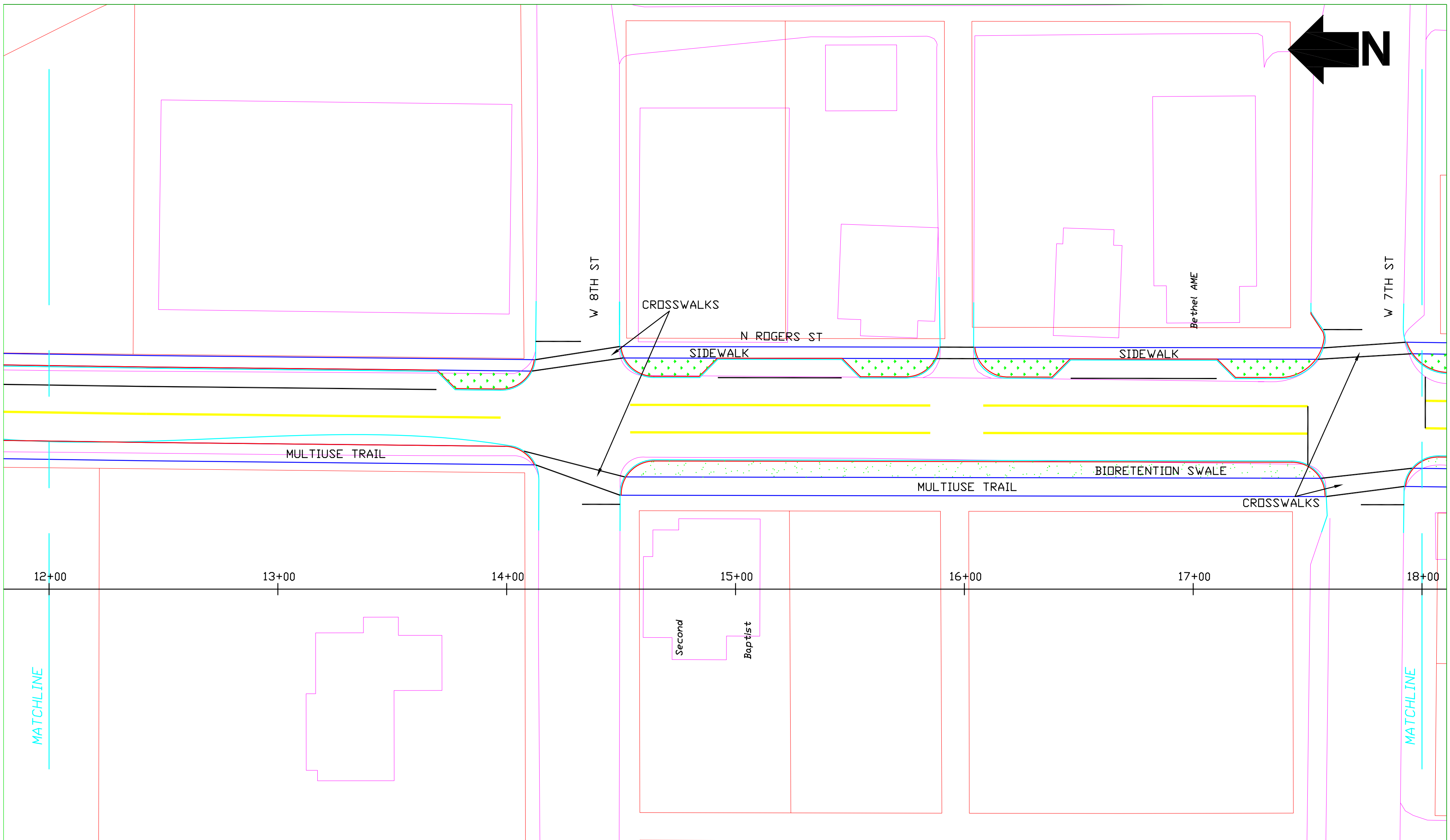
DESIGNED BY: JAB	DRAWN BY: JAB
CHECKED BY: ZLS	APPROVED BY: XXX

PROJECT:
ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

PROJECT No: XXXXXX	HORIZ. SCALE: 1" = 40'
DATE: 4-29-07	VERT. SCALE: NONE
	SHEET NO. J2.1



No.	DATE	REVISION

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47803
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CERTIFIED BY:	DESIGN ENGINEER DATE
DESIGNED BY: JAB	DRAWN BY: JAB
CHECKED BY: ZLS	APPROVED BY: XXX

PROJECT: ROGERS STREET CORRIDOR CONTEXT SENSITIVE DESIGN STUDY

PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

PROJECT No: XXXXXX	HORIZ. SCALE: 1" = 40'
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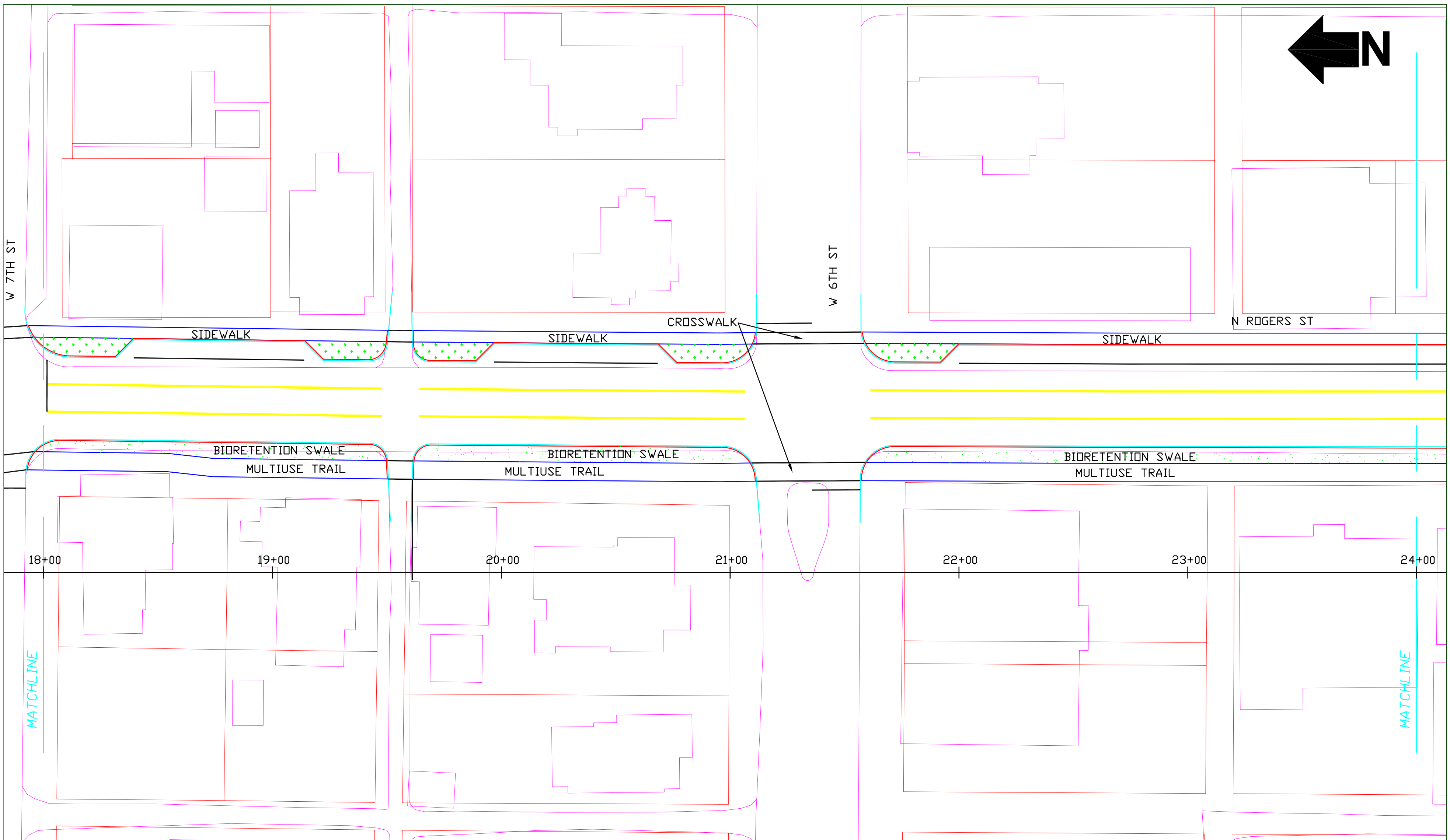

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PLAN VIEW

ROGERS STREET BLOOMINGT0N, INDIANA

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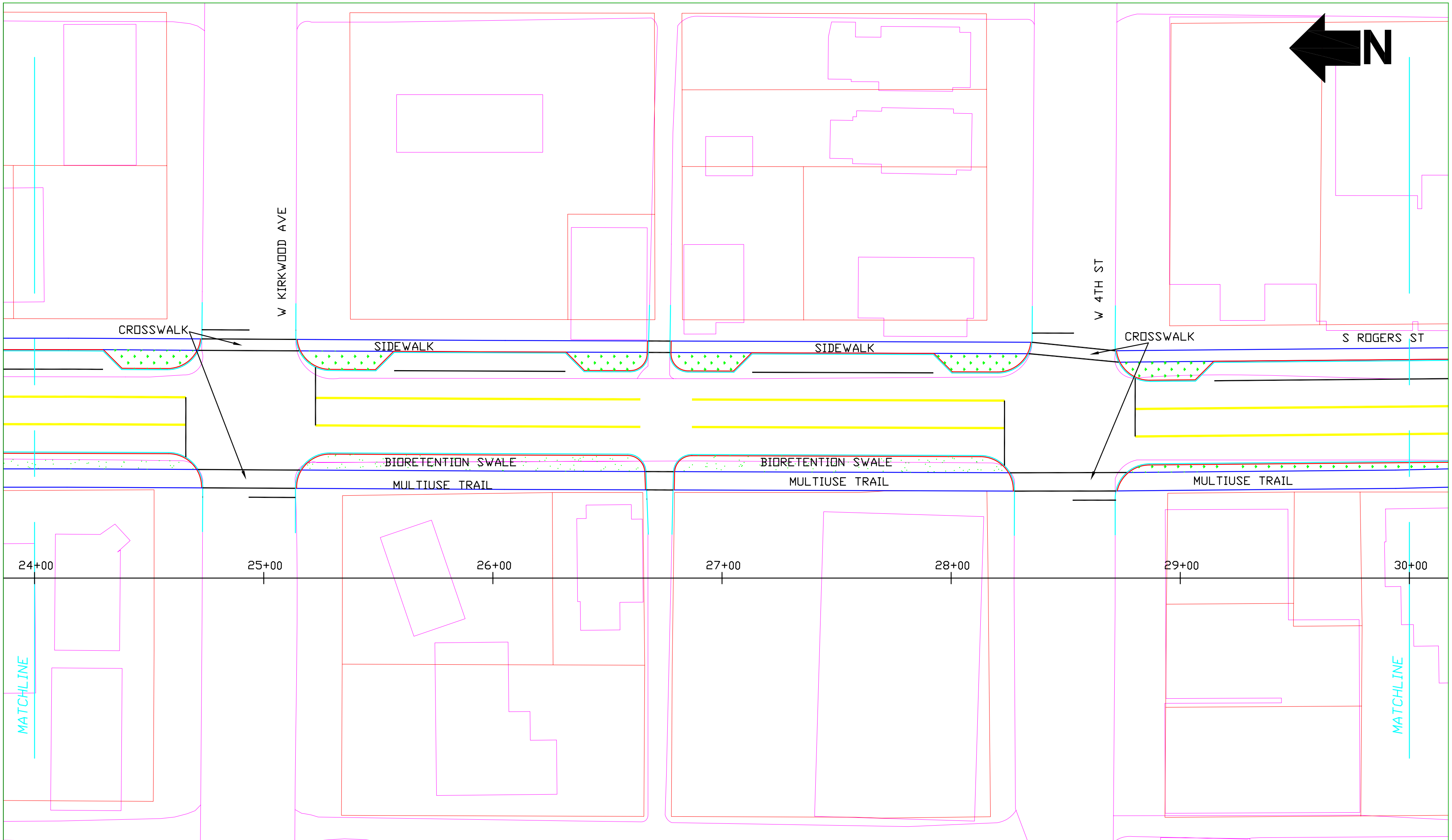

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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DATE: 4-29-07
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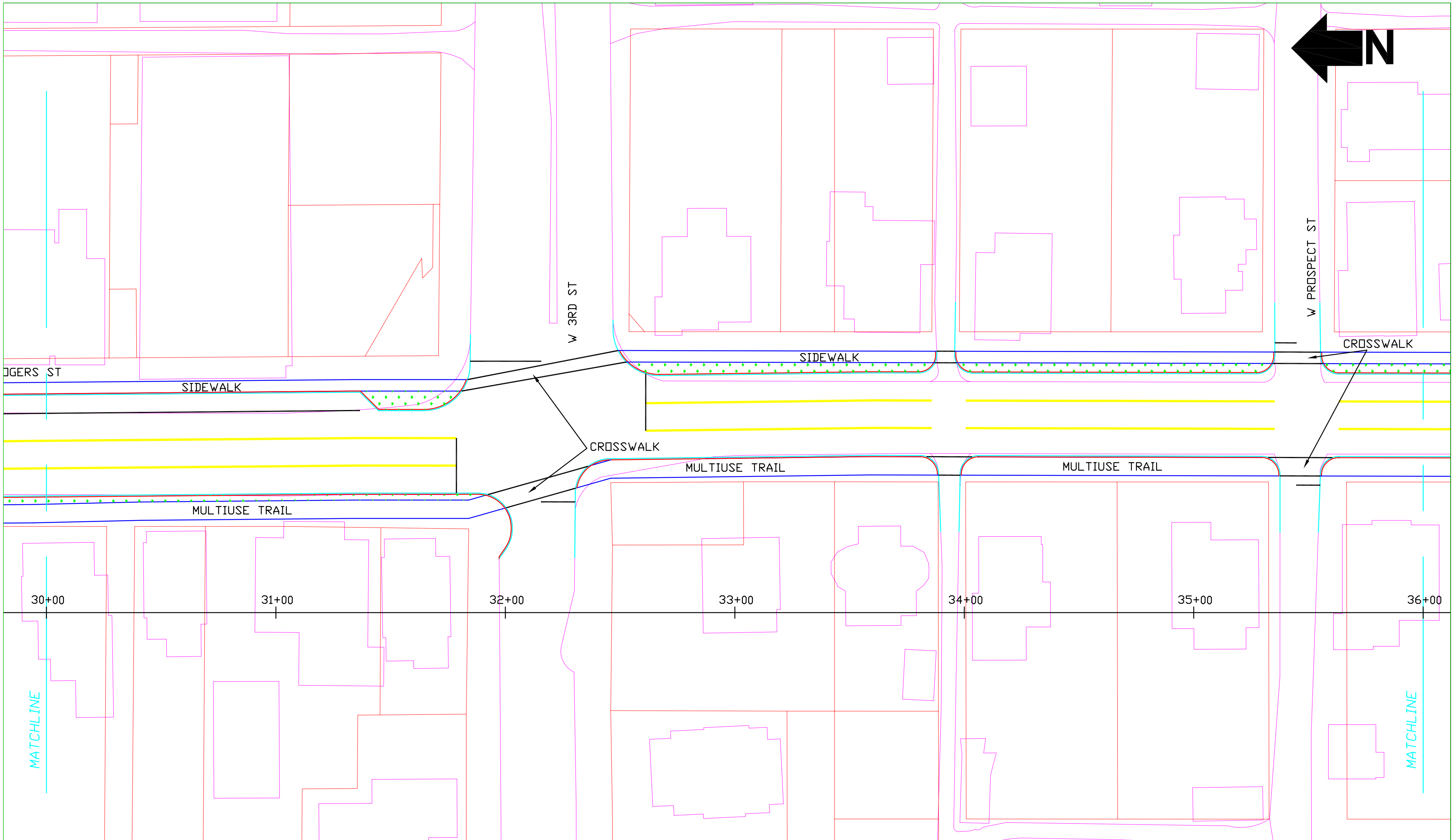

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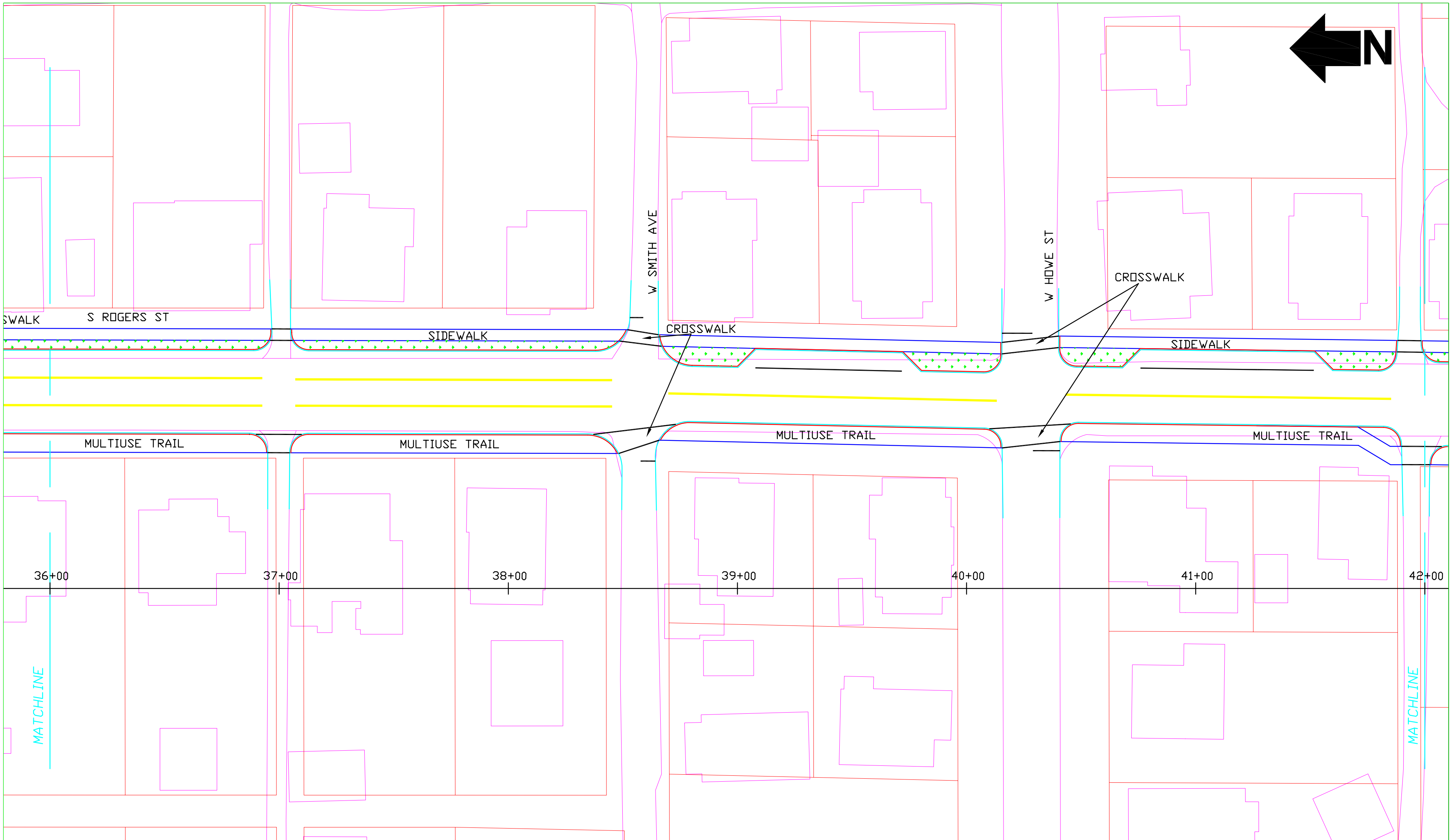

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PLAN VIEW

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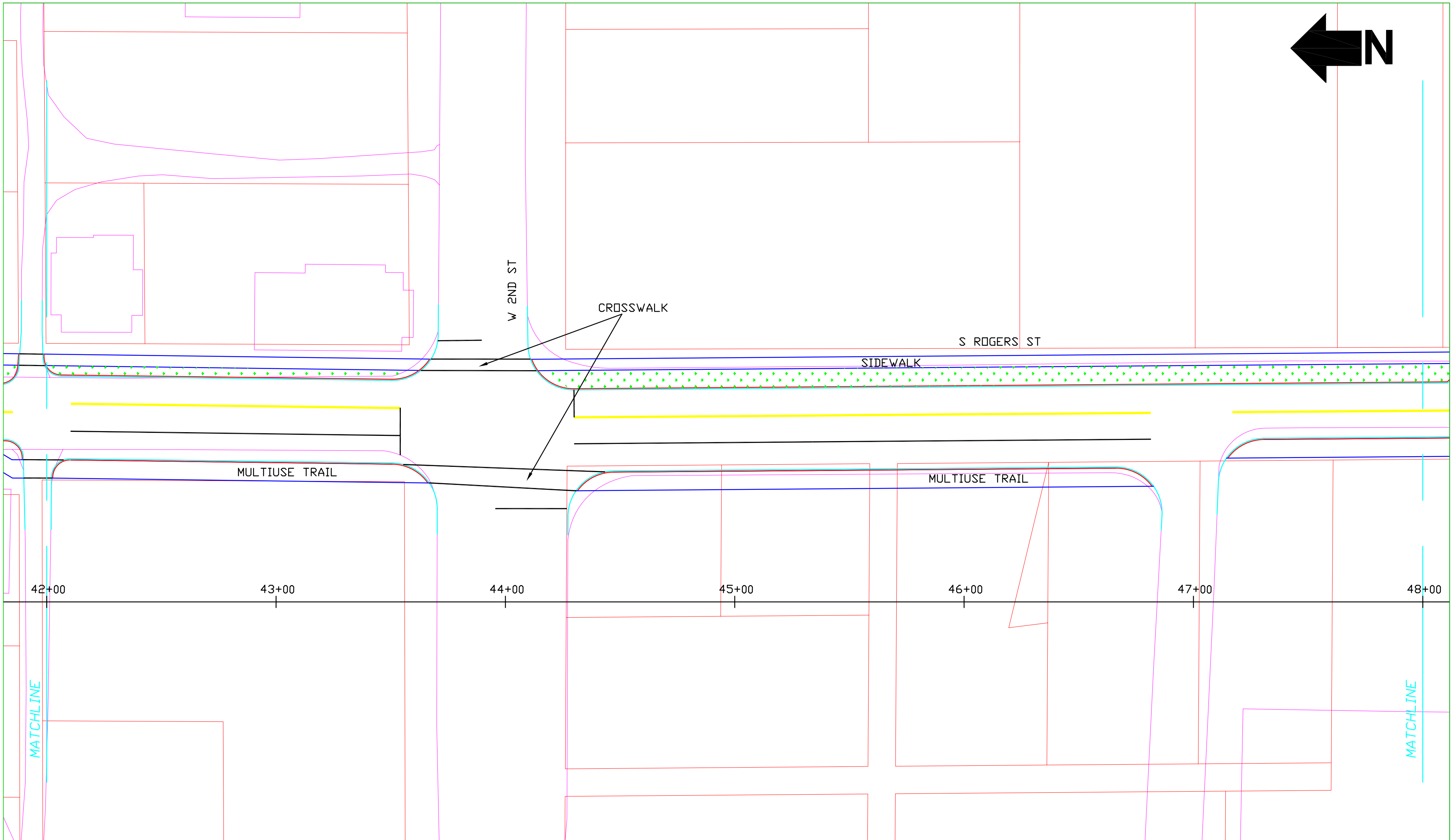

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PLAN VIEW

ROGERS STREET
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PROJECT No: XXXXXX

DATE: 4-29-07

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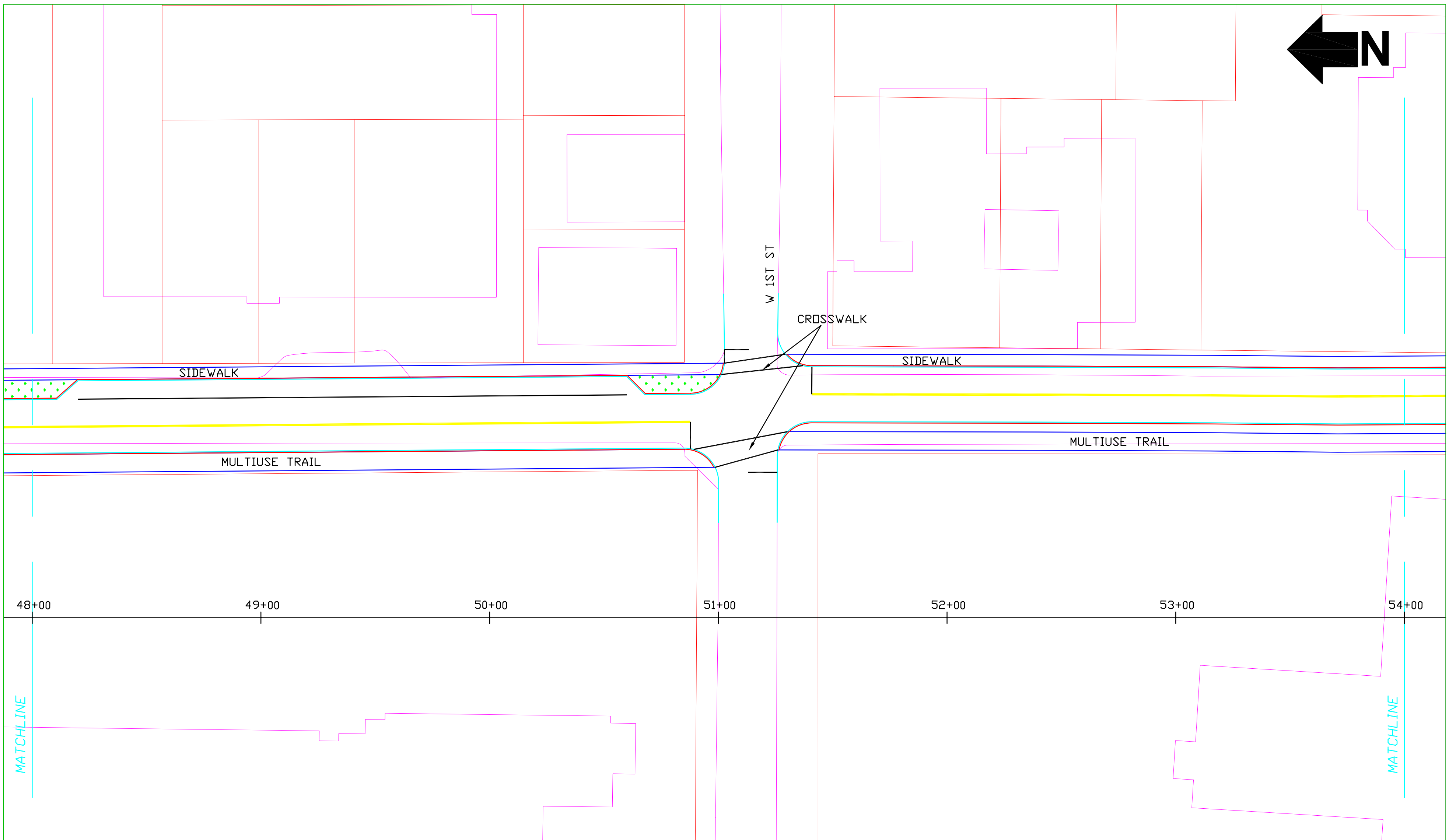

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PLAN VIEW

ROGERS STREET
BLOOMINGTON, INDIANA

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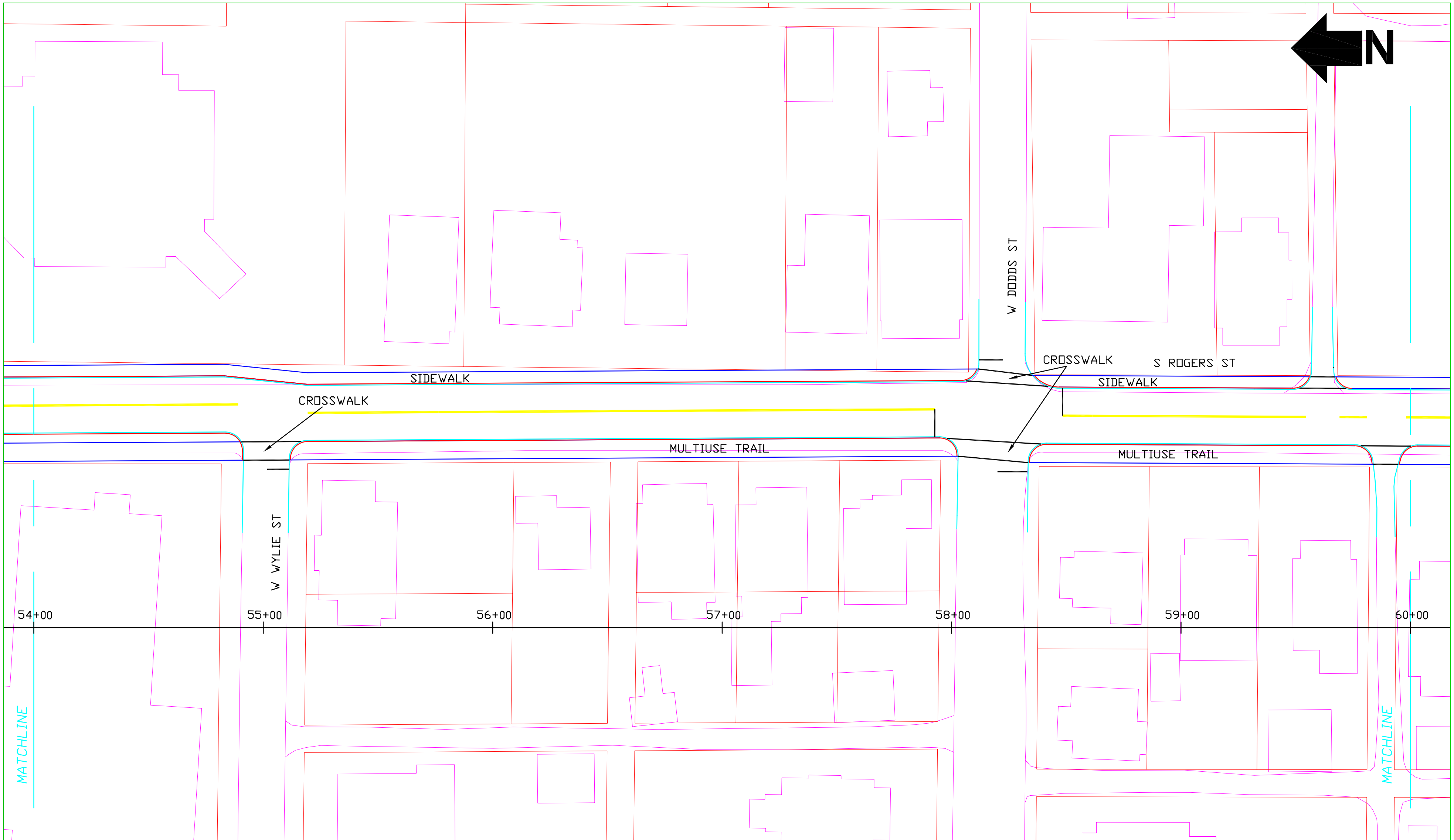

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

PROJECT No: XXXXXX
DATE: 4-29-07
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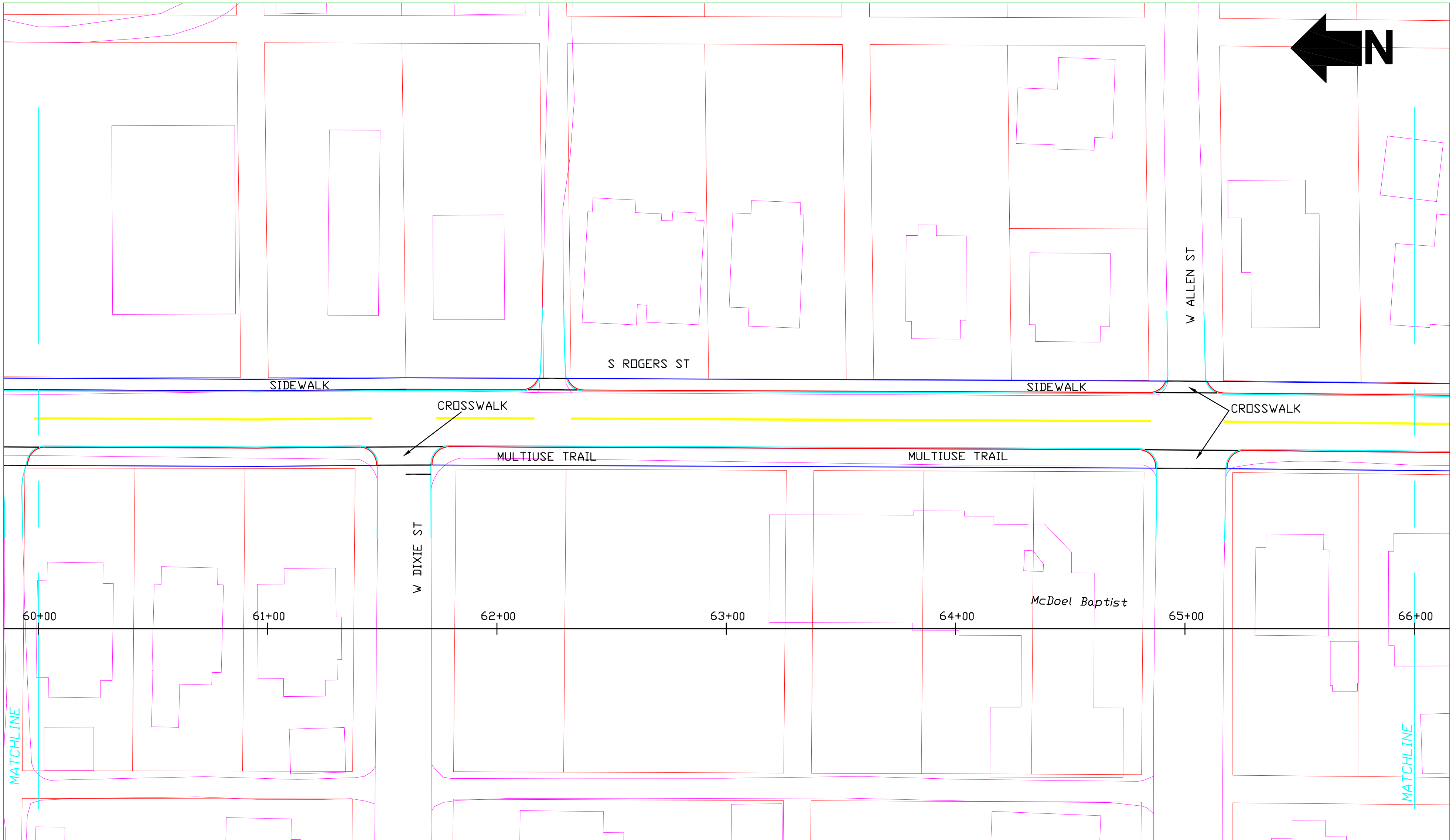

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PLAN VIEW

ROGERS STREET
BLOOMINGTON, INDIANA

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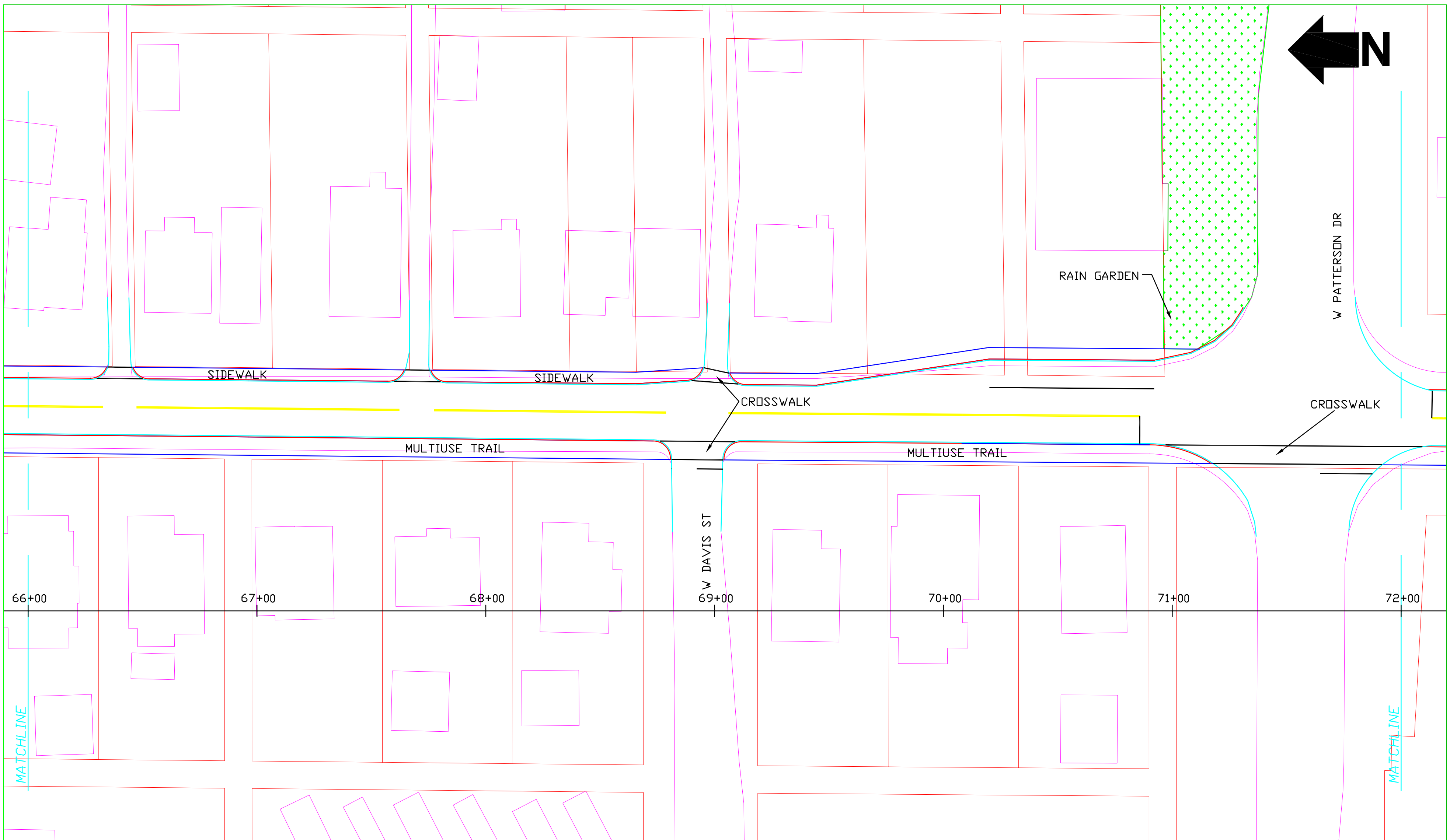

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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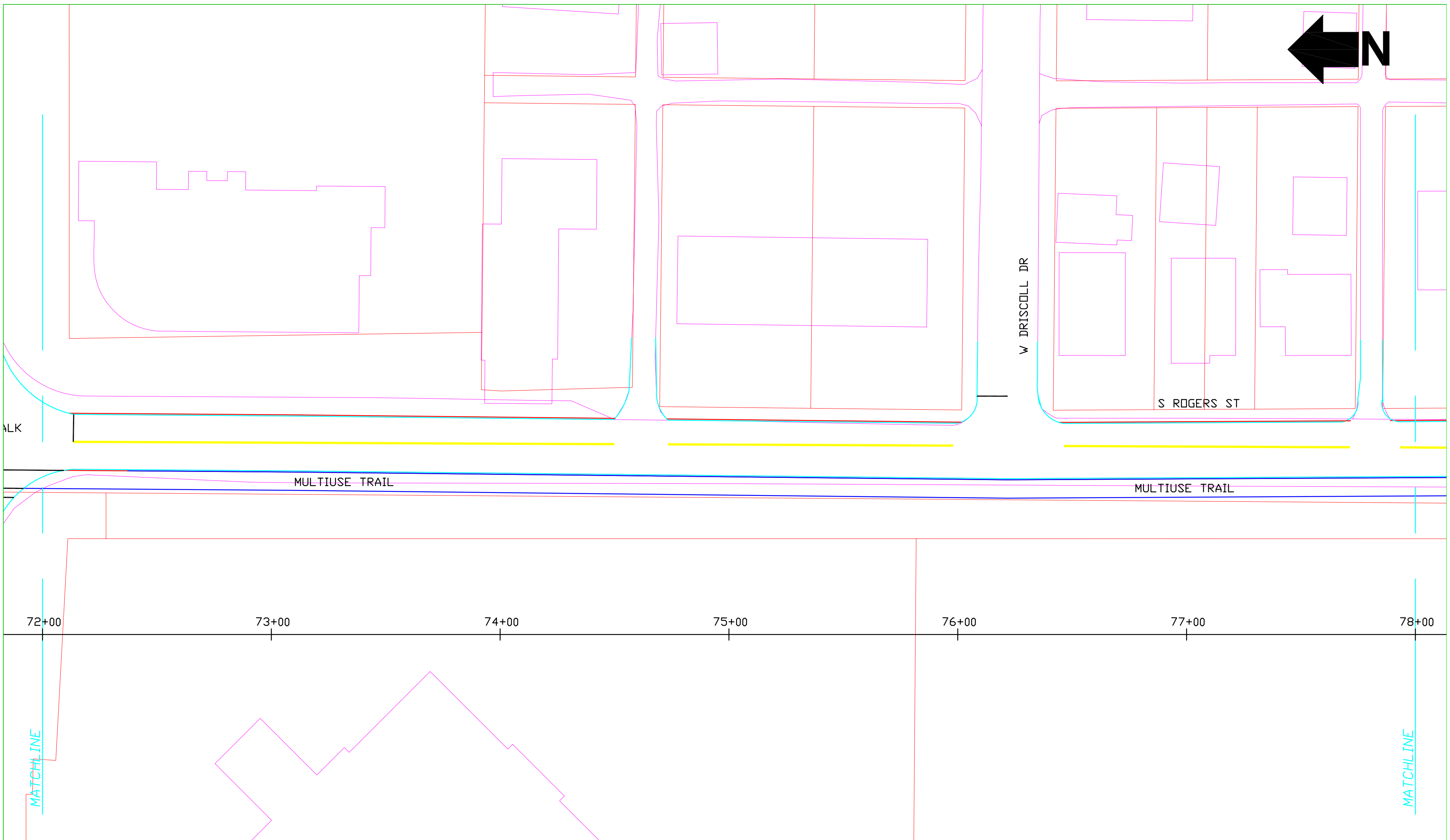

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PLAN VIEW

ROGERS STREET
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DATE: 4-29-07	VERT. SCALE: NONE
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BLOOMINGTON, INDIANA

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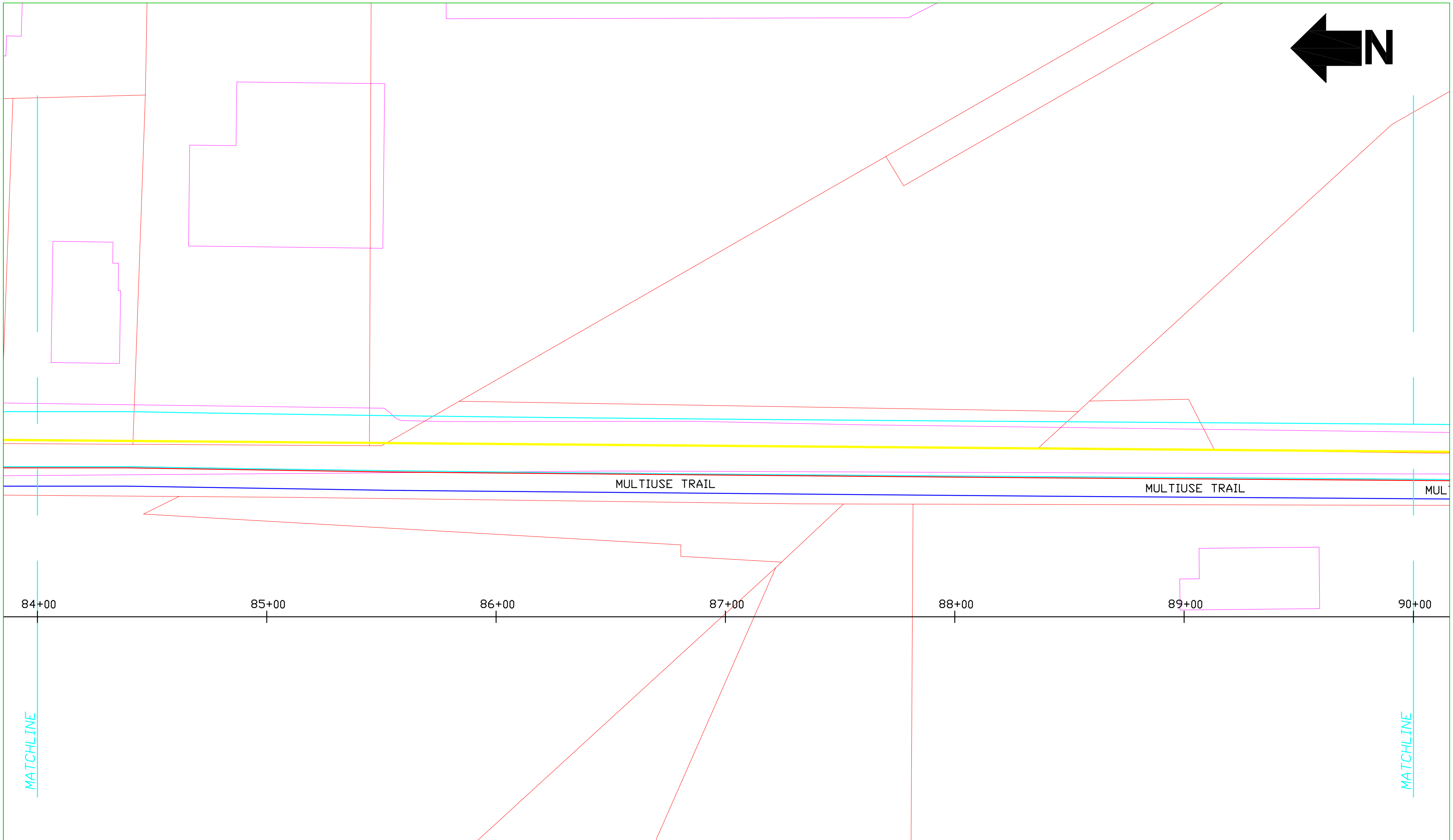

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PLAN VIEW

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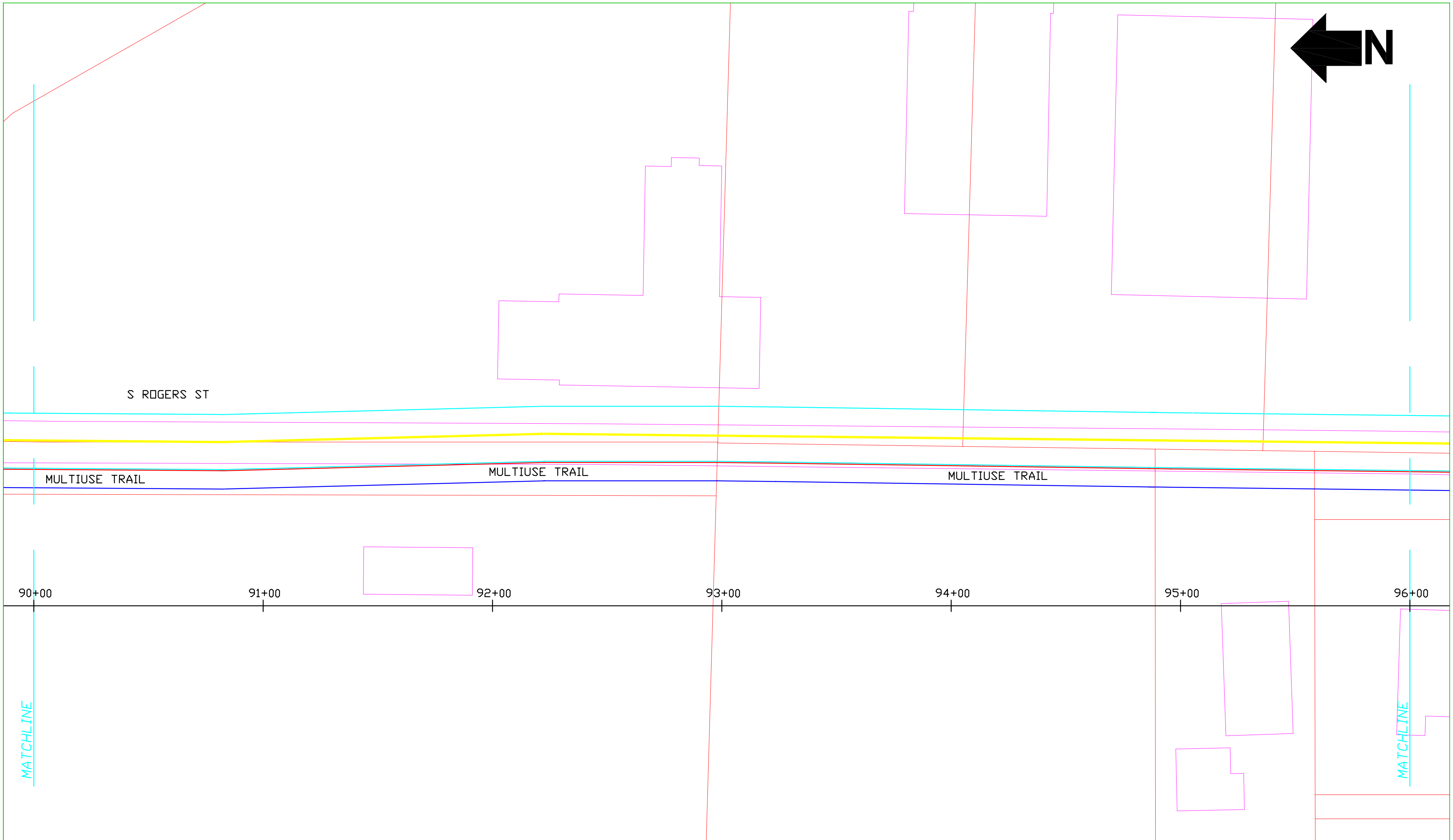

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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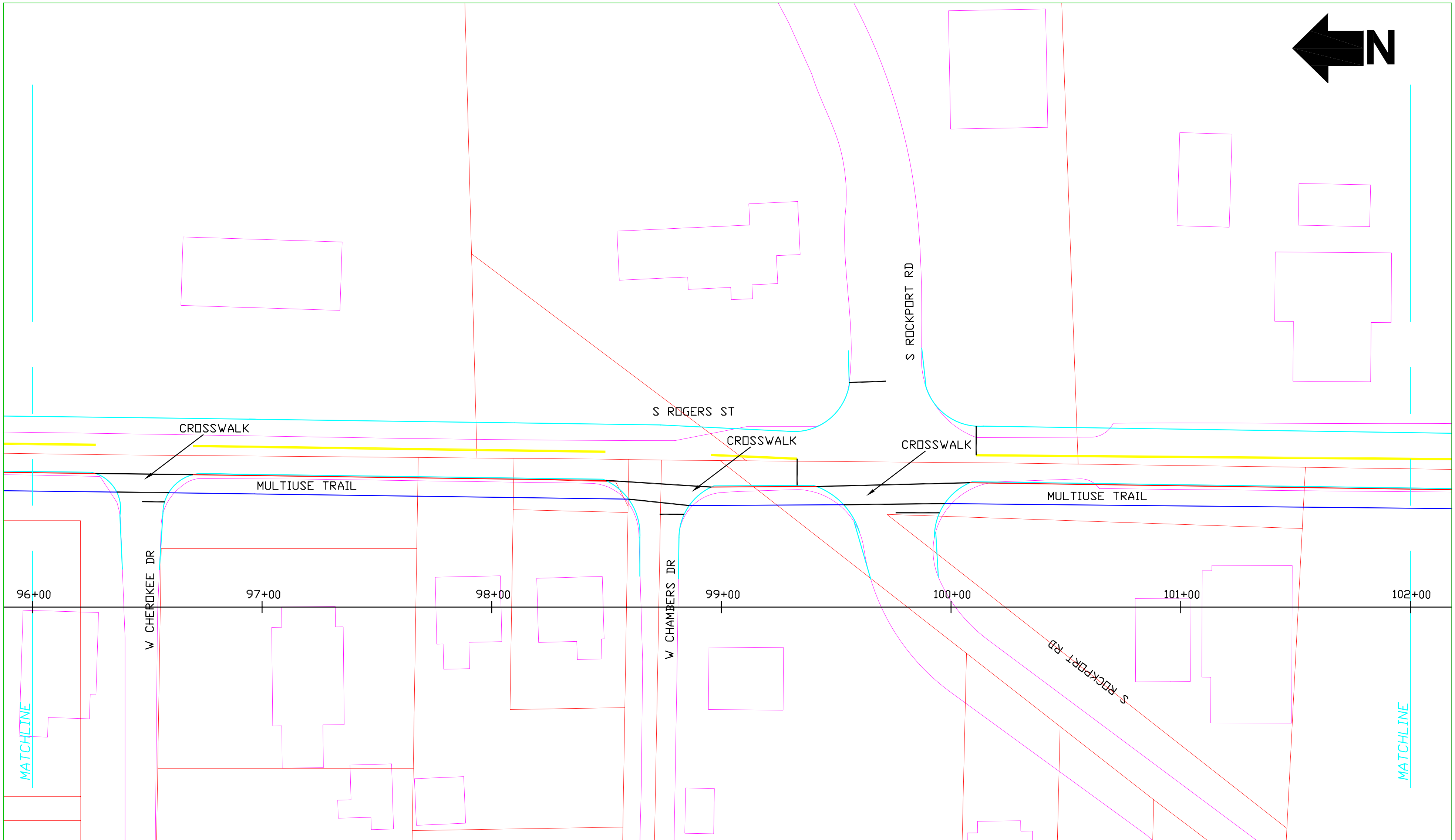

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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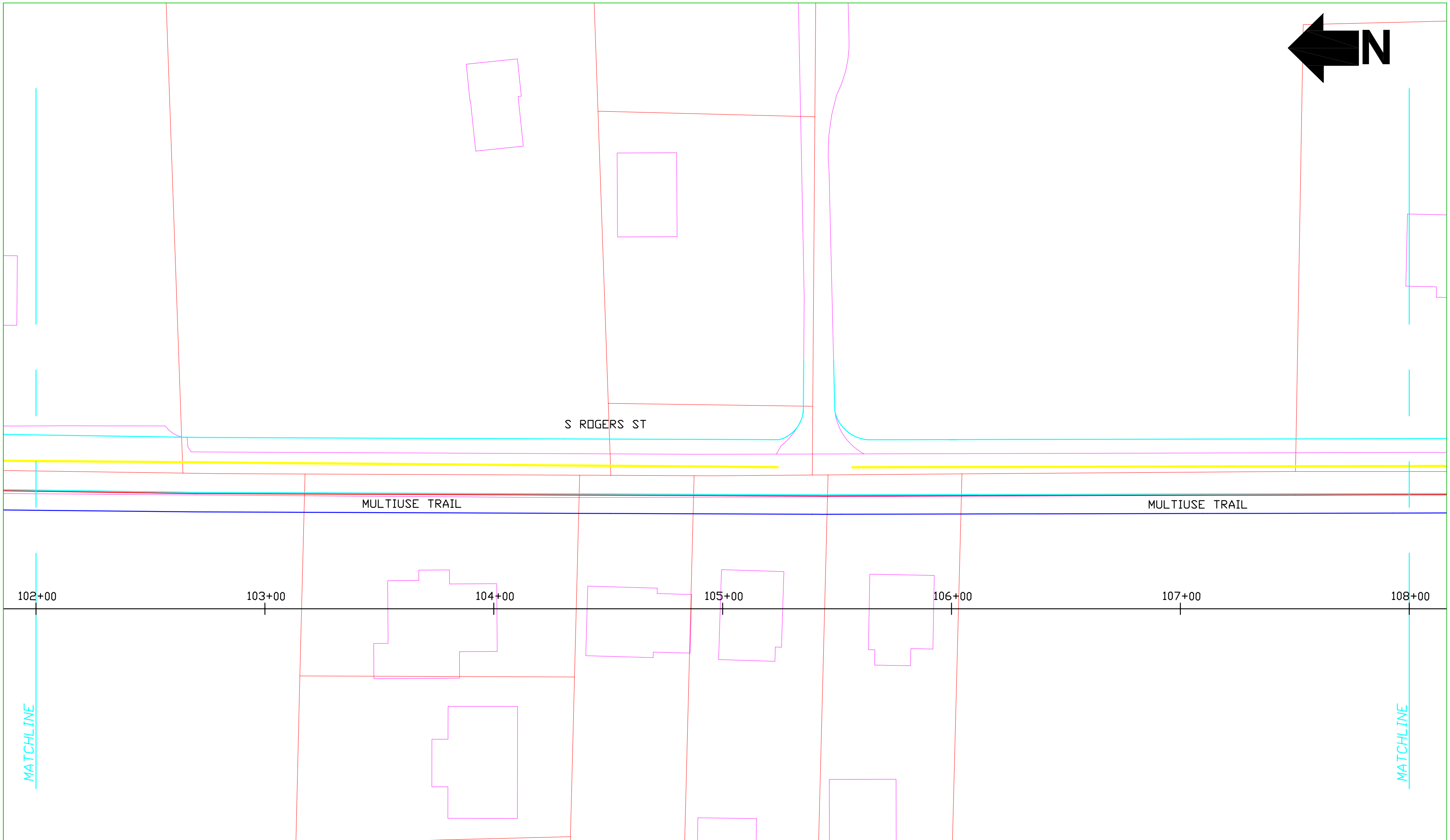

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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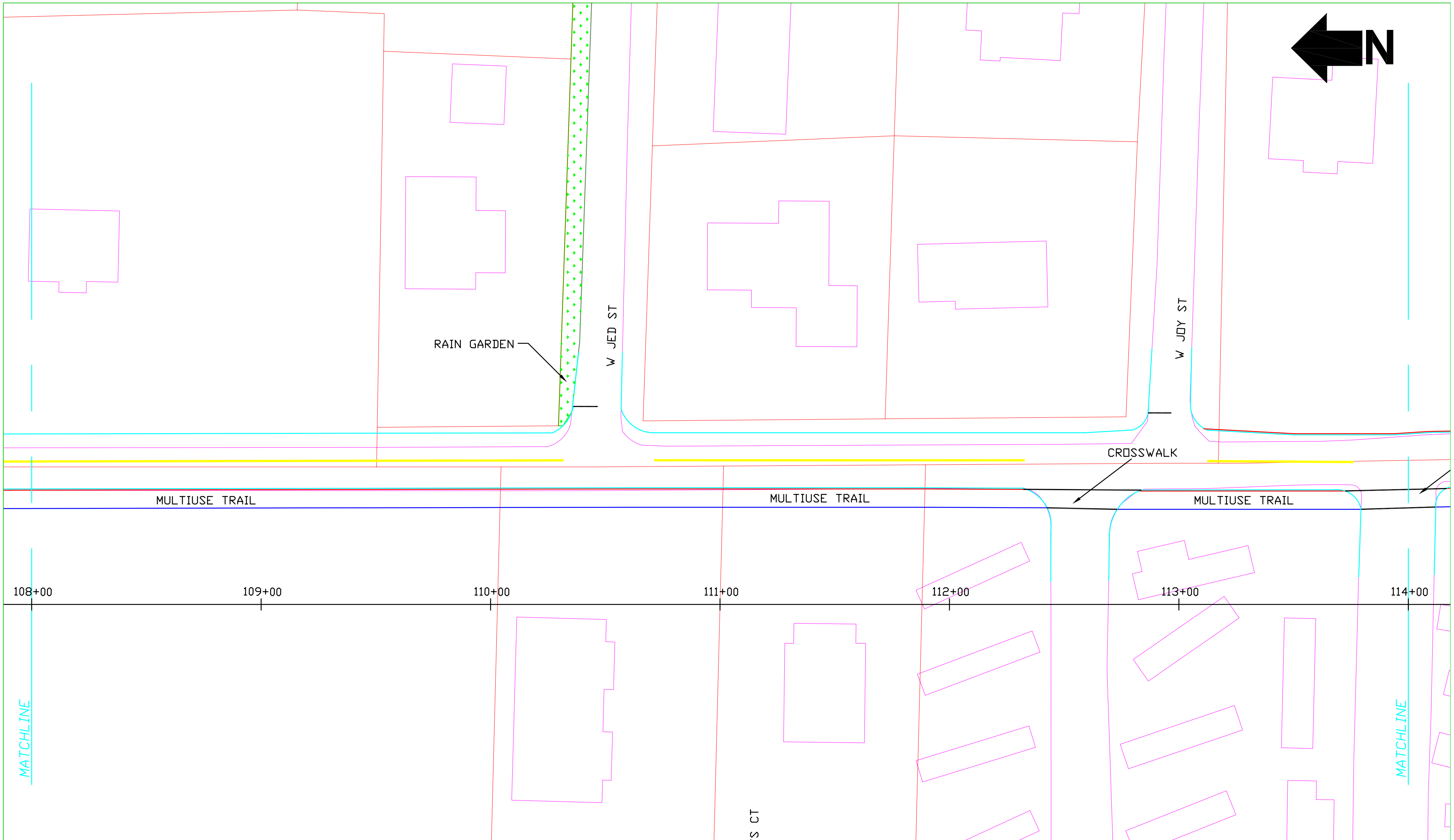

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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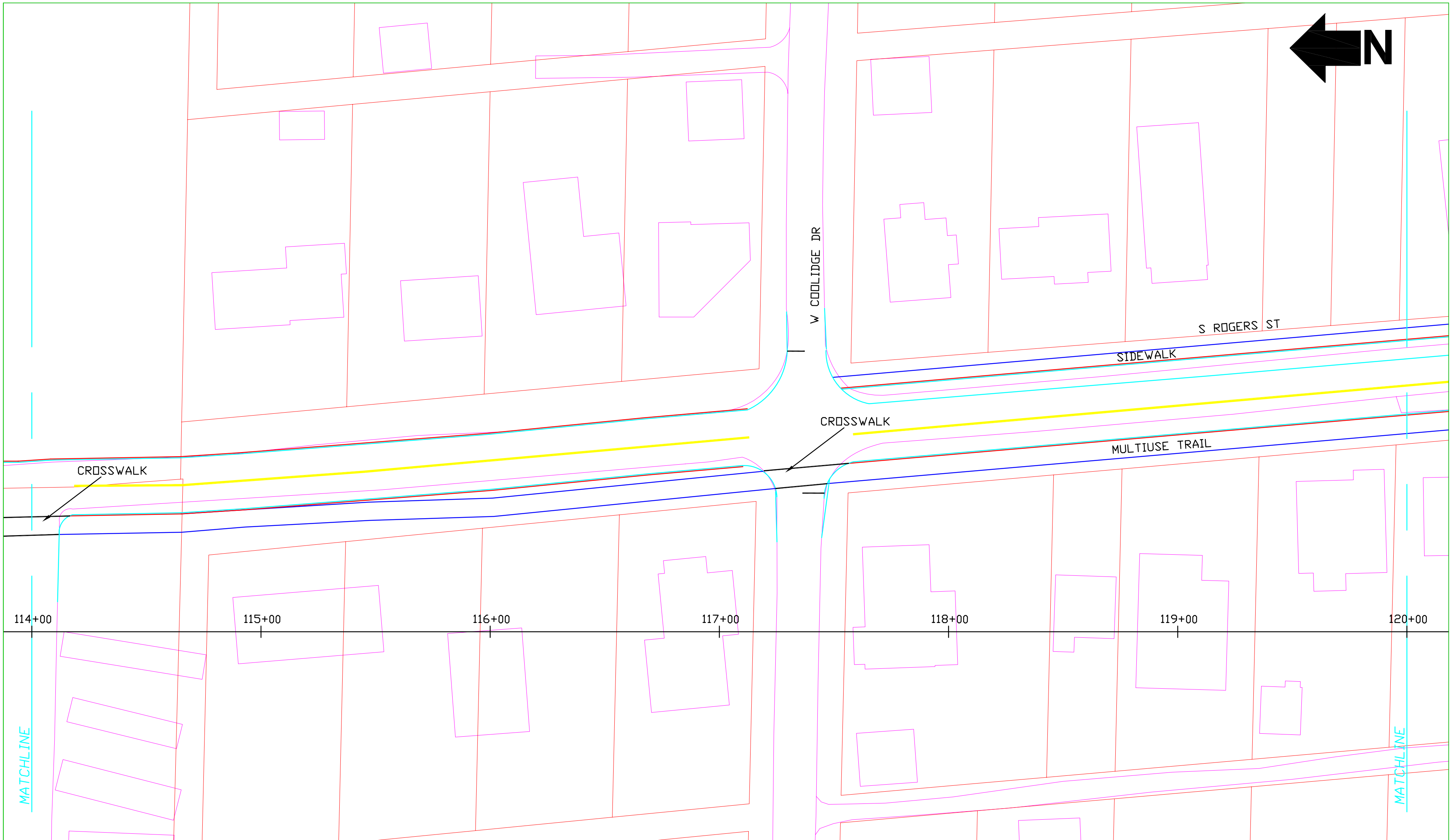

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ROGERS STREET
BLOOMINGTON, INDIANA

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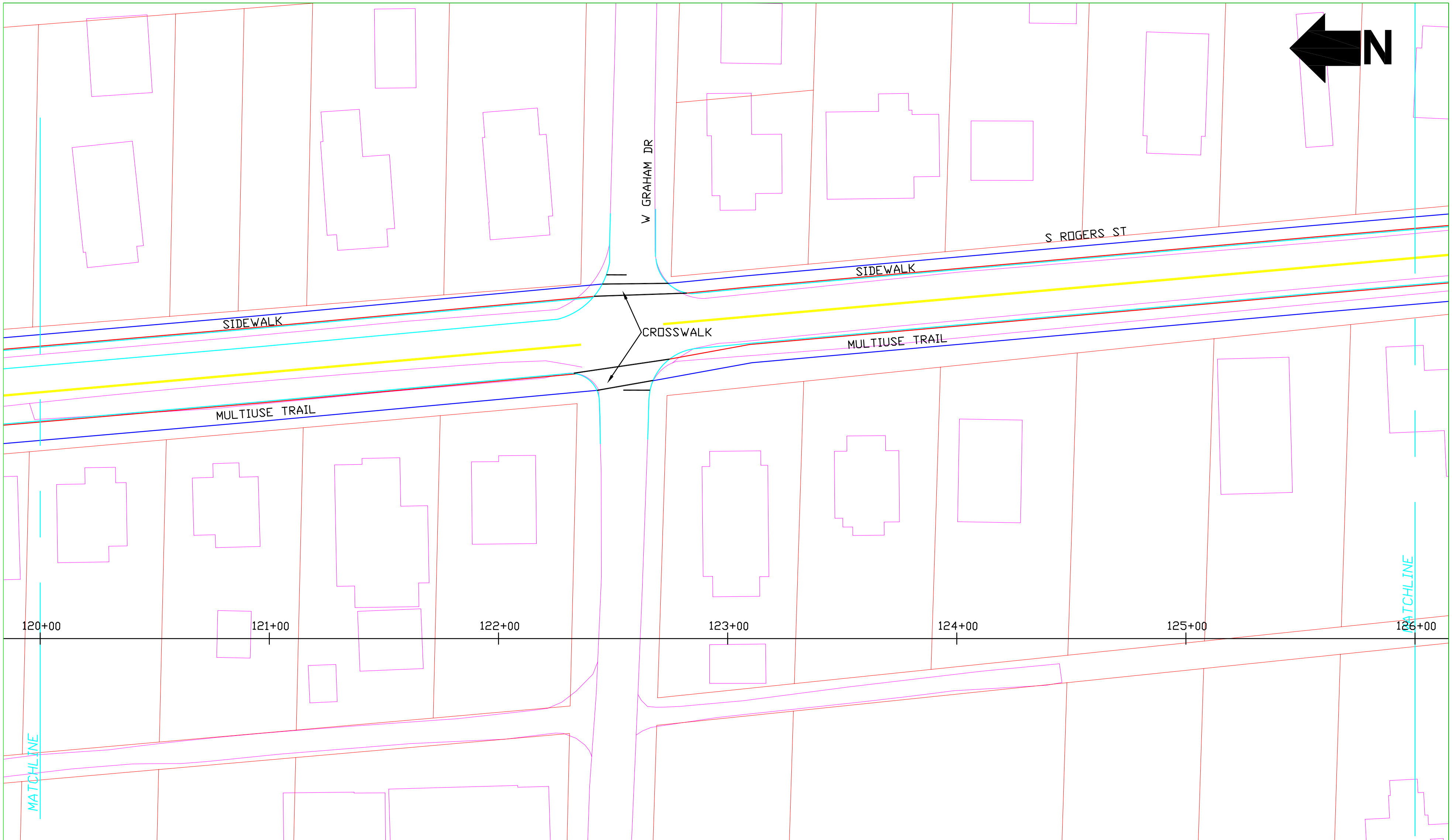

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

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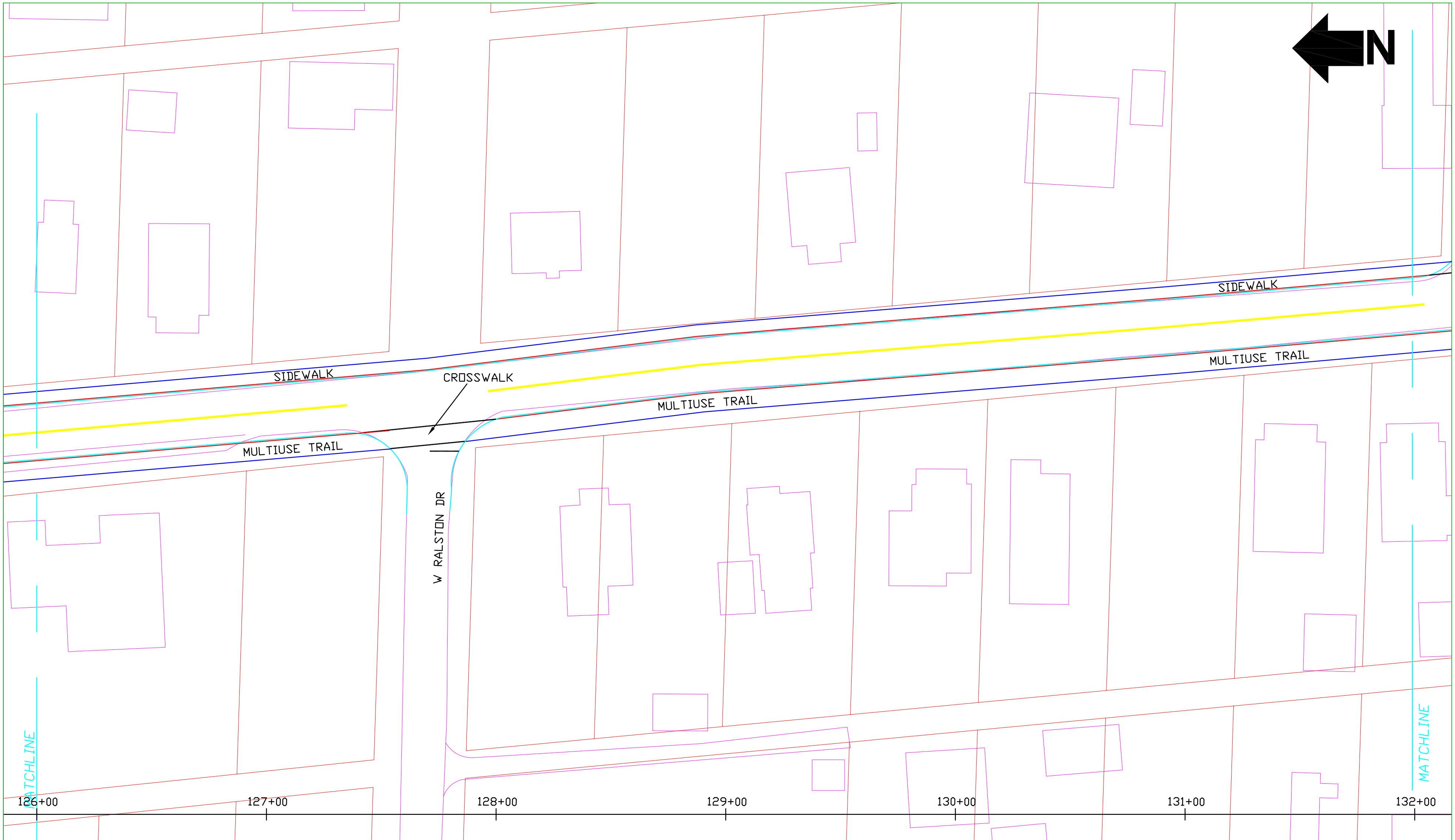

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PLAN VIEW

ROGERS STREET
BLOOMINGTON, INDIANA

PROJECT No: XXXXXX
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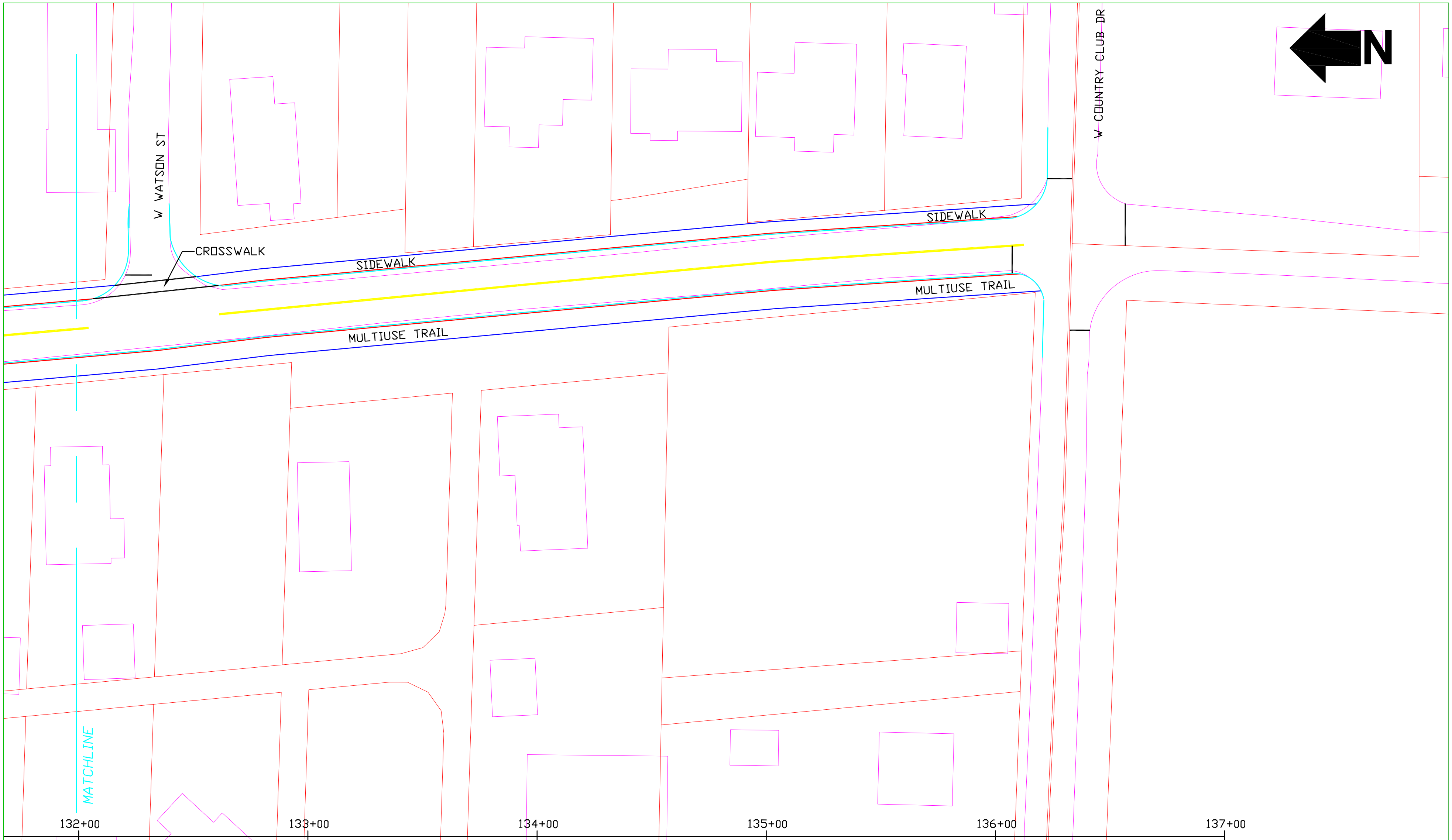

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PLAN VIEW

ROGERS STREET BLOOMINGTON, INDIANA

PROJECT No: XXXXXX
DATE: 4-29-07
HORIZ. SCALE: 1" = 40'
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APPENDIX K – COST ESTIMATE

K.1 Introduction to Cost Estimate

The Bloomington/Monroe County Metropolitan Planning Organization (MPO) plans to redesign and improve transportation conditions along a 2.5 mile segment of the Rogers Street corridor. Improvements to the current transportation conditions will be made by reconstructing the pavement for a 2-lane, 24-foot width road, an 8-foot multi-use trail, sidewalks, as well as rain gardens, catch basins, and bio-retention swales. Since the project will likely not be built all at once, Atlas Engineering performed a five-phase cost estimate. For more information about the five phases, refer to Appendix I. We used the Indiana Department of Transportation (INDOT, 2007) unit price averages as well as the RSMeans *Building Construction Cost Data* (Construction Publishers and Consultants, 2005) to determine the units and prices for the reconstruction of the 2.5 mile corridor.

K.2 Description of Cost Estimate

Atlas Engineering intends for this appendix to be used as a guide for cost estimation and a tool for the client to seek funding and should not be taken as exact cost. We decided to mainly use the INDOT unit price averages because it provided for a closer estimation of current and competitive prices on past projects throughout Indiana. We used the RSMeans *Building Construction Cost Data* on items that were not included or not well specified in the INDOT unit price averages. Estimated construction costs do not include contractor's profit, mobilization or demobilization, additional design and engineering costs, utility relocation, or any type of insurance.

K.3 Conclusion

Costs were calculated for each item in each phase separately (Tables K.2 – K.6). Table K.1 displays the total direct cost for each phase. The final cost for the entire project is $6,550,000.

Table K.1 Total Direct Costs for all Five Phases

Description	Cost
Phase I (11th Street to Kirkwood Avenue)	$ 1,360,000
Phase II (4th Street to 2nd Street)	$ 950,000
Phase III (1st Street to Davis Street)	$ 1,270,000
Phase IV (Patterson Street to Rockport Road)	$ 1,660,000
Phase V (Jed Street to Country Club/Tapp Road)	$ 1,310,000

Total Cost	**$ 6,550,000**

K.4 References

Construction Publishers and Consultants (2005). "RSMeans Building Construction Cost Data 2005, 63 Annual Edition".

Indiana Department of Transportation Unit Price Averages, 2007. Indiana Department of Transportation. Retrieved March 20, 2007 from source <http://www.in.gov/dot/div/contracts/pay/average.htm>

Table K.1: INDOT Unit Price Cost Estimate Phase 1
Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Reference	Unit Cost	Total Amount
Drainage					
B-Borrow for Structure Backfill	2400	CYD	203 - 02070	$ 23.00	$ 55,200.00
Reinforced Concrete Pipe, 12"	3448	LFT	715 - 05118	$ 47.00	$ 162,056.00
Reinforced Concrete Pipe, 15"	1368	LFT	715 - 05119	$ 43.00	$ 58,824.00
Reinforced Concrete Pipe, 18"	0	LFT	715 - 05120	$ 63.00	$ -
Reinforced Concrete Pipe, 24"	0	LFT	715 - 05123	$ 63.00	$ -
Concrete Pipe End Sections	2	EACH	715 - 01472	$ 811.00	$ 1,622.00
Inlet J-10	52	EACH	720 - 02367	$ 2,650.00	$ 137,800.00
Inlet Protection	52	EACH	205 - 06933	$ 120.00	$ 6,240.00
Aggregate for Underdrains	750	CYD	718 - 94889	$ 21.00	$ 15,750.00
Riprap, Revetment	125	TON	616 - 03472	$ 32.00	$ 4,000.00
Adjust Casting to Grade	25	EACH	720 - 01894	$ 785.00	$ 19,625.00
Rogers Street Pavement					
Common Excavation	5000	CYD	203 - 02000	$ 33.00	$ 165,000.00
Rock Excavation	750	CYD	203 - 02010	$ 70.00	$ 52,500.00
Borrow	500	CYD	203 - 02070	$ 23.00	$ 11,500.00
Sub-base Aggregate	17118	SYD	***02720 200 0390***	$ 5.84	$ 99,969.12
Base Course Aggregate 3" deep	5706	SYD	303 - 04853	$ 21.00	$ 119,826.00
Driving Lane HMA 3" thick	1926	TON	402 - 07438	$ 64.00	$ 123,264.00
Milling, Asphalt Removal	1200	SYD	306 - 08039	$ 10.00	$ 12,000.00
Signs, reflective aluminum street	40	EACH	***10430 200 4900***	$ 129.95	$ 5,198.00
White Painted Lines, 4" for driving lanes	2427	LFT	***02760 300 0010***	$ 0.26	$ 631.02
White Painted Lines, 4" for parallel parking	1728	LFT	***02760 300 0010***	$ 0.26	$ 449.28
White Painted Lines, 8" for crossing	1548	LFT	***02760 300 0500***	$ 0.39	$ 603.72
Yellow Painted Lines, 4" for driving lanes	950	LFT	***02760 300 0010***	$ 0.26	$ 247.00
Thermoplastic Stop Bars, 24" White	100	LFT	808 - 01045	$ 5.00	$ 500.00
Multiuse Trail					
Common Excavation	250	CYD	203 - 0200	$ 33.00	$ 8,250.00
Rock Excavation	100	CYD	203 - 02010	$ 70.00	$ 7,000.00
Silt Fencing	2,305	LFT	205 - 06937	$ 2.00	$ 4,610.00
Base Compacted Crushed Stone	461	TON	303 - 04489	$ 33.00	$ 15,213.00
HMA Overlay	231	TON	402 - 07438	$ 64.00	$ 14,784.00
Signs, reflective aluminum street	40	EACH	***10430 200 4900***	$ 129.95	$ 5,198.00
White Painted Lines, 4" for multiuse trail	2305	LFT	***02760 300 0010***	$ 0.26	$ 599.30
Thermoplastic Stop Bars, 24" White	100	LFT	808 - 01045	$ 5.00	$ 500.00
Sidewalk					
4" Concrete Sidewalk	1,281	SYD	604 - 91531	$ 42.00	$ 53,802.00
Concrete Sidewalk Removal	128	SYD	202 - 52710	$ 17.00	$ 2,177.70
Concrete Curb & Gutter	2,427	LFT	605 - 06140	$ 19.00	$ 46,113.00
Concrete Curb Removal	500	LFT	202 - 02278	$ 8.00	$ 4,000.00
Signs, reflective aluminum street	45	EACH	***10430 200 4900***	$ 129.95	$ 5,847.75
Green Space					
Mulched Seeding, Legume	130	SYD	621 - 01660	$ 2.00	$ 260.00
Sod	130	SFT	621 - 06574	$ 9.00	$ 1,170.00
Trees (Ginkgo, 6'-7')	30	EACH	***02930 410 0900***	$ 226.50	$ 6,795.00
Construction Contingency @ 10%	1	LSUM		$ 122,912.49	$ 122,912.49
				Total Phase I:	**$ 1,352,037**

Table K.2: INDOT Unit Price Cost Estimate Phase 2
Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Reference	Unit Cost	Total Amount
Drainage					
B-Borrow for Structure Backfill	2400	CYD	203 - 02070	$ 23.00	$ 55,200.00
Reinforced Concrete Pipe, 12"	3794	LFT	715 - 05118	$ 47.00	$ 178,318.00
Reinforced Concrete Pipe, 15"	0	LFT	715 - 05119	$ 43.00	$ -
Reinforced Concrete Pipe, 18"	0	LFT	715 - 05120	$ 63.00	$ -
Reinforced Concrete Pipe, 24"	0	LFT	715 - 05123	$ 63.00	$ -
Concrete Pipe End Sections	2	EACH	715 - 01472	$ 811.00	$ 1,622.00
Inlet J-10	24	EACH	720 - 02367	$ 2,650.00	$ 63,600.00
Inlet Protection	24	EACH	205 - 06933	$ 120.00	$ 2,880.00
Aggregate for Underdrains	600	CYD	718 - 94889	$ 21.00	$ 12,600.00
Riprap, Revetment	125	TON	616 - 03472	$ 32.00	$ 4,000.00
Adjust Casting to Grade	25	EACH	720 - 01894	$ 785.00	$ 19,625.00
Rogers Street Pavement					
Common Excavation	4150	CYD	203 - 02000	$ 33.00	$ 136,950.00
Rock Excavation	250	CYD	203 - 02010	$ 70.00	$ 17,500.00
Borrow	400	CYD	203 - 02070	$ 23.00	$ 9,200.00
Sub-base Aggregate	14034	SYD	***02720 200 0390***	$ 5.84	$ 81,958.56
Base Course Aggregate 3" deep	4678	SYD	303 - 04853	$ 21.00	$ 98,238.00
Driving Lane HMA 3" thick	526	TON	402 - 07438	$ 64.00	$ 33,664.00
Milling, Asphalt Removal	950	SYD	306 - 08039	$ 10.00	$ 9,500.00
Signs, reflective aluminum street	35	EACH	***10430 200 4900***	$ 129.95	$ 4,548.25
White Painted Lines, 4" for driving lanes	1902	LFT	***02760 300 0010***	$ 0.26	$ 494.52
White Painted Lines, 4" for parallel parking	515	LFT	***02760 300 0010***	$ 0.26	$ 133.90
White Painted Lines, 8" for crossing	550	LFT	***02760 300 0500***	$ 0.39	$ 214.50
Yellow Painted Lines, 4" for driving lanes	634	LFT	***02760 300 0010***	$ 0.26	$ 164.84
Thermoplastic Stop Bars, 24" White	75	LFT	808 - 01045	$ 5.00	$ 375.00
Multiuse Trail					
Common Excavation	200	CYD	203 - 0200	$ 33.00	$ 6,600.00
Rock Excavation	50	CYD	203 - 02010	$ 70.00	$ 3,500.00
Silt Fencing	1,774	LFT	205 - 06937	$ 2.00	$ 3,548.00
Base Compacted Crushed Stone	355	TON	303 - 04489	$ 33.00	$ 11,715.00
HMA Overlay	30	TON	402 - 07438	$ 64.00	$ 1,920.00
Signs, reflective aluminum street	35	EACH	***10430 200 4900***	$ 129.95	$ 4,548.25
White Painted Lines, 4" for multiuse trail	1774	LFT	***02760 300 0010***	$ 0.26	$ 461.24
Thermoplastic Stop Bars, 24" White	35	LFT	808 - 01045	$ 5.00	$ 175.00
Sidewalk					
4" Concrete Sidewalk	986	SYD	604 - 91531	$ 42.00	$ 41,412.00
Concrete Sidewalk Removal	99	SYD	202 - 52710	$ 17.00	$ 1,676.20
Concrete Curb & Gutter	1,902	LFT	605 - 06140	$ 19.00	$ 36,138.00
Concrete Curb Removal	400	LFT	202 - 02278	$ 8.00	$ 3,200.00
Signs, reflective aluminum street	40	EACH	***10430 200 4900***	$ 129.95	$ 5,198.00
Green Space					
Mulched Seeding, Legume	120	SYD	621 - 01660	$ 2.00	$ 240.00
Sod	120	SFT	621 - 06574	$ 9.00	$ 1,080.00
Trees (Ginkgo, 6'-7')	25	EACH	***02930 410 0900***	$ 226.50	$ 5,662.50
Construction Contingency @ 10%	1	LSUM		$ 85,786.08	$ 85,786.08
				Total Phase II:	**$ 943,647**

Table K.3: INDOT Unit Price Cost Estimate Phase 3
Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Reference	Unit Cost	Total Amount
Drainage					
B-Borrow for Structure Backfill	2400	CYD	203 - 02070	$ 23.00	$ 55,200.00
Reinforced Concrete Pipe, 12"	2774	LFT	715 - 05118	$ 47.00	$ 130,378.00
Reinforced Concrete Pipe, 15"	665	LFT	715 - 05119	$ 43.00	$ 28,595.00
Reinforced Concrete Pipe, 18"	0	LFT	715 - 05120	$ 63.00	$ -
Reinforced Concrete Pipe, 24"	1438	LFT	715 - 05123	$ 63.00	$ 90,594.00
Concrete Pipe End Sections	4	EACH	715 - 01472	$ 811.00	$ 3,244.00
Inlet J-10	91	EACH	720 - 02367	$ 2,650.00	$ 241,150.00
Inlet Protection	91	EACH	205 - 06933	$ 120.00	$ 10,920.00
Aggregate for Underdrains	1250	CYD	718 - 94889	$ 21.00	$ 26,250.00
Riprap, Revetment	175	TON	616 - 03472	$ 32.00	$ 5,600.00
Adjust Casting to Grade	30	EACH	720 - 01894	$ 785.00	$ 23,550.00
Rogers Street Pavement					
Common Excavation	3200	CYD	203 - 02000	$ 33.00	$ 105,600.00
Rock Excavation	620	CYD	203 - 02010	$ 70.00	$ 43,400.00
Borrow	750	CYD	203 - 02070	$ 23.00	$ 17,250.00
Sub-base Aggregate	10765	SYD	***02720 200 0390***	$ 5.84	$ 62,867.60
Base Course Aggregate 3" deep	3588.333	SYD	303 - 04853	$ 21.00	$ 75,355.00
Driving Lane HMA 3" thick	404	TON	402 - 07438	$ 64.00	$ 25,856.00
Milling, Asphalt Removal	1500	SYD	306 - 08039	$ 10.00	$ 15,000.00
Signs, reflective aluminum street	50	EACH	***10430 200 4900***	$ 129.95	$ 6,497.50
White Painted Lines, 4" for driving lanes	2775	LFT	***02760 300 0010***	$ 0.26	$ 721.50
White Painted Lines, 4" for parallel parking	240	LFT	***02760 300 0010***	$ 0.26	$ 62.40
White Painted Lines, 8" for crossing	1350	LFT	***02760 300 0500***	$ 0.39	$ 526.50
Yellow Painted Lines, 4" for driving lanes	1000	LFT	***02760 300 0010***	$ 0.26	$ 260.00
Thermoplastic Stop Bars, 24" White	120	LFT	808 - 01045	$ 5.00	$ 600.00
Multiuse Trail					
Common Excavation	350	CYD	203 - 0200	$ 33.00	$ 11,550.00
Rock Excavation	32	CYD	203 - 02010	$ 70.00	$ 2,240.00
Silt Fencing	2,577	LFT	205 - 06937	$ 2.00	$ 5,154.00
Base Compacted Crushed Stone	515	TON	303 - 04489	$ 33.00	$ 16,995.00
HMA Overlay	43	TON	402 - 07438	$ 64.00	$ 2,752.00
Signs, reflective aluminum street	50	EACH	***10430 200 4900***	$ 129.95	$ 6,497.50
White Painted Lines, 4" for multiuse trail	2577	LFT	***02760 300 0010***	$ 0.26	$ 670.02
Thermoplastic Stop Bars, 24" White	120	LFT	808 - 01045	$ 5.00	$ 600.00
Sidewalk					
4" Concrete Sidewalk	1,432	SYD	604 - 91531	$ 42.00	$ 60,144.00
Concrete Sidewalk Removal	143	SYD	202 - 52710	$ 17.00	$ 2,434.40
Concrete Curb & Gutter	2,775	LFT	605 - 06140	$ 19.00	$ 52,725.00
Concrete Curb Removal	750	LFT	202 - 02278	$ 8.00	$ 6,000.00
Signs, reflective aluminum street	50	EACH	***10430 200 4900***	$ 129.95	$ 6,497.50
Green Space					
Mulched Seeding, Legume	120	SYD	621 - 01660	$ 2.00	$ 240.00
Sod	120	SFT	621 - 06574	$ 9.00	$ 1,080.00
Trees (Ginkgo, 6'-7')	30	EACH	***02930 410 0900***	$ 226.50	$ 6,795.00
Construction Contingency @ 10%	1	LSUM		$ 115,185.19	$ 115,185.19
				Subtotal:	**$ 1,267,037**

Table K.4: INDOT Unit Price Cost Estimate Phase 4
Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Reference	Unit Cost	Total Amount
Drainage					
B-Borrow for Structure Backfill	2400	CYD	203 - 02070	$ 23.00	$ 55,200.00
Reinforced Concrete Pipe, 12"	656	LFT	715 - 05118	$ 47.00	$ 30,832.00
Reinforced Concrete Pipe, 15"	0	LFT	715 - 05119	$ 43.00	$ -
Reinforced Concrete Pipe, 18"	3642	LFT	715 - 05120	$ 63.00	$ 229,446.00
Reinforced Concrete Pipe, 24"	1322	LFT	715 - 05123	$ 63.00	$ 83,286.00
Concrete Pipe End Sections	4	EACH	715 - 01472	$ 811.00	$ 3,244.00
Inlet J-10	96	EACH	720 - 02367	$ 2,650.00	$ 254,400.00
Inlet Protection	96	EACH	205 - 06933	$ 120.00	$ 11,520.00
Aggregate for Underdrains	750	CYD	718 - 94889	$ 21.00	$ 15,750.00
Riprap, Revetment	125	TON	616 - 03472	$ 32.00	$ 4,000.00
Adjust Casting to Grade	25	EACH	720 - 01894	$ 785.00	$ 19,625.00
Rogers Street Pavement					
Common Excavation	4200	CYD	203 - 02000	$ 33.00	$ 138,600.00
Rock Excavation	500	CYD	203 - 02010	$ 70.00	$ 35,000.00
Borrow	420	CYD	203 - 02070	$ 23.00	$ 9,660.00
Sub-base Aggregate	14460	SYD	***02720 200 0390***	$ 5.84	$ 84,446.40
Base Coarse Aggregate 3" deep	4820	SYD	303 - 04853	$ 21.00	$ 101,220.00
Driving Lane HMA 3" thick	542	TON	402 - 07438	$ 64.00	$ 34,688.00
Milling, Asphalt Removal	1500	SYD	306 - 08039	$ 10.00	$ 15,000.00
Signs, reflective aluminum street	50	EACH	***10430 200 4900***	$ 129.95	$ 6,497.50
White Painted Lines, 4" for driving lanes	2810	LFT	***02760 300 0010***	$ 0.26	$ 730.60
White Painted Lines, 4" for parallel parking	0	LFT	***02760 300 0010***	$ 0.26	$ -
White Painted Lines, 8" for crossing	1000	LFT	***02760 300 0500***	$ 0.39	$ 390.00
Yellow Painted Lines, 4" for driving lanes	1000	LFT	***02760 300 0010***	$ 0.26	$ 260.00
Thermoplastic Stop Bars, 24" White	120	LFT	808 - 01045	$ 5.00	$ 600.00
Multiuse Trail					
Common Excavation	400	CYD	203 - 0200	$ 33.00	$ 13,200.00
Rock Excavation	25	CYD	203 - 02010	$ 70.00	$ 1,750.00
Silt Fencing	2,810	LFT	205 - 06937	$ 2.00	$ 5,620.00
Base Compacted Crushed Stone	562	TON	303 - 04489	$ 33.00	$ 18,546.00
HMA Overlay	47	TON	402 - 07438	$ 64.00	$ 3,008.00
Signs, reflective aluminum street	45	EACH	***10430 200 4900***	$ 129.95	$ 5,847.75
White Painted Lines, 4" for multiuse trail	2810	LFT	***02760 300 0010***	$ 0.26	$ 730.60
Thermoplastic Stop Bars, 24" White	45	LFT	808 - 01045	$ 5.00	$ 225.00
Sidewalk					
4" Concrete Sidewalk	5,760	SYD	604 - 91531	$ 42.00	$ 241,920.00
Concrete Sidewalk Removal	576	SYD	202 - 52710	$ 17.00	$ 9,792.00
Concrete Curb & Gutter	2,810	LFT	605 - 06140	$ 19.00	$ 53,390.00
Concrete Curb Removal	500	LFT	202 - 02278	$ 8.00	$ 4,000.00
Signs, reflective aluminum street	45	EACH	***10430 200 4900***	$ 129.95	$ 5,847.75
Green Space					
Mulched Seeding, Legume	120	SYD	621 - 01660	$ 2.00	$ 240.00
Sod	120	SFT	621 - 06574	$ 9.00	$ 1,080.00
Trees (Ginkgo, 6'-7')	30	EACH	***02930 410 0900***	$ 226.50	$ 6,795.00
Construction Contingency @ 10%	1	LSUM		$ 150,638.76	$ 150,638.76
				Total Phase IV:	**$ 1,657,026**

Table K.5: INDOT Unit Price Cost Estimate Phase 5
Rogers Street Road Reconstruction- Planning Stage

Item Description	Quantity	Unit	Reference	Unit Cost	Total Amount
Drainage					
B-Borrow for Structure Backfill	2400	CYD	203 - 02070	$ 23.00	$ 55,200.00
Reinforced Concrete Pipe, 12"	6404	LFT	715 - 05118	$ 47.00	$ 300,988.00
Reinforced Concrete Pipe, 15"	0	LFT	715 - 05119	$ 43.00	$ -
Reinforced Concrete Pipe, 18"	0	LFT	715 - 05120	$ 63.00	$ -
Reinforced Concrete Pipe, 24"	0	LFT	715 - 05123	$ 63.00	$ -
Concrete Pipe End Sections	6	EACH	715 - 01472	$ 811.00	$ 4,866.00
Inlet J-10	53	EACH	720 - 02367	$ 2,650.00	$ 140,450.00
Inlet Protection	53	EACH	205 - 06933	$ 120.00	$ 6,360.00
Aggregate for Underdrains	1100	CYD	718 - 94889	$ 21.00	$ 23,100.00
Riprap, Revetment	175	TON	616 - 03472	$ 32.00	$ 5,600.00
Adjust Casting to Grade	30	EACH	720 - 01894	$ 785.00	$ 23,550.00
Rogers Street Pavement					
Common Excavation	3500	CYD	203 - 02000	$ 33.00	$ 115,500.00
Rock Excavation	1200	CYD	203 - 02010	$ 70.00	$ 84,000.00
Borrow	350	CYD	203 - 02070	$ 23.00	$ 8,050.00
Sub-base Aggregate	12040	SYD	***02720 200 0390***	$ 5.84	$ 70,313.60
Base Course Aggregate 3" deep	4013.333	SYD	303 - 04853	$ 21.00	$ 84,280.00
Driving Lane HMA 3" thick	452	TON	402 - 07438	$ 64.00	$ 28,928.00
Milling, Asphalt Removal	1500	SYD	306 - 08039	$ 10.00	$ 15,000.00
Signs, reflective aluminum street	65	EACH	***10430 200 4900***	$ 129.95	$ 8,446.75
White Painted Lines, 4" for driving lanes	3668	LFT	***02760 300 0010***	$ 0.26	$ 953.68
White Painted Lines, 4" for parallel parking	0	LFT	***02760 300 0010***	$ 0.26	$ -
White Painted Lines, 8" for crossing	1200	LFT	***02760 300 0500***	$ 0.39	$ 468.00
Yellow Painted Lines, 4" for driving lanes	1250	LFT	***02760 300 0010***	$ 0.26	$ 325.00
Thermoplastic Stop Bars, 24" White	125	LFT	808 - 01045	$ 5.00	$ 625.00
Multiuse Trail					
Common Excavation	500	CYD	203 - 0200	$ 33.00	$ 16,500.00
Rock Excavation	50	CYD	203 - 02010	$ 70.00	$ 3,500.00
Silt Fencing	3,650	LFT	205 - 06937	$ 2.00	$ 7,300.00
Base Compacted Crushed Stone	730	TON	303 - 04489	$ 33.00	$ 24,090.00
HMA Overlay	61	TON	402 - 07438	$ 64.00	$ 3,904.00
Signs, reflective aluminum street	50	EACH	***10430 200 4900***	$ 129.95	$ 6,497.50
White Painted Lines, 4" for multiuse trail	3650	LFT	***02760 300 0010***	$ 0.26	$ 949.00
Thermoplastic Stop Bars, 24" White	50	LFT	808 - 01045	$ 5.00	$ 250.00
Sidewalk					
4" Concrete Sidewalk	1,197	SYD	604 - 91531	$ 42.00	$ 50,274.00
Concrete Sidewalk Removal	120	SYD	202 - 52710	$ 17.00	$ 2,034.90
Concrete Curb & Gutter	3,668	LFT	605 - 06140	$ 19.00	$ 69,692.00
Concrete Curb Removal	500	LFT	202 - 02278	$ 8.00	$ 4,000.00
Signs, reflective aluminum street	55	EACH	***10430 200 4900***	$ 129.95	$ 7,147.25
Green Space					
Mulched Seeding, Legume	150	SYD	621 - 01660	$ 2.00	$ 300.00
Sod	150	SFT	621 - 06574	$ 9.00	$ 1,350.00
Trees (Ginkgo, 6'-7')	40	EACH	***02930 410 0900***	$ 226.50	$ 9,060.00
Construction Contingency @ 10%	1	LSUM		$ 118,385.27	$ 118,385.27
				Total Phase V:	**$ 1,302,238**