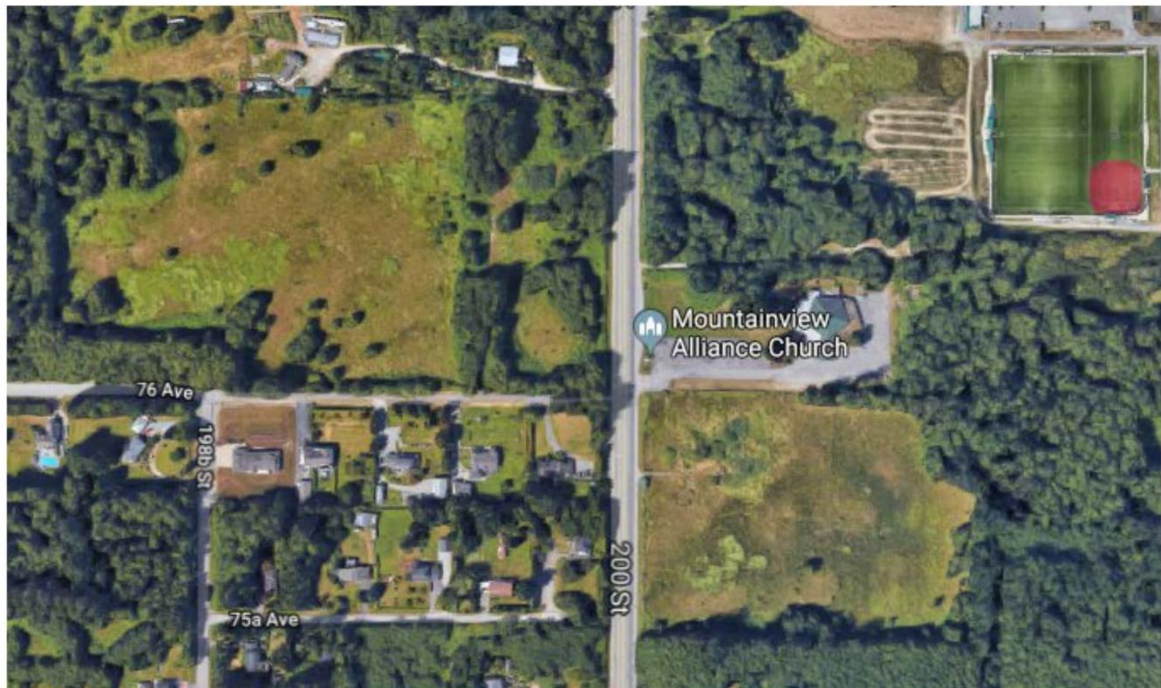# DESIGN OF ROADWAY , INTERSECTION, AND STORM SEWERS FOR 76 AVENUE, 200th STREET TO 20100 BLOCK, LANGLEY

(Google Maps, 2018)

200th Street and 76 Avenue in Langley

Prepared for:

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Submitted on:

April 15, 2019

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The title of this document is longer than most and there are more people mentioned than is common, but this title page provides the four required bits of information: title, name of the author (or authoring organization), name of recipient (or receiving organization), and date (or time span covered)

Disclaimers and legal pages are not uncommon. These are generally written by lawyers or provided by the employer. Writers tend to insert them as boiler plate (ready-made text that is inserted repeatedly into different reports). In some cases disclaimers are part of the corporate template.

DISCLAIMER

The work represented in this client report is the result of a student project at the British Columbia Institute of Technology. Any analysis or solution presented in this report must be reviewed by a professional engineer before implementation. While the student's performance in the completion of this report may have been reviewed by a faculty advisor, such review and any advice obtained therefrom does not constitute professional certification of the work. This report is made available without any representation as to its use in any particular situation and on the strict understanding that each reader accepts full liability for the application of its contents.

Note that the pagination of the orientation (or navigation) section is in lower-case Roman numerals because it is not part of the report. The report really starts after the Table of Contents or List of Tables and Figures (if included).

ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their help and time:

- Richard Welfing for providing me with this project and always answering my questions
- Poureya Bazargani for reviewing my drawing set
- Deanna Levis for answering my questions about my report

The acknowledgements could have been put on the same page as the Disclaimer.

SUMMARY

This project included designing a segment of 76th Avenue and the intersection with 200th Street, as well as the storm sewer for 76th Avenue. I designed the segment of 76th Avenue from 200th Street to the 20100 block. 76th Avenue will continue to intersect with 202A Street, but that portion is not included in the scope of this project. This project was provided by my industry sponsor, Richard Welfing, PEng, MBA, Manager of Engineering Services, for the Township of Langley.

I began my project by researching the bylaws and guidelines that I needed to follow to complete the design. I also did some reading about Civil3D since I used that to create my design and I had limited experience with it.

After completing the research portion of my project, I designed the road. The horizontal alignment of the road was already determined as the right of way was included in the survey provided by my sponsor. For the profile of the road, I followed the guidelines in the Transportation Association of Canada *Geometric Design Guide for Canadian Roads, 2017.* I designed the cross section for 76th Avenue by modifying one of the cross sections supplied in the *Subdivision and Development Servicing Bylaw 2011 (No. 4861)* from the Township of Langley. By combining these elements with the existing ground surface, I was able to generate a corridor for 76th Avenue.

For the intersection design, I referred to a similar intersection in the area. I used the curb returns to create the turning lanes and then to draw the centre island. The island is included to allow only right in and out turns and discourage other turning movements.

To design the storm sewer, I followed the methods outlined in the *Subdivision and Development Servicing Bylaw 2011 (No. 4861)* from the Township of Langley. I used the Rational Method to determine the maximum flow that the storm sewer would need to handle, and sized it accordingly. I determined the invert elevations of the storm sewer from the connection to an existing culvert. The existing culvert approximately 100 metres east of 200th Street.

To show my completed design, I put together a full set of design drawings for this project.

The summary is a complete, but highly condensed second version of the report, focusing on the key information: the purpose of the report, your methodology, the conclusions, and the recommendation.

Note that the summary could also have been placed after the List of Tables and Figures, just before the Introduction. In that case, it would have had page number 1.

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    Appendix D: Survey of Project Site

    Appendix E: Storm Sewer Design-Rational Method Calculations

MS Word will generate the table of contents, as long as you have applied heading styles (from the Styles Section on the Home Ribbon) to your various levels of headings.

Figure 7.4 (in Chapter 7) illustrates how to generate a Table of Contents in Word. Other word processing software offer the same function.

Because the appendices are tabbed, they don't require page numbers. In fact, because you may be inserting pages that have their own page numbers (like copies of manuals or specifications) we don't paginate the appendices at all.

It's a flaw in Word, however, that the page numbers will always appear in the ToC, even if you don't put them in the header.

LIST OF GRAPHICS

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Like the Table of Contents, MS Word will generate the lists of figures and tables for you, as long as you have applied the caption style (from the Styles Section on the Home Ribbon) to the figure and table captions.

Figure 7.4 (in Chapter 7) illustrates how to generate these lists in Word. Other word processing software offer the same function.

1.0 INTRODUCTION

I was assigned to design a segment of 76th Avenue, an intersection between 76th Avenue and 200th Street, and the storm sewers for 76th Avenue. As my sponsor, Richard Welfing, PEng, MBA, Manager of Engineering Services, from Township of Langley provided me with this project. My solution will be an original design, but the Township of Langley will complete the design for this project.

1.1 Background

Figure 1 shows an aerial view of the site, before any construction has taken place. The new segment of 76th Avenue intersects with the existing 200th Street. It goes along the edge of the parking lot for Mountain Alliance Church and will intersect with 202A Street in a later design completed by others. The new intersection will be where the entrance to the church is now. In the design, the entrance to the church parking lot is provided on 76th Avenue.

(Google Maps, 2019)
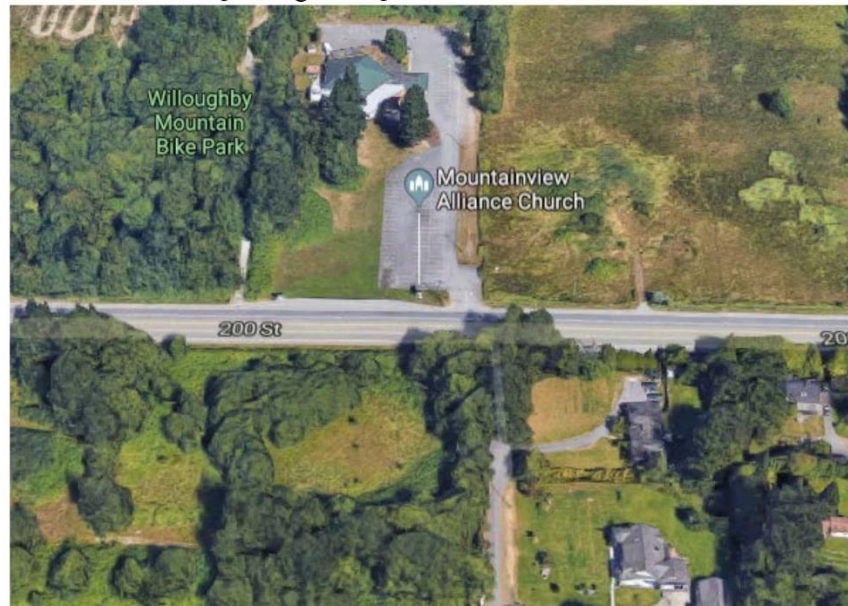
Figure 1: Aerial View of Project Site

The site has mostly flat terrain, without many restricting qualities. There is an environmentally sensitive waterway running along the south side of the site that has been taken into consideration in the roadway placement. The site is located in Langley, as shown in Appendix A.

76th Avenue and this intersection are being added to allow for better access to Mountainview Alliance Church and to reduce congestion on 200th Street. The final design will also allow for traffic between 200th Street and 202A Street.

1.2 Objectives

The objectives for my project as outlined by my sponsor are to

- design 76th Avenue from 200th Street to the 20100 block and present the design on plan and profile drawings
- create detailed cross sections at 20-metre intervals
- show the design of the intersection and storm sewer on appropriate drawings
- write a final report summarizing the design criteria and how I approached the design process.

This report includes the findings of the readings I completed and my approach for designing the road, intersection, and storm sewers.

2.0 RESEARCH

To design the road, intersection, and storm sewers, I read and summarized the applicable bylaws outlined by the Township of Langley. I also read about and reviewed the Civil3D features that would be helpful for creating the design.

2.1 Township of Langley Bylaws

I started my project by reading and summarizing the applicable bylaws in the *Township of Langley Subdivision and Development Servicing Bylaw 2011 (No. 4861)* so I knew what guidelines I would need to be aware of while creating my design. A summary of these bylaws are included in Appendix B.

Since many of the bylaws refer to following guidelines outlined in the *Transportation Association of Canada's Geometric Design Guide for Canadian Roads*, I also read the applicable sections of this manual.

2.2 Civil3D

To learn more about Civil3D, I read articles on the Autodesk website and reviewed my CIVL 3050 course notes. I learned that although creating a corridor is necessary for finding design data, it doesn't need to be shown on design drawings. For this reason, I created a corridor to complete my design, but it is not shown in my drawing set.

Note that every heading has some text beneath it. You cannot follow a heading with a subheading. In this case, the introduction to this section describes the organization of the section, that is, it introduces the subsections.

3.0 ROAD AND INTERSCTION DESIGN

From CIVL 3050, I knew the basic steps to follow for designing the roadway. First, determine the horizontal and vertical alignment, design the typical cross section, and then combine them with the existing ground surface to make a corridor surface for the design road. For the intersection design, I followed the guidelines and referenced a similar intersection provided by my sponsor. The final road and intersection designs are shown on drawing 1953-04 in the drawing set provided in Appendix C.

Note that every appendix has been introduced precisely where the reader would most benefit from looking at it. Note that they have also been introduced in alphabetic order (the way the figures are referred to in numeric order)

3.1 Horizontal Design

Indenting can be an effective way to indicate subsections, but you should only indent one level of subheading. You don't want too many margins or a text column that gets increasingly skinny.

In the survey drawing from my sponsor (see Appendix D), the right of way for the road design was already defined. This meant that the alignment was best as a straight line through the centre of the right of way.

Since the location of the road was already defined, I assumed that the sensitive waterways adjacent to the site would not be negatively affected as long as the road stayed within the defined right of way.

3.2 Vertical Design

To design the vertical profile, I created a profile view of the existing ground surface along the centerline alignment of 76th Avenue. I tried to keep the design profile as close to the existing surface as possible to reduce the amount of earthworks required.

For the vertical curve design, I made sure that the curve lengths met the requirements of Table 3.3.2 and Table 3.3.4 from the Transportation Association of Canada's (TAC) *Geometric Design Guide for Canadian Roads*. Since street lighting is not included in my scope of my project, I used the values for when there are no headlights. This way, even if street lighting is installed on 76th Avenue, this will be a conservative and more comfortable design.

To use an acronym, you first need to define it, unless you are sure that all your readers will recognize it without having it defined.

After designing the storm sewer, I realized that the road profile I originally designed did not provide the minimum cover. For this reason, I changed the road profile to provide the minimum cover and still follow the TAC guidelines. The curve lengths and data are shown in the profile view on drawing 1953-03 in Appendix C.

3.3 Cross Section Design

To design the cross section of the roadway, I needed the road classification. 76th Avenue is classified as a Major Collector Residential on the Master Transportation Plan (Township of Langley, 2009). For this road classification, there is a typical cross section drawing in the *Subdivision and Development Servicing Bylaw (No. 4861)* from the Township of Langley, which is shown in Figure 2.

Figures must be introduced in the preceding text.
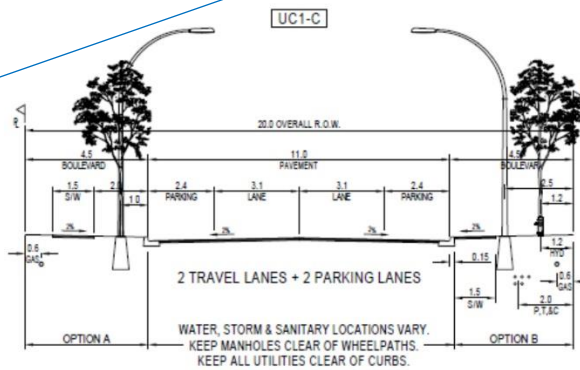
If you did not create the graphic yourself, you have to provide a source citation.

(Township of Langley, 2011)

Figure 2: Major Urban Residential Collector Cross Section

The cross section shown above has a 20-metre right of way. Since the right of way defined for 76th Avenue was only 10 metres across, I made a modified cross section (Figure 3) to use in the 10-metre right of way.
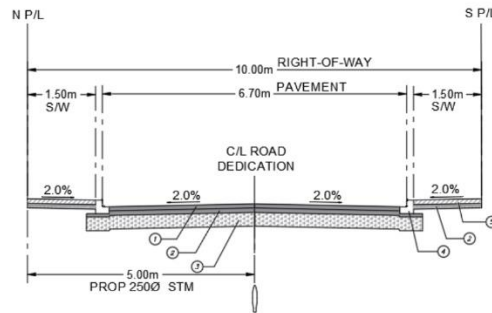
(Van Vliet, 2019)

Figure 3: Modified Cross Section for 76 Avenue

It can be awkward if the graphic already includes a title, but the figure still requires a figure title (caption) for consistency and so that it will show up in the List of Figures.

This modified cross section includes a 3.35-metre lane, a typical Type B curb, and a 1.5-metre sidewalk on each side of the centreline of the road. I did not include any space for streetlighting since streetlighting was not within the scope of my project.

I included a sidewalk on both sides of 76th Avenue because it is classified as a residential road. The sidewalk on the north side of the road extends around the curb return and could continue along 200th Street to the nearby bus stop. The sidewalk on the south side of the road ends at the beginning of the curb return since there is no sidewalk on 200th for it to connect to, and there is not a lot of pedestrian traffic along 200th Street, if any. I still decided to include the sidewalk on the south side of the road because it is classified as a residential street and the adjacent properties may be developed in future.

The typical cross section for 76th Avenue includes pavement and base thicknesses. Since I was not provided with any geotechnical data for the site, I assumed that the minimum values outlined in the *Subdivision and Development Servicing Bylaw (No. 4861)* could be used. These values are shown in Table 1.

Tables are treated like figures. They are introduced in the preceding text, numbered sequentially (and separately from figures), and require a table title (caption). Table titles go above the table so they are closer to the column headers. This makes it quicker for readers to comprehend the purpose and layout of the table.

Note that the table was inserted as a figure from another document, but it is still a table, so it was introduced as such. See the table on page 7, created by the author, for comparison.

If you didn't create the table, provide a source. If you created the table with someone else's information, provide a data source, for e.g., "Data source: Township of Langley, 2011"

Table 1: Pavement and Bases Thicknesses for 76 Avenue

Classification	Min Sub-base mm	Min Base mm	Min Asphalt mm		Max Seasonally Adjusted Design Deflection (mm)	
			Base	Surface	Base	Pavement
All Arterial & Industrial Collector	300	100	85	40	1.75	1.00
Other Collector	300	100	50	40	2.20	1.20
Urban Local	200	100	50	35	2.60	1.50
Industrial Local	300	100	50	35	1.75	1.00
Lane	200	100	50	35	3.10	1.50
Rural Local	200	100	75	-	3.40	1.50
Emergency Access	200	100	65		3.1	1.5

(Township of Langley, 2011)

I used the values for 'Other Collector' in Table 1 because 76th Avenue is classified as a collector road, but is not an industrial road. This is shown in Appendix C on Drawing 1953-04.

Using the corridor that I created in Civil3D, I generated cross sections at 20-metre intervals along 76th Avenue. These cross sections are shown on drawings 1953-07 and 1953-08 in Appendix C.
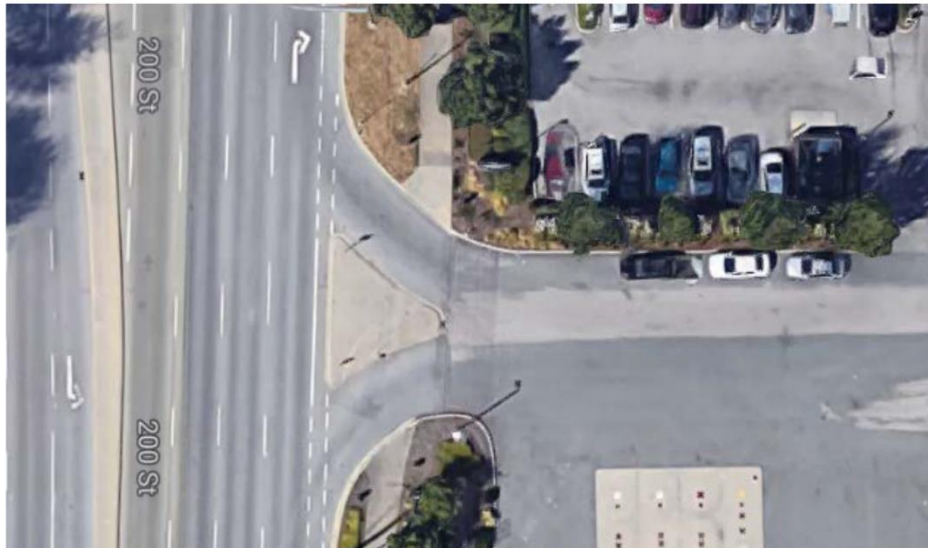
3.4 Intersection Design

The intersection that I designed for 76th Avenue and 200th Street is a T-intersection that only allows right turns in and out. This type of intersection was used to minimize traffic congestion on 200th Street and make it easier to turn onto 200th Street. There is an island in the middle to discourage any other turning movements. As a reference for my intersection design, my sponsor referred me to an intersection north of 86th Avenue on 200th Street, shown in Figure 4.

(Google Maps, 2019)

Figure 4: T-intersection along 200th Street north of 86th Avenue

The intersection shown above has the same features as the intersection I designed for 76th Avenue and 200th Street but has a much larger island than the one that I designed because there is more space available here.

To design the intersection, I used a curb return radius that was larger than the minimum curb return. These values and curb return details are shown on Drawing 1953-04 in Appendix C. Using these larger curb return values makes these corners easier to turn but will require some additional property acquisition. This is noted on Drawing 1953-03 in Appendix C.

To design the island, I offset the curb returns by the lane width and some extra space for a small shoulder between the island and the lane. The edge of the island parallel to 200th Street lines up with the outside edge of the shoulder, following the example shown in Figure 4.

To determine the elevations in the intersection, particularly along the curb returns, I created an alignment along each curb return so that I could create a profile of the existing ground. Matching each end of the curb to the design elevation on 76th Avenue or the existing elevation on 200th Street, I created a smooth curve between the points, using the slopes of the roads at each end to determine the direction of the curve. The elevation details of the curb returns are shown on drawing 1953-04 in Appendix C.

4.0 STORM SEWER DESIGN

The storm sewer design included sizing the storm sewer based on the maximum flow, the horizontal and vertical placement of the storm sewer, and determining the locations of the catch basins.

4.1 Calculations

I followed the process outlined in the *Subdivision and Development Servicing Bylaw 2011 (No. 4861)* by the Township of Langley. Since the catchment area for this storm sewer is less than 10 hectares, I used the Rational Method. The formula I used to calculate the maximum flow is shown below.

$$Q=RAIN$$

A description of each variable, the value I used, and the reference for the values in this formula are shown in Table 2.

Table 2: Variables used to calculate the maximum flow

Variable	Description	Value	Reference*
R	Runoff Coefficient * Soil Adjustment Factor	0.7*1.0	Page 19
A	Drainage Area in Ha	Varies	-
I	Rainfall intensity in mm/h	33	Page 22
N	Conversion Factor	0.00278	Page 16

*   All references in Table 2 are taken from Schedule B of the *Subdivision and Development Servicing Bylaw 2011 (No. 4861)*

This is an alternative way to cite the source of data, in a footnote.

The drainage area is shown as varying in Table 2 because it is different for each segment of the storm sewer. To determine the catchment area of each segment, I downloaded a 1-metre contour map from the Township of Langley website and found the area surrounding my project to determine the general direction of the water flow.

The contour map showed that the water on the south side of 76th Avenue flows towards the ditches along 200th Street or the streams along the south side of the road. The streams flow into the existing culvert that flows from the south side to the north side of 76 Avenue. The areas that I used for my calculations are shown in Figure 5.

(Google Maps, 2019)

Figure 5: Catchment Areas used for Sizing the Storm Sewer

As seen in Figure 5, for the west side of the existing culvert, the catchment area includes the intersection and a portion of the road. For the east side of the culvert, I included the roadway area as well as the area that will be the continuation of 76th Avenue to 202A Street.

Once I determined the maximum flow for each segment of the storm sewer, I created a spreadsheet following the one outlined in the bylaws to show the calculations for the required storm sewer sizes. This spreadsheet is shown in Appendix E. The variables used in the spreadsheet are shown in Table 3.

Table 3: Variables for Storm Sewer Calculations

Variable	Description	Reference*
T_i	Inlet or overland flow time	Page 19
T_t	Travel time in sewers, ditches, channels or watercourses	Page 20
T_c	Time of Concentration	Page 19
Q_{cap}	Capacity flow of minimum storm sewer	-
$\emptyset$ min	Minimum storm sewer diameter	-
n	Roughness Coefficient	Page 35
s	Slope of pipe	Page 35
v	Velocity	Page 35
l	Length of pipe	-

* All references in Table 3 are taken from Schedule B in the Subdivision and Development Servicing Bylaw 2011 (No. 4861)

The values used for the variables in Table 3 vary for each pipe segment. To ensure that the velocity in the storm sewer would meet the minimum requirement of 0.75 m/s I used slopes of 1% for each segment of the pipe.

4.2 Storm Sewer Placement

For the horizontal design of the storm sewer, I followed the *Township of Langley's Subdivision and Development Servicing Bylaw 2011 (No. 4861)* summarized in Appendix B. The bylaws require that the storm sewer be placed in straight runs and be kept out of vehicle wheel paths where possible. The best way to meet these requirements in this case is to place the storm sewer along the centreline of 76th Avenue.

To find the invert elevations of the storm sewer, I started by considering the connection. The storm sewer connects to an existing culvert approximately 100 metres east of 200th Street. Using the invert elevation of this culvert, I started each segment of pipe at the same invert elevation and then drew the storm sewer on the profile view of the centreline along 76th Avenue. The invert elevations are shown in Table 4.

Table 4: Invert Elevations for Storm Sewer

Manhole & Invert	Elevation (m)
D1 W	73.82
D2 W	73.06
D2 E	73.06
D3 W	74.33

Once I had drawn the storm sewer using the inverts shown in Table 4, I realized that the road profile that I had originally drawn did not meet the minimum cover requirements. Since the existing culvert cannot be moved, I had to change the profile of the road to meet these requirements.

To make the design of the road profile easier and to use less material for the storm sewer, I do not extend the storm sewer to the intersection of 200th Street and 76th Avenue. Instead, I determined the end of the storm sewer by considering the places along 76th Avenue where there would need to be catch basins, which in this case was the low point in the road profile and started the storm sewer start at that point.

4.3 Catch Basin Locations

According to Township of Langley's *Subdivision and Development and Servicing Bylaw (No. 4861)*, for a road of less than 5% slope, a catch basin can service an area of up to 500 square metres. I first placed catch basins at the low points along the road and at the upstream side of the curb returns on the driveway into the church parking lot. Once I had those placed, I calculated the area that each of those catch basins would serve. For any catch basin area that was over 500 square metres, I added another catch basin along the road so that each one would only serve an area of 500 square metres or less.

I determined the catch basin locations based on the north side of the road since the curb returns for the driveway for the church parking lot affected the catch basin locations. Then I kept the south side of the road locations the same as the north side to create a symmetrical design. The final design had four catch basins on each side of the road. The locations of the catch basins with rim elevations are shown on drawing 1953-05 in Appendix C.

5.0 CONCLUSION

This project included designing a segment of 76th Avenue in Langley that intersects with 200th Street and the storm sewer for 76th Avenue. Before starting the design, I researched the *Subdivision and Development Servicing Bylaw (No. 4861)* that I needed to follow as well as the guidelines from the Transportation Association of Canada. Then, I designed the road and intersection following the bylaws and guidelines. I also designed the storm sewer for 76th Avenue, connecting it to an existing culvert approximately 100 metres east of 200th Street. To show my final design, I created a drawing set.

REFERENCES

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Google. (n.d.) [Catchment Areas used for Sizing the Storm Sewer]. Retrieved on April 10, 2019 from https://www.google.com/maps/@49.1410327,-122.665231,417m/data=!3m1!1e3

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Township of Langley. (2011) *Subdivision and Development Servicing Bylaw 2011 No. 4861* [PDF].

Transportation Association of Canada. (2017). *Geometric Design Guide for Canadian Roads*.

MS Word has a citation function (on the References Ribbon) that will keep track of your sources and generate in-text citations and the References section. See Chapter 9 of the textbook on how to do so.

Appendix A: Site Location

(Google Maps, 2018)
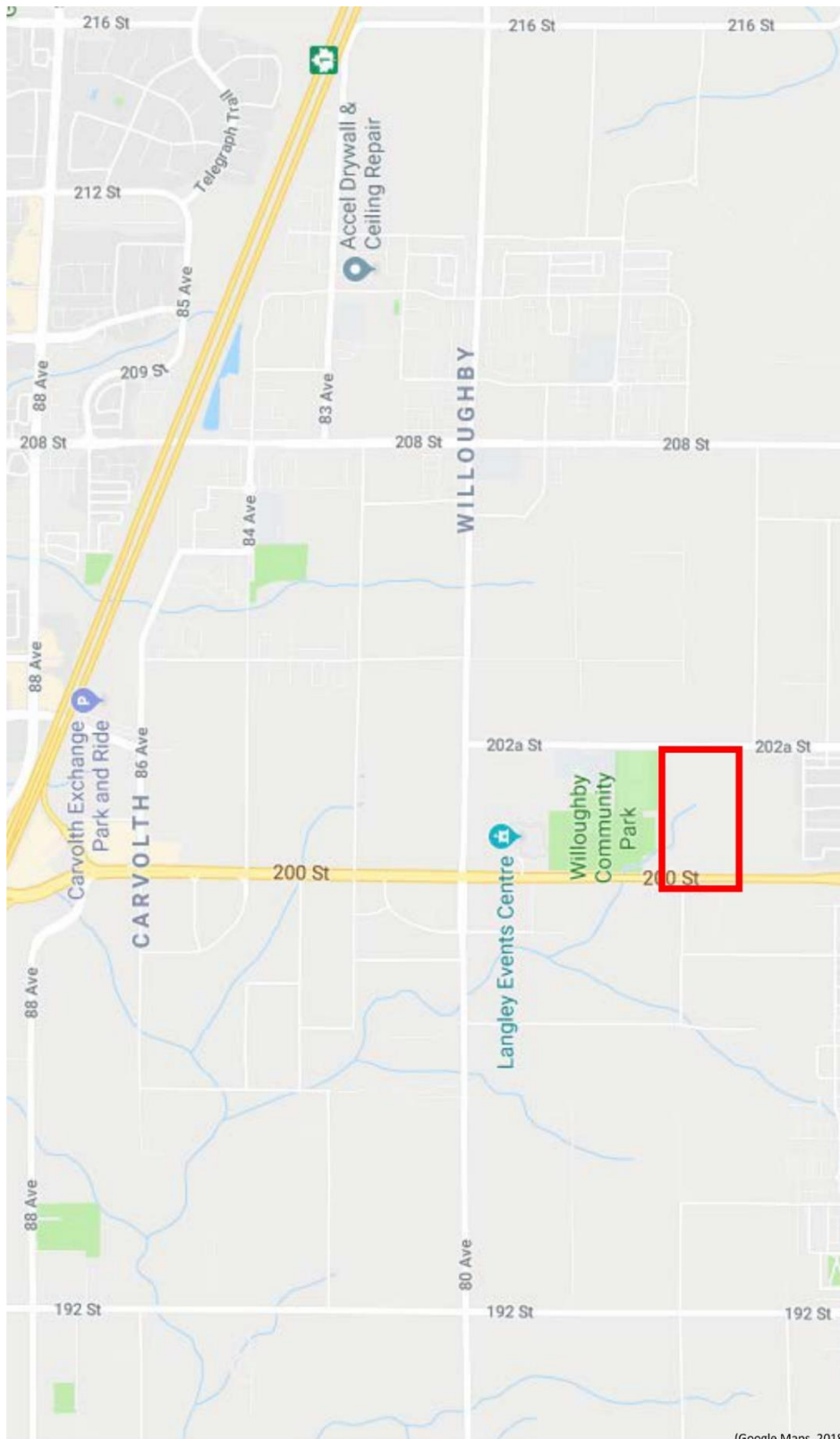
Because this appendix is only one page long, the title and the content can be on the same page. But if the appendix breaks across the page (is more than one page long), you need a title page instead of just a title.

Appendix B: Summary of Township of Langley's Subdivision and Development Servicing Bylaws 2011 (No. 4861)

Section D-Drainage

- Minor systems are to be designed to a 1 in 5 year storm
- The Rational Method can be used to calculate the maximum flow since the catchment area is less than 10 hectares
- Use Manning's equation to size the storm sewer pipes
- Minimum cover for the storm sewer is 1 meter, as long as the storm sewer is smaller than 600 millimeters
- The storm sewer should be installed in straight runs under the pavement, at least 1 meter away from the curb
- The minimum velocity for the storm sewer is 0.75 m/s
- Manholes should be placed at changes in grade, direction, or pipe size
- Manholes should be set off from the vehicular wheel path when possible
- Catch basins should be provided at regular intervals, at low points, and the upstream end of curb returns
- Each catch basin can service an area of 500 square meters of the slope of the road is less than 5%, or 350 square meters if the slope of the road is greater than 5%
- Catch basin leads should be a minimum of 200 millimeters for single catch basins
- Catch basin leads should be perpendicular to the storm sewer and road centerline

Section R-Roads

- Roads should be provided in accordance with the Road Classification and Right-of-Way and Cross Section Maps adopted by Council
- Minimum longitudinal grade is 0.5%
- Maximum longitudinal grade is 8%
- Cross sections should have a 2% cross slope with the crown at the center of the pavement
- The cross slope may be reduced to 0.5% in intersections
- The minimum allowable side slope is 1.5 horizontal to 1 vertical
- The design speed of 76 Avenue is 50 to 60 km/h since it is a collector road
- There should be a 20-meter tangent between horizontal curves and intersections
- Intersections should be at right angles, with an allowable variance of 15 degrees
- Min depths for each pavement and base (treated as other collector)
- Signage and Pavement markings should be in accordance with the Transportation Association of Canada 1998 Manual of Uniform Traffic Control Devices for Canada revised to December 2002
- Both sides of the road should have concrete curbs and gutters
- Wheelchair ramps should be included at intersections where deemed appropriate

Township of Langley. (2011) *Subdivision and Development Servicing Bylaw 2011 No. 4861* [PDF].

Appendix C: Design Drawing Set